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Knowledge Sharing by means of OpenAdap.net

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Abstract: OpenAdap.net is a Free Software project aimed at breaking existing barriers in the flow of data access and data processing. The infrastructure allows the dissemination of knowledge and its exposure to evaluation in unanticipated ways. The architecture is designed by analogy with a virtual distributed operating system in which the dynamic resources are presented as files in a structured virtual file system featuring ownership and access permissions. OpenAdap.net brokers are responsible for dynamically decomposing and routing end-user tasks to appropriate resource sharers for execution. The inter-broker communication is aimed to be self-adaptable via learning processes that could give rise to modifiable broker-broker connections specialisation or generalisation of broker behaviour, etc. This approach allows OpenAdap.net to benefit of the full range of advances achieved in the fields of cognitive computation and computational intelligence.

1. Introduction

The Cyberspace has become the main site of information exchange and its extension in terms of bandwidth is opening the way equally to all media. Most of this information flow still remains associated to a 'declarative' approach, i.e. associated to the knowledge of 'what', as illustrated by the web portals built around search engines. Thus, Internet still has a huge unexploited potential in applying the complementary 'procedural' approach based on the knowledge of 'how'. Despite the immediate availability of information published on Internet, the information processing methods are generally released in small niches and for specific computing environments.

Potentially meaningful contributions may remain unexploited, or even forgotten, within the same field of competence and their availability is severely restricted in particular for cross-fertilization with other fields. This situation often leads to the delayed re-invention of similar methods and the re-discovery of the same knowledge. Unnecessary expenses are generated worldwide with tremendous impact on the less favoured countries.

The procedural approach necessarily relies on a trial-and-error paradigm that is more efficiently achieved when the results are shared within a community of human and non-human agents. The benefits in terms of education, business developments, market diversification and employment generated by the access to the results of trial-and-error procedures clearly emphasize its importance to the society. Knowledge sharing leads to share information processing methods and socialware becomes the vehicle for a user adaptive collaborative support [1].

The European Commission has recognized the importance of the evolution of Internet as a global knowledge eco-system and launched in September 2005 the Networked European Software & Services Initiative (NESSI) [2]. The vision proposed by NESSI

emphasizes the role of service sharing to drive the transformation of the European economy towards a dynamic and competitive knowledge-based economy. Besides this initiative the first call for Information and Communication Technologies projects in the EU 7th Framework Programme included a thematic challenge for "Pervasive and Trusted Network and Service Infrastructures". A consortium featuring academic, SME and industrial partners gathered to submit a proposal for OpenAdap.net to that call.

2. Objectives

The OpenAdap.net (OAn) project is aimed at breaking the barriers increasing the overall cost of information processing and restricting its availability to less favoured countries. The ability to evaluate the best available solution to a given problem may have significant impact on areas such as economics, environmental and health care sciences. By offering systems that aim at supporting various networked social activities, it is possible to test alternative solutions and let the most appropriate ones emerge.

OAn stands in the area of socialware and aims at providing a distributed environment where a Community can access tools of all kinds transparently through the Internet. The platform helps the community to aggregate pre-existing tools by dynamically composing new information processing chains using the output of existing programs as the input to others, thus opening the way to serendipity. The system allows the dissemination of resources across domains in ways that might be unanticipated by the contributor. For example a solution developed by experts in medical statistics could permeate to the field of botany, and become a key tool in the analysis of tree distributions, or vice versa. The key to this vision is the development of a sharing architecture independent of a specific type of information, such that through web portals and standalone applications, the community will share domain-specific sets of resources.

