

HP PalmVue: A New Healthcare Information Product

The HP PalmVue system integrates personal computer, alphanumeric paging, and palmtop computer technology into an effective solution for delivering timely and high-quality patient data to mobile physicians.

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The HP PalmVue system (HP M1490A) is a new offering from HP's Medical Products Group that allows transmission of clinical patient information to HP palmtop computers via conventional alphanumeric paging systems. This system integrates several forms of current technology, including computer networks, palmtop computers, paging systems, and devices to deliver a powerful new capability to hospitals and physicians who use HP monitoring systems and cardiographs. This article will provide an overview of the operation of the PalmVue system and show how the system integrates several components to deliver this new service to clinical users.

The User Need

It's Saturday evening, and Dr. Ikeda is enjoying a rare dinner out with his spouse and another couple. As chief cardiologist of the Memorial Medical Center, he does not get much time to relax. This evening, he has largely been able to put out of his mind the unstable condition of Frank Nielsen, a patient under his care in the Memorial cardiac care unit (CCU) who is recovering from a recent heart attack. Suddenly, the waiter taps him on the shoulder and informs him of an important telephone call. He goes to the phone, to be told by Laura in the CCU that Frank has developed a very irregular heart rhythm and she is very concerned about his condition. Since he always carries his portable computer and modem card, he suggests that Laura send him a fax of Frank's ECG so that he can assess the clinical situation himself. He goes to get his computer, and finds his way to a telephone jack that the restaurant has allowed him to use. After several failed attempts, he finally gets the faxed ECG transmitted to his laptop computer. He is able to tell from the fax that Frank is in no immediate danger, but cannot read the ECG well enough to make a clear diagnosis. He tells Laura that he will quickly finish his dinner and stop by the CCU on his way home.

It happens that Dr. Washington, another local cardiologist, is also out with his family celebrating a birthday at the same restaurant. He has several patients in the CCU at St. Francis Hospital. As he is about to enjoy his appetizer, he hears the familiar sound of a paging alert from his pocket computer. He removes his HP palmtop computer from his pocket, waits a moment until the computer displays the HP PalmVue index screen, and presses a key to display the message. It is a message from Tony in the CCU. Dr. Washington's cardiac patient Olga Smetana has been having an increased number of premature ventricular contractions (PVCs), and they seem to him to have changed shape. Tony's message says he needs to know if a change in dosage, or perhaps a new medication, is needed. Dr. Washington pushes another key and views Olga's ECG waveform in a crisp and detailed display on the palmtop screen. He can easily see that the PVCs are not really clinically different from those he has been seeing in Olga's ECG for the past few days. He pulls out his pocket-sized cellular phone, calls Tony in the unit and tells him that everything is OK with Olga, and he will check on her in the morning. He then proceeds to enjoy the rest of his dinner.

HP PalmVue System Description

The HP PalmVue system integrates personal computer, alphanumeric paging, and palmtop computer technology into an effective solution for delivering timely and high-quality patient data to mobile physicians (see Fig. 1). The dispatch station PC handles acquisition of the clinical patient data. It also runs the user application to review and select the data, converts the clinical data to paging messages, and sends these messages to a commercial paging system through a modem connection. The HP PalmVue critical care system acquires patient data (such as patient waveforms and vital signs) from the HP CareNet monitoring network via the SDN interface card. For the HP PalmVue ECGstat application, the patient's 12-lead electrocardiographic signals taken by an HP cardiograph are transferred to the dispatch station PC via flexible disk.

The paging messages travel through the paging system in exactly the same form as a typical "call me at 301-457-8438" paging message, except that each message consists of a string of up to 230 meaningless characters. Most of the major paging providers (radio common carriers) send these pages from their paging system computers (known as switches) to a satellite uplink. The satellite retransmits the messages through a downlink to ground-based paging transmitters in the geographical area covered by the subscriber's paging service arrangement. This coverage territory may be a metropolitan area, a region, or an entire country. The transmitters broadcast the signals, which are then received by the pager.

