Chapter 21
Arguing on the Semantic Grid

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1 Introduction

In the last decade, the rapid evolution of Internet technologies has opened new perspectives, created new application areas, provided new social environments for communication and posed new challenges. Among the most influential domains of Internet sciences to date we find Web services, Grid computing, the Web 2.0, and the Semantic Web. These are components of a wider vision, which we call the *Semantic Grid*.

We believe that the Semantic Grid is an interesting domain for Argumentation, for two reasons. First, its new challenges can give motivation to further Argumentation research in ways that have not been explored so far. Second, existing Argumentation theories and technologies can find in the Semantic Grid a natural and convenient application domain.

With this chapter we aim to give a gentle introduction to the Semantic Grid, to Argumentation researchers potentially interested in this new research and application domain. In particular, the next section will be rich in pointers and is mainly intended for "novices" to provide them with a global picture of the main ideas, mainstream technologies and challenges. In addition, we position in this global picture some Argumentation research done, and motivate future work by discussing possible roles that Argumentation can play in Semantic Grid research and applications.

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We will not present new argumentation theories and technologies. We will rather refer to other chapters of this book when needed. Moreover, by no means we aim to produce an exhaustive survey of research done across Argumentation and the Semantic Grid. We will instead give some specific examples, so as to adopt a concrete approach when discussing the bigger picture and the challenges that wait for us.

Some readers will agree that the Semantic Grid is a natural arena for Argumentation to apply its results and further its development following the influential themes identified by Bench-Capon and Dunne [2]. These themes are: argumentation's origins in non-classical logics, models of argumentation as dialogue processes, and diagrammatic views of argument structure.

Important motivations that brought argumentation theory into use in AI arose from the issues of *reasoning and explanation under incomplete and uncertain information*. Some fundamental traits of the Web are openness, incompleteness, and peaceful coexistence of contradictory information. These are not to be seen as limitations but rather as an asset, and their presence is one of the main reasons that caused the popularity of the Internet to reach today's levels. The Semantic Grid swarms with new technologies, standards and abstractions, but all of them are faithful to the open nature of the traditional Web.

The possibility to engage in *dialogue processes* was one of the main social drivers of the Web and of the development of the notion of Social Web and community. These are fundamental elements of the Semantic Grid. At a more abstract level, dialogue is a particular form of interaction, and the Semantic Grid, from Grid computing through Web services to Web 2.0 is all about interaction.

Finally, Web communities have become a reference model for new social participation paradigms such as those of eGovernment and eDemocracy. These paradigms rely on applications and user interfaces, aimed to help exchange of concepts and ideas, accessibility, communication and debate. Thus an influential theme of Semantic Grid development is *visualization methods*.

In this chapter, we argue that Argumentation research can contribute to the creation of an "argumentation-enabled Semantic Grid" vision. We give concrete examples of how this can be achieved, and we discuss the main challenges that must be faced. We conclude by discussing some application areas where argumentation-based approaches to the Semantic Grid may be particularly influential.

2 The Semantic Grid: A bird's-eye view

The Semantic Grid is a vision of collaboration and computation on a global scale, which emerges from the synergy of Semantic Web technologies and ideas coming from three different domains of Internet sciences: Web services, Web 2.0, and Grid computing. These domains differ from one another in terms of inspiration, architecture, technologies, resources they target and features they offer, but they also have many areas of intersection. The Semantic Grid vision proposes to build on the technologies developed in these domains and to add meaning to the Grid, to enhance

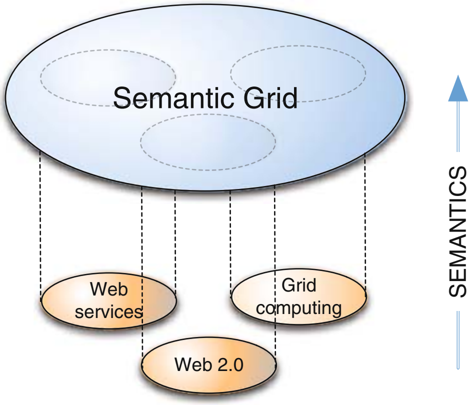

Fig. 21.1 The Semantic Grid

the existing features and offer new ones. In this section we present the main concepts and technologies of each domain, and we discuss the features envisioned by the global picture.

2.1 Semantic Web Technologies

Since its presentation on the pages of a popular scientific magazine [4], the Semantic Web (SW) has appealed to many computer science researchers and outsiders for its features and promises. It has motivated so many research directions, that it has become hard nowadays to clearly identify what the SW is anymore. However, looking back eight years later, it is easy to see how some parts of the original proposal have been dropped or postponed, while the core ideas have resisted and evolved, and the adoption of standards has begun in the information industry.

The SW initiative,[1] in its fundamentals, aimed to overcome the main limitations of the World Wide Web, as it was perceived in 2001. A huge amount of information was available, but machines could not automatically exploit it in full, since its representation only targeted human users. In fact, standard mark-up languages such as HTML—the most common format for Web pages—define how the information should be *presented* to the human users, but do not tell anything about *what* is being presented. This type of information structuring would not help automatic information extraction from Web sites, because the quality of the result highly depends on how frequently a Web site's presentation—i.e., its graphical appearance—changes.