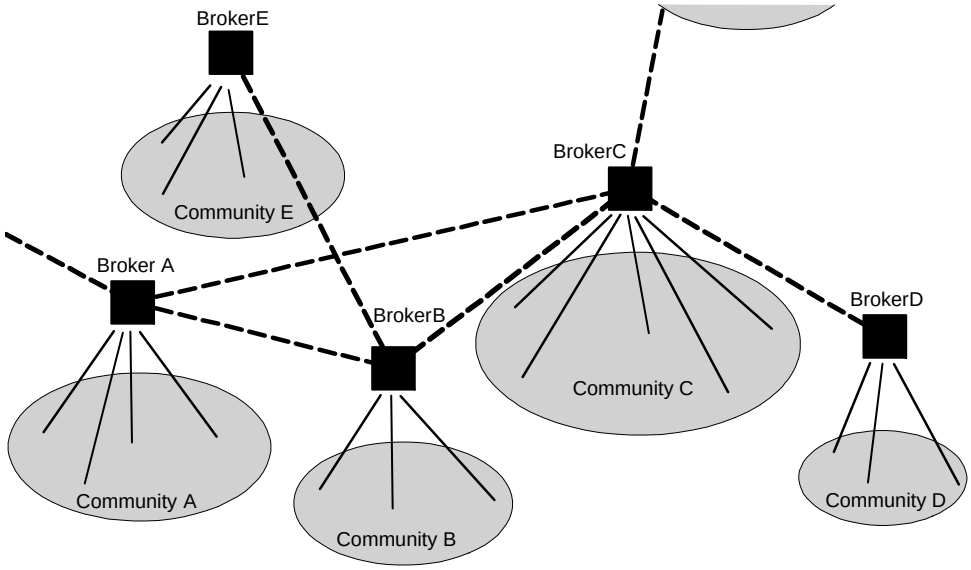

Figure 1: OpenAdap.net communities (grey ellipses) virtually laid down in an ontological space organized around their domain-oriented brokers (black squares). Intelligent inter-broker communications (interrupted lines) allow the contextualized sharing of community resources across the semantic barriers.

3. Methodology

OAn falls somewhere between the three architectures used in this field – Grid, Web Services, and Peer-to-peer networks – exploiting several of their aspects including published resource interfaces, data sharing and transparent user-resource connection, with the intention to address a two-way problem: (i) provide a community of users with the

means to interchange their resources in an open, dynamic and secured way and (ii) provide a community of users with the access to the information processing solutions contributed to other communities.

OAn users can be classified as either contributors of shared resources or end-users. People who develop and provide new data analyses methods are able to share their contribution and people interested in processing their own data or access data stored elsewhere can extract the results of their analysis. OAn is also open to exploitation by networked organisations and alliances by providing an infrastructure with which they can share and integrate resources and develop new business opportunities.

By sharing a program and the computer running it, contributors keep complete control over their authorship on the software. At the same time, they will be responsible for maintaining the quality of the results that the community will validate. From the contributor viewpoint, OAn allows the dissemination of resources, and their exposure to application by a broader user community. This approach emphasizes a crucial challenge for middleware architectures aimed at supporting resource sharing that is to guarantee quality of service levels in large-scale open environments. Errors in service behaviour may cause considerable damage, not only in terms of economic loss. Quality properties are part of the contract between resource users and contributors. OpenAdap.net constitutes the link between the two parties, but it will provide an assurance that users will get quality-agreed services so that they neither harm nor annoy them.

This model is a valuable implementation of the ‘procedural’ approach because it emphasizes the value of learning by trial-and-error. The end-users are motivated by a goal-driven rather than by a content-driven process. The contributors are also primarily motivated by a goal-driven process based on the recognition and dissemination of their work. Knowledge sharing is a key for any technological progress and with OpenAdap.net middleware users' privacy is as important as contributors' traceability. We believe that any piece of information sent for processing by end-users to a contributors' resource should be anonymized, yet the transactions are identified and the activity is traced like in any computer system. Meta-information concerning the contributed resource including program authorship and version number should be made available to the end-user, as a mark of diligence to the contributor, but also to emphasize the responsibilities in the information processing chain and enhance quality assessment and reproducibility.

The users need to discern technological and informational elements to build the confidence in online services. OpenAdap.net is designed to implement confidentiality (including identification, authentication, authorization and cryptography), integrity and traceability (including signature, responsibility and auditability). Trust in a distributed resource-sharing system can only be achieved by an end-to-end support for privacy and dependability addressing complicated interdependent issues spanning security and information systems as well as legal, social and economics. By anonymizing the information sent by the users and emphasizing the traceability of contributors, OAn provides more than the minimum confidence level mandatory for an effective digital exchange based on e-services [3].