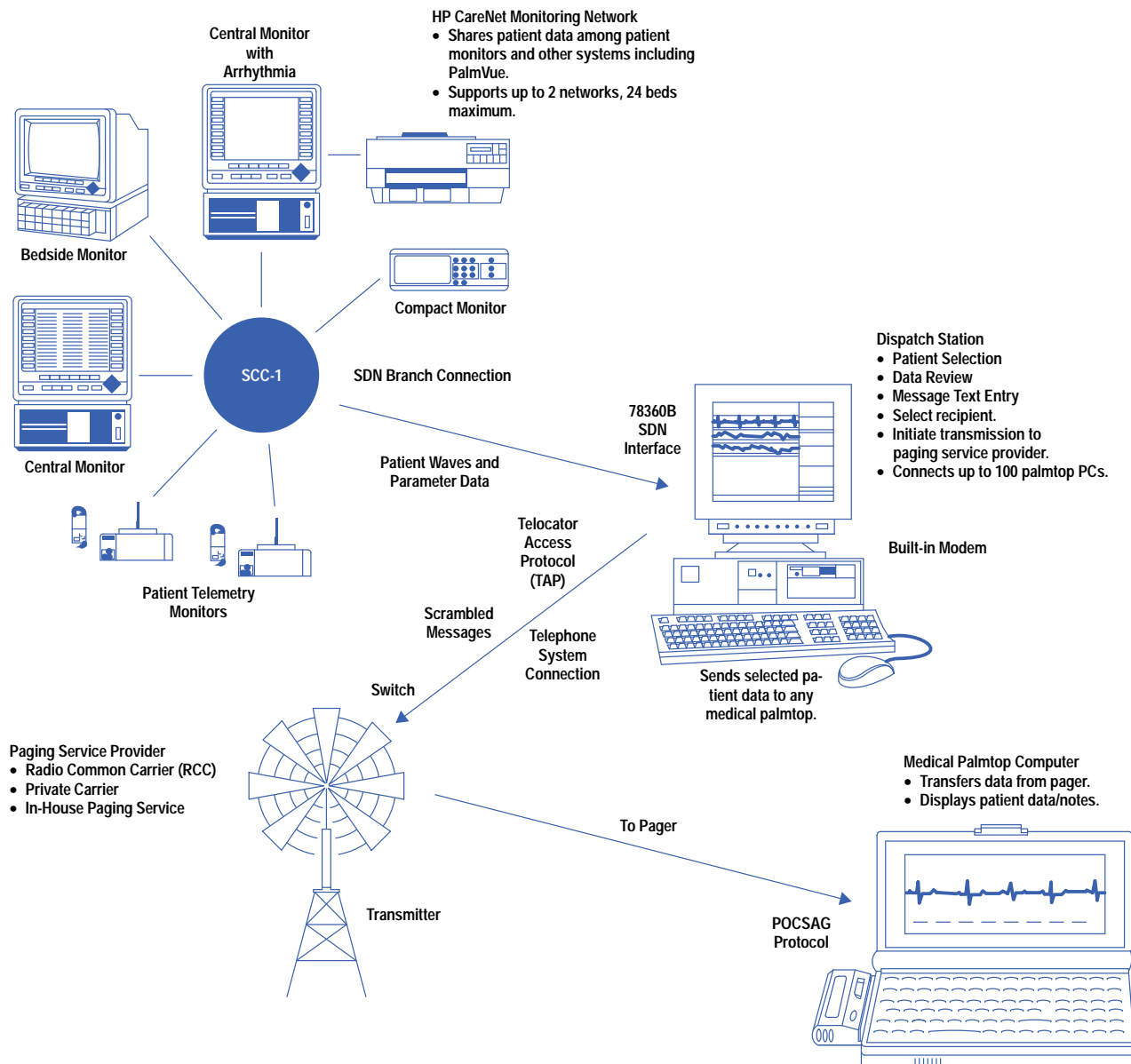


Fig. 1. HP M1490A PalmVue system.

The paging receiver used in the HP PalmVue system is a device called a NewsCard, provided by Motorola. This device combines the radio circuits from a standard pager with processing, memory, and a PCMCIA (Personal Computer Memory Card International Association) interface. The individual paging messages are transferred to the HP 200LX palmtop computer by a software program developed by HP for use in the HP StarLink paging service. If the NewsCard is plugged into the palmtop when an HP PalmVue message arrives, the palmtop turns on and the messages are automatically transferred into the memory of the palmtop. If the NewsCard is not plugged in, the messages are transferred later after the user plugs in the card and turns on the palmtop.

