An Integrated View of GRID Services, Agents and Human Learning

Stefano A. Cerri

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Stefano A. CERRI[1]
LIRMM: CNRS & University Montpellier II

Abstract. The contribution reports on three aspects of our research activities on GRID services, Agents and Human learning: an integrated vision, a statement of intentions concerning a relatively new life cycle for Service Engineering and a review of achieved results, presented by embedding remarks and quotations in the relevant points. The essence of the contribution lies in the concept of service that is considered to be intrinsically conversational both during its dynamic definition and during its delivery. It is shown that Agents are the most promising abstractions (and technologies) offering a concrete approximation for future conversational GRID services and that Human learning is a quite suitable context for including the Human in the loop of the higher level services to be developed for mixed Virtual Organizations on future GRID networks.

Keywords. GRID services, Agents, Technology Enhanced Human Learning, Virtual Organizations, Service Engineering, Open Grid Human Service Architecture.

1. Introduction

Current research results in Informatics can be metaphorically depicted as a forest. Understanding and using the opportunities offered by discoveries as well as inventions available in the forest - where trees, and families of all sorts of plants often allow to evaluate the details, but paradoxically hide their essential contribution to the overall scene - becomes quite hard if not impossible due to the complexities both of the demand - requirements for solutions of very complex problems - and of the offer - multiple and sophisticated technologies and standards continuously evolving and competing with each other -. The only way to "understand" and "choose" seems to be, in the metaphor, to try to fly a bit above the forest and a bit behind in time: evaluating not only the results but also the historical processes as well as the reasons that have produced those results, with a continuous effort of integration and forecast for future research directions offering potential solutions in the years to come.

This paper presents the author's vision on the integration of advances in Agent technologies within Technology Enhanced Learning scenarios such as those emerging from

[1] Author: Stefano A. Cerri, LIRMM, 161, rue Ada; F-34392 Montpellier cedex 5; E-Mail: cerri@lirmm.fr

the availability of GRID services [1-4] . The vision has been in part adopted within the ELEGI project[2]. Sections 2, 3 and 4 actualize previous reports on the pair wise intersection between the cited concepts.

Further, Section 5 highlights:

- the proposed Service Engineering life cycle such as it has been intended within the SEES: Scenarios dedicated to Service Elicitation, Exploitation and Evaluation for Informal Learning as well as
- the necessity for including the human in the GRID architecture, by extending the Open Grid Service Architecture to Human services (OGHSA).

Finally, the research advances as they are documented by other papers and software experiments produced by the author and/or collaborating members of the team are inserted in the text when convenient.

A conclusion rounds off the paper.

2. e-Learning versus Grid Services[3]

2.1. Introduction

While e-Learning is a quite established concept, to be traced back in its roots in the 60ties (the PLATO and TICCIT experiences in the US), the GRID notion is considered as the evolution of the WWW and therefore is quite novel both as a technological solution and as its associated opportunities.

The ELEGI project is an important effort that aims to anticipate the conditions for an effective diffusion of the GRID, i.e.: by identifying design constraints that will fit a large significant class of expected uses of the GRID, those around e-Learning. Therefore, it seems to us important to point out where e-Learning and the GRID may eventually cross, i.e.: why e-Learning's traditional problems may find adequate solutions from developments around the GRID and, vice versa, what kind of developments on GRID' s properties will be required by e-Learning needs.

In order to identify the link between GRID' s potential technological innovations and e-Learning, one has first to agree about a few basic assumptions concerning the GRID and e-Learning.

2.2. Assumptions about the GRID

As to our current knowledge, the most important aspect of the GRID concept consists in going beyond the client-server model of one-to-one communication between software applications for a peer-to-peer one, many-to-many and distributed. The same principle has been for years a major objective of autonomous Agent's technologies, even if one may still

[2] www.elegi.org
[3] This section actualizes the previously published paper [5] .

ask how many multi-agent systems indeed are equipped with a peer-to-peer communication model and thus whether software Agents are really autonomous.

This view of the GRID as the large scale embodiment of autonomous Agent's concepts has recently found an authoritative support [4]. However, in the cited paper the roadmap from Agents to GRID services and vice versa is still in its infancy: we will comment on that roadmap in section 4 . By now, we will assume in a first approximation that the GRID will consist of technologies allowing autonomous Agents to perform computations and to communicate on the Net in an optimal way, i.e.: exploiting resources where they are available in a fashion transparent for the Agent user. In the following, a few remarks on how we came to this conclusion.

Looking more deeply into the GRID fundamental notion (movement of processes in order to optimize resource allocation) one indeed discovers that, in order the movement to be useful (effectively optimizing), it has to be decided and executed dynamically. This dynamicity has as a consequence that

a. we have to shift to the GRID the responsibility to execute the movement at run time;
b. we have to assign to each process the responsibility to propose to GRID at run time such an optimizing event.

Processes, therefore, have to decide autonomously (at least for what concerns their potential reallocation) taking into account the expected workload, their proximity to other processes, etc. The decision process, within each computational process on the GRID, may be very complex - as well as very useful -. Processes, being autonomous on the issue, have to be granted the liberty to formulate requests to other processes about Information necessary for them to decide. Conversations among processes become necessary, initiated by any process and addressing, in principle, any other process. The client-server model is thus insufficient.

Once processes may take the initiative to trigger conversations, they may arrive to the conclusion that it would be good to move to a more suited computational resource to perform optimally their task. This movement has then been decided dynamically by the process as a result of conversations. If we consider that the relocation of processes for optimizing the workload of processors in a distributed environment is a typical service asked to the network, the conclusion is that a service is dynamically generated by processes, thanks to previous autonomous conversations.

If a service may be generated dynamically, many other services do, as they would use a similar technology (autonomy of taking an initiative, conducting adequate conversations with peers, deciding and finally asking the GRID to deliver the physical transfer service). One comes to the conclusion of Foster et al. [1,2] that what initially was conceived for supercomputing and optimization may offer a new generation of models, tools and infrastructures for any activity on the GRID, including e-Commerce, where the dynamic generation of service from conversations is a necessary step for credible transactions. One immediately realizes also that the Web, as it is, has its major shortcoming in the lack of state of the HTTP protocol, thus the lack of persistency of conversations.

