# InPhO @ Work: Providing Integrated Access to Philosophy

## Abstract

A wealth of humanities resources is available on the world wide web. Access to these resources remains hampered, however, by the absence of sophisticated tools for aggregating, searching, and navigating the various digital collections. As the resources grow, we must also improve our ability to represent their contents in meaningful ways accessible to novices, experts, and machines. Due to the increased scale and dynamic nature of digital humanities resources, traditional methods of gathering and organizing metacontent (indices, cross-references, tables of contents) are so resource-intensive and inefficient as to be impracticable. More sophisticated techniques of generating metacontent from large, asynchronously-updated corpora are required.

The Indiana Philosophy Ontology (InPhO) project combines human expertise and software analysis to generate a "dynamic ontology" for the domain of philosophy. An ontology is a formally-encoded, hierarchical taxonomy of the entities relevant to a subject domain. The InPhO is dynamic because it tracks changes in the content of the online Stanford Encyclopedia of Philosophy (SEP) http://plato.stanford.edu/. Initial funding from Indiana University and from a NEH Digital Humanities startup grant has yielded a populated taxonomy of almost 2,000 philosophical ideas and a database of information about over 1,700 historically significant philosophers. In addition, the InPhO has started to capture information about published documents belonging to the permanent written record of the discipline, and we are also working to capture organizational aspects of the discipline, such as journals, schools, academic departments, professional associations, and conferences.

An InPhO-based crossreferencing tool is already being used by the SEP editors to help identify related entries at publication time. At the InPhO website http://inpho.cogs.indiana.edu/taxonomy/ we have debuted a text-based interface that allows users to explore related concepts and thinkers through the taxonomic structure itself. Each term or name provides links to the corresponding SEP article (where one exists) and links to appropriately constructed search queries at the SEP search engine, the Noesis search engine http://noesis.evansville.edu/, and Google Scholar. The search links are constructed by combining search terms from two levels of the taxonomy to help steer users towards more focused results than if they searched with either term alone. Thus we provide integrated access to a variety of resources. The current proposal seeks to extend the document and organizational parts of the ontology and to develop new applications of value to general readers and to trained philosophers. These applications will include bibliographic and bibliometric tools that can be deployed in a variety of integrated and free-standing Digital Philosophy applications. We will also develop and deploy network visualization tools for the data in the InPhO that will allow users to see and explore the relations among thinkers, ideas, documents, and institutions.

Our proposal fosters integrated access, and interoperability between digital philosophy projects generically and specifically. Specifically, the prototype text-based interface at the InPhO website already provides basic single-point access to two other NEH-supported projects in philosophy, the SEP and Noesis. Generically, our goal is achieved through publication and regular updates of InPhO data, made available through publication of the ontology and an API to our database. Thus we provide a backbone that other developers of open access digital philosophy projects may build upon. We believe the project to be sustainable in the long term because it is dynamically updated from its primary data source, the SEP, which itself is a sustainable project, and because our long-term equipment needs involves only open source and freely-licensed software running on stock hardware.

# Contents

# Project Narrative—InPhO @ Work: Providing Integrated Access to Philosophy

## Significance

The rise of digital projects in the humanities presents scholars and technologists with unique challenges. Software is needed to aid the construction, management, and presentation of machine-readable representations of complex ideas, especially for WWW-based projects. The task of information integration and extraction in the context of the humanities is particularly challenging because the humanities use abstract language that demands the kind of subtle interpretation often thought to be beyond the scope of computers. Nevertheless, the viability of many digital humanities projects depends on having tools for automatically extracting the semantic relationships which hold within and between different texts. Widely-used statistical methods of analyzing documents (e.g., latent semantic analysis) are alone inadequate to the task; such techniques will need to be enhanced by expert knowledge, using feedback directly obtained from domain experts and indirectly from machine-readable representations of the organizational principles that experts impose upon their professional work. Digital tools for the humanities will need to be capable of dynamically tracking the introduction of new ideas and interpretations and applying them to older texts in ways that foster novel understanding.

