A novel application of Web Services in Computer Science education

Ciarán O'Leary, Mark Humphrys and Ray Walshe

Abstract — **Many computer based tools exist which facilitate collaboration among groups of students. The majority of such tools, however, simply serve as communication devices in substitute for face to face communication. This paper describes how Computer Science students can use their skills to collaborate in a new way. Using web services to develop interactive content, a group of undergraduate Computer Science students collaborated to develop solutions for an assessment in an Artificial Intelligence course. The term *web services* describes a new and exciting family of technologies for connecting online programs. Although they are rapidly becoming popular in industrial applications, we feel they have been ignored in educational environments, where they can serve as simple mechanisms for collaborating to develop content. This type of collaboration requires technical skill of a level higher than that of a computer user, but it provides collaborating Computer Science students with an excellent opportunity to employ the networked computer as an enhanced learning tool, and not simply a communication device.**

Keywords — **Collaborative Learning, Computer Science, Education, Web Services, XML**

I. INTRODUCTION

COMPUTER Science (CS) students find themselves in a unique position within education whereby the medium through which they learn can be strongly linked to the content of what they are learning. Students within this discipline can employ the expertise they are developing in the area of CS to support their learning by quickly adapting to the use of tools such as Virtual Learning Environments (VLE), Personal Digital Assistants (PDA) and on a wider scale, the World-Wide-Web (WWW). In turn, by using technology in this way their learning of core concepts is grounded in real world experience of communication protocols, interface design and operating systems.

Given that the level of expertise of CS students in the use of technology is typically higher than students in other areas, it is possible to push the boundaries of what is expected of these students when using technology in a learning environment. CS students have experience of developing software applications, writing program code and building web applications, among other things, following the early years of their tertiary education. These skills can be employed in a variety of ways to take further advantage of tools such as the WWW in the remainder of their formal education.

We describe our experience in assessing a set of over three-hundred CS students by requiring them to employ their networking and communications skills for online collaboration in a course on Artificial Intelligence (AI). Whereas it is often the case that students use the discussion board and chat room facilities of VLEs to collaborate for educational purposes [16], the students we describe collaborated on a higher level by making their assignments available online for others to observe and re-use.

Reuse in this case took place through *web services* [18], a recent development in networking technology which simplifies remote interaction between executable programs. Various formats exist for web services (primarily SOAP [19]), and are being employed by numerous online applications such as Google, Amazon, EBay and FedEx [8]. We have, however, not yet found another application of web services in education.

The type of web service we use was originally developed for a distributed AI project called the World-Wide-Mind [7]. This project, its goals and its technologies are briefly introduced in section II. Sections III-VIII describe the format of the assessment that was given to the students and the results of this assessment. The remaining sections analyse the assessment and discuss the advantages and potential for the use of web services in CS education.

II. THE WORLD-WIDE-MIND

The World-Wide-Mind (WWM) is a project which aims to facilitate the *scaling up* of AI research to the point where multiple interested parties can collaborate on the development of control software for robots and intelligent agents [7]. The inspiration for the project came from the popular *Society of Mind* model of mind [10], which proposes that real intelligence arises from the interaction of vastly diverse, highly specialised, heterogeneous components. It is proposed that if humanity is ever to produce an AI, it will not be as a result the work of small groups of researchers, rather it will require the involvement of experts from multiple fields working in

Ciarán O'Leary is with the School of Computing, Dublin Institute of Technology, Kevin St., Dublin 8, Ireland (phone: 353-1-4024718; fax: 353-1-4024985; e-mail: ciaran.oleary@comp.dit.ie).

Mark Humphrys is with the School of Computing, Dublin City University, Glasnevin., Dublin 9, Ireland (phone: 353-1-7008059; fax: 353-1-7005442; e-mail: humphrys@computing.dcu.ie).

Ray Walshe is with the School of Computing, Dublin City University, Glasnevin., Dublin 9, Ireland (phone: 353-1-7005597; fax: 353-1-7005442; e-mail: ray.walshe@computing.dcu.ie).

loosely coupled collaboration.

To facilitate such collaboration, the WWM project proposed a web service format called SOML (Society of Mind Markup Language) [12]. Researchers who wish to contribute to the WWM project can make their components available online, with the only requirement being the provision of an SOML interface. Others can interact remotely with this component, possibly integrating it with their own components to produce a component with greater functionality.

SOML defines two core service types. *World services* represent a problem world inhabited by an agent or robot of some sort. *Mind services* represent the control software for this agent. Multiple mind services in geographically dispersed locations can be made available for one world service. When these minds run in the world, their score is recorded on a publicly available online scoreboard, for other participants to observe. Anyone can reuse an existing mind service by simply querying it for control information during a run in the world.

The purpose of this paper is not to discuss the WWM, rather we explain how the remote reuse idea was employed in an educational setting. For further details on the WWM the reader is directed to [7] and [6].