Indeed, we share the following vision of GRID computing [3]: “The grid metaphor intuitively gives rise to the view of the e-Science infrastructure as a set of services that are provided by particular individuals or institutions for consumption by others. Given this, and coupled with the fact that many research and standards activities are embracing a similar view, we adopt a service-oriented view of the Grid throughout this document …. This view is based upon the notion of various entities providing services to one another under various forms of contract (or service level agreement).”

Shifting from a product-oriented to a service-oriented view of the Network is a challenging goal that has necessarily to pass through the analysis, definition and implementation of dynamic conversation protocols.

2.3. Assumptions about e-Learning

There is currently much interest on e-Learning. We will not survey here the reasons for this interest (see, for instance, the Introduction to [6]).

However, in spite of the apparently massive growth of the offer of e-Learning products and services, and, in principle, of the demand for human learning as it is expressed at individual, institutional and corporate level, we are not convinced at all that the offer and the demand meet in an acceptable way. There are exceptions, but the rule holds that effective, large scale applications of e-Learning are rare.

Our primary interpretation of this paradox concerns the quite simple observation that e-Learning requires a profound transformation of an established practice, for individuals and for Institutions. In e-Learning the three axiomatic assumptions for traditional educational settings: same content, same time, same location, are not valid. Even if we keep the “same content”, yet e-Learning implies asynchronous interactions at a distance. These properties are claimed to be the value added to e-Learning with respect to traditional Education, but may also represent a constraint for its wide acceptance.

Historically, distance learning has been implemented and studied since many years[4]. From those studies, as well as from our own experience in the domain, the lesson we have learned is that we cannot consider e-Learning as an electronic variant of classical Education. That is indeed the problem. Not only the conditions of the educational offer are totally different, but also the cognitive and social attitude of humans require a completely dedicated analysis that most of the times has no precedents and thus requires a research attitude.

e-Learning is therefore not an application of technologies to human learning, in the sense that assuming to know what to apply (the technologies) and how (the pedagogy) one puts things together and the result will be a success (people learn). On the contrary, each serious effort has to be considered unique in the sense that it requires specific technologies and specific pedagogical principles to be developed and applied in a trial and error fashion within a specific context. This is the fundamental challenge of e-Learning: services and products have to be combined differently each time, according to each e-Learning situation.

We believe that the major obstacles for e-Learning are bound to the innovative nature for individuals and Institutions of the asynchronous distance interactions among humans and electronic resources. Surprisingly, the available technical tools are quite sophisticated and ripe, in many respects (for instance, looking at the recent Intelligent Tutoring Systems

[4] For an impressive list of contradictory scientific reports on pro's and con's of technologies in Education in the last century, see: http://teleeducation.nb.ca/nosignificantdifference .

or AI in Education Conferences one may notice the progress). Perhaps one may better even more the offer by putting efforts in the integration, or in the dialogue management, that is yet poor in real situations. However, we believe that the bottleneck is more to be found on the human motivation and trust for engaging in e-Learning practices. By "human" we encompass any role: learners, teachers, managers, experts, ... as well as combinations thereof, i.e.: societies (classes, groups of teachers, etc.). One of the reasons for a lack of motivation in learners is the difficulty for certification of their learning when is has occurred at a distance. Another is the relative lack of friendliness of systems (when I'm stuck: who helps me?). The list of problems continues, yet human motivation and confidence is crucial in order technologies to be successfully introduced in human social practices.

2.4. Requirements

If the above outlined assumptions about the GRID and about e-Learning are correct, our priorities should be consequent. Hereafter a few consequences.

The technological research priorities for the Learning GRID concern the integration of simple yet very powerful tools supporting the communication in virtual human communities in such a way that the concerned human Agents feel safe, are motivated and trust the effectiveness of the learning process in which they engage. Included in this confidence we may consider the effectiveness of heavy computational processes, when required, such as video streaming, simulations, virtual reality. However, very large potential audiences for e-Learning are far from even envisioning those applications, as they are not convinced that e-Learning helps them to solve their problems. In order to avoid the GRID to become a set of solutions in search of the problems (as it has been sometimes the case for Web technologies in e-Commerce a few years ago: once more people overestimated short term effects of innovation and underestimated long term ones), we should give the priority to the motivation of humans for e-Learning, we should assume a human-centered or - better - social view of system design. The peer-to-peer model of human learning by focused conversations with teachers, experts and the like (for instance: the pragmatics of dialogues as it is currently expressed in a rudimentary way by Agent Communication Languages and Speech Act Theory) may become a fundamental inspiration for autonomous Agent's software technologies to be developed in order to realize the GRID. Complex standards for interoperability of educational documents - such as SCORM, IMS, EML and the like - may be considered as a technology push attitude, complementary to the social-user-pull one outlined in these pages. The last deserves a priority as it is relatively immature and at the same time crucial for success. The Semantic GRID will emerge insofar the technologies for Agent-to-Agent conversations and their pragmatic layers will be realized.

The strategic priorities for the Learning GRID concerns the evaluation and certification of learning effects. Traditional Institutions (in particular: teachers) do not trust e-Learning unless in a quite trivial utilitarian fashion. Teachers do not have the right to consider their e-Learning activities as part of their pedagogical duties. Traditional Institutions are not prepared to certify the knowledge and skills of learners independently from the way they have acquired them (in presence). Retrospectively, in spite of the recommendations to teachers and Institutions, the practice of e-Learning is rare because no one sees his or her interest in investing into a fundamental modification of traditional behaviors. One may show any impressive result of e-Learning experiments, but unless the practice is considered useful by the delegated people and Institutions (the teachers), as a consequence of a reformed statute, it will not be accepted at a large scale as a serious complement to traditional Education. Most probably, it is useful to look for non institutional potential users, having sincere learning needs (as we do within the Informal SEES, addressed in section 5 hereafter), instead of pushing technologies into reluctant Institutions.