For OpenAdap.net the security will be addressed transversally, not only by the use of strongly encrypted authenticated connections, but by the definition of rules on how to handle data at any point in the system to ensure data confidentiality and integrity. Each task submitted to the system will be returned to the submitter with a record attesting where the information travelled, which processes were applied and who was responsible for the computers and the programs. Mechanisms will be defined to require the signature by each component handling the task to enable the traceability and the proof of the processing, the determination of the responsibilities in the chain and *in fine* the assessment of the point-to-point quality of service and the protection of data delivered from one component to another.

The security meta-information collected during the processing of the task will be made available in a form that will allow its inspection by end-users with limited knowledge in computer security, even years after the execution of the task. A single file containing both the processing results and the meta-information will be proposed for download, with the opportunity of keeping it for future assessment. Such a feature is particularly relevant in scientific experimental research where reproducibility of results is challenged by the use of ever more complex information processing chains.

4. Technology Description

OpenAdap.net is a distributed system composed by three types of components: brokers, workers and OAn-aware applications. A broker is a process permanently running on a server in charge of managing a community and dispatching tasks and results. Workers are processes shared by community members in charge of giving secured distant access to contributed resources. OAn-aware applications are pieces of software (standalone applications, web portals, etc.) providing authenticated access to a broker [3].

The components are running on a network of computers, each of them defined by their specific CPU, operating system, etc. OAn is designed by analogy with a virtual distributed OS in which all the resources are presented in a virtual file system where they are assigned to files. Security is enforced through access permissions defined on a per-file basis. OAn goes beyond a traditional OS, as the configuration is highly volatile. The file system structure and contents are the result of the dynamical aggregation of several sources of information: user database, inter-process message queues, etc.

The open development paradigm implemented by OpenAdap.net is committed to the holistic view proposed by the Networked European Software & Services Initiative (NESSI) [2]. The platform is based on the already available achievements of the NESSI partners – including ObjectWeb's JORAM Java Message Service (JMS) implementation. Brokers, workers and OAN-aware applications are loosely coupled, distributed components that asynchronously communicate through a message-oriented middleware (MOM) as defined by the JMS API. It is expected that JMS implementations available for other platforms facilitates applications written by third parties to connect to OAn brokers and interoperate seamlessly [5]. We also expect to interface OAn with established distributed systems like grids and clusters. For that purpose, specific workers will be developed to provide OAn to Condor or Portable Batch System (PBS) interfaces. The public interface of OAn is designed to be simple to use and to maintain for users with limited knowledge in computer science. A public available issue tracking system initially contributed by the developer community will support the Open Source development of the middleware.

The security is addressed transversally by defining rules to data handling at any point in the system, providing the required profiles for authentication, and offering strongly encrypted connections. Standards and models of the field have been applied from the begin of the project [6]. Each broker will be in charge of the usual identity and access management issues: certification of user identity, enforcement of context-dependant security policies, and management of user data. Different rules may govern different communities depending on broker implementation (possibly through modules) and/or configuration: some brokers may restrict enrolment of new users while others will be completely open, reproducing other human society's models. The flexible and interconnected trust at both levels of users and resources will have an impact on the community's trust in the inter-broker communications.

5. Developments

We have defined three key elements in the coming development: (i) making brokers adaptive and dynamically interconnected into an OAn network, (ii) implementing a broker-related accounting system, (iii) offering OAn the utilities to become pervasive in mobile technologies.

5.1 Inter-Broker Adaptive Communication

Brokers are responsible for decomposing and routing end-user tasks to appropriate workers for execution. The requests for resources are processed and dispatched among the components of the system following a set of learning rules dynamically modifying the routing according to, for example, the computing load generated by specific tasks, availability of the resources, or the number of accesses. The required negotiation between brokers (and workers) may be compared to agent interaction. The OAn network will also be able to self-adapt via learning processes derived from neural and artificial life learning. Such learning might result in new broker-broker connections, reassessments of the value of such connections, specialisation or generalisation of broker behaviour, etc. The choice of the ontology behind the inter-broker communication hast not yet been done, although it has been foreseen from the beginning of the project.