The current proposal seeks to extend methods developed by the Indiana Philosophy Ontology (InPhO) project[1] for managing "metacontent" (machine-readable descriptions of the primary content) in a "dynamic reference work." The general goal is to extend the methods that we have already developed for representing conceptual relations among ideas in any complex, dynamically changing corpus. Crucially, however, the proposal also has some entirely practical goals, which are to enhance one of the most successful digital humanities projects on the Web—the Stanford Encyclopedia of Philosophy (SEP)[2]—and to use the InPhO framework to enhance the Noesis philosophy search engine[3] and to mine the datasets returned by Noesis to further extend InPhO. The scale of the SEP necessitates the development of automated methods if the full advantages of the digital medium are to be exploited within the constraints of a sustainable operating budget. The open-ended nature of the Noesis project will force us to consider a wider range of data sources and relationships among them than the SEP alone might require. By putting InPhO to work, the specificity of these tasks will keep the project grounded and provide an important context in which the proposed work can be evaluated and its impact measured.

The InPhO begins with a small ontology that has been "hand built" to capture the major subdisciplinary divisions within Philosophy. The process of populating and extending this ontology begins with statistical methods to extract idea keywords (which include multiword terms)[4] from the SEP entries, to assess document and term similarity in the context of those entries, and to assess relative generality of the terms across the SEP. These statistical data are used to generate hypotheses about taxonomic relations for evaluation by the domain experts, i.e. the authors and editors of the SEP. We combine these judgments (and data similarly gathered from other interested individuals)

[1] http://inpho.cogs.indiana.edu/

[2] http://plato.stanford.edu/

[3] http://noesis.evansville.edu /

[4] It is sometimes convenient to use *term*, *keyword*, and *idea* interchangeably, but it should be kept in mind that a term or keyword is not the philosophical idea itself but rather its label.

with the statistically derived information to induce the best taxonomic structure for the keywords, using answer set programming,[3] a non-monotonic reasoning method. We will also harness this feedback to train the statistical methods.

Because our approach depends on gathering input from domain experts and other knowledgeable individuals, we face the notorious problem of motivating people to provide the needed information. We have addressed this by designing interfaces (described below) that assume no knowledge of ontology design, which are being inserted into the SEP workflow, and which replace the more onerous task that the authors currently face of gathering crossreferences by hand. Furthermore, because of the dynamic nature of the SEP, we have repeated opportunities to gather judgments incrementally from the authors each time they revise their entries. In this way, a moderate amount of concentrated expert effort can be bootstrapped by a mixture of automatic methods, distributed human effort, and repeated expert review, into a more sophisticated representation of the discipline. Because the InPhO will be updated each time new material gets published in the SEP, it can be described as a "dynamic ontology."[5]

We are less strict with the notion of an ontology than some.[6] Nevertheless, we accept formal constraints that might make other less formal alternatives seem more attractive. For instance, "folksonomies" derived from "social tagging" rely on the power of the collective to mark up content in ways that are useful.[4] However, we have at least three reasons for preferring an ontology for our scholarly context. First, because the ontology is easily inspected it can be held to the high standards of peer review and assessment applied to other scholarly products. Second, as we describe below, the format allows us to gather information more effectively from experts, i.e. the SEP authors. Within the InPhO structure, authors will need only to click buttons to verify suggested relations among items. Social tagging would require the more laborious task of going from text to tagged entities, and some authors might not even know what tagging is. Third, the ontology format makes it possible to accumulate knowledge through automated inferences, and use this knowledge to improve the automated methods. Ontologies are designed to support such inferences, whereas a freer, more heterogeneous system of tagging is less likely to do so. The point about lack of depth in socially built taxonomies is illustrated in the too-shallow structure of Wikipedia's lists of philosophical topics.[7]

The InPhO project treats the SEP as one among many sources of data about philosophy, but one whose authoritativeness and open access makes it the best starting point for any effort to represent Philosophy digitally. It has already proven useful, however, to access other sources of information about philosophers and philosophy. One potentially rich source of authenticated information is the Noesis philosophy search engine, which uses predifined search sets to conduct area-restricted searches through Google. Noesis's target is academic scholarship in philosophy that is available online. It does this by mapping those areas of the Internet where professionals in philosophy are overwhelmingly likely to appear, principally, their home bases on the web, the academic departments where they teach, the organizations and conferences they populate, and the online versions of

[5] According to the USC Brain Project http://www-hbp.usc.edu a "dynamic ontology" is a shared ontology that adapts to an application domain and evolves with time as the concepts in that domain change.

[6] E.g. [10, 11]. Our approach carries a specific danger of conflating non-taxonomic relations, which would be appropriately represented in a semantic net, with the narrower set of taxonomic relations properly belonging to formal ontology, in particular our use of the *is-a* relation. We address this issue below.

