

CareWeb Prototype – Technical Summary

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Summary

CareWeb is a Web based healthcare information system under development by a multidisciplinary team at Syracuse University with the initial focus on the school nursing domain. This note describes briefly the technology aspects of the current prototype demo and outlines the planned next steps in the CareWeb technology development.

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1 Introduction

CareWeb is a school-based healthcare program designed to provide an integrated, coordinated system of healthcare for children and their families using the combined resources of school nurses, nurse practitioners and pediatricians, supported by Web based pervasive information technologies.

CareWeb project [CareWeb96] is a joint effort by Syracuse University College of Nursing, Northeast Parallel Architectures Center, SUNY Health Science Center and Syracuse City School District. This team developed a pilot demonstration in spring '96 which was presented at several conferences over the summer '96 and attracted considerable interest of the healthcare community. Several individuals

contributed to the CareWeb success; the list of the major players is included in the following chapter.



Figure 1: Sample Web page from the CareWeb prototype demo: Home Page for Nurse Practitioner. Includes access to student healthcare record database, educational material and video teleconferencing tools for interactive consultation with nurses and pediatricians.

This document contains a brief technical overview of the CareWeb prototype demo and its underlying Web/Oracle database. A more complete overview of the project, including its healthcare and education mission and content can be found at <http://www.npac.syr.edu/projects/careweb>.

2 The CareWeb Team

CareWeb project is lead by Grace Chickadonz, Professor and Dean, SU College of Nursing. Wojtek Furmanski, Research Professor of Physics and Chief Technologist of NPAC, is coordinating the technology part of the project. Karen Hughes, Associated Director of Health Services,

Syracuse City School District, is representing the school needs. Eileen Lantier, Director of Learning Resources, SU College of Nursing, is providing expertise in nursing and telemedicine informatics. Donald Leskiw, President of Ultra Corporation, is contributing his company resources to productize the current prototype and deploy it in selected pilot schools. Edward Lipson, Professor and Acting Chair of Physics at SU, is representing Web based educational technologies with the focus on children with chronic disabilities. Roman Markowski, Research Scientist at NPAC, provides expertise in networking and video conferencing infrastructure. Victoria Meguid, M.D., SUNY Health Science Center is providing pediatrics expertise and connectivity with the Department of Pediatrics at the University Hospital. Ingrid McGraw, Director of Corporate and Foundation Relations, is involved in project management, identifying funding opportunities and proposal development. Maureen Thompson, Assistant Professor at SU College of Nursing and nurse practitioner, is providing nursing and educational content for the CareWeb information system. Gene Woodcock, Managing Director of NPAC and CASE is exploring the industry outreach avenues related to CareWeb as a new telemedicine technology.

CareWeb consultants and advisors include: Bob Corona, Medical Director at Welch-Allyn Corporation; Jon Denison, Senior Director of SU Corporate and Foundation Relations; Thomas Harblin, Senior Director for SU Major Gifts and International Development; Liz Liddy, Professor at SU School of Information Studies; and David Warner, M.D., SU Nason Fellow and president of the Institute of Interventional Informations ad Loma Linda, CA.

The initial impetus of the CareWeb project was provided by Dave Warner who successfully translated his and Balch's telemedicine bridge [Bridge96] vision ideas into a focused project for the school nursing, and Tom Harblin who put together the CareWeb team.

3 CareWeb Demo Development

Technology infrastructure for the CareWeb pilot project was provided by the Northeast Parallel Architectures Center at Syracuse University, directed by Geoffrey Fox, Professor of Computer Science and Physics. NPAC infrastructure included Oracle database installation, SGI based demonstration platform, and previous experience from an early Web / Oracle based patient record database project conducted at NPAC by Ed Lipson, Roman Markowski and Jiangang Guo in collaboration with Bob Corona, at that time director of the telemedicine program at the SUNY HSC.