The tactical choices for the Learning GRID should be guided by an experimental, socially oriented and evolutionary view of the infrastructure supporting generic virtual communities. Dialogues are central. Any human collaborative activity requires and implies human learning. Initially the GRID technologies may be dedicated to facilitate mainly human-to-human dialogues (by written, by voice, by video and voice); considering that artificial Agents (our GRID services) may incrementally be introduced, once the communities are stable and motivated, in order to enhance learning effects in suitable conditions. The Learning GRID will be a success when communities of users will eventually testimony their positive experiences, not just when communities of producers will advertise their performing solutions. The challenge will be to transform curiosity driven virtual communities into performing virtual organizations.

3. Agents versus Human Learning[5]

3.1. The historical emergence of Agents

From the seminal work of Newell concerning the Knowledge Level in Knowledge Based Systems [8], we know how to separate the analysis and synthesis of Knowledge from the ways it may be implemented at the Symbol level. Different approaches may be adopted, e.g. Description Languages that assume as an hypothesis the availability of Ontologies and identify methods for deducing Facts, Relations and Rules from interoperable multiple descriptions [9]. An orthogonal approach based on Propositionalisation, instead, uses Terms, Constraints and Machine Learning for inducing and revising Ontologies in interactions among Agents [10,46].

As Informatics is the art of transforming semantics into syntax, evaluating results of syntactic processing, and mapping them back to semantics; the historical challenge in Informatics consisted of relating syntactic structures to their semantics with respect to meanings in the real world. Semantics denotes here the real world concepts, not just the "world of the Computer" at in the case of Denotational, Operational or Algebraic semantics of programming languages.

Due to the availability of the Web, the process is currently more and more conversational, between and among "abstract computational entities", human or artificial ones, called Agents, on the Web. As a consequence, people are more concerned with

[5] This section actualizes the previously published paper [7] .

conversations on the Web, their semantics, their pragmatics. Among existing conversations, and those that are envisioned to occur in the next future with an impressive growth rate, we consider commercial transactions in e-commerce and intellectual transactions in e-learning to be pivotal for crucial developments. We also assume as intuitive the idea that e-learning and e-commerce, as well as, in general, e-work conversations, share a similar nature and therefore are characterized by similar requirements.

It may therefore be useful to evaluate if and how these developments may integrate different areas of Computing and Artificial Intelligence under a common manifesto, allowing to identify a shared research agenda. In the following, we will mainly concentrate on relations between technologies for human learning and Agents, but we will show that similar arguments hold for distributed systems, software engineering, programming languages and Human-Computer Interaction research. The section is therefore an attempt to unify views in modern Informatics research, apparently diversified, substantially convergent in a Web-centered, Knowledge Communication vision of problem solving [11].

3.2. From Computing as Control to Human-Computer studies: the User in the loop

The essential "conversational" aspect of solving problems by humans and machines is not new, it existed all the time. What is relatively new is the massive impact of Communication Technologies on everyday life. Communication Technologies have not raised new scientific problems, they just have shifted our focus of attention by offering us totally new tools for communicating.

Previously, Computing consisted in its essence of humans conceiving, designing and implementing programs able to activate processes according to well defined algorithms; the result of these processes was back interpreted by humans. This vision of Computing, in order to be useful, required one to adopt many important assumptions. Let us briefly review them hereafter. We will call the User a human or a society of humans interested to solve a problem; the Computer an artifact, or a set of artifacts constructed to perform computations.

a. User was supposed to have a need and to have identified the problem(s) the solution of which would help in satisfying the need;
b. User was supposed to be unable to solve alone the problem;
c. User was supposed to have the intention to use the Computer to help him/her to solve the problem(s);
d. User was supposed to know how to decompose the goal associated to the problem into tasks; design alternative methods able to execute tasks, each of which would generate sub-goals, linked to subtasks and so on. The decomposition of a problem into trees of Tasks and Methods was in itself an issue: is that decomposition possible independently from the application domain [12], or are the two intertwined (as Clancey showed to be the case in GUIDON [13])?

All these assumptions were taken as granted.

e. Once a. through d. were valid assumptions, User was supposed to be able to code his/her representation of the problem and of the problem solution in a formal language that was known for the Computer. In the case of misunderstandings by the Computer, User was supposed to be able to remediate his/her coding until the Computer showed no apparent error.

f. User was supposed to activate the processes in the Computer associated to the code produced; these processes were supposed to terminate with "results" that User was supposed to be able to map against the expected solution so that a judgment was possible, namely if the solution obtained would satisfy his/her need. In the positive case, the process ended; in the negative one: User was supposed to modify the code and/or the abstract problem description until the obtained results from the activated Computer processes would satisfy his/her need.

Clearly, such a scenario for Computing seems ad-hoc constructed in order to support some claim. It is so: "traditional" Computing focused mainly on Computer behaviors by leaving open many important questions concerning the User. We all developed through the years many complex, sophisticated, powerful Computer languages and studied accordingly in depth the properties of Computation - mainly seen as Control - disregarding the simple fact that Computers are for helping Humans, and not the reverse; and that they do that by means of Conversations. We were not interested in how a human comes to the code [14], and how he/she interprets the results. Elliot Soloway, for instance, tried for years to model novice programmer's errors in order to make "skilled debuggers" or Intelligent Tutoring Systems able to remediate programming misconceptions (e.g.: [15]). One of those misconceptions may originate thousands of errors in the millions of lines of Ada code for the US DoD. The work was hard, and not really supported; it was stopped in spite of the encouraging results around PROUST.

We were not interested in the Communication component of the Wiener manifesto on Cybernetics [16]. Computers were considered control systems transforming symbols into symbols according to (possibly terminating and efficient) algorithms. Communication issues were transformed into Transmission concerns.

Artificial Intelligence first, and Human-Computer Studies later have put humans in the loop [17]. They have recognized that two major issues were neglected in Computing:

- how people transform a need into a problem description then into some code in a formal language;
- how people interpret the results of computations with respect to the real world need.