[7] See http://en.wikipedia.org/wiki/List_of_philosophical_topics and http://en.wikipedia.org/wiki/List_of_basic_philosophical_topics . Crucial concepts, such as *mental content* from the philosophy of mind, remain unmapped there.

traditional forums through which they publish (e.g., journals, reference works, etc.). The relationship between InPhO and Noesis is thus reciprocal: the InPhO can help structure the searches that are conducted through Noesis, while the results of those searches can be used to supply additional data to InPhO.

The potential of InPhO to enhance scholarship and learning in philosophy is indicated by preliminary testing of ontology-guided searching through the SEP and Noesis. For instance, we noticed that our automatic methods had paired the terms "divine illumination" and "mental representation". The structured searches through the SEP and Noesis revealed that indeed the terms are related through the medieval problem of universals. Thus, the taxonomic structure of the InPhO led us to discover a real connection beyond a mere verbal coincidence between *mental representation* and the medieval concept of *divine illumination* through the problem of *universals*, revealing an historical influence on a psychological concept that is not well-known even to experts in philosophy of mind. Perhaps there is a handful of experts who knew this already, but we regard the prospects of getting such information into the hands of everyone as genuinely exciting for the discipline. In addition, through the SEP we have the potential to reach the scholars, students, and members of the public who are downloading over 600,000 to 1,000,000 entries each week. We provide visitors to our website with integrated access to a variety of sources of high quality information about philosophy. We will make the ontology available for download on the Web, which should have three main effects: to prompt suggestions for revisions and extensions of the ontology, to inspire new applications in Digital Philosophy, and to spark philosophical discussion of the prospects and dangers of Digital Philosophy. Finally, because this is not a "toy" application, we expect our InPhO to inform other Digital Humanities projects.

With our startup funding from the NEH's Digital Humanities initiative, we have deployed our InPhO systems to help ensure that the metacontent tracks the content of the SEP, and we have modified the SEP's workflow system to support metacontent extraction and maintenance of our InPhO dynamically. The most recent version of our taxonomy organizes almost 2,000 philosophical ideas and includes a database of information about over 1,700 historically significant philosophers. We have also compiled a database of over 1,000 journals that publish philosophical papers, and we have started the daunting task of converting the other 65,000 bibliographic citations in the SEP into structured database records. A major effort under this NEH proposal is to complete this task using a mixture of software and human input. The result will be a taxonomically structured bibliographic database, seeded by the reference sections of SEP articles, that would both enhance and be enhanced by the automatic metadata handling routines described in this proposal. Such a database will provide a valuable resource in its own right to scholars and students of philosophy, and would bring the resources available to philosophers closer to those available to scientists through projects such as PubMed and CiteSeer.[8] Importantly for InPhO purposes, the possibility of buidling a citation network from this database will provide another important source of information that is relevant to populating the ontology and generating crossreferences.

The other major component of the present proposal is to develop effective ways of presenting and visualizing the information in the InPhO database. A variety of network visualization tools will be tested and at the end of the 2nd year, we will deliver a working visualization of the conceptual space of the discipline of philosophy.

[8] At http://www.ncbi.nlm.nih.gov/entrez/ and http://citeseer.ist.psu.edu/ respectively.

**History, scope, and duration**

The InPhO project was initiated in 2006 with internal funding from Indiana University's "New Frontiers in the Arts & Humanities" program in the amount of $43,000 for a project titled "Automatic Metacontent Management for Dynamic Reference Works." This money supported two graduate students, Cameron Buckner (philosophy) and Mathias Niepert (computer science). During this period, the initial version of an ontology was built to cover approximately one half of the subject areas in the SEP, and the algorithms for carrying out statistical analysis of the textual content of the SEP entries were developed. This work was presented at the IEEE/ACM Joint Conference on Digital Libraries in Vancouver, Canada, as described in Niepert, Buckner, and Allen (2007a [5]). An informal account was published in the American Philosophical Association's Computing and Philosophy newsletter (Niepert, Buckner, and Allen 2007b [6]) and the work was additionally presented by Buckner and Niepert at the North American Computing and Philosophy conference in Chicago, July 2007.