Based on the nursing content specification developed by Maureen Thompson with help of Eileen Lantier and Karen Hughes, CareWeb software system was designed and developed by Wojtek Furmanski with help of NPAC graduate students Jiangang Guo and Tom Pulikal. VIC/VAT based video-teleconferencing and mobile demo capabilities were provided by Roman Markowski. CareWeb project information pages were designed by Ed Lipson with the help of NPAC graduate student Sangeeta Aggarwal who acted as the site webmaster. Two other NPAC graduate students, Zeynep Odcikin-Ozdemir and Meryem Ispirli were helping with the development of promotional and presentation materials such as screendumps, viewgraphs and posters.

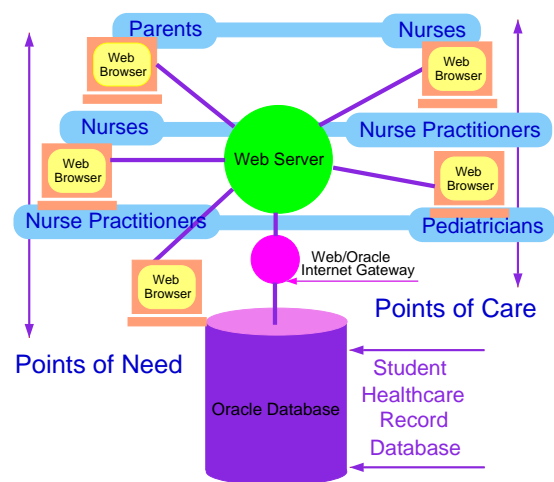


Figure 2: Overall architecture of the CareWeb prototype: a set of Web browsers operated by parents, nurses, nurse practitioners and pediatricians connects to a shared Web/Oracle based student record database and forms interactive collaborative sessions ("bridges") that connect "points of need" with "points of care".

4 WWW Entry Points

On-line information about the CareWeb project can be obtained at the following URLs:

1. <http://www.npac.syr.edu/projects/careweb> – home page of the project (also includes links to the following two locations)
2. <http://king.syr.edu:2006/WebMed/Demos/CareWeb/Slideshow.html> – an organized carousel of screendumps that offers a guided walk through the CareWeb prototype and/or random access to individual screens.
3. <http://king.syr.edu:2006/WebMed/Demos/CareWeb> – home page for the real-time demo. This space is password protected to illustrate

support for security but current CareWeb database does not contain yet any patient-confidential information. To connect, please use username=root, password=cwdba.

The recommended order of visiting individual pages is as in the list above. Entry 1 provides the overview and links to prototype demos. Entry 2 offers a useful walkthrough guide that facilitates the CareWeb space navigation during the real-time demo in Entry 3 (which contains still some occasional bugs and caveats, listed in Chapter 7).

5 Demo Description

Initial CareWeb prototype offers school student health record database, implemented in Oracle and accessible via Web by parents, nurses, nurse practitioners and pediatricians. The system can be viewed as an instance of the Telemedicine Bridge, conceptualized by Warner and Balch [Bridge96] and it supports interactive consulting channels depicted in Fig. 2. CareWeb offers a collaboratory navigational framework on top of relational database. This current early prototype includes ~30 hyperlinked databases and some navigational pathways are not yet fully operational. The most representative demo scenario is available in the slideshow carousel (Entry 2 above) and described below.

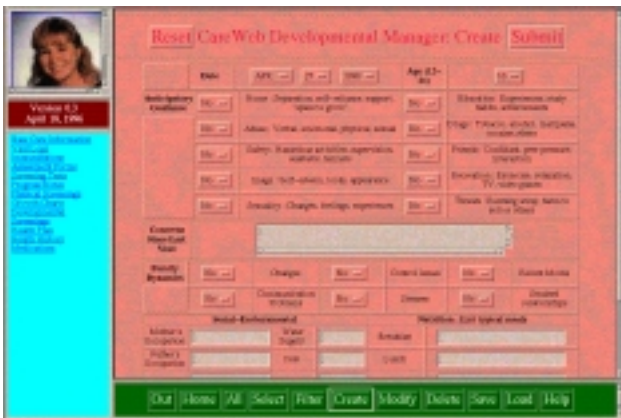


Figure 3: A sample component of the student healthcare record: developmental screening. Most CareWeb pages come both in the active (editable) mode (such as the one displayed here) and in the passive (view) mode. Command buttons [Create], [Modify] and [Delete] support base interactive functions for the patient record authoring.