The heart of the HP PalmVue system is the software. The program in the dispatch station PC compresses the complex patient data, transforms it into a series of short, character-based messages, and sends them to the paging service. The palmtop software processes the paging messages to reconstruct the patient data, and handles the user interface and display of the patient data on the palmtop screen. Refer to subarticle ***"Data Through Paging Technology"*** for details of the packetizing and reconstruction process.

The HP PalmVue critical care application provides a snapshot of the current patient data as acquired from the HP patient monitor through the HP CareNet. This data may consist of a 15-second waveform snapshot (typically the ECG, used for assessing the patient's heart rhythm), up to three 5-second snapshots of other physiological waveforms (blood pressure waveforms or other measurements), and the full set of vital signs (heart rate, blood pressures, etc.). The user at the dispatch station selects the patient data, reviews it on the PC screen, and freezes a particular snapshot of information for transmission to the remote physician. The user can also enter a text note to explain particular concerns or provide

additional data to the physician. After choosing the recipient's name, the user initiates the transmission of the message. An example of the user screen on the dispatch station is shown in Fig. 2.

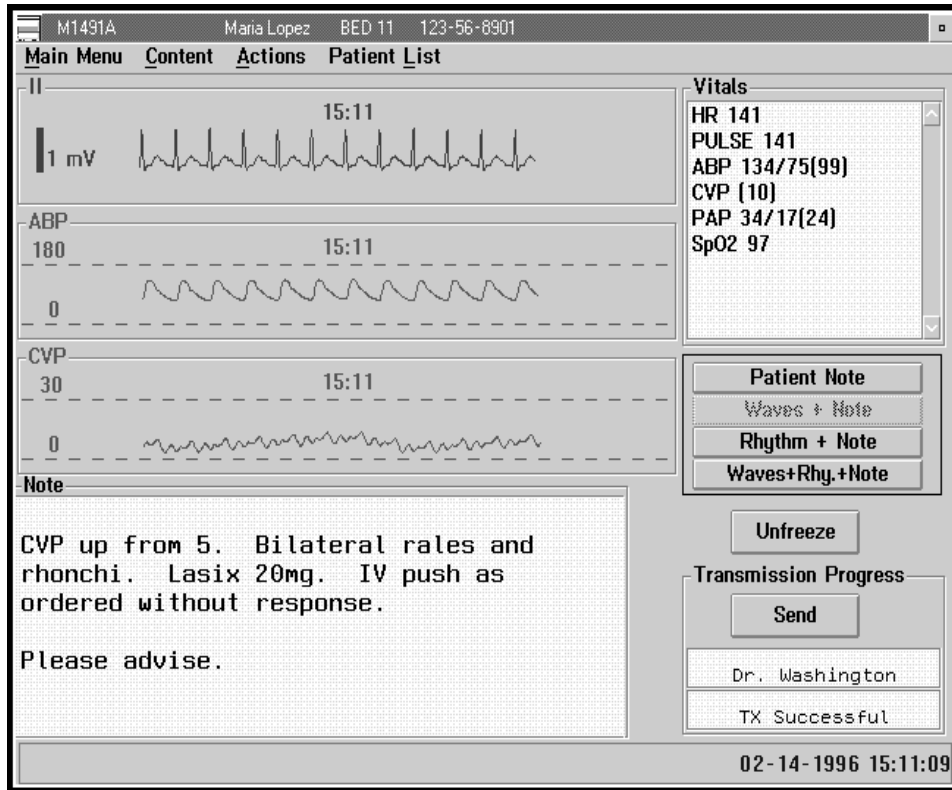


Fig. 2. An example of the user screen on the dispatch station PC.

The operation of the HP PalmVue ECGstat application is very similar, except that a previously acquired patient ECG is read in from a flexible disk (or it may have been previously stored in the dispatch station PC).