The first step towards the SW consisted in identifying standards supporting interoperability, to overcome problems arising from the heterogeneity of software and hardware. It was decided to build upon UNICODE and XML. Such a choice

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[1] See the W3C Semantic Web Activity's official Web site, `http://www.w3.org/2001/sw/`.

sets the same alphabet for SW applications, but it does not suffice to guarantee interoperability, like the French and the English are not guaranteed to interoperate by simply using the same letters.

The introduction of the Resource Description Framework (RDF)[2] represented a step ahead towards Web information structuring. RDF is simple yet effective. The idea is to represent each piece of knowledge by sentences of the form *subject, predicate, object*. Each part of the sentence is an entity identified by a name. The whole sentence—or *triple*—is read as a binary relation between *subject* and *object*, whose name—or *type*—is defined by the *predicate*. The SW consortium adopted an existing naming system standard: the Uniform Resource Identifier (URI).

With the introduction of RDF, the SW initiative met one of its goals: it managed to provide a standard, structured way for representing information. This again did not suffice to capture the *meaning* given to information. The French and the English structure their sentences in a similar way, but they do not necessarily give the same meaning to words. Therefore, standards were developed to define the meaning of terms/entities, which converged into RDF Schema (RDFS)[3] and its successor, Web Ontology Language (OWL),[4] endorsed by the W3C.[5]

OWL enables to formally define *ontologies*, i.e. to specify the features that characterize a concept, and the relations among concepts. One of the main relations linking concepts with one another is *inheritance*, which defines a parent-child hierarchy. Many other relations are supported, and, above all, users can define their own relations, treated by OWL as first-class objects.

Ontologies are usually defined by a *Terminological Box* (TBox), plus an *Assertion Box* (ABox). The TBox is the set of logical axioms, defining the concepts and the relations among them. The ABox is a set of TBox-compliant concept instances. OWL comes in three different flavours (Lite, DL and Full), each one characterized by a different language expressiveness and underlying formal semantics. OWL Lite and DL refer to the family of Description Logics, while OWL Full refers to First Order Logic and Higher Order Logic. To date, a large number of ontologies have been defined for all sorts of general concepts and specific domains. A new research theme is: how to find suitable ontologies from libraries, such as the Protégé[6] and the DAML[7] ontology libraries, or from the Web. There are also many ontology design tools. The most popular one is probably Protégé [18] developed by the Stanford Center for Biomedical Informatics Research.

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[2] The work of the RDF Core Working Group, completed in 2004, is summarised in the W3C Resource Description Framework official Web site, `http://www.w3.org/RDF/`.

[3] See the W3C RDF Vocabulary Description Language 1.0: RDF Schema, `http://www.w3.org/TR/rdf-schema/`.

[4] See the W3C OWL Web Ontology Language Reference, released as a W3C Recommendation on 10 February 2004 `http://www.w3.org/TR/owl-ref/`.

[5] W3C is the World Wide Web Consortium, see `http://www.w3.org/`.

[6] See the Protégé Ontology Library on `http://protegewiki.stanford.edu/ index.php/Protege_Ontology_Library`.

[7] See the DAML Ontology Library `http://www.daml.org/ontologies/`.

The SW architecture has been conceived as a layered cake, in which each layer uses the services offered by the one below, and offers new, richer and more complex services to the one above. The layers above OWL however are still at an early development stage. Recently, great interest is on the Linking Open Data initiative,[8] which aims at making data freely available to everyone and at defining best practices for exposing, sharing, and connecting pieces of data, information, and knowledge on the Semantic Web using URIs and RDF. The interested reader can find more material on the Semantic Web Activity's official Web site.

2.2 Web services

The Service Oriented Architecture (SOA) has recently emerged as a paradigm for structuring complex information systems within a distributed environment. The main idea consists in organizing a system in terms of re-usable components (services) that provide a precise functionality. To maximize re-usability, services are intended to be loosely coupled with one another. Thus the invocation of a service is typically stateless, and the interaction is based on message passing. Complex applications are then built as groups of services that provide the desired behaviour as a whole, by interacting with each other. Developing complex systems amounts to selecting the services and establishing how and in which order they should interact.

A requirement for the feasibility itself of a SOA is service *interoperability*. To this end, the SOA envisages a de-coupling between the description of the service and its real implementation. Each service publishes a set of metadata describing how it can be invoked by a service requester. The content of such information spans from the logical location were the service can be invoked, to the supported communication protocols and the parameter types.