The adaptive and behavioural models for the broker implementation represent major innovations of the OAn project. This is definitely a novelty and a plus to the existing architectures for distributed environments like grids and web services that points out the project expected income to the networked computing field. We believe that SMEs and research institutions will be interested in developing novel interdisciplinary solutions associated to the psychological and technological aspects of evolvable simulation tools, the psychological environment of remote user support and the formal aspects of artificial processing in resource-sharing.

5.2 Broker-Related Accounting System

The sharing could be free or depend on a commercial relationship (following an appropriate business model) between a contributor and an end-user bound by a Service Licence Agreement and requiring the payment of a fee (pay-per-use, monthly fee, etc). A specific module implemented in the broker would be in charge of maintaining the accounting system, setting the micro-payments through existing business platforms and contribute to the trust in the commercial exchange through authenticated and secured connections. This module would, for example, allow non-for-profit organizations to help support infrastructure costs through community members' contributions (per-month, per-submission, donations, etc). Service companies could develop their business model around the domain-specific communities.

5.3 OAn Pervasive Implementation

Field data gathering is one sample of use cases where mobility can be of special interest for end-users. An embedded mobile application exploiting the OpenAdap.net middleware could be implemented to allow data collection on a portable device and transparent submission to a broker over an authenticated connection. Some of the main advantages provided by this mobile OAn-aware application would be the use of advanced functionalities featured by mobile devices compared to traditional notepads including real time data gathering and submission/access to online databases, the possibility of ubiquitous multimedia recording (voice/pictures/video) and associate them with the collected field data. Location-awareness provided by the mobile telephone network or an optionally integrated GPS device is an additional information of interest that OpenAdap.net could

manage for open field applications, e.g. data could be generated in large sets through sensors mounted in a moving vehicle associated with high-valued information provided by an expert. Using specific mobile features, users would be asynchronously notified as soon as tasks would be completed thanks to a widget permanently running on the mobile screen foreground. Results would be available for visualization on the same mobile device and elsewhere in a collaborative working environment using a desktop OAn-aware application authenticated on the broker where the results were stored in a user's defined secured area.

6. Results

In the last few years, we have been developing, running and testing a prototype for OpenAdap.net (www.openadap.net). The concept proof and feasibility have been checked in an early prototype since 2001 [7]. At the end of 2006 a public test bed that illustrates most of the characteristics of OAn has been released in partnership with the Neural Coding community. This community is composed by academicians, students and researchers who investigate the neural coding schemes within the brain. On the website of the Neural Coding community (www.neuralcoding.org) there is a link to "Spike Train Analyses". This link leads to an OAn-portal application, the entry point to perform neural related data processing via an OAn-broker using several resources contributed by the Community using the tools of the OAn middleware (Figure 2).