To run the real-time demo in the most efficient way, please follow the steps listed below. The indicated links are guaranteed to work, whereas you might get 'lost in the cyberspace' if you start exploring all possible navigation pathways through the CareWeb database. The particular "Visit" demo corresponding to the path suggested below

represents a typical set of nurse actions in response to student's visit. More detailed explanation follows after the list of steps/mouse clicks.



Figure 4: A sample CareWeb page with the healthcare educational content: accessible from the nurse home page and as one of the branching modes in the Progress Note development demo, described in this chapter.

1. Start the CareWeb demo by pointing JavaScript-capable Web browser such as Netscape3 at the following URL:
http://king.syr.edu:2006/WebMed/Demos/CareWeb
2. Press [Connect] button to connect to the CareWeb space.
3. Specify username=root, password=cwdba and press the [Login] button.
4. Click the <Schools> link.
5. Select the first school <Hughes Magnet>
6. Click on <Nurses> link at the school home page.
7. Select the first nurse <Robyn A. Saxton>.
8. Click on the <Student Health Records> at the nurse home page.
9. Select a student, for example click <Sarah Elizabeth Thompson> link, explore individual record components (see e.g. Fig. 3)
10. Click <Visit Logs> record component.
11. Click [Create] to generate new Progress Note.
12. Select Reason = Pharyngitis from the Option Menu.
13. Press [Submit] button to submit the form
14. Click <Consult WebMed> page, explore the educational material there (see Fig. 4), return to the VisitLog Manager page (e.g. via right-mouse-click generated Netscape Commands popup).
15. Click [Fill Assessment Form]
16. Fill and submit the form, return back to the VisitLog-Manager page

17. Click <Contact NP> (see Fig. 1), explore the nurse practitioner home space.
18. Click [Video] to setup video teleconferencing (requires VIC/VAT installation)
19. Click [Audio] to setup audio teleconferencing (requires VIC/VAT installation)
20. Click [Whiteboard] (requires VIC/VAT installation)

Steps 1–7 set the nurse context. When nurse Robyn Saxton logs in to the CareWeb facilities, she gets her home page as in step 8 above by default. Since you are logged in as CareWeb database administrator ('root'), you need to pass through steps 1–7 to 'become a nurse'. The actual 'Visit' demo starts at step 7, i.e. when student Sarah visits nurse Robyn. Nurse selects Sarah home page (step 9) and creates new progress note record (step 11) for this visit. Sarah's complaint is sore throat and nurse selects pharyngitis as the initial diagnosis (step 12).

The visit scenario branches now into several options (items 14, 15, 17), accessible as buttons on the Progress Note page. Nurse can [Fill Assessment Form] to record the symptoms, [Consult WebMed Pages] to ask for healthcare educational information, [Consult NP] and ask for consulting help, or finally [Sign and File This Progress Note].

Interactive consultation with the nurse practitioner would typically involve collaborative inspection of the student record, audio and/or video teleconferencing. We used for these purposes a public domain VTC system from Berkeley, VIC/VAT to send live audio and camera feed or Welch-Allyn multipurpose videoscope recordings.

6 Implementation Notes

6.1 Overall Architecture CareWeb prototype architecture includes Oracle database with the set of stored PL/SQL packages providing the CareWeb functionality, Oracle Internet Gateway and a set of JavaScript capable Web browsers that connect to the database to navigate, learn, collaborate, or modify, create and destroy patient record components. All Web pages that form the CareWeb space and generated dynamically in PL/SQL. The session continuity is assuring by communicating the connection identifier between client and server during each request.