Although several application frameworks support SOA principles and claim to be SOA-oriented, the most common technological implementation of an SOA is based on Web services. Already supported by many industrial vendors, Web services are characterized by a set of standards regulating all the aspects concerning interaction, leaving a great deal of freedom about the implementation of the services. E.g., the Web Service Description Language (WSDL)[9] provides a standard for describing a service in terms of its logical location, its invocation parameters and the interaction protocol, such as SUN's RPC, HTTP, or the Simple Object Access Protocol (SOAP).[10] The Universal Description, Discovery and Integration standard (UDDI)[11] regulates service description publishing and brokering.

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[8] See the Linking Open Data Web site, `http://linkeddata.org` and Berners-Lee's report on Linked Data at `http://www.w3.org/DesignIssues/LinkedData.html`.

[9] See the Web Service Description Language Web site, `http://www.w3.org/TR/wsdl20/`.

[10] See the W3C's SOAP V1.2 Specifications,`http://www.w3.org/TR/soap12-part1/`.

[11] Documents produced by the UDDI Specification Technical Committee are available from the following Web site: `http://www.oasis-open.org/committees/uddi-spec/`.

Let us give an example of Web service. In the scenario illustrated in [24], Sarah is a research scientist who often travels to conferences, and must abide by her department's regulations concerning refunds. A problem is that Sarah is not an expert in such regulations. A traditional solution consists of publishing all relevant information on a public repository, such as a Web site. Every time Sarah needs to travel, she reads the most recent regulations, downloads the relevant forms from the Web, does the necessary paperwork, and delivers the filled-in forms to her administration. However, this solution does not help Sarah using the information properly, it is prone to errors and misunderstandings, and is not highly automated, instead it heavily relies on direct interaction between Sarah and the administration.

A different solution based on SW technologies seems more appropriate: regulations are encoded in a semantically rich, machine-understandable format, and made available via a "department Web service." Using a smartphone with an intelligent agent running in it, Sarah can have all relevant information automatically downloaded from the Web service. Whenever Sarah needs to travel, she queries her smartphone to know if her trip is approved. Because the rules are published in a machine-understandable format and a semantically rich language, the intelligent smartphone agent can understand their meaning, reason from them, and determine whether Sarah's goal can be accomplished given the current regulations.

While the technological implementation of Web services is now well developed, the task of composing services into a complete system is still the focus of intense research activities. Here we find two main approaches: one relying on the idea of *orchestration*, by a central actor, the other one stressing instead the concept of *choreography*, of many cooperating peers. The textual Business Process Execution Language (BPEL),[12] proposed in an industrial setting, supports the definition of a system as a service that coordinates (orchestrates) many other services. Commercially available BPEL engines can be used to execute the BPEL definition of a system. The graphical Web Service-Choreography Description Language (WS-CDL)[13] instead assumes that services are organized like a choreography, where each peer plays a role and the overall system is given by the contribution of all the players.

It is worthwhile mentioning another language whose aim is also to define complex applications. The Business Process Modeling Notation (BPMN),[14] developed in the Business Processes domain, is a high-level, graphical notation for defining a business process in terms of a procedural flow of business activities. BPMN is highly expressive, but its specifications are not executable—although research has mapped fragments of BPMN into BPEL.

Key issues in the Web services context are discovery and interoperability. The Web services' ability of discovering and being discovered, and then effectively interoperate, greatly affects their potential success. The aforementioned UDDI standard

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[12] See IBM's Business Process Execution Language for Web Services V1.1 Specifications, `http://www.ibm.com/developerworks/library/specification/ws-bpel/`.

[13] See the W3C's Recommendation for Web Service-Choreography Description Language V1.0, `http://www.w3.org/TR/ws-cdl-10/`.

[14] See the Object Management Group's Business Process Management Initiative Web site, `http://www.bpmn.org/`.

was proposed to meet this need. UDDI addresses service discovery using WSDL. However, WSDL descriptions do not contain any metadata about the service semantics, thus UDDI cannot use any information about *what* services provide.

To this end, researchers have studied ways to extend service descriptions with semantic information, by exploiting the results obtained within the Semantic Web Activity. The Semantic Markup for Web Services (OWL-S)[15] and the Web Service Modeling Ontology (WSMO)[16] are the two main proposals. They both rely on SW technologies, in particular on the ontology layer. They extend service descriptions by characterizing the semantics of the input parameters, of the outputs, as well as of the preconditions and the effects related to the service invocation. Semantically enhanced Web services are called *semantic Web services* [17].

2.3 Grid computing

The World Wide Web is mainly about presenting content. It was not designed to provide other types of resources, such as storage space or computing power. Web services enable to invoke a specific service via the Web, but they do not allow user processes to target computing resources of other computers. The Grid started as an idea to overcome these shortcomings, building on two successful distributed schemes for the Internet: peer-to-peer computing and Internet computing.

Nowadays, most of the network traffic in the Internet is due to peer-to-peer. Peer-to-peer applications, such as those mainstream relying on the BitTorrent protocol,[17] and other former file sharing applications such as Napster, GNUtella, and Freenet [7], provide a means to distribute files across a network, by replicating them on many storage devices. The ubiquity of these types of applications paved the way to a new model for mass storage, in which a distributed file system over the network gives a user petabytes of virtual space, transparently distributed across the hard-disks of many users, providing replication, fast distributed access, and increased reliability.