III. ASSESSMENT

Over a period of two academic years students in third year of the four year BSc Computer Science in Dublin City University (DCU) were given the task of developing control software, or minds, for a simulated world inhabited by a small animal faced with multiple conflicting goals (locating food, escaping predators, mating etc.). The success of the animal was measured by the number of times that it successfully mated with a member of its species. A variety of well-known approaches to developing this type of control software exist including learning, evolutionary and hand-designed techniques. The job facing the students was to come up with an algorithm that outperformed those of their classmates.

The rules of the assessment stated that students needed to make their algorithm available online as an executable mind service, so that others could execute the mind in the world and observe its behaviour. The scores achieved in each run would be recorded online as stated earlier. Mind services could also be reused by others who *wrap* a successful mind service in their own – in a type of hierarchy, or society of mind.

IV. HOW TO MAKE A SERVICE

Given the students' expertise in developing networked and web based applications, the task of making a mind service was reasonably straightforward. Their software needed to be put on a web server with a CGI script or servlet prepared to receive a request. Upon receiving the request, the servlet needed to consult the software to provide a response.

For example, a mind service should be able to receive the state of the world (what the animal perceives, how it feels) as a vector of numbers, and return an action that the animal should execute (run, eat etc.). To satisfy this requirement, services process SOML requests such as `getaction` and return responses, as shown in Figure 1 and Figure 2.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<soml>
    <getaction type="request" runid="12345">
        <state>
    (0, 0, 0, 9, 7, 8, 2, 0, 4)
        </state>
    </getaction>
</soml>
```

Figure 1: `getaction` request.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<soml>
    <getaction type="response" runid="12345">
        <action>
            RUN
        </action>
    </getaction>
</soml>
```

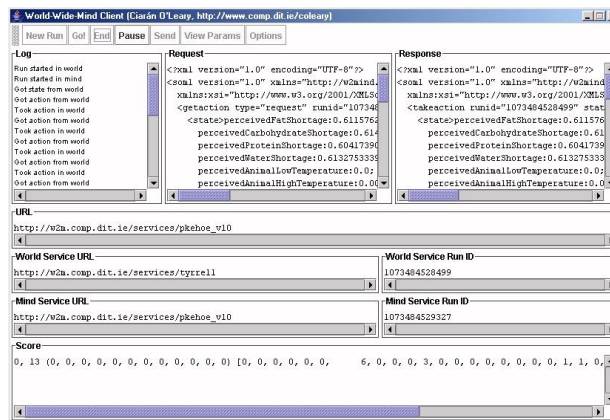**Figure 2**: `getaction` response.

Figure 3: Interface of client software

V. HOW TO RUN A SERVICE

Client software (shown in Figure 3) was made available to the students which they could use to run a service once it was online. The client would accept as input the URL of the mind service and the URL of the world service (the world service had been made available online at a specific URL prior to the assessment). The client would then request the world for its state, the mind for its action, and the world again to instruct it to take the action, looping until termination. The score was then recorded online.

VI. HOW TO REUSE A SERVICE

To reuse an existing service, a student would need to rewrite their mind service so that when it receives a `getaction` request it would in turn request another mind service by opening a socket, issuing a request in SOML and parsing the response. The mind service could then use the returned action, or decide upon an alternative.

VII. EXPERTISE REQUIRED

Aside from the AI techniques employed, students partaking in the assessment needed the following expertise:

1. Create a CGI script, or Java servlet on a web server.
2. Generate and parse SOML – since SOML is an XML language any number of different parsers and APIs can be used to perform these functions.
3. For those wishing to reuse other services, the ability to open a network socket and issue a HTTP request.

In order to simplify the task, some examples, tools, code and managed web space were made available to the students – which were used by the vast majority of the class. Despite this, the level of expertise that was required in order to develop a service from scratch could not be considered beyond the capabilities of third year CS students.

VIII. RESULTS OF EXPERIMENT

A detailed discussion of the results of the experiment are provided elsewhere [11], and are not considered a contribution of this paper. In brief, we were able to develop a society of mind for the animal in the artificial world which out-performed any one of the minds alone. This was done through a process of profiling the individual minds to establish their strengths (large amounts of data were recorded on the scoreboard following each run), and combining the minds to take advantage of the individual strengths. The best performing mind was the one which combined the most successful *mater* (per timestep) with the best *survivor* (best at finding food and avoiding predators, but not finding mates).

IX. COLLABORATIVE LEARNING

There is wide acceptance for the view that collaboration among students actively supports the learning process [3]. Some of the many benefits listed in the published literature [5] on the subject include:

1. increased interest among the participants
2. promotion of critical thinking
3. improved retention of ideas and content
4. development of communication skills

In general, collaborative learning, and cooperative learning has been restricted to individuals actively placed into groups by an instructor, where the group meets face to face at fixed times. However, much attention in recent literature focuses on the use of information technology, in particular VLEs incorporating discussion boards and chat rooms, in facilitating collaboration on a wider scale than localised groups [16].