6.2 Oracle Internet Gateway CareWeb demo as described above was implemented in spring '96 in terms of Oracle database with Netscape/JavaScript interface. At this time, we didn't have Oracle Web Server products at SU, only the base Oracle 7.1 installation. We therefore constructed a custom Oracle Interface Gateway given by a hybrid WOW/OWA construct. OWA (Oracle Web Agent) is

Oracle product including both commercial and freely available components. Published modules include: PL/SQL libraries and CGI gateway binaries for the Solaris platform. WOW is public domain C code for CGI gateway to the Oracle server. WOW/OWA gateway allowed us to: a) base our Web/Oracle interface work exclusively on public domain components where we had full control of the gateway; b) utilize fully the publicly available OWA PL/SQL libraries, c) run our OWA-like gateway on the AIX platform (host of our Oracle installation), d) develop PL/SQL code which was forward-compatible with coming OWS/OWA commercial products.

6.3 Database Design and Organization CareWeb database is implemented in terms of ~30 tables, handling institutions, accounting, various types of users and individual record components. The full list of current tables is include below and grouped into three major categories: CareWeb participants, individual components of patient record, and miscellaneous information on database utilization, transaction processing etc.

Participants	Record Components	Miscellaneous
Customers	Base Care Information	Information Pages
Friends	Immunizations	Transactions
Guests	Screenings	Connection States
Nurses	Physicals	
Nurse practitioners	Laboratory Reports	
Pediatricians	Developmentals	
Parents	Health Histories	
Doctors	Visit Logs	
People	Assessment Forms	
Schools	Progress Notes	
Students	Growth Charts	
Teachers	Health Plans	
	Medications	

6.4 PL/SQL Source Organization Each table in the above list is associated with a PL/SQL module, including four generic packages. For example, the *Schools* table is associated with the `school` module which maintains the following packages:

Module Name	Module Description
<code>school_table.sql</code>	SQL table generating routine
<code>school.sql</code>	Object-oriented interface to the <i>Schools</i> table
<code>school_mgr.sql</code>	Support for database navigation and management functions such as creation, deletion or modification of records
<code>school_util.sql</code>	Table-specific GUI package collecting HTML and JavaScript routines for dynamic generation of CareWeb Web pages

Each CareWeb module is of order of ~1K lines of PL/SQL and so the whole current demo is of order of 30K lines of PL/SQL.

6.5 Session Control Session continuity across subsequent Web client- Oracle server connections is maintained by records in *Connection States* table, one record per session. A new connection state record is created during each successful login action. This record identifier is then being passed to the client in each HTML document, generated by Oracle, and then returned back to the server for the synchronization purposes, either as the URL query parameter or as a hidden form item. Records in the connection state table are time (re)stamped upon each new connection. Connection states left unattended by the client for a time period exceeding a certain threshold (with the default value of 1 hour) are automatically reclaimed by the system. This prevents trashing the connection table with ghost records, corresponding to initiated and then dropped CareWeb sessions.

6.6 Web GUI Design Most demo pages follow the multi-frame design pattern and include the following frames: *nbar*, *cntl*, *version*, *list*, *view*, *cmd*, *sign*. The functionality of individual frames is as described below.

1. *nbar frame* – navigation bar to provide the full WebTools [WebTool94] style navigability over a hy-

perlinked set of databases. This frame is not finished yet – currently only the [Root] and [Home] buttons are fully implemented and the [Tools] button is drafted.

2. *cntl frame* – used to display image icons. [Tools] contains a toggler between various cntl frame services. Database pages use graphics icons or people photos to assign visual marks to individual subspaces.
3. *version frame* – displays current version of the system.
4. *list frame* – displays the content of current virtual directory in the CareWeb navigational space.
5. *view frame* – the main content frame.
6. *cmd frame* – contains a set of command buttons, supporting interactive creation, deletion and modification of database records (see [Help] button for details).
7. *sign frame* – page signature frame.

The content of cntl, list and view frames is dynamically generated and correlated. For example, if the view frame displays a student home page, then the list frame displays the list of all other students in the current virtual directory (e.g. school) and the cntl frame displays the 'school children' icon.

Each click on a link in a CareWeb page results in dynamic generation of HTML for the requested page by a suitable PL/SQL utility procedure; the associated content of the list, cntl and cmd frames is also generated in the form of frame-targeted JavaScript inserts to the main page. The resulting chunk of HTML is shipped to the client and all correlated frames are updated simultaneously in a synchronized fashion. All new links generated this way include the Oracle connection id in their query string or hidden form, thereby assuring session continuity in the multiframe database navigation process.