The success of this model was also due to a steady decrease in the cost of home computers. Mainframes and supercomputers became less used, while intensive, number-crunching applications are more and more split into (almost) independent sub-parts and fed to computer clusters. The ubiquity of home computers and extension of the Internet made it possible to target and use new resources, such as idle CPU time of millions of computers. One example is given by the famous SETI@Home project and its quest for extraterrestrial life, which has produced the largest computation in history to date, and by other projects which adopted the same method and gave birth to the new model of Internet computing.

The Grid is, in general, the possibility to publish and use computational resources (as opposed to Web pages) on the Internet. For example, the computer of a European

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[15] See the DAML Services Web site on DAML-S and OWL-S, `http://www.daml.org/services/owl-s/`.

[16] See the The ESSI WSMO working group Web site, `http://www.wsmo.org/`.

[17] See the BitTorrent.org forum, `http://www.bittorrent.org/`.

user is often idle when its owner is sleeping: there we have a resource—computing power—which could be made available on the Grid, for the benefit of another user who is not sleeping, say an Australian. The Grid concept heavily relies on the idea of reciprocation, thus the amount of accessible resources will depend the amount of shared resources. For instance, the Australian is expected to return the favour at some point, say 12 hours later, as night falls in Oceania. The implementation of the Grid opens a number of issues [11], such as the need to define new standards and protocols, to ensure security and to provide new accounting methods, access rules and policies, but it also offers unprecedented computing power and storage capacity. The organization leading the global standardization effort for Grid computing is a community of users, developers, and vendors, called the Open Grid Forum (OGF).[18]

Besides providing computing resources, research on the Grid is focussed on the concept of *Virtual Organizations* (VOs) [9]. Users that have similar goals but belong to different (physical) organizations might be interested in sharing various types of resources. For example, the members of a project might work in different departments or universities, but they want to share memory and CPU time, but also software, data, experimental results, partial computations that could be reused by other members of the VO. A type of VO could be a Data Grid: as a single virtual data store which is actually distributed. The VO concept is also used in the context of Web services, for example by the ArguGRID project (see Section 3.3).

A notable example of Data Grid was the Comb*e*Chem project [22], which also represented a step towards the evolution of the Grid in the direction of adding meaning to data. The project's aim was to build a distributed repository of chemical experimental results. A requirement was that the repository should accept data taken from any sort of chemical experiment, possibly with new types of inputs (instrument sensitivity, substance purity, etc.), unforeseen at the time the repository was being designed. Another requirement, to ensure practical usability and automated processing, was that the input data would have to have a machine-understandable semantics. The adopted solution was to use RDF. Every laboratory can add new information associated with some chemical compound (either new or already present) simply by adding a triple in the (distributed) RDF store. Despite all the limitations of RDF compare to, say, OWL, Comb*e*Chem was nevertheless an example showing the practical need of adding semantics to the Grid. The need for semantic information is present at the various levels of the Grid, as it is discussed in the Open Grid Service Architecture (OGSA) documentation produced by the OGF [8].

2.4 Web 2.0

The World Wide Web, originally conceived and developed to enable automatic information sharing between geographically distributed individuals, is being more and more strongly shaped by the idea of community. The so-called Web 2.0 is a

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[18] See the Open Grid Forum Web site, `http://www.ogf.org/`.

place where people exchange ideas using Web sites, blogs, chats, and spaces for social networking, such as Orkut, mySpace, Flickr, Blogger, LinkedIn, FaceBook and many others [19]. The mainstream technologies developed in this context are mostly application-driven. They are wikis, blogs, microformats, and social tagging tools. Differently from the areas presented above, the Web 2.0 was not born from a vision but it rather emerged from the grassroots. This is why we would not talk about an architecture for the Web 2.0, but rather about a collection of Web-based applications. According to IBM software architect Steven Watt,[19] the Web 2.0 is best described as a core set of patterns that are observable in applications that share the Web 2.0 label. These patterns are *services* (as an architectural feature), *simplicity*, both for the user and the developer, and *community mechanisms*. Web 2.0 applications are dominated by sites that explicitly seek to create communities and connect people via the artifacts that they share [5]. Differently form Grid computing and Web services, Web 2.0's expansion found its main driver in the people's need to feel a part of a community, in which they can contribute and give their best efforts without expecting any direct return on investment. We could say that the Web 2.0 comes from a view of the Internet as a social experiment, and therefore has a strong social connotation.

The area in which Semantic Web and Web 2.0 meet is sometimes called *Social Semantic Web*. There we find initiatives such as SIOC (Semantically Interlinked Online Communities)[20] and FOAF (Friend Of A Friend).[21]

2.5 Putting it all together

From a historical perspective, Grid computing and SW research have joined forces as researchers in the two communities realised that they had a common goal: fostering collaborative work. Semantic technologies enable machines to share information, and to feed it to applications which have been developed independently from one another. Adding meaning to the Grid amounts to associating semantic information to computing resources, which allows for resource discovery [14], and inherits features of SW services, such as interoperability. SW services gain from the Grid better reliability and scalability, thanks to the replication of data and services. On the other hand, from a technological and business-oriented perspective, XML and Web services are becoming the industrial standard for integrating distributed systems.