In 2007, the P.I. received Digital Humanities startup award HD-50203-07 in the amount of $29,800 which has been used to continue supporting Buckner and Niepert, and to employ an additional undergraduate student programmer. During this period, the full set of SEP subject areas have been incorporated into the ontology, additional statistical analyses of corpus is continuing, and public interfaces to the InPhO have been made available at http://inpho.cogs.indiana.edu/, feedback has been gathered from volunteers, and automated reasoning tools have been applied to the feedback data to "populate" the ontology with the 1,900 terms in the database. This research has been summarized in Niepert, Buckner, and Allen (2008 [7]), presented at the Florida Artificial Intelligence Research Society conference in May 2008, and demoed at JCDL 2008[8]. In addition, we have implemented the crossreferencing tool for the SEP editors and authors, set up a secure tunnel between the SEP server at Stanford and the InPhO server at Palo Alto to allow database queries to be answered remotely, and by the end of the NEH grant period we will have fully integrated the crossreferencing and data collection routines into the SEP workflow. Other descriptions of the project and its goals are forthcoming in two journals, one in *First Monday* is based on Allen's presentation at the NEH-organized panel at the WebWise 2008 conference in Miami Beach, Florida in March, and is directed at the library and museum community. The other, slated for a special issue of *Synthese* on "Representing Philosophy" is directed at philosophers. The work was also presented by Allen at the North American Computing and Philosophy conference in Bloomington, Indiana, in July 2008, and Allen has accepted an invitation to give a presentation on the InPhO approach to philosophical knowledge and expertise in November 2008 in Paris, France, at the European Commission workshop "Sciences in Society—Dialogues and scientific responsibility."

At the end of the grant period in 2011, we intend to have accomplished the following:

- A database of the works cited by philosophers containing all the documents cited in the SEP and more, and tools allowing philosophers anywhere to read and edit this bibliographic database. Along the way we will develop software that can parse unstructured bibliographic records by machine and an interface which makes the human task of cleaning up the machine parsing relatively straightforward. This will also be integrated into the SEP so as to convert all of their unstructured bibliographic items into a structured set of records that will then be used to develop an application for SEP authors to insert, read, and cite only the items in the database. Work on the code and interfaces to accomplish this has already begun (see appendix for a screen shot).

- An application which applies recent advances in information visualization research [9] to use the structure available in the ontology for thematic and conceptual navigation of the SEP's content. This part is crucial to the plan for InPhO to be of general interest to the discipline rather than behind-the-scenes management of the SEP's workflow and metacontent generation. Visualization will provide the main window through which this rich source of information in the InPhO becomes visible to the public at large. The goal is to design a graphical user interface which can be used to navigate through online resources in philosophy with the InPhO as guide to various kinds of relationships among and between philosophical ideas, thinkers, and resources (documents and organizations). An envisioned user interface with the system is described as follows: A user will search for some specific keyword; a graph will then be displayed with the closest keyword contained by the ontology displayed in the center; the graph will be populated with a number of other related keywords linked to the search keyword, where the links are labeled with the relationship recorded in the ontology; and the user can browse this structure, re-center it, and repopulate it; and each time the user clicks on one of the bubbles, a small window will be displayed showing the first few lines of the SEP article most correlated with that keyword. Moreover, the user can control the type of links displayed by checking various options, such as focusing on philosopher-philosopher relationships, idea-idea relationships, etc.[9] There has been much work on visualization of academic subjects [9], some of it originating at IU.[10] However, the application of general visualization principles to the navigation of a large reference work is far from trivial, and our proposed system would involve several innovations. First, the information displayed will be directly supervised by the ontology (similar to, e.g., [2]). We go further by labeling the links between nodes according to the relationships between those ideas recorded in the ontology. Second, we observe that the ontology will nearly always contain many more candidate nodes than can be intelligibly displayed to the user upon a search and that some selection process will have to be made to determine which candidates are shown to the user. We believe the InPhO combined with the database of statistical relations can be used to generate weighted selections in ways similar to priming effects in human memory.

- We will develop a strategy and implementation for using parallel computation to run multiple models that fit the data to the ontology. We have already tested the DLV (Datalog with disjunction) reasoner on IU's Big Red supercomputer and we have started to map out ideas for parallelization of our tasks.[11]

- We anticipate writing several publications for computer science journals and conference proceedings, describing the technological aspects of the project, and for philosophy and humanities journals, and for librarians' journals, to highlight the rationale and continuing benefits for research and teaching that flow from our work on this project.

[9] Mock-up at http://inpho.cogs.indiana.edu/NSF/mockup.jpg

[10] E.g., the InfoVis lab in IU's School of Library & Information Science http://ella.slis.indiana.edu/~katy/ .