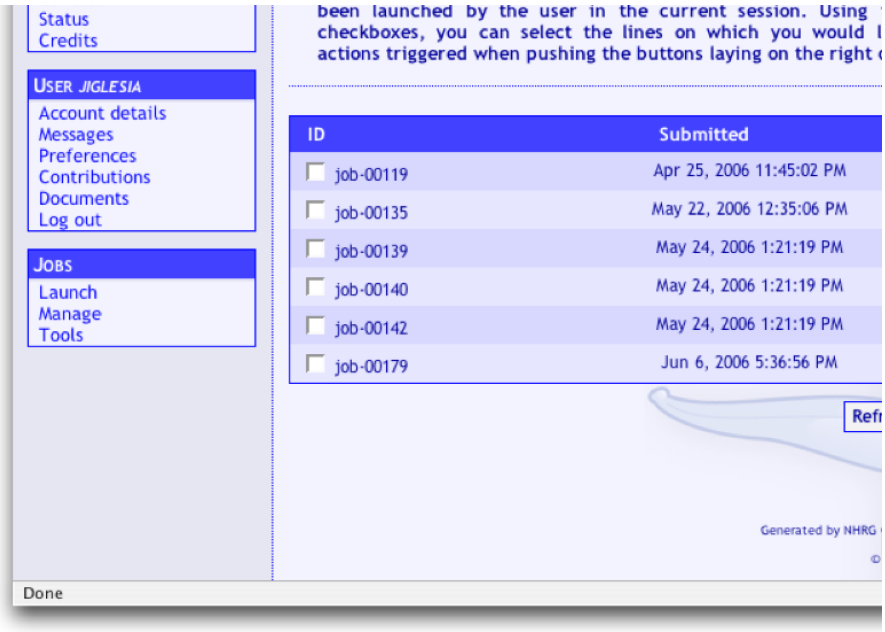

Figure 2:Screenshot of the OAn Web Portal using Mozilla Firefox on Apple MacOS X.

During the prototyping phase, the need appeared to have a portable and user-friendly tool that could provide a fast glimpse on the numerical output of unrelated programs. We searched for a generic front-end for plotting a wide range of graphics obtained through the web, and none could be found that was able to run on multiple platforms without requiring dedicated installation procedures, and capable of producing journal-quality graphics output for free. XY-Viewer is a Java application that is being developed for that purpose as a sub-project of the main project, featuring a dedicated XML data format that can be produced with the help of libraries made available to interested contributors in C and Java under the LGPL licence.

XY-Viewer is a tool that illustrates the concept and the potential of OAn-aware applications. It is a standalone application that can be launched directly from the OAn-portal to visualize files in the appropriate format (Figure 3). Let us consider the case of two

users located anywhere in the Cyberspace. They share an access right to the OAn portal. <User_1> has an access to some raw data that do not represent an interest as such for <User_2>. Then, <User_1> submits several jobs for data processing through the OAn-portal. <User_2>, provided the necessary rights, can access to the results of the data processed by <User_1> in real time with information about the job status. <User_2> can immediately exploit the results, thus avoiding the need of receiving the raw data and being confronted to the selection and parameterization of the correct resource for data processing. This example illustrates also the concept of collaborative working environment that can be transparently embedded in the OAn-aware applications.

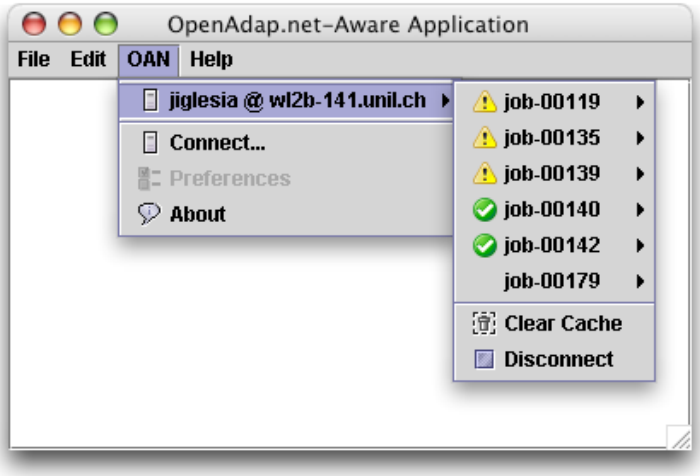

Figure 3. Screenshot of the OAn plug-in of a OAn-aware application.

7. Business Benefits

The business model of OpenAdap.net includes an explicit no profit business model, based on the adoption of the OpenAdap.net middleware and the development of the brokers thanks to a Free Software and patent-free policy. This model is aimed at the widespread dissemination of knowledge without economical barriers, e.g. at no cost to the communities that will rely on this system, and contains no profit motivation whatsoever. A complementary business plan is rooted on the potential benefits that appear with the growth of the adoption of the middleware. It takes into account many of the traditional business models that are associated to the Web [8], in particular the Community, the Brokerage and the Affiliate models. Our overall business model opens the way to unlimited Third Parties and added-value services and carries an embedded advantage for competitive businesses. Competition is greatly to the advantage of all members of the communities and OpenAdap.net offers the mean to build up new standards for trusted and quality controlled knowledge sharing. Such dual business plan is not new and several success stories are associated with members of Free Software Foundation [9] who developed moneymaking businesses, e.g. Neda Communications Inc. in the field of communication protocols [10].