Many researchers have recognized the synergy of ideas developed in these different communities. Thus a vision has emerged which draws from all the above and goes under the name of *Semantic Grid*. Among others, De Roure defines the Semantic Grid as an "extension of the current Grid in which information and services

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[19] See *Mashups—The evolution of the SOA, Part 1: Web 2.0 and foundational concepts* by Steven Watt on the IBM Web site, `http://www.ibm.com/developerworks/ webservices/library/ws-soa-mashups/`.

[20] See the SIOC initiative Web site, `http://sioc-project.org`.

[21] See the FOAF project Web site, `http://foaf-project.org`.

Table 21.1 Inspiration, architectures, resources and features of the Grid

	Web 2.0	**Web services**	**Grid computing**
Technologies	wikis, blogs, microformats, social tagging	protocols, standards, implementations, tools	middleware, standards, implementations, tools
Inspiration	social, community	business	e-Sciences
Architecture	Web-based applications	SOA, distributed systems	distributed computing
Resources	social communication	services	storage space, CPU time
Features	freedom of expression, cooperative work, dissemination, exchange	service-level agreement, quality of service, fault tolerance	VOs, performance, transparency, fault tolerance, accessibility

are given well-defined meaning, better enabling computers and people to work in cooperation."[22] Nowadays, the user base of Web 2.0 technologies is limited only by the extension of the Internet. The extent and impact of the Web 2.0 phenomenon cannot be neglected, and we consider technologies oriented to social networking and community to be first-class citizens of the Semantic Grid grand vision.

Table 21.1 gives the global picture. By Semantic Grid, we mean the vision where semantic technologies contribute to achieving, as a whole, enhanced virtual organisations, resource discovery, selection, cooperation, user-oriented communication and creative content browsing.

3 Argumentation and the Semantic Grid

State-of-the-art research has recently identified several areas in the Semantic Grid vision in which argumentation can play a role, either by exploiting Semantic Grid technologies, or by contributing to them.

3.1 Web 2.0 and Semantic Web Technologies for Argumentation

The advent of Web 2.0 has opened up new horizons for participation and expression. Arguments definitely play a role in this picture. Any basic blog and community software supports posting of user comments, replies to comments, etc., and although conversations sometimes tend to drift to eristic dialogues, still there is a large share of information which could represent a valuable asset if it was put in a structured way. Consider for example typical Web 2.0 topics of discussion such as "Monogamy is out of date," "The phrase *war on terrorism* is a misnomer" or "Being a nihilist ain't that bad." The level of discussion could raise significantly if search engines could answer queries such as "what is the support of such a topic," "what are all arguments that attack a given argument," or "what can a given argument be used

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[22] See the Semantic Grid Community Portal, `http://www.semanticgrid.org/`.

for," and possibly reason about the results automatically. Technology has not yet reached this stage, but there are tools aimed to facilitate structured Web discussion. They include, for example, TruthMapping.com,[23] which incidentally hosts discussions about the topics above, and Discourse DB, already mentioned in Chapter 19. TruthMapping.com provides an intuitive interface to enable users to engage in structured argumentation dialogues about topics, by identifying arguments, rebuttals, undercuts, and organise them using a simplified structure. Discourse DB[24] is a more specialized forum to discuss politics, and it can export content in RDF.

In this direction also goes work by Rahwan et al. on a World Wide Web of arguments [20]. A standard, semantically rich format is assumed for Web information, as well as for arguments. Arguments can be published on the Web using a well-defined structure, that enables automatic agents to use the published information, without posing excessive difficulty to non-expert human users. The challenge is to take the best balance of usability with automatic agents and simplicity for human users. Automatic agents should be able to understand arguments published by humans as humans understand them. On the other hand, humans should not be burdened by complicated tasks that would refrain them from publishing, in everyday life, arguments in a semantic form.

With a look at a future in which several argumentation-enabled Web applications will interoperate with one another, Rahwan and colleagues [6] propose the Argument Interchange Format (AIF), an ontology to represent arguments, together with RDF encodings and tools for authoring and navigating arguments (see Chapter 19). The AIF ontology was implemented in RDF and RDFS using Protégé (see Section 2.1).

3.2 Argumentation Technology for the Semantic Web

In the same way as SW technologies can help community-oriented argumentation and argumentation-based reasoning, also argumentation technologies can help the development of the SW. Laera et al. have identified a possible role of argumentation technologies in the ontology mapping process [16]. Ontologies, as we have seen earlier on, specify concepts and their relations in a formal way. In a distributed context, agents or Web services that need to interact will refer to some specific ontology, possibly developed by their designer for completing specific tasks. The ontology might be published on the Web, or simply inserted in an agent's knowledge base. When the interacting parties need to communicate, they can either use a common ontology, or they can try to establish a set of correspondences between terms in one ontology and the other. Various methods can be conceived to perform such an *alignment* [21]. The proposal presented in [16] is to provide agents with means to discuss, via argumentation, a mapping that is satisfactory for both parties. In this

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[23] See TruthMapping.com Web site, `http://www.truthmapping.com`.

