Just Tell Me What You Want!: The Promise and Perils of Rapid Prototyping with the World Wide Web

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Construction of applications using the World Wide Web architecture and Hypertext Markup Language (HTML) documents is relatively simple. We are exploring this approach with an application, called PolyMed, now in use by surgical residents for one year. We monitored use and obtained user feedback to develop new features and eliminate undesirable ones. The system has been used to keep track of over 4,200 patients. We predicted several advantages and disadvantages to this approach to prototyping clinical applications. Our experience confirms some advantages (ease of development and customization, ability to exploit non-Web system components, and simplified user interface design) and disadvantages (lack of database management services). Some predicted disadvantages failed to materialize (difficulty modeling a clinical application with hypertext and inconveniences associated with the "connectionless" nature of the Web). We were disappointed to find that while integration of external Web applications (such as Medline) into our application was easy, our users did not find it useful.

INTRODUCTION

One of the most appealing aspects of the Internet relates not to its ubiquitous connectivity, but to the ease with which eye-catching applications can be developed for it by constructing documents and forms using the Hypertext Markup Language (HTML) and the World Wide Web architecture (using Common Gateway Interface programs (CGI's) to create documents dynamically).[1,2]

We[4,5] and others[6-8] have been using this technology to develop clinical information browsers. We have previously reported on one such system called PolyMed, used by the surgical residents at Presbyterian Hospital in New York.[9] Preliminary experience seemed to show that development using the Web approach would provide several advantages for rapid prototyping of clinical applications. The application was designed to support creation of service-specific patient lists with assigned attendings. From this list, users could display all results for particular laboratory tests (such as complete blood count) for all patients on a service or assigned to an attending. We made a number of additions to the "original features" during the first few months of system deployment, based on user feedback and suggestions, including: the ability to review all information from the clinical information system (CIS) for specific patients on the list, addition of a "chief resident" column on the patient list, and addition of a "Stat Panel" option to the list of laboratory results displays.[9]

We predicted advantages to the Web approach: ease of development and customization, ability to use non-Web resources to support the application, ease of incorporation of external Web applications, and use of Web clients to alleviate the burdens of user interface development. We also predicted some disadvantages, including: inappropriateness of the hypertext paradigm for some applications, lack of basic computing services within the Web server (such as a database management system), and difficulties with the connectionless paradigm of Web client-server interactions. The original report was based on our experiences with five months use of the application, the first three of which were largely beta testing with a small group of motivated users. Since then, the application has been in general use by surgical housestaff. We monitored usage, collected comments on problems and desired features, and modified the application in response to user feedback (Figure 1). This paper describes our experience with this approach to application prototyping.

METHODS

Information on user experience was obtained through three methods: log files, user's e-mail comments, and user group meetings. Log file entries were created by the application CGI's. With each function call, a line was added to the log which included: user name, date/time, and function name. If appropriate, the name of the surgical service and the patient identifier were also included. User comments were obtained through a comment function which evoked a Web "mail-to" function to send comments typed by the user to the system developers. User group meetings were held during the regular noon-time conference session where food was provided. To measure actual