It is felt that in these situations the learner can benefit from the asynchronicity of the environment, where learners who are both spatially and temporally dispersed can collaborate to share ideas, stimulate thought and reflect upon each other's contributions.

It is clear that the primary role for the networked computer in most modern learning environments is as a communication device. It is, however, our contention that the use of the computer as a tool in collaborative leaning should be extended beyond communication when the students possess skills which enable them to embrace more fully the potential for the computer in the networked environment.

Although there are many examples of the Internet being used to give students access to content, instruction, devices and instruments [14] these are all at the level of the user, where no technical skills above a very basic level are required. Similarly, much publicised projects which require large scale collaboration for their success, such as the SETI@HOME project [15], and distributed.net's DES-cracking [2] attempt do not require any technical know-how from the end users, thus restricting their involvement and limiting their contribution.

X. THE WWW MODEL

We favour the collaboration model of one of the greatest success stories of the technological era – the World-Wide-Web. The WWW is a success because it is open to all, the content of the web is as diverse as the authors of the content, and the technology is relatively simple [4]. Prior to the wide-scale deployment of WYSIWYG editors, the evolution of the web was driven by those with an interest in the emerging technology, and the entry level skills required to create content from scratch.

Collaboration on the WWW often consists of one web author linking to another. In education, it gives the instructor the potential to gather together vast amounts of related materials, simply by providing a link in a web page. For the student, it expedites the research process, where a series of clicks in a browser exposes them to a wide range of new ideas and alternative perspectives.

In this form of collaboration, the person being linked to is often not actively involved in the learning process of the person performing the linking, but they are nonetheless tied into a loose relationship. The WWW is surely the greatest collaborative achievement of the technological era, and one of the finest learning tools of the same era, where learners both contribute to and learn from the masses of interlinked information.

XI. WEB SERVICES

We envisage a partial evolution of the WWW, from pages to services. Those with the technical skills to do so can contribute to the WWW not simply by creating static content, but by creating interactive programs, clients for which can be written relatively easily. Learners can then interact with each-other's WWW resources not simply by viewing web pages, but by incorporating remote resources in their own web services or by running other author's services in certain problem domains.

XII. ANALYSIS

Clearly this is primarily focused towards Computer Science students and instructors, and the experiment we described was limited to the domain of Artificial Intelligence, but the potential of this expands beyond these narrow boundaries.

For instance, mathematics, physics, chemistry and other areas could benefit by the availability of resources online as interactive web services. Where a student can develop web content that satisfies the following criteria, we feel that it would be useful for the student to make the content available as a service:

1. Content of an algorithmic nature, e.g. a sorting algorithm *or* content that changes in real time, e.g. date, time, stock quote.
2. Content that could be tested against other content to determine which performs better *or* content that represents a new problem for others to develop solutions.
3. Content that could be integrated into another problem or solution by another student.
4. Content developed according to an accepted web service specification, or a minimally simple web service format to permit simple reuse.

Ultimately, our goal is to embrace our students' skills and provide them with a new means of using the networked computer as a tool for collaboration.

Computer Science students' interest in topics can be maintained and stimulated by providing them with novel approaches to learning, using technologies and approaches that are strongly tied to the theory they are being taught.

The feedback received following the experiment described above was very positive, and the interest in the project was significantly greater in many cases that was previously the case for the subject. Several factors were central to this, including the novelty of the technology employed and the competitive nature of the collaboration.

XIII. Other Forms of Technical Collaboration

Although we stress the importance of web services in the future of collaborative learning, we recognise with enthusiasm the many emerging technologies that facilitate collaboration beyond basic communication.

WikiWikiWeb [1] applications, in particular the Wikipedia [17], provide independent authors with opportunities to contribute to large knowledge bases, where they simultaneously act as contributor, editor, censor and formatter. The technical skills of CS students place them in a position where they are potentially suited to all four of these roles.

Several game environments, such as Project Nero [13], allow users collaborate for agent development by providing training opportunities or generating experience that stimulate agent development.

Elsewhere, blogging and RSS feeds provide people with excellent opportunities to collaborate and share knowledge. In these cases, technical competence is certainly an advantage, but not necessarily a requirement.

XIV. Summary

Collaboration among students improves their ability to learn and promotes key skills such as critical thinking and reflection. Much collaboration in the modern learning environment employs the computer as a tool for communication, or delivery of content.

We described an experiment we performed with a set of over three-hundred Computer Science students where we embraced the students' nascent technical skills by requiring them to contribute to a large collaborative project that spanned the entire cohort of students in their class.

As students of Computer Science, they were in a unique position among learners where their technical skills provide them with new ways to collaborate, facilitating new ways to learn. A web service is a new type of interactive web resource. If employed in a learning environment, it can open new doors for learners eager to share ideas, work together and solve large problems, piece by piece. This is a new and exciting way for education to use the computer as a tool.

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