7 Known Bugs and Caveats

1. The “visit” path described in Chapter 5 is fully functional. Pages listed in the demo description can be also accessed along other navigation pathways but the system will likely refuse to serve pages if the navigation context is not set appropriately. For example, going directly from the root home page to *Nurses* and bypassing *Schools* might result in an 'undefined school' error message at some hierarchy level.
2. Since the [Back] button in the navigation bar is not yet implemented, sometimes the only available way to backtrack from a given subspace is via the right-mouse-click generated “Netscape Commands” popup menu. This backing mode sometimes fails due to the dynamic nature of the CareWeb pages but repeated application of the back command via Netscape popup

menu will eventually deliver a functional page. In a true emergency case, [Out] command button always returns to the root home page where one can restart the whole navigation path.

- Several constraints between various databases are not yet fully implemented. For example, a given school contains the same set of students regardless of the school name (i.e. the school filter is not activated yet and the whole list of students is displayed in each school). In a similar way, [Select] and [Filter] buttons are not implemented – both problems will be fixed by activating the context-dependent search mechanisms which are only partially implemented in the current prototype.

8 Current Status and Next Steps

The CareWeb team resumed the fund raising and development activities in fall '96. Based on prototype presentations over the summer '96, considerable local support was solicited (including donation from Welch-Allyn and commitment from Blue Cross Blue Shield) which is now being used as input for the matching grant proposal to the Robert Wood Johnson Foundation. In preparation is also a major proposal to the Kellogg Foundation.

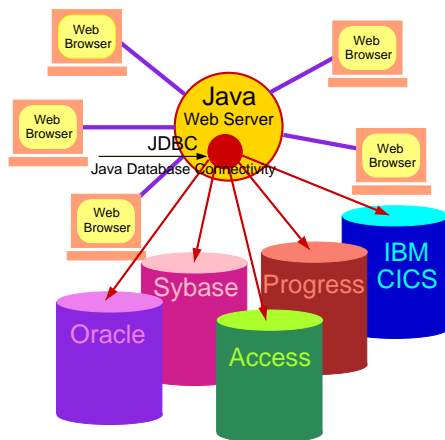


Figure 5: Common JDBC interface to any ANSI SQL compliant RDBMS, implemented as a servlet managed by Java Web server such as Jeeves or Jigsaw.

On the technology development front, two new parallel tracks are being pursued:

- The current prototype demo is being transferred to Ultra Corporation for production level implementation and pilot deployment in a few selected schools in the Syracuse City School district;

- A new, more portable and distributed version of the system, based on Java servers and JDBC protocol is being prototyped as described in the following chapter.

9 Towards Web based Distributed Medical Informatics

To deploy a usable CareWeb system in schools and then port it to other nursing areas and telemedicine services, support is needed for heterogeneous databases and their Web based integration. Patient record databases need to be managed locally at “points of need” but the underlying healthcare information should be also mobile to easily reach “points of care” for consultation, as well as the “bridge” facilities for archival or statistical analysis.

Various sites of distributed medical information systems will likely maintain different databases, ranging from MS Access for school nurses to high-end Oracle servers in bridges. Java networking and JDBC (Java Database Connectivity) protocol [Glossary96] suit ideally such emergent needs. We are currently prototyping a telemedicine “HyperWorld” given by a mesh of Java Web servers (such as Jigsaw from W3C/MIT or Jeeves from JavaSoft) and armed with JDBC based tools of functionality similar to the early CareWeb prototype described in the previous chapters.