[24] More information on `http://discoursedb.org/wiki/DiscourseDB:About`.

setting, each agent can have its preferences and interests in the correspondence between terms. For example, one agent might have a very shallow ontology, and might prefer using terminological correspondences, instead of structural correspondences that would make less sense in this case.

The alignment starts with an ontology alignment service [10] that provides the possible matchings, together with a confidence level for each matching and a set of justifications that explain why the mapping was proposed. The agents compare the confidence level with an internal threshold. Mappings that do not reach the threshold are discarded. The arguments are the possible matchings returned by the ontology alignment service based on a Value-based Argumentation Framework (see Chapter 3).

3.3 Arguing Virtual Organizations: ArguGRID

The ArguGRID project, led by Francesca Toni, proposes a vision in which Web services/agents and argumentation technologies may be combined to support decision making and negotiations inside Virtual Organizations (VOs). Some of the main issues addressed by way of argumentation are Web service selection and composition. The project proposes an architecture consisting of a platform [23] using peer-to-peer computing, and VOs made of Web services associated with argumentation-based agents using resources of various kind. Agents are built on top of a middleware, which is the main component of the ArguGRID platform.

ArguGRID agents are responsible for the negotiation of contracts regulating their interaction. Argumentation is used for different tasks: to solve a decision-making problem in the service selection process, to support contract negotiation and agreement about executable workflows, and to help dispute resolution with respect to agreed workflows and contracts. The agents use CaSAPI [12], a general-puropose argumentation tool for Assumption-Based Argumentation (see Chapter 10).

The project focusses on three main applications: Earth Observation, eProcurement, and eBusiness. In first application, the problem is information source heterogeneity and distribution. The role of argumentation is mainly in decision-making and service composition, especially in crisis scenarios such as oil spill or fire detection. The purpose is to produce user-tailored solutions that combine existing services in a workable and effective way. The eProcurement application investigates use cases based on automating decision-making processes and negotiations among a large number of partners. There are specific example cases showing, for instance, how eAuction parameters can be optimised. The last application focusses on the idea of contract. Argumentation is used to negotiate contracts based on a formal framework using goals and preferences and to resolve conflicts. ArguGRID uses a two-level reasoning process. The acceptability of certain beliefs and facts is established at the "object-level," while at the "meta-level" the legal doctrines determine the risk allocation. More information is on the ArguGRID Web site.[25]

3.4 Arguing Semantic Web Services: ArgSCIFF

The research presented by Torroni et al. in [24] proposes a framework that supports dialogic argument exchange between SW services. Interaction among Web services is essentially of a request-response kind. This is sometimes not enough informative for human users, who cannot understand the justification of the interaction outputs nor can effectively intervene to modify it. ArgSCIFF aims to making Web service reasoning more visible to potential users by using dialogues for service interaction. Argumentation technology is used to drive the interaction at a high level, where human users can perceive message exchanges and service-request sequences as dialogues that they can understand better than current modalities. ArgSCIFF agents use the SCIFF[26] abductive logic programming framework [1] to implement an argumentation framework in the style of Assumption-Based Argumentation (see Chapter 10). Let us look into ArgSCIFF in more detail.

3.4.1 Argumentation for machine-supported, collaborative problem-solving

Let us consider again the scenario introduced in Section 2.2. The solution based on Web services greatly automates the process, but it is not enough to accommodate interactive, dialogical problem-solving. If Sarah's request is rejected, Sarah cannot interact with the administration staff and find out why. This is true of all client-server based systems which provide definitional answers rather than informed justifications that users could argue with and, possibly, eventually understand and accept. The risk is the creation of a barrier to human adoption of IT solutions.

What ArgSCIFF proposes instead is a third scenario, in which the department's service and Sarah's smartphone agent interact by exchanging arguments in a dialogical fashion. Sarah's smartphone not only posts requests to the department's service and obtains replies but also reasons from such replies. When the replies are negative, the agent challenges them and tries to understand ways to obtain alternative, positive replies. If necessary, the agent can provide fresh information that could inhibit some regulations and activate others. This solution delegates most of the reasoning and interaction to the machine by relying on semantic Web service technology, and it gives Sarah understandable, justified answers and decisions. The whole process is a machine-supported, collaborative problem-solving activity rather than a flat client-server, query-answer interaction.

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[25] See the ArguGRID project Web site, `http://www.argugrid.eu/`.

[26] See the SCIFF framework Web site, `http://lia.deis.unibo.it/sciff`.