[11] We are mainly exploring techniques that would allow us to run multiple rule sets or multiple data sets in parallel, rather than parallelizing each individual instance of the answer set program itself. The latter is a very hard problem.[1]

**Methodology and standards**

Users will access our materials through the inpho.cogs.indiana.edu website, and through customized interfaces developed for SEP and Noesis. By distributing our code around different machines at Indiana University, Stanford University, and the University of Evansville, we will guarantee redundant storage. Wherever possible, we use open source tools including the MySQL database, the Apache webserver, and the PHP, Perl, and Java programming languages. For the machine reasoning portion of our project, we use the DLV reasoner, which is free for academic and non-profit uses[12]. Although we currently run on Apple hardware using the OS X operating system, there is nothing in principle to prevent us from running the same software on other unix-like platforms. However, for ease of system management and maintenance, we presently prefer the hybrid combination of OS X proprietary and open source nature of OS X with the open source component of Apple's darwin project.

Our mysql database contains primary tables for ideas, thinkers, journals, documents, institutions, and users. In addition there are tables containing relational information for idea-idea, thinker-thinker, and idea-thinker relations. The basic ontology structure is also stored as a database table, and we will be building the tables to store other relational information. SEP authors and editors automatically have user accounts at InPhO which enable them to submit and us to store their evaluations. Other users who wish to contribute may obtain accounts by registering through the InPhO website. The appendix shows examples of the screens encountered by users during different activities. We will publish our ontology monthly in OWL (Web Ontology Language) format, an XML format that can be imported into several ontology management tools. Our choice of names and terms in these datasets is driven by the SEP content itself, but we also crosscheck such terms against the Wikipedia's list of entries under the philosophy.[13] Because the SEP and Noesis will provide links back to the InPhO project, we will be discovered by webcrawlers. The databases and software developed for the InPhO projects will be stored on two servers at IU and backed up using IU maintained systems. Extra copies will also be kept on SEP and Noesis servers. The mysql and OWL formats of the data are expected to remain available for the forseeable future.

We also wish to develop more accurate methods for the task of metacontent extraction in a discipline that is of central importance to the humanities and the sciences. Assessment and evaluation of outcomes related to this goal will draw from several sources: (i) the evaluative judgments of the SEP authors and editors of the InPhO as it evolves; (ii) patterns of usage of InPhO-enhanced SEP interfaces by its readers; (iii) successful deployment of the InPhO to other digital applications; (iv) formal verification methods; (v) the outside consultants.

For (i) we aim to discover and test combinations of methods which can dynamically improve the accuracy of our algorithms (e.g., by adjusting statistical confidence weights, and exploring different kinds of relevance feedback). The success of these methods can be assessed by the proportion of machine-generated hypotheses that are confirmed by the judgments of the SEP authors. For (ii) we predict that SEP readers using InPhO-enhanced search, navigation, and visualization methods will interact with these tools in ways that improve their access to the content of the encyclopedia. We will assess this through server logs which will enable us to track the pattenrs of search and access by SEP readers. We will analyze whether users who enter either site from the InPhO taxonomy interfaces behave in a statistically different way than those who enter from other sources. We will

[12] http://www.dvai.tuwine.ac.at/proj/dlv/

[13] http://en.wikipedia.org/wiki/Philosophy/

solicit peer review from developers of external applications and, in exchange for supporting their deployment of the InPhO, we will ask them to include similar assessments of their users' patterns of interaction. In particular we will be interested in determining whether such users spend longer on the sites, visit more entries or run more searches on the site, and any other measures of the utility of the InPhO-provided tools. For (iv) we will modify evaluative methods developed for other ontology projects, such as comparing the InPhO keywords to Wordnet to check for coverage and completeness, and formal validation with a theorem prover to assure consistency. For (v), we will have annual site visits from the outside consultants who are ontology experts.

# Work plan

The project will be coordinated through weekly meetings between the PI and the student employes, bi-weekly metings with Prof. Tony Beavers of Noesis who will be running the University of Evansville subcontract, monthly video conferences with the Uri Nodelman, Senior Editor of the SEP, and annual visits from the two ontology consultants, Pierre Grenon and Chris Menzel. Regular reports will be submitted to suitable conferences such as the ACM/IEEE Joint Conference on Digital Libraries (JCDL) and the North American Computing and Philosophy conference. During the first year of the grant period, the P.I.'s 25% salary will buy a one-course release, allowing 4 hrs/week to be committed to the project. During the second year of the grant period, the P.I. is eligible and will apply for sabbatical leave, thus with %50 salary will be able to commit 20 hrs/week to the project, with the remaining 50% time commited to the P.I.'s other ongoing research and writing projects. One month summer salary is requested each year to allow the P.I. to commit 33% effort (approx. 1.5 days/week) distributed across all three summer months.