AI and HCI studies stand to Computing in the same way as Statistics stands to Probability. It is not the concern of Probability to make claims on the real world pertinence of the assumed probabilities of elementary events, nor of the computed probabilities of complex events. Those concerns regard Statistics (constructing formal models of real world problems including random variables and interpreting results emerging when “running” or simulating the models). Similarly, AI and HCI have been mainly concerned with defining models and interpreting their resulting deductions.

3.3. From Computer Agents as Servers of a single Client, to Actors and Operating Systems

If we assume that the human-computer communication loop is the object of study, then we should adopt the view that in the loop, two Agents are operating, exchanging messages, evaluating and judging. Two Agents are hardly to be reduced to a single one, insofar they are behaving autonomously [18].

However, for years the loop metaphor of Human Problem Solving with the help of Computers was strongly influenced by a single viewpoint: even if the autonomy of the User was not discussed, the Computer was considered a slave, a server for an important client: the User. With a few notable exceptions, most studies on Interactive Systems were bound to a Client-Server model of Interaction. The most important interactive applicative domains at the time (Information Systems and CAD-CAM or Programming Environments) were developed under this view.

Exceptions consisted on research efforts around Intelligent Tutoring Systems. As an example, from the very beginning, Carbonell, in his foundational paper [19] clarified the quite simple idea that a realistic teacher-student interaction would be neither purely student-driven (as in Information Systems, where the user takes all the initiatives with respect to the system, considered as a server of information, or in CAD-CAM and Programming Environments, where the User commands the Computer to do things for him/her) nor teacher-driven (as it has been the case in most Computer Aided Instruction or Computer-Based Training for decades) but instead should allow mixed initiatives in the course of conversations. After more than 30 years, the "mixed initiative" view of conversations is again considered necessary for modeling realistic Agent-to-Agent conversations [20].

In Intelligent Tutoring Systems, the Computer Agent was designed to "guide" the User to acquire knowledge and expertise (see, for instance, the impressive achievements described in [21]). Most studies on Instructional Design represent explorations concerning the pro-active, autonomous behavior of the Computer Agent in Tutoring Systems that is currently required in Agent languages and applications.

Similarly, Student models were considered necessary in order to personalize the simulated teacher's behavior with respect to the student since the 70ties. Currently, User models are introduced in interactive applications for the same purpose.

As the Computer is a symbol processing device, one may say that the human art of solving problems by using Computers consisted for the User in transforming into symbols (the syntactic-symbolic level) the meanings linked to the problem (the semantic-knowledge level) and back from the symbols-results reconstruct meanings. The syntactic work was left to the machine, the semantic one to the human. Knowledge representation systems and - later - Ontologies were conceived in order to help humans in their semantic task, delegating part of it to the Computer. It is questionable to evaluate their concrete achievements, what is certain is that almost no attention was dedicated to the pragmatics of conversations, again with the exception of studies in Intelligent Tutoring or AI in Education [22,23].

In these conversations between the User and the Computer the "time dependent external world", also called "context" in the Agent's literature, was not considered: during the conversations, the User was not supposed to change his/her mind; s/he was just supposed to "implement" the specifications . In such a scenario, modifications of the state of the

Computer, were only possible as a consequence of some action (message) of the partner. Such a single-user Computer, therefore, "knows" only what the User said. As a consequence of this single client - single server view, we could deduce that a closed world assumption was adopted in the temporal evolution of the early software Agents.

It is evident that human Users evolve as a result of communicating with the outside world. Therefore, an initial plan (sequence of tasks) may be modified during the conversation [20,24]. Users do not have static plans; in fact they generate one move at a time, as a consequence of their local judgment of the state of the conversation. At least for the User, a closed world assumption is not realistic. However, this lack of attention to the User's evolving context, and evolving state, was not previously perceived as a good reason for modifying in their essence the fashionable assumptions about the software life cycle. Other phenomena did. Once more, a change of focus of attention in the scientific community was originated by technical, economical needs and not by scientific reflections.

Constructing Computer programs able to satisfy User needs is a costly endeavor. Once you have done it properly, you like to reuse it several times, and perhaps abstract and generalize to other domains. Software engineering was and is concerned with that. If a service delivered by a Computer artifact satisfies a client User, you wish this service to be exploited by as many users in as many different domains as possible. Assuming the service is a function, and the different domains are associated to different data types, reusing the service for different domains implies to develop generic functions (functions applicable to data instances, belonging to several types known only at run time) . As the developments around Object Oriented Programming have been originated by the necessity of managing knowledge in order to build generic functions, we may conclude that Computer Agents - initially simple programmed functions - evolved to Objects.

The next step was to offer concurrently functionalities to many potential Clients. Operating Systems fulfill that property: they offer one or many Users the services corresponding to many available functionalities, keeping track of the state of each service for each User. They allow to capitalize heavily upon the efforts spent in order to implement a problem solution, offering to reuse the solution constructed. The needs for reuse have dominated the developments in Computing in the last decades, and still motivate most of them. The issue for us, then, becomes how to integrate these developments into more advanced (and realistic) Agent architectures.

In a multi-process, multi-user scenario such as that offered by Actors [25] or Operating Systems, the conversational cycles assume the "autonomy of human Users" and introduce some liberty for the Computer: for instance the autonomy to suspend autonomously a process in a round-robin loop in order to dedicate resources to another process. Yet, the Computer is still a server for clients; its autonomy is restricted to facilitate services but does not rely on any shared knowledge at the application level. You would be surprised if an Operating System would say: "please, excuse me but the conversation I have with your colleague Jean, who just connected from Paris, is so important for me that I wish to dedicate my time to him; please come back tomorrow". Only the owner of the OS, as an Operating System's Manager, would be entitled to explicitly give a priority to Jean's processes. The autonomy of Actors and Operating Systems is limited to the knowledge, available for them, dedicated to how to serve many clients in the "best" way, i.e. the "most efficient" way. All scheduling algorithms are of this, rather "syntactic", nature. The "semantics" yet remains in the autonomy of human Users and is eventually made available to the Computer at the level of each conversational application, under the convention that the Computer is not entitled to autonomously use the knowledge obtained in one conversation in order to manage other conversations.