3.4.2 Dialogue based Web service interaction

The ArgSCIFF architecture extends the semantic Web service architecture with argumentation technology implemented through *request* and *challenge* methods. The ArgSCIFF argumentation protocol is asymmetric: the requester agent sees a dialogue, and the provider agent sees service requests. Requester and provider interact with each other using SW technologies. From the SW's ontology layer downward, the two semantic Web services will adopt some agreed standard, such as HTTP, SOAP, and RuleML for rule exchange. At the logic level, knowledge is expressed by SCIFF programs. The ArgSCIFF proof procedure instead is used to evaluate queries and replies, according to the abductive semantics defined in [24]. The exchanged messages follow a simple request-reply protocol, but at a high level, the user can see a dialogue, in which the requester service engages, to argue for its own case. From the provider's standpoint, no dialogue occurs. The two different views of the ongoing interaction generate a decoupling, and this decoupling makes it possible to marry stateless Web services with argumentation dialogues.

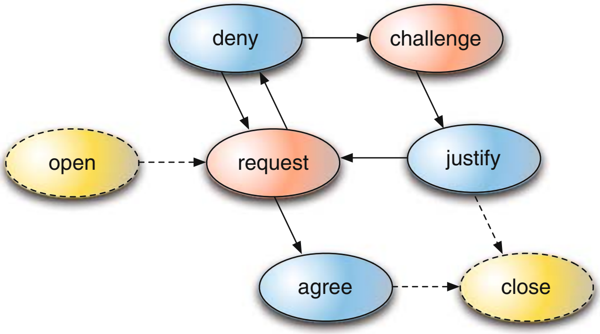

Fig. 21.2 The ArgSCIFF dialogue protocol starts by a *request* and can *challenge* the provider in case of negative answer.

The dialogue protocol starts by a *request*, which can result in an agreement or a denial. In case of denial, the requester can *challenge* the provider, which will answer by justifying his previous answer. Depending on the requester's knowledge and goals, the dialogue can proceed by a new request, or reach an end. The protocol is depicted in Fig. 21.2.

The dialogue protocol's implementation relies on two kinds of knowledge: (1) a domain-independent knowledge that encodes the argumentation protocol and is the same for both requester and provider, and (2) specific, private knowledge, which distinguishes one party from the other. This separation makes the ArgSCIFF able to accommodate other kinds of possible scenarios, in which the domain knowledge will be different, and it supports heterogeneity of policies and negotiation strategies.

3.5 Concluding Remarks

With this brief review we covered only a part of the research pursued at the intersection between Argumentation and the Semantic Grid. There are many other important contributions, such as work by Bentahar et al. [3], who propose to help Web services better interact by giving reasons that support their conclusions and receive counterarguments, and Buckingham Shum's Cohere project [5] mentioned in Chapter 19. Without even attempting to be exhaustive, this short survey suffices to demonstrate an existing interest of various research groups in these topics. We believe that such an interest will grow. In the near future, we expect application-driven development in theories, standardization, and tools and a closer dialogue between the Semantic Grid and the Argumentation communities. In the next, concluding section we give a subjective and speculative view about the future of this exciting new multidisciplinary domain.

4 Future Directions

We believe that the marriage between Argumentation and Semantic Grid will result in an enrichment of the Semantic Grid features. We identify some possible directions and challenges that motivate future research, and discuss Semantic Grid applications in which Argumentation can take a lead.

Argumentation and Grid computing. Some of the main issues in the Grid are accounting, access rules and policies specification, management, and enactment. Argumentation technologies can be used to reason and negotiate about the rights acquired over some resource's access. Moreover, they could help cross-domain reasoning, encompassing user preferences, regulations, and technical constraints. For example, a user could prefer not to give resources to other users that have a certain profile—users that are weapon producers or that are not generous with their own resources. Argumentation could play a role in the procedures that determine resource access by taking such kinds of preferences into account. Semantic technologies, and in particular ontological reasoning, could become more important when these procedures need to determine, e.g., that a "gun" is a kind of "weapon." A challenge here is to provide powerful reasoners that are lightweight, performing, and customizable, so that many different argumentation proof procedures and semantics such as those discussed in Chapter 2 and Chapter 6 can be made available. Another one is to develop suitable policy specification languages that can be used on top of these reasoners.

Argumentation and the Web 2.0. Web social communities nowadays seem to be among the best places to argue. Argumentation-related technologies could play a role in the Web 2.0 by automating tasks that help social communication activities. Some possible scenarios may involve tools to find related discussions and related results of discussions, tools to verify argument backing from specialized corpora, and tools to find arguments from selected communities, which could be used in other contexts as "expert opinions." This should be done in integration with ontological reasoners, able to find meaningful links between elements of discussions, whether inside the same topic or across multiple topics. Moreover, research presented in books such as [15] demonstrate the rich potential of state-of-the-art argument mapping and visualization tools. They can also have a great impact in the Web 2.0. We identify, as a challenge, gearing existing tools for Web 2.0 usage, following the patterns of service, simplicity and community seen in Section 2.4. Great effort has to be put into graphical user interfaces and usability.