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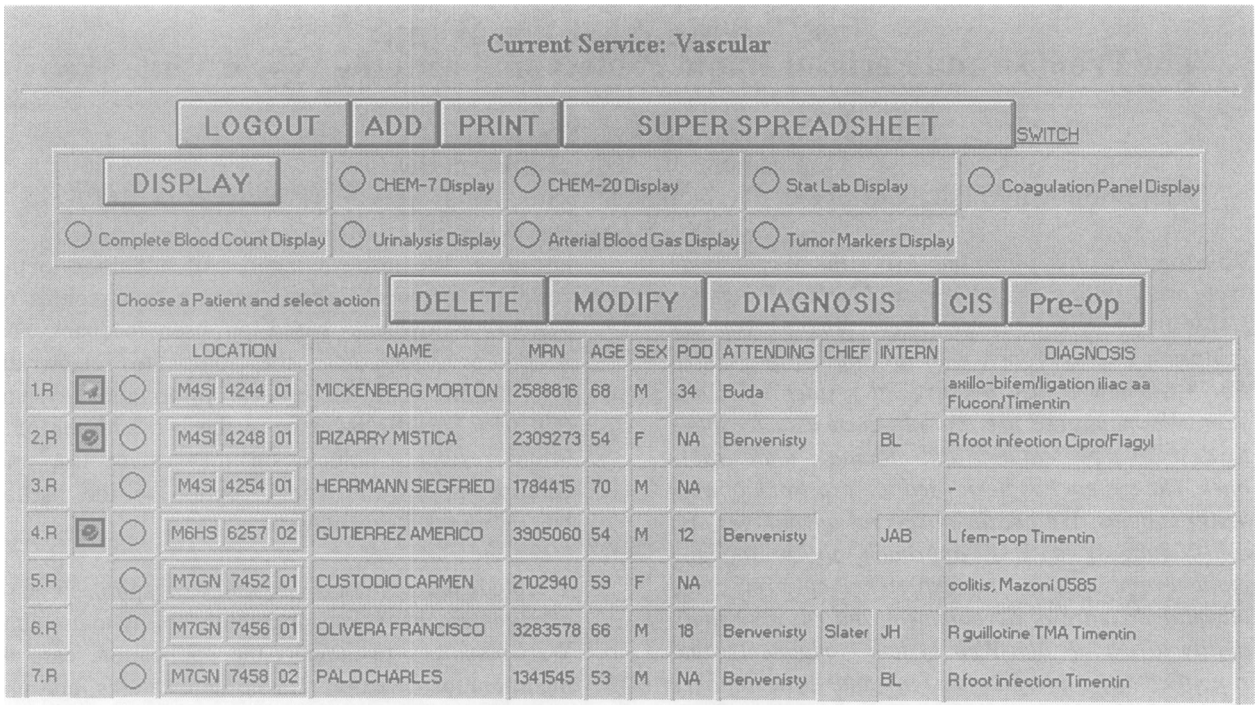

Figure 1 - A sample PolyMed screen, showing the patient list for the Vascular Service. Original features[8] include list management functions (Add, Delete, Modify), laboratory "Displays", access to the clinical information system (CIS) and information about attendings and chief residents. New features include a Print function, the "Superspreadsheet", Pre-operative data sheet, and the ability to add intern and diagnosis information. The graphics on the left hand side of the list indicate the presence of clinical alerts for three patients. Patient and physician identifiers have been altered for reasons of confidentiality.

use of data entry, we surveyed all service lists to determine how many patients had been assigned attendings, chief residents and interns and how many had problems or diagnoses listed.

RESULTS

From April 10 of 1995 to March 24 of 1996, over 22,000 lines were included in the application log. Users logged onto the system a total of 5,248 times, with usage climbing during the first few months, to level out at about 720 per month or 24 per day. Eighteen different users added 4,225 patients to service lists 4420 times, modified information about them 2,374 times, and deleted them 3,950 times. Users submitted 9 comments via e-mail. User's group sessions were held in November 1995 (attendance 19) and March 1996 (attendance 22). The survey of data entered on service lists was conducted on March 25, 1996. Information about usage of each of the system features was collected from the various sources is described below and summarized (see Table 1.

Original Features

The original motivation for the development of the PolyMed application was to provide the surgical housestaff with summary displays showing all labs of a particular type across a service list. For example, a single button click will show all the most recent complete blood counts for all patients on the list. Subsequent meetings with the housestaff revealed that this feature was desirable only to the chief resident; the remainder of the housestaff expressed no enthusiasm for the feature. This was reflected in the log file, which showed that these displays were requested 680 times, or about once out of every eight logins. Our previous paper stressed the ease with which a new display ("stat labs") could be added to the application. After its addition to the application, it was selected only once.