3.4. From Actors to Agents

The Agent metaphor comes into the scene exactly at this point. Agents are supposed to be autonomous, i.e. to evaluate what to do and how with respect to the current state, as denoted by the multiple conversations ongoing. In order to be autonomous, one needs to have a proprietary goal, or intention in order to decide among actions what to do next in order to reach the goal. No autonomy without the right to decide, no decision without alternatives, no choice criterion among alternatives without an evaluated "distance" of each alternative with respect to a goal. Control theory, cybernetics, and the like have taught us that.

The Agent metaphor therefore gives an equal status to Human and Artificial Agents: that of autonomy in conversational behavior. In our approach, we have outlined a model - and a set of methods and tools - that realize conversational Agents showing autonomous behavior [24,26] . At the same time other authors [27] have chosen a similar approach concerning how to realize autonomy.

The issue comes into the scenario, if the symbolic representations in machines are sufficient, or even necessary to represent - at least in a primitive way - realistic social behaviors such as those addressed by the community of Situated Cognition. William Clancey is a testimony of such a radical shift: from years of recognized activity in Intelligent Tutoring, AI and Cognition [28], the lessons learned are critical and profound, supporting a synergy but not a confusion between "classical" work at the symbol and the knowledge level on the one side, and more realistic approaches that privilege action and social interactions on the other. The question posed concretely is if the focus of Agent computations should remain in processing networks of symbols, or if we better should concentrate in the social aspects of multiple conversations as a source of Agent's actions and behavior. This shift is not incompatible with our thesis: if we better understand Communication among Autonomous Agents and the social aspects of coherent conversations within a holistic model of human activity, we may be able to better approximate the adequate social behavior described in [29].

Unfortunately, there is a lack of usable, Symbol level models that deal with conversations, i.e. the Pragmatic or Knowledge Communication level[6]. On the contrary, there are important advances on modeling of problem solving methods (see, e.g: [30, 31]). Insofar problem solving methods and their formal representations will deal with distributed reasoning, including conversations among Agents, they will be foundational not only for the Semantic Web – as it is the case now – but also for the Semantic GRID. This Knowledge Communication level is the fundamental glue missing in most situations, where, we believe, behavior is generated from messages and not the contrary.

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[6] Some linguists call it Dynamic Semantics.

4. Agents vs GRID services[7]

The relations between GRID and Agent research and applications are preliminarily described in [4] : we will annotate hereafter some crucial statements on the light of our recent work and try to show that their considerations (the what to do and why to do it) may receive partial answers (how to do it) within our current research efforts in ELEGI and outside.

T e n   R e s e a r c h   P r o b l e m s[8]

We conclude by outlining ten areas (in no particular order) in which research is needed to realize an integrated agent-Grid approach to open distributed systems.

4.1. Service[9] architecture.

The convergence of agent and Grid concepts and technologies will be accelerated if we can define an <u>integrated service architecture</u> providing a robust foundation for <u>autonomous behaviours</u>[10]. This architecture would define baseline interfaces and behaviours supporting <u>dynamic and stateful services</u>[11], and a suite of <u>higher-level interfaces</u> and services codifying important <u>negotiation</u>, monitoring, and <u>management</u>[12] patterns. The definition of an appropriate set of such architectural elements is an important research goal in its own right, and, in addition, can facilitate the creation, reuse, and composition of interoperable components.

4.2. Trust negotiation and management .

All but the most trivial distributed systems involve interactions with entities (services) with whom one does not have perfect trust. Thus, authorization decisions must often be made in the absence of strong existing trust relationships. Grid middleware addresses secure authentication, but not the far harder problems of establishing, monitoring, and managing trust in a dynamic, open, multi-valent system. We need <u>new techniques for expressing and reasoning about trust</u>[13]. Reputation mechanisms […] and the ability to integrate assertions from multiple authorities ("A says M can do X, but B disagrees") will be important in many contexts, with the identity and/or prior actions of an entity requesting some action or asserting some fact being as important as other metrics, such as location or willingness to

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[7] This section actualizes part of the ELEGI deliverable D12 [32]

[8] The original conclusion section (n. 6 of [4]) is hereafter pasted in Italic; annotations are in the footnotes.

[9] The concept of service is central. Differently from most authors, we distinguish it from the one of product not according to its "type" (e.g: a Web service is an active procedure, different from a static datum) but in terms of its behavior (a service is conversational both at define and at run time).

[10] Integration and autonomy are paradoxically at odd. One may say that Agents privilege autonomy, while GRID services privilege integration.

[11] For an account of our current view on how to model the state in conversational Agents, see [33] .

[12] A quite simple, yet very promising contribution to model the centralized control – including security – of movement and interaction services in a distributed, open, dynamic multi-agent environment is reported in [45] .

[13] Trust is important in Virtual Organizations (VOs) within the current OGSA, where services are delivered by software. In VOs that include Humans, such as ours, trust is fundamental: it is the basis for motivation.

pay. Trust issues can also impinge on data integration, in that our confidence in the "data" provided by an entity may depend on our trust in that entity, so that, for example, our confidence in an assertion "A says M is green" depends on our past experiences with A.

4.3. System management and troubleshooting.

Grid technologies make it feasible to access large numbers of resources securely, reliably, and uniformly. However, the coordinated management of these resources requires new abstractions, mechanisms, and standards for the quasi-automated ("autonomic" […]) management of the ensemble—despite multiple, perhaps competing, objectives from different parties, and complex failure scenarios[14]. A closely related problem is troubleshooting, i.e., detecting, diagnosing, and ultimately responding to the unexpected behaviour of an individual component in a distributed system, or indeed of the system as a whole. This requirement will motivate the development of robust and secure logging and auditing mechanisms. The registration, discovery, monitoring, and management of available logging points, and the development of techniques for detecting and responding to "trouble" (e.g., overload or fraud), remain open problems. We also require advances in the summarization and explanation (e.g., visualization[15]) of large-scale distributed systems.