Argumentation and Web services. ArgSCIFF and ArguGRID have shown the potential impact of argumentation technologies in Web service interaction, selection and VO creation. Service discovery and selection are key aspects of Web service technologies. Argumentation-enabled Web service search engines could greatly improve these processes and thus have a considerable impact in the Web service domain. An open challenge is the development of standards, necessary for the integration of argumentation technologies in the service-oriented world.

Argumentation and the Semantic Web. Ontological reasoning nowadays focusses on concepts such as subsumption and consistency. In the future, other ontological relations could become important, such as for example relations of strength, support, and the trustworthiness and reliability of sources. They could be properly determined by argumentation procedures, and become key elements of distributed ontological reasoning. Here the main challenges that we see are of a theoretical nature. Essential steps in this direction must be moved towards integrating Semantic Web languages and logics, such as Description Logics, and argumentation theories, similarly to what authors have done in the past to combine, e.g., Description Logics with Logic Programming to help integrating ontological reasoning with rule-based reasoning [13].

4.1 Challenges

These directions draw a vision in which the Semantic Grid will offer richer services, more links, better interaction, information, and transparency of its processes. To achieve this goal, two challenges must be faced.

The first one is in the **theory**. Much of the potential of argumentation technologies depends on the ways they can be *integrated* with other logics and reasoning frameworks, such as ontological reasoners. Issues of *computational complexity* and *distribution* must be addressed, to propose methods that can be applicable in such a vast and heterogeneous domain.

The second one is in the **tools**. The Web 2.0 has became so popular thanks to the applications. A relatively small part of the argumentation community today works on implementing tools. This is a limitation. To produce an argumentation-enabled Semantic Grid, tools must be developed for argument visualization, exchange, tagging, and the theory must be followed by automated procedures that are user-friendly and efficient. In particular, the main issues here are about *reasoners*, which must be fast and easy to use on the Web, *user interfaces*, which must be simple and ergonomic, and *standards*, needed to leverage the deployment of Semantic Grid applications.

4.2 Applications

We conclude the chapter by suggesting five areas where argumentation-based approaches to the Semantic Grid may be particularly influential.

Trust and service selection. The proliferation of Web services is an asset. Because it is important to make the best out of it, semantic search engines are now subject of extensive investigation. But do current technologies provide the necessary guarantees to the user? Nowadays, users seek reassurance in reputation-based methods such as customer reviews and feedback forums. This method does not obviously scale up. Along with scalable semantic search methods, we need powerful tools that help service selection based on an increasing amount of information. We see a big role of argumentation-based techniques in supporting qualitative, open, community-oriented trust management.

Contracting and negotiation. Business contracts are synchronization points that enable services to create, evaluate, negotiate, and execute interaction. They can answer some of the challenges posed by the future Semantic Grid requirements, such as quality of service, rights of use, and interoperability at a very large scale. Thus contract specification, generation, update, management, and negotiation methods are and will be subject of increasing research efforts. Here there is an opportunity for argumentation technologies to take a lead in supporting declarative, collaborative Web services contracting, and in integration with Semantic search engine technologies, to play an important role in service selection and composition, negotiation, dispute resolution and legal reasoning.

Human-Web service interaction. A great amount of business resources is devoted to interaction with people. Keeping customers happy can be challenging and expensive. We are moving towards a world of composite services, dynamically created on demand, specialized and tailored to the need of the individual. Traditional resources and interfaces with the user, such as call centers, user manuals, information repositories may soon be not up to the task any more. The knowledge needed to understand a service's behaviour and explain it to a potential customer may grow too fast, and equally fast it may become obsolete. Argumentation theories can provide a solution in the difficult task of selecting relevant, non-contradictory information that can be used for the interactive advertisement of new products or for justifying the behaviour of a Web service to a human user.

E-Sciences. Some pilot projects in the Semantic Grid domain, such as ArguGRID, consider argumentation as a core technology to manage Virtual Organizations. Argumentation may be particularly influential in enhancing distributed global collaborations, and can play a key role in some application domains, such as oil drilling or pharmaceutical testing, in which costly experiments must not be repeated and each one of them must be exploited scientifically to the full. To take a lead in this direction, research in argumentation will have to push towards cross-domain decision making support, encompassing domain-specific know-how, contract-based reasoning, and normative reasoning, to cite some.

Digital Libraries and Technology Enhanced Learning. The application of ICT to cultural heritage, education, and learning, is catalysing the interest of many research groups. At the time of writing, the European digital library, museum and archive—Europeana—is being launched to provide users direct access to some 2 million digital objects, including film material, photos, paintings, sounds, maps, manuscripts, books, newspapers and archival papers.[27] We think that suitable evolutions of the AIF and new argument exchange, mapping and visualization methods for cross-domain knowledge exploration are directions to pursue. The products of such research will be an invaluable asset for scholars and may determine new trends in the creative exploration of cultural content.

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[27] See the Europeana Web site, `http://www.europeana.eu/portal/`.

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