• **Year 1** *Goals:* (i) Review InPhO design for compatibility with the needs of other digital philosophy projects, especially Noesis, and work with Tony Beavers on University of Evansville subcontract to develop software and interfaces for Noesis-InPhO exchange; (ii) Continued development of information retrieval and automated reasoning methods for InPhO, including use of machine learning methods, and applications of supercomputing where possible; (iii) Development of system for machine parsing of text bibligraphies, and construction of web browser interfaces to allow correction of machine results, plus manual clean up required for import of bibliographies from SEP entries to the system; (iv) Prototype visualization methods for InPhO data sets. *Effort:* PI will be involved with server system management, the design and coding of all aspects of the project, and writing reports for conferences and journals. Student programmer(s) will work 12 weeks during summer at 30 hrs/week (= 360 hrs) plus 10 hrs/week for 30 weeks during semester (= 300 hrs) for a total of 660 hrs. Current graduate programmers (Niepert & Buckner) will be available during first summer to help train new programmers, and also to work on publications and presentations. Programmers will assist with all of (i)-(iv) and will be selected based on their skills and ability to contribute to specific parts of the project. Other graduate and undergraduate student hourly employees will provide data input required for (ii) and (iii), and testing and refinement of interfaces for all parts of the project.

• **Year 2** *Goals:* (i) Visualization methods for navigation and retrieval of information about philosophical ideas and thinkers; (ii) Training of methods for automated metacontent extraction using human feedback gathered from SEP authors and from the search and navigation behavior of users of the Noesis search engine; (iii) Improvement of techniques for combining multiple sources of machine generated and human provided information using supercomputing methods; (iv) Development of an API (application programming interface) to allow InPhO to be used by digital philosophy applications outside the SEP and Noesis; (v) Evaluation and assessment. *Effort:* PI will be involved in all phases of project design and implementation, and dissemination of results. Graduate and undergraduate hourly employees will be divided among all tasks, programming and data input and verification.

# Staff

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[Consultant] Grenon, Pierre, Ph.D. (Researcher, Eidos Centre in Metaphysics, University of Geneva, Ontology Expert)

[Consultant] Menzel, Christopher, Ph.D. (Professor, Texas A&M University, Ontology Expert)

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# Dissemination

During the two years of the InPhO project so far, we have given six conference presentations, published three articles in conference proceedings, one newsletter article, and we have two other journal articles under preparation, and one more conference presentation scheduled. We expect to continue producing publications and presentations at a similar for the duration of this award.

In addition, once we publicize that the InPhO website is open, we anticipate a rise in visitors to the site, more links from other sites, and a corresponding rise in the visibility of InPhO in search engine results. (On July 25, 2008, Googling "InPhO" returned our site at number 3, and search for "philosophy ontology" with quotation marks around the string placed our site at #10 on the first page of results.)

## Sustainability

At the end of the grant period, the developed software will run with minimal oversight, requiring only that the server be kept running with a unix-like operating system (e.g., linux, freebsd, or Mac OS X), and occasional bug fixes. The P.I.'s software development experience includes writing the document management system for the SEP, which has been in continuous production since 1999, and two web-based logic instructional systems[14] that have been running since 1995 and 2000 respectively. Thus he has extensive experience in designing and maintaining systems that run continously on the world wide web, and that are sustainable at minimal costs for the long run. Because the ontology itself is dynamic, it will never become obsolete so long as the underlying data sources are kept up to date, and the long term prospects for the SEP are relatively well assured. Nevertheless, we expect there to be many potential uses of the InPhO and further technological developments possible that will make it desirable well past 2011 to continue to pursue both the technical research and software develpment needed to support those uses with effective software tools. We expect that it will be possible to make a compelling case to funding agencies for the need to pursue such developments in the future, and we will therefore continue to seek funding from a variety of sources that will allows us to pursue projects that go beyond more than the minimal maintenance of the system.

In the two years since the project began, the InPhO project has been hosted on the P.I.'s desktop machine and then on a server belonging to the Cognitive Science program at Indiana University. As our data and computation needs increase, we anticipate the need for a dedicated server, particularly for the machine reasoning portion of the system which is computationally intensive. We have also started exploring the use of parallel supercomputing through IU's Big Red platform, where we have already run some preliminary tests of the reasoning program. For the proposed period of this grant, we will set up a dedicated server, but will continue to use the Cognitive Science server as a backup machine. A dedicated server will give us complete control of the machine and the capacity to coordinate data analysis between Big Red, the SEP, Noesis, and our database.

[14] http://logic.tamu.edu and http://www.poweroflogic.com/

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