4.4. Negotiation.

We have already discussed negotiation at some length; here we simply note that major open problems remain in this vital area.

4.5. Service composition.

The realization of a specific user or VO requirement may require the dynamic composition of multiple services[16]. Web service technologies define conventions for describing service interfaces and workflows, and WS-ResourceFramework (WSRF) provides mechanisms for inspecting service state and organizing service collections. Yet we need far more powerful techniques for describing, discovering, composing, monitoring, managing, and adapting such service collections.

[14] While in complex artificial systems "failure" is an enemy, in complex human VOs misconceptions, contradictions and paradoxes may become a source of learning, when associated to adequate remedial procedures (or services) [34] .

[15] Visualization of networks of resources, when part of them are human resources, comes down to Enhanced Presence, one of the major research endeavors in ELEGI [32] .

[16] Service composition is a "new" engineering challenge, assuming that most services are stateful and intrinsically conversational. Our approach foresees bottom-up composition of lower-level services into more complex ones as well as top-down decomposition of higher level services into simpler ones (see section 5).

4.6. VO formation and management.

While the notion of a VO seems to be intuitive and natural, we still do not have clear definitions of *what constitutes a VO*[17] *or well-defined procedures for deciding when a new VO should be formed, who should be in that VO, what they should do, when the VO should be changed, and when the VO should ultimately be disbanded .*

4.7. System predictability.

While open distributed systems are inherently unpredictable, it can be important to provide guarantees about system performance (e.g., liveness or safety properties, or stochastic performance boundaries). However, such guarantees require a *deeper understanding of emergent behaviour*[18] *in complex systems.*

4.8. Human-computer collaboration.

Many VOs will be hybrids in which *some problem solving is undertaken by humans and some by programs*[19]*. These components must interwork in a seamless fashion to achieve their aims. New collaboration models are necessary to capture the rich social interplay in such hybrid teams.*

4.9. Evaluation.

Meaningful comparison of new approaches and technologies requires the definition of appropriate benchmarks and challenge problems and the *creation of environments in which realistic evaluation*[20] *can occur. Perhaps the single most effective means of advancing agent-Grid integration might be the definition of appropriately attractive challenge problems. Such problems should demand both the brawn of Grid and the brains of agents, and define rigorous metrics that can be used to drive the development in both areas. Potential challenge problems might include the distributed monitoring and management of large-scale Grids, and robust and long-lived operation of agent applications. Evaluation can occur in both simulated and physical environments. Rapid*

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[17] In our human learning scenarios, the very first step for humans to be helped by technologies consists in entering an adequate Virtual Community, then facilitating its progressive mutation into a Virtual Organization (see section 5).

[18] This is absolutely true for artificial systems. Having put the human in the loop, we may argue that humans are much better as machines to predict emergent behaviors. We insist on the concept of "smooth integration" of the artificial services into VOs, initially consistent of connected human services, in order to avoid unforeseen failures or at least facilitate the human control of unforeseen behaviors. In particular, the goal of "one click human help", necessary for most end users communities, should minimize the risks in our mixed VOs. The issue raised on unpredictability of open distributed systems, however, should also favor machine learning studies: GRID services should perform "better" as a consequence of previous experiences. We have started to investigate the feasibility of inducing patterns (rules or even protocols) from real Human conversations in Virtual Organizations: preliminary results are available in: [47] .

[19] This seems a rewriting of the goal of Open Grid Human Service Architecture within ELEGI.

[20] Our SEES (cf: section 5) have been conceived exactly for this purpose.

progress has been made in simulation systems for both agents and Grids (e.g., […]). Production deployments such as Grid3 […], TeraGrid […], and NEESgrid […], and testbeds such as PlanetLab […], are potentially available as experimental platforms for the evaluation of converged systems, for example within the context of the challenge problems just mentioned.

4.10. Semantic integration .

Open distributed systems involve multiple stakeholders that interact to procure and deliver services. Meaningful interactions are difficult to achieve in any open system because different entities typically have distinct information models. Advances are required in such interrelated areas as <u>ontology definition, schema mediation, and semantic mediation[21]</u> […].

5. Where do we want to go? [22]

5.1. Introduction

The evolution of the technological offer associated to the GRID [1 - 4] induces one to reflect on its consequences on the entire life cycle of the new generation of applications on the Internet. In the following, we highlight our understanding of the core of the OGSA concept and we derive our convictions on a new life cycle for GRID technical (infrastructural) developments and GRID applications.

5.2. OGSA: Open Grid Service Architecture

The notion of a service is radically different from the one of a product, even if there may be a smooth transition between the two viewpoints. Assuming typical products to be cars, washing machines, DMBS or Web sites consisting of collections of static HTML pages, typical services may be represented by legal, financial, medical, educational or advising services of many different kinds, including electronic services complementary to and integrated with human services. In order to simplify our subsequent arguments, we will consider "providers" and "consumers" of services, both called Agents, irrespectively on their human or artificial (software + hardware + network) nature.

In order to set the stage, hereafter a few considerations on the differences:

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[21] The integration of semantics, in our view, will focus on the semantics of distributed problem solving methods by Agents in VOs (see, eg: [30,31]) as a prerequisite for exploiting the semantics of pedagogical documents [35]. In the last case, the approach was to allow remote authors to attribute semantics to documents by means of a Web based XML editor – called DYXWEB - helped by Ontologies caring for adapting the document structure and meaning to the user's profile.

[22] This section actualizes the previously published paper [36] .

- a product is developed by the producer with a clearly predefined goal for the potential consumer, a service is offered within a service domain – or competence area, yet the consumer-specific objectives have to be defined during the initial conversations between the provider and the consumer of the service;
- a product is supposed to be in correspondence with a well established and a clearly identified need; a service often anticipates to the customer combinations of needs that were not clearly recognized as such by him/her before;
- a product is most often designed and prototypically developed once, produced many times; the value added by a product increases with the number of copies effectively distributed; a service must be conceived, designed, developed and distributed once for all, as it is custom made for a specific customer with specific needs; the value added by a service increases proportionally with the customer's satisfaction that entails an indirect publicity for the service producer and generates new customers ready to invest resources in order to have similar services;
- a product's evolution is slow, as it requires modifications in the conception, design and development; shortly; a revision of the whole life cycle. A service evolves naturally as it is a combination of basic services and products on the fly as a consequence of a service definition and tuning during the conversations with a customer;
- a product is often chosen as a solution for an established need, even when the customer does not really "trust" the producer's performance (e.g.: even if I dislike cars and prefer a car-less city center, I need one for very practical reasons, and I choose the cheapest one because I plan to use it as little as possible); a service requires trust by the customer on the producer (e.g.: I do not go to a dentist or a lawyer unless I believe s/he is trustable).

