Optimizing the Performance of Educational Web Services

Mark Floryan
Department of Computer Science
University of Massachusetts
Amherst, MA
mfloryan@cs.umass.edu

Beverly Park Woolf
Department of Computer Science
University of Massachusetts
Amherst, MA
bev@cs.umass.edu

***Abstract* — We describe how web service architectures can provide better performance to applications by offering fine-grained services. We define web service granularity in terms of the amount of data that can be retrieved from a service in a single request on average. This is important because developers cannot predict if students will be using state of the art hardware. Thus, service-oriented architectures (SOA) with fine service granularity can minimize network communication and allow server machines to perform more work for applications. We present the Rashi Intelligent Tutoring System and describe how its architecture has been adapted into a web service with two competing application interfaces. We show how the interface that uses more fine-grained services leads to significant improvements in network message response time, message size, and response size, without a significant change in the number of requests.**

Keywords-Web Services; Cloud Computing; Intelligent Tutoring; Serious Games

I. INTRODUCTION

One of the primary goals of educational technology is to provide useful instruction that is valuable and accessible to as wide an audience as possible. To help serve this requirement, many modern educational technologies utilize some form of the client server architecture in their design. This is primarily due to the popularity of collaboration systems [1], Web Based Systems [2], or systems that must perform unified data collection [1][2]. Thus, an inevitable design question for these architectures regards the division of work among a client module and a server module, with an interest in the communication needs between the two. Additionally, providers of advanced technologies are more likely to have access to state of the art resources.

To levy this situation, we propose that designers of educational web service technologies consider offering fine-grained functions. Many researchers have explored the positive design attributes of web service architectures [3][4]. These attributes include interoperability, reusability, loose coupling, and language development flexibility. Fine grained service can maximize network efficiency as well.

II. RASHI

Rashi is an intelligent tutor that teaches human anatomy through a problem-based environment [1][6]. It provides an inquiry-learning environment in which students explore diagnostic problems, form hypotheses about diseases, and gather data to support or refute those hypotheses, (Figure 1). Rashi provides several tools to support students while engaged in diagnosis of diseases, including tools to explore and collect data (Patient Examination and Laboratory Tests), cognitive tools to support formalizing arguments and clarifying thought process (Inquiry /Argument Notebook), and collaboration tools that allow students to discuss and share work. This tutor uses an expert knowledge base to recognize (with 88% success) when students are discussing content relevant to the case and to correctly link (with 70% success) that content with an actual medical topic [1]. Students move opportunistically from one inquiry phase to another as they sort, filter, and categorize data in order to form hypotheses about the patient's illness [5][6].

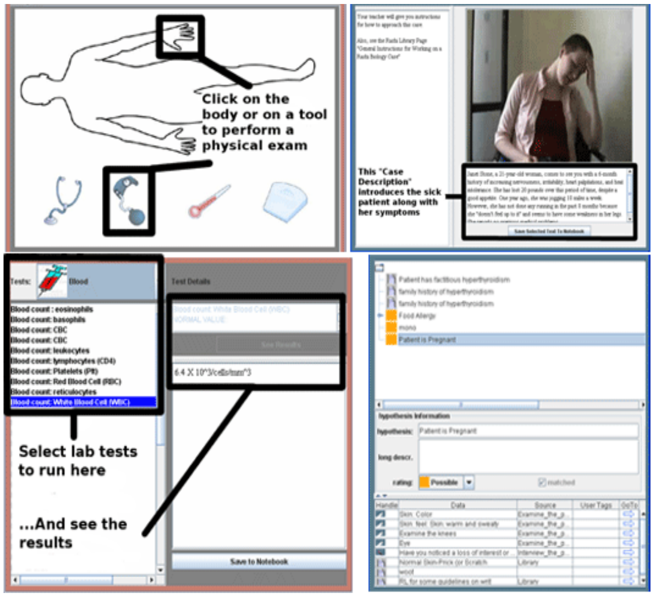
Click on the body or on a tool to perform a physical exam
This "Case Description" introduces the sick patient along with her symptoms
Save Selected Text To Notebook
Tests:
Blood
Blood count : eosinophils
Blood count: basophils
Blood count: CBC
Blood count: CBC
Blood count: leukocytes
Blood count: lymphocytes (CD4)
Blood count: Platelets (Plt)
Blood count: Red Blood Cell (RBC)
Blood count: reticulocytes
Blood count: White Blood Cell (WBC)
Test Details
Blood count: White Blood Cell (WBC)
NORMAL VALUE:
See Results
6.4 X 10^3/cells/mm^3
Select lab tests to run here
...And see the results
Save to Notebook
Patient has factitious hyperthyroidism
family history of hyperthyroidism
family history of hyperthyroidism
Food Allergy
mono
Patient is Pregnant
hypothesis information
hypothesis: Patient is Pregnant
long descr.
rating: Possible
matched
Handle
Data
Source
User Tags
GoTo
Skin: Color
Skin: feel: Skin: warm and sweaty
Examine the knees
Eye
Have you noticed a loss of interest or ...
Normal Skin-Prick (or Scratch
wool
RL for some guidelines on writ
Examine_the_p
Interview_the_p
Library