A particular exploitation of the project is the development of web portals tailored to the needs of end-user communities centred on specific domains, possibly by SMEs (Affiliate model). The prototype has already attracted individuals from different research groups to cooperate and share resources in the domain of multivariate time series analysis. These early adopters constitute real-life case studies that assess the validity of the concepts and the usability of the implementation towards a broader diffusion. Moreover, community specific ontologies and benchmark file repositories represent an added value for businesses to adopt the OAn middleware.

Interactions with Publishers and Editors could have an incredible impact on the way scientific dissemination, including visualization, is performed, mainly by facilitating peer review in refereed publications and for results comparison and validation for peer scientific readers (Community model). Such interactions could be envisioned once the OpenAdap.net system will be fully available to the scientific community and should be encouraged. A major impact on the scientific community could be obtained by attracting well known scientific editors to encourage the scientific authors to provide source data to the community repositories, and to share their methods through an OAn broker, hence promoting reproducibility of results and direct peer review of the published article methodologies and results by the readers. All parties can profit of this interaction because on the one side the costs for publishing and editing would become drastically reduced given the access to community based applications and on the other side a broader, faster and transparent dissemination is likely to represent an optimal vehicle for authors' promotion.

8. Conclusions

The ability to tackle problems relies on both the past experience and new skills adopted by an individual. This is the feature of the trial-and-error paradigm and characterizes the "procedural" ("how") approach vs. the "declarative" ("what") approach. In our view the "know what", i.e. the explicit knowledge, is basically determined by supervised rules and relies on the accessibility to a good "teacher". Conversely, the "know how" is mainly determined by a self-experience (trial-and-error) and is keen to represent an appetitive way of information processing. No one likes to repeat a mistake and the success in a procedure is a reward by itself as observed in animal experiments [11] and exploited by mass consumer gaming consoles.

The access to information processing flows from both ends (end-users and contributors) is free with OAn because it occurs without supervision and is dynamically adaptable to the community usage. The problem of limiting the diffusion of illegal practices or contents should be eased by the OAn architecture in the way that it is the community as a whole who can better implement an ethical control on its own behaviour. Distributed ethics work better than individual ethics at the level of the society. The traceability of all brokers' activities should also contribute to restrain the malicious usage of OAn.

OpenAdap.net is based on the collaboration between computer scientists, telecommunication engineers and neuroscientists having very specialized backgrounds. We feel that such a transdisciplinary approach is necessary for the achievement of real advances in the Information Society Technologies. The OAn infrastructure makes possible the dissemination of resources and their exposure to application and evaluation across domains in ways that might not be anticipated. For example, processing tools from physics could permeate studies oriented to the dynamics of social interactions, linguistic analyses, crops forecast, traffic congestions, and life sciences. The case of communities based on compatible formats for multivariate time series data is a good example of transdiciplinary applications promoted by the OAn architecture.

Brokers route user requests to appropriate workers for execution. During the upcoming developments, brokers will be made adaptive and dynamically interconnected into an OAn network akin to a neuronal network. Learning rules will dynamically modify the routing according to e.g. the computing load generated by specific resources. The OAn network will be able to adapt autonomously via learning processes derived from the neural and artificial life fields. Such learning might result in new broker-broker connections, weighting of such connections, specialisation or generalisation of broker behaviour, etc.

Last but not least citizens of less favoured countries will have access to all shared OAn resources with a basic Internet connection, thus benefiting from the knowledge transfer and available assets, and contributing back to the community with their own approaches and

resources [12]. Side effects are expected on the quality and harmonization of the resource documentation and standardization. The outcome of such cross-cultural interactions is unpredictable and is likely to bring a full spectrum of challenges and opportunities to OAn end-users and contributors throughout the world, especially for SMEs able to develop innovative business plans. The development of pervasive tools may also represent an interesting aspect of OAn middleware for the less favoured countries because they tend to produce an increasing amount of information to be processed that is delayed by limited access to expensive added-value processing applications.

Acknowledgments

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