In general, it is quite hard – some say it is even impossible - to clearly cut the difference between a product and a service. Most probably, the same "object" may be seen on turn as a product or as a service, depending on the viewpoint, the context. Probably, the distinction is not an ontological one, but an epistemological: in relation to the "object's behavior" in a specific context of use.

A few considerations seem to help to start a reflection on ICT services with respect to ICT products. Let us consider the most classical ICT application, i.e.: an Information System, and let us reflect on a paradigm shift: from product to service – for future Information Systems.

Typical Information Systems were developed to satisfy the needs of accurate, well organized, timely updated and trustable Information. This Information is necessary in order to take decisions.

In all the cases where the Information evolves dynamically, as well as the informative needs from the customer evolve continuously, the "Information management system" has to account for both evolutions.

A classical DBMS performs very well under static assumptions, such as the persistence of the logical and physical schemes of the DBMS and of the informative needs of the user.

A classical DBMS, and its application for a specific Information system, is much like a "product": developed once and used for years. Any evolution requires heavy resources to redesign the schemas, and import the old as well as the new data.

Now, suppose neither the Information available to the Information system is stable, nor the information needs by the user. In this situation, more and more frequent in our organizations, the value added by an Information system becomes directly dependent from its flexibility, adaptability, dynamicity.

Let us now consider a classical query to an Information system. The success of the query depends of many assumptions, including the following three:

the querier knows exactly what s/he needs;

the querier knows that the system's information may satisfy his/her need;

the querier knows how to formulate the need.

Current daily situations are far from respecting the above outlined assumptions. Users of Information Systems, as well as navigators on the Web, for any purpose – including eCommerce – do not have a well defined need, do not know if and how the system may satisfy their need, do not know how to formulate a query correctly. The consequence of this situation is that often there is no adequacy at all between the user's real needs and the system's answers (for an outstanding detailed description of a realistic scenario, see: [29]) .

We may synthetically define the informative process described above as a process where Information is offered as a product while the Information needed is a service. Typically, in most realistic non trivial situations, one needs to express his/her intentions, desires, constraints and investigate the system's available Information before being able to formulate correctly a query. The classical run time behavior of an Information system requires as a prerequisite for the user's satisfaction to support a complex conversational phase in order the subsequently formulated query to be adequate with the user's need.

In the case that the user's needs do not fit with just one Information system (e.g.: I wish to organize my holidays next summer) each partial information (about available flights, trains, ... and about hotels ... and about cultural events, climate, ... and so on) in order to acquire a meaning for the user has to be integrated with other information coming from other information sources (hence the need for interoperability of information sources). Eventually, a combination of choices will emerge from a sequence of conversations between the user and several information sources, and among information sources themselves (what justifies XML typing and Ontologies). A user wishing a "service for holidays" has currently to compose his/her own chosen "products".

Such a scenario of dynamic generation of services is the major challenge for ICTs in the next years. It is as well described as being the major challenge of the OGSA: Open Grid Service Architecture.

5.3. The dynamic generation of services for human learning

In order for GRIDs associated to OGSAs to be successful, one needs first a well founded definition of services that eventually may be required by users of OGSA-based Grid applications. The problem is to identify those services in order to construct the software applications necessary to generate them on the fly.

Let us jump back to the anthropomorphic metaphors. It is perhaps necessary, but not sufficient for a doctor to know the anatomy and the physiology of the human body to become a good performing doctor. For a lawyer, the knowledge of the civil code and the jurisprudence is useful but insufficient in order to be a competitive lawyer at the court. One needs practice, examples, real cases. Further, while medical knowledge is for a large part independent from the health context (a doctor, say, in France may cure a patient in Morocco, considering that most of its citizens speak French), legal knowledge is highly culture, context dependent. Even Codes are fundamentally different: a process in a Country submitted to the Roman law is quite different from the analogous one submitted to the Anglo-Saxon tradition. Certainly, the degree of context dependency is much higher in services as it is in products.

The case of Educational services is perhaps the most extreme. The service has to stimulate, evaluate and credit human learning, knowledge and skills. Nothing is more context dependent as human knowledge and skills, as well as the associated emotional aspects (motivation, cultural awareness, ...). It is evident that no educational model will ever be successful for human learning if not highly linked to the socio-economic and cultural context of human users.

If we wish to build on GRIDs this kind of services, we have to identify them in an accurately context dependent way. In analogy with the lawyer and the doctor's examples above, the most secure way to identify them is to practice them concretely in well controlled experimental situations and integrate the lessons learned into new requirements and better services.

The first time, for each context, we may conceive to operate like a junior doctor or lawyer: accompanying and helping seniors, better experienced, operating exactly those services to those users[23]. However, in our case – Education – one more difficulty emerges: there are no seniors, as the classical behavior of parents and teachers – the two major educators known – does not at all include ICTs.

Therefore, we will have to use a quite traditional method for introducing innovation, perhaps to be called a “Trojan horse”, hereafter indicated in steps:

a. distribute among communities of future users (learners) the infrastructures necessary for accessing the Web in the simplest and most supportive way (by accessing a GRID portal) and rely on their motivation and enthusiasm for a quite popular, accepted activity: bidirectional access to Web Information (collaborative reading and writing). We have identified three of those communities (also to be identified as scenarios supporting complementary aspects of informal learning):
    1. the VIAD: Virtual Institute for Alphabetization for Development scenario, currently ongoing in Pays Coeur d’Hérault, as well as in other remote and less developed areas of the world [38,39,40];
    2. the ENCORE scenario, on the construction of an encyclopaedia for Organic Chemistry [41,42];

[23] The system described in [34,37] operated in this way.