Another early feature was the ability to access all patient information residing in the central clinical data repository. Since its addition, the log file shows this feature was used only 209 times, usually to obtain laboratory information. The housestaff

reported that their lack of use of this feature was due to slow response time. They reported that it was faster for them to get their patient list from PolyMed and then log onto the CIS to get specific test results. In the last month of the study, changes were made to the data server architecture which improved response time dramatically. Subsequently, a significant increase in usage occurred (146 uses in the 11 months before the change and 63 uses in the 3 weeks afterward).

The final original request was for the ability to allow assignment of chief residents and attendings to patients on the service lists. The log file does not presently capture this specific information (it is included in the "Add" and "Modify" functions); however, a survey of all the service lists, conducted on March 25, showed that of the 260 patients on the eight active service lists, assignments of attendings and chief residents were made 210 (81%) and 56 (22%), respectively.

Feature	Avg. Number per Login (%)
Add patients	0.80 (80)
Print	0.59 (59)
Display labs	0.13 (13)
Review alerts	0.11 (11)
Superspreadsheet	0.07 (7)
Access to CIS	0.04 (7)
Pre-op checklist	0.02 (2)
Links to other resources (DXplain, Medline, PDR)	0.0 (0)

Feature	Number of Patients (%)*
Enter diagnosis	210 (91)
Assign attending	237 (81)
Assign intern	76 (29)
Assign chief	56 (22)

* 260 patients appeared on service lists as of March 25, 1996

Table 1: Use of main PolyMed features

New Features

Since the original report, the users have requested several new features. The first was a request to display, on the service list, the current antibiotics for each patient. This request was readily accommodated by querying the CIS for all active medication orders in the antibiotic class for each patient. However, the housestaff reported that this information did not often reflect the reality of the patients' actual medications. Apparently, this is due to a delay between the cessation of drug administration on the floor and the reporting of that information to the pharmacy system. This feature was subsequently removed from the patient list display.

Housestaff also requested to be given the ability to enter a short patient description and/or diagnosis for the patients on their service. The March 25th survey showed that some information was added for 237 (91%) of the patients. In addition to service, attending and chief resident, the housestaff requested the ability to enter the initials of the covering intern for each patient on the service. The March 25th survey showed that this was utilized for 76 (29%) of the patients.

The housestaff indicated that their main interaction with the application was to enter patients onto the patient list and then print that list out (automatically sorted by hospital location). Printing from the Web browser is accomplished using a local print function which dumps the current screen to the printer. Since the application screen contains a variety of function buttons (see Figure 1), the printout was considered too cluttered. A "print" function was therefore created which generated a more streamlined version of the service list. The housestaff requested the ability to add "footer" information to the list (such as beeper numbers of the interns). The log file shows that the Print function was used heavily - 2341 times since its inception in October - and by March was being used approximately once per login. The "footer" function, however, was used sparingly: only 57 times during the same period and only 10 times in March.

In October, the housestaff requested the ability to generate "pre-op checklist" reports which would show the most recent laboratory, chest x-ray report and cardiogram report for a requested patient. The report could then be printed out and placed in the medical record instead of the usual hand-written check list. This function proved to be extremely popular. Of the nine e-mail comments, five were about this feature - with praise for the rapid development time and suggestions about ways to improve it. The log file showed that this feature was used about 160 times a month since it was instituted.

The discussion at the November users' group meeting revealed that the service-oriented laboratory results displays were not particularly useful to the majority of the housestaff. When asked for alternatives, several suggested the creation of a "super

spreadsheet" which would display all the recent laboratory results for all the patients on the service, grouped by patient, rather than by result type. This feature was instituted in January and was used sparingly. The March users' group meeting revealed the problem was slow response time. Since the change to the CIS data server, response time has dropped from 20-30 minutes (for a long service list) to 5 minutes or less.

PolyMed includes several linkages to nonclinical Web applications, including a drug reference source, a diagnostic expert system, and Medline. These links include capabilities for transferring patient information to these searches to facilitate information retrieval. Development of the links has been interesting from a technical point of view, but not particularly difficult. However, it appears that such links are of little interest to our users. During the user group meetings, they universally indicated that such resources were not necessary because of the "noncognitive" nature of their work rounds.