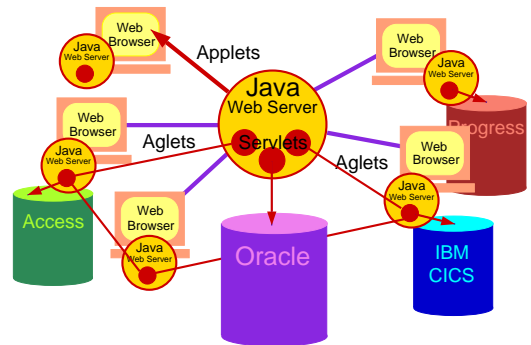


Figure 6: Distributed medical informatics system, built as a mesh of Java servers, interconnected by aglets, linked by applets with the client front-ends and via JDBC servlets with the heterogeneous distributed database backend.

Unlike Oracle-specific PL/SQL stored procedures, such JDBC servlets managed by Java Web servers will be capable to access multiple RDBMS in terms of the common Java code (Fig. 5). Java Web servers will be installed on all nodes of a distributed system, interconnected by 'aglets' (i.e. Java based intelligent agents), and linked to browsers via GUI applets (Fig 6). Such Java servers will host a spectrum of on-demand servlets [HPDC96], ranging from

conventional Web page servlets to collaborative, video teleconferencing, medical instrumentation, and communication with other bridges and with user front-ends, ranging from conventional PCs to sensory devices to Network Computers and Personal Digital Assistants (Fig. 7).

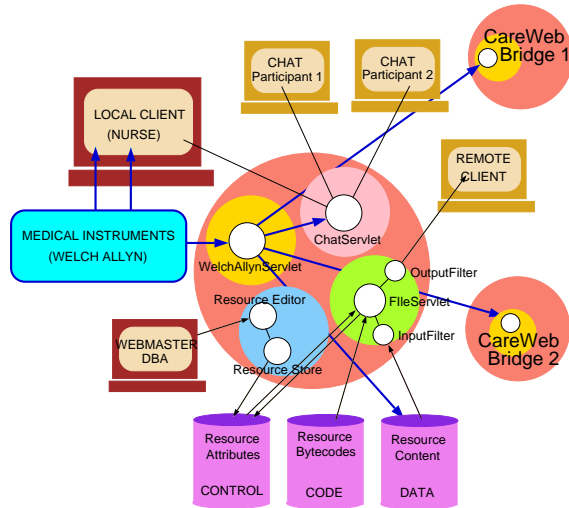


Figure 7: Java Web server such as Jigsaw or Jeeves, customized for the telemedicine services. Servlets presented in the picture include base Web page delivery, collaborative (chat), database management, connectivity with other unit or bridges of a distributed CareWeb environment.

We are currently developing visual interactive framework called WebFlow [WebHPCC96] to facilitate management of such dynamic multi-server systems and user-

10 References

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friendly development of customized applications in terms of visual graph authoring tools. Fig. 8 illustrates our planned telemedicine bridge authoring toolkit with specialized services such as RDBS, Agents, VTC, TVR (Televirtuality) and HPCC based simulations (e.g. for virtual surgery [VisibleHuman96]) represented as visual building block icons. System integrators will be able to click-and-drag-to-activate modules with required functionality and then interconnect such active components according to a specific topology required by a particular healthcare customer.

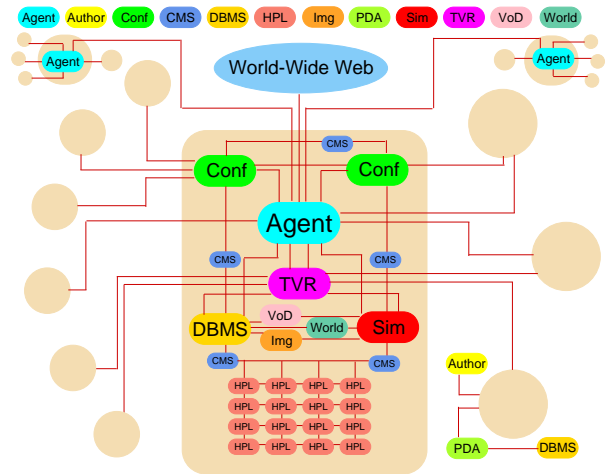


Figure 8: WebFlow based telemedicine bridge authoring toolkit. Individual services are represented as visual icons and can be interactively assembled to build customized distributed medical information systems.