3. The e-Qualification scenario, focusing on monitoring and qualifying human learning services as well as their effects across ELEGI applications [43,44];

b. introduce scenario-specific "champions" able to animate the human users in virtual communities, allow collaborative activities to be developed initially in order to establish mutual confidence and interests and progressively mutate towards structured Virtual Organizations;
c. offer support to developments that are selected, identified and described by the communities themselves, coordinated by the "champions";
d. highlight, underline and make explicit the relations between any development of the community and the associated human learning; develop human learning strategies and practices as a support to higher priority goals, such as economic, cultural and scientific success of each member of the community thanks to the collaboration;
e. study the communicative processes in order to identify the technological and human requirements of services adapted to each community, then finally
f. formulate the requirements as functional specifications for the next generation of GRID's services.

Hereafter, as a consequence of the above consideration, what we believe to be an innovative definition of service developments for GRID applications, i.e.: the different function of scenarios versus more classical test beds accompanying OGSA developments for e-Learning.

5.4. SEES: Service Elicitation and Exploitation / Evaluation Scenarios

In classical software engineering, the major phase were approximately:

1. software functional (informal) specification;
2. software technical (formal) specification;
3. software design;
4. software development (coding);
5. software testing and evaluation (within test beds);
6. generation of new guidelines in order to loop to 1. and 2. until satisfied.

Testing and evaluation occurs at the end of the process by means of carefully planned and controlled experiences with real potential customers. This life cycle reflects a "product" view of software applications.

When services have to be supported by software, as it is our case, we envision a different life cycle for successful service generation and use, briefly outlined in the following. We will call the two classes of scenarios for each class of actors involved in this new life cycle: SDS (Service Developer's Scenarios) and SUS (Service User's Scenarios).

Each scenario is timed by / belongs to a "phase". Each new "phase" adds up the previous ones as a new task cumulating for a holistic integrated approach. Notice that the distinction between SUS and SDS reflects the wide spectrum of meanings the word "service" adopts: from a quite high level, domain dependent meaning (e.g.: the learning service for a minimal competence on business accounting) , to a low granularity, domain independent, technical meaning (e.g.: the authentication service for a Peer to access to another Peer, both being software processes).

1. Service <u>motivation for SUS</u>. In this phase, one has to make sure that the potential users are aware of the value added by the service and wish to be able to use it, once it will be available. Motivation in e-Learning in our case comes from locally empowered virtual communities that experience in their practice the interest for collaborating on the Web.
2. Service <u>definition by SUS</u>. During this phase, potential users, coordinated by seniors – the "champions" that are aware of the opportunities potentially offered by technological innovations - formulate and discuss among themselves and with other peers initially vague, yet more and more precise functional specifications of the services they might need for their own purposes. Scenarios are generated. From scenarios, drafts of collaborative protocols are extracted. These functional specifications are then used as an input to GRID's technologists working in different work packages on OGSA for Learning (SDS).
3. Service <u>use by SUS</u>. While SDS are specifying, designing and developing innovative services, SUS use <u>state of the art (Web + GRID)</u> technologies for their goals, including progressively e-Learning, generating new experimentally founded considerations, guidelines, observations to be fed back to SDS.
4. Service <u>evaluation by SUS</u>. During this phase, we wish the services to be evaluated, as well as their e-Learning effects, by submitting SUS to the evaluation (e-qualification) procedures suggested by the corresponding scenario.
5. <u>Service abstraction and generalization by SUS and SDS</u>. This task allows one to propose and realize a significant upgrade of the "old" Service Elicitation and Evaluation/Exploitation Scenarios and the identification and implementation of completely new Scenarios. For instance, from the ENCORE scenario, one may propose biologists to use the services for their own construction of ontology's.

5.5. OGHSA: Open Grid Human Service Architecture

The role of standard architectures, such as OGSA, is to propose guidelines to the developers of Infrastructures such that the subsequent developments are cumulative and well integrated. Once the Human is considered a potential service provider and consumer in a GRID network, it becomes natural to submit human participation in Virtual Organizations to rules and conditions that regulate the correct social behavior of the VOs.

The risk in oversimplification is obvious. The advantage is as well easy to appreciate. As we have described above, Humans participate to VOs either as Users or as Developers. In both cases, they may provide or consume services. While developers are well familiar with elementary GRID services and ways of combining them into more complex ones, users reason in terms of context dependent, high level services, and their contribution is better in their decomposition into lower level ones.

The acceptance of Humans in GRID VOs seems ho bring naturally to the situation where define time and run time of software are nicely intertwined. The gap between the complexity of vaguely specified, coarse grain, but real world service demand and the formally specified, but fine grain and artificial (software) service offer, seems to be potentially bridged in a smooth way by humans playing the role of providers and consumers of services.

Finally, the OGHSA concept includes the notions of progressive enhancement of previously purely human or purely artificial services by coupling the two service sources; and smooth degradation in the sense that in case of human or software failure an alternative should remain open and feasible.

6. Conclusion

The success of the Web consists of the opportunity to access any electronic information wherever it has been produced and stored. The limits of the Web (potentially overcome by the GRID and the autonomous Agents) consist of the lack of conversational, truly collaborative tools: HTTP is a stateless protocol, and most activities on the Web consist of finding a static page somewhere. The Web is mainly a library.

The GRID may transform the source of Information into a source of Knowledge, i.e: a set of documents, programs and humans accessible at any time from anywhere capable to proactively assist “me”, a human, in my daily problems by means of conversations that indeed serve me to achieve my own goals.

If that is the new scenario for e-Learning, the success is ensured, since the major limit of traditional educational applications was due to a multimedia, passive, book-like, at best: retroactive offer while real learners - as well as teachers or humans with other roles - require one - or more - partner(s) in conversations, patient but authoritative, that keep the motivation high while offering assistance just in time, collaboratively and dialectically.

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