We postulated that users might look at alerts if we posted a red flag on the service list next to each patient with a clinical alert on the CIS. If a user selects the flag, the alert message is displayed. When the user returns to the list, the flag will be yellow, indicating that this user has seen the alert. During the final three weeks of the survey period, this feature was used 66 times.

Finally, we hoped to use PolyMed as a vehicle for providing access to other on-line resources,[5] such as Medline, the *Physicians Desk Reference* (PDR) and DXplain[10,11]. These features were not used by the housestaff. During the second user group meeting, most indicated that they were not aware of these features. They also stated that, with the possible exception of the PDR, they were unlikely to do so.

DISCUSSION

The Web is widely recognized as a medium for improving access to biomedical information.[12] Users of PolyMed have demonstrated this to be true, at least for some well-chosen functions. Many of the functions added to the system, even some which were requested, were largely ignored. Nevertheless, the system has had a solid user base for almost one year and has been used by 17 of 20 surgical interns in the care of over four thousand patients. The log files have been particularly useful for separating the useful from the extraneous as the users "vote with their mice." Attempts at direct user feedback have been less productive. E-mail comments have been rare; user group meetings are minimally successful and even then only because of enticement with food (similar to experience related by CJ McDonald in a personal communication). Based on our experience, we can now look back on our original predictions for advantages and disadvantages of prototyping clinical systems with the Web.

Advantages of Web-Based Prototyping

The original reason for prototyping with the Web was its potential for rapid development using a hypertext approach to assemble components into complex applications. Our experience confirms this assumption: all of the features described in this paper were created with effort ranging from a few hours to a few days. This has allowed us to experiment with many different types of features and has minimized our disappointment when some of them were ignored.

The CPMC computing environment provides a two key components for clinical applications: a data server and a vocabulary server. These components were readily available to PolyMed through the CGI's. For example, the ill-fated display of current antibiotic orders was accomplished by querying the data server for all active drug orders and then looking at the classification of each drug in the vocabulary server to see if it was in the class of antibiotics.

Our last postulated advantage was that HTML would allow us to develop adequate user interfaces without the development overhead which is typically involved in user interface design. Our experience support this assumption. User comments on such aspects as screen layout and data entry features have been easy to address. It is unusual for our clinical users to ask for features which require them to provide additional data entry, such as the patient description feature, yet our users not only requested them, but used them as well.

Disadvantages of Web-Based Prototyping

If our predicted advantages were not always realized, we can be consoled by the fact that not all of our predicted disadvantages materialized. In particular, we were concerned with the potential problems inherent in the hypertext paradigm. For example, when a user adds a patient to a service list, the application provides the user with a button that takes them "back" to the list which actually moves them forward through the screen path by creating an

updated list. However, the Web browser will allow the user to move back through the path to see the old list. If the user is unaware of this difference, he or she may think the data entry was lost and repeat the entry. If the Web "Back" button is pressed again, the problem will recur. Fortunately, such problems did not occur; our users navigate the application (at least the parts they were interested in) without difficulty.

One disadvantage which was felt was the lack of advanced system development functions on the Web server. In particular, there are no built-in database management services to support the application. This required the development of our own local data set, as well as tools for supporting it.

Finally, we predicted that the connectionless nature of the Web would cause some additional work for the application to keep track of who is doing what. This was clearly true for our security mechanisms as previously described,[9] but since then we have found that we can allow the Web browser to maintain application states for us by including data as hidden variables in the HTML documents. In this way, each document serves as an application state and the applications can rely on these hidden data as needed to carry out their functions.

CONCLUSIONS

Attempts at prospective system development have been mixed. Our user population is quick to request application features and sometimes just as quick to reject them. The system log has been the single best tool for estimating what users like and dislike. We believe that the use of the World Wide Web architecture has facilitated our rapid prototyping. This has allowed us to experiment with implementation of new functions quickly without large investments of effort. This ability to support rapid prototyping has allowed us to adapt our system and develop reactively in ways not possible with our legacy systems.

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