Figure 1: The Rashi 2D interface. Students can examine the patient (top left), run lab tests (bottom left), interview the patient (top right), and organize their work (bottom right)

III. THE RASHI WEB SERVICE

The Rashi web service is implemented using commands that support an "on-demand" need for case specific knowledge. In particular, the web service purposely does not support requests for an entire case specification, but instead offers individual propositions from the case. To illustrate proper usage of our web service, we designed and implemented a 3D game that utilizes the service. Rashi Game is designed to use the Rashi web service described above, and thus it provides a new interface to the system.

IV. Methods

The purpose of this experiment is to show that the Rashi web service (when using fine-grained commands) reduces the size of each request, the size of each response, and the speed of each response significantly without a significant increase in the number of requests. We altered the classic 2D interface for Rashi to utilize only the large-grained commands. We implemented the 3D Rashi Game to utilize the fine-grained commands. Both the original Rashi 2D client and the 3D Rashi Game were outfitted with code that analyzed performance. The code collected three data points for every request made to the server for each condition. First, we collected the time (in milliseconds) for the server to process a request and transmit a response. We also collected the size of each request along with the size of each response.

We hypothesized that the second experimental condition, which uses the fine-grained services, would yield the best performance. We believed, however, that the "total number of requests", due to the on demand nature of the web service, would increase. This is primarily because a greater quantity of smaller messages was expected. However, we did not expect this increase to be significant, thus suggesting that the fine-grained approach is more advantageous.

V. Results

For baseline results (condition 1), we see that the 2D Rashi application yields an average response time of *208.31* milliseconds. In addition, we see that the requests are on average small (about *127* characters). However, the responses tend to be very large (more than *5,000* characters).

The second condition yielded the following results. As expected, the request size significantly decreased, from an average of *126.92* characters to an average of *91.74* characters. We determined that this represents a significant difference (*p = 3.01 E-39*). The response sizes also decreased on average, from *5137.64* characters in condition one to *158.64*. This is also significant (*p = 2.12 E-2*).

	Num Req. / Trial	Request Time (ms)	Request Size (chars)	Response Size (chars)
Normal Rashi	193	208.3	126.9	5137.6
Web Service	95	37.9	91.7	158.6
p-value	**N/A**	**6.8E-12**	**3.0E-39**	**2.1E-02**

Table 1: A summary Internet efficiency, comparing the former Rashi design with the web service design

Lastly, and perhaps the most important metric, request time decreased from an average of *208.31* milliseconds per request in condition 1 to an average of *37.94* milliseconds per request in condition 2. This also represents a significant decrease (*p = 6.77 E-12*).

We also noted that the number of requests made to the server for each trial decreased (opposite our expectations). Condition 1 yielded *193* requests per trial, while condition 2 yielded *95* requests per trial.

VI. Discussion

We have empirically shown that web services, when designed with an emphasis on small-grained commands, can lead to an increase in the efficiency of communication over the web. Clients are thus required to perform less computation. The Rashi web service design provides several additional advantages. With a generalized inquiry framework and the ability to access our inquiry engine from any location with a web connection, we have opened up the door for developers to design and build lightweight inquiry tutors that run efficiently over the web. The language independence provides an additional layer of flexibility for developers, and the web service provides on- demand information regarding inquiry cases with small and easily understood XML.

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