Operation of the palmtop application is designed to be as simple and intuitive as possible. If the NewsCard is plugged into the palmtop when a new HP PalmVue message arrives, the palmtop turns on, automatically transfers the paging messages into the palmtop, and executes the application program. This program reconstructs the patient data file and shows the index screen on the display with the new message highlighted (see Fig. 3). The user simply presses Enter, and the first screen of the new HP PalmVue message appears on the palmtop display (see Fig. 4). This screen provides patient identification, the time the data was taken, and the text note as entered by the sending clinician. The user can access the clinical data portion of the message by using the function keys. For example, pressing **f5** Vitals brings up the patient's vital signs (see Fig. 5). The 15-second ECG waveforms can be accessed by pressing **f6** Rhythm (see Fig. 6). Other portions of the patient data file, or alternate views such as expanded waveform time scales, are similarly accessed by using the function keys. Again, the palmtop application for display of a patient's 12-lead ECG operates in a very similar fashion, with display formats tailored to useful presentation of the 12-lead waveform and diagnostic information.

6 unread		PalmVue Message Index		15 of 16	
Bed 1	David Murphu	14-Feb 11:43	Mem Med Ctr	300-293-5295	
Bed 2	Mary Rizzo	14-Feb 12:46	Mem Med Ctr	300-293-5295	
Bed 21	Olga Smetana	14-Feb 14:07	Mem Med Ctr	300-293-5295	
Bed 15	Vincent Molnar	14-Feb 14:48	Mem Med Ctr	300-293-5295	
Bed 18	Philip Dubois	14-Feb 14:49	Mem Med Ctr	300-293-5295	
Bed 3	Rita Alvarez	14-Feb 14:50	Mem Med Ctr	300-293-5295	
Bed 17	Edward Ajawian	14-Feb 14:51	Mem Med Ctr	300-293-5295	
Incomplete Message					
»Bed 5	Helen Zhang	14-Feb 15:07	Mem Med Ctr	300-293-5295	
»Bed 22	Richard Kramer	14-Feb 15:08	Mem Med Ctr	300-293-5295	
»Bed 1	David Murphu	14-Feb 15:09	Mem Med Ctr	300-293-5295	
»Bed 6	Richard Rouse	14-Feb 15:10	Mem Med Ctr	300-293-5295	
»Bed 11	Maria Lopez	14-Feb 15:11	Mem Med Ctr	300-293-5295	
»Bed 13	Andrea Malik	14-Feb 15:12	Mem Med Ctr	300-293-5295	
»Bed 19	Richard Pacheco	14-Feb 15:28	Mem Med Ctr	300-293-5295	
»Bed 16	Sarah Putnam	14-Feb 15:49	Mem Med Ctr	300-293-5295	

Fig. 3. Index screen on the palmtop display with the new message highlighted.

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Bed 11 Maria Lopez      14-Feb 15:11
Mem Med Ctr 300-293-5295
From: Sarah Putnam
To: Dr. Washington
----- Sender Note -----

CVP up from 5. Bilateral rales and
rhonchi. Lasix 20mg. IV push as
ordered without response.
Please advise.
  
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Fig. 4. When the user presses Enter at the index screen, the first screen of the new HP PalmVue message appears on the palmtop display.

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Bed 11 Maria Lopez      14-Feb 15:11
Mem Med Ctr 300-293-5295
-- Vitals from Patient Monitor 15:11 --
HR 141                  CUP (10)
PULSE 141              PAP 34/17(24)
ABP 134/75(99)        SPO2 97

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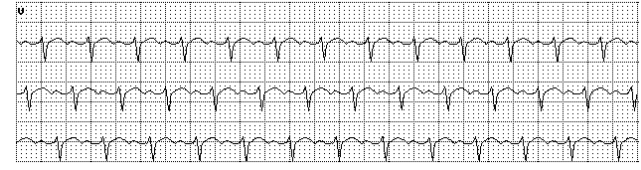
Help Index Notes Vitals Rhythm Waves II ABP CUP

Fig. 5. Pressing *f5* Vitals brings up the patient's vital signs.

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Bed 11 Maria Lopez      14-Feb 15:11 Mem Med Ctr 300-293-5295
V

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Help Ruler Zoom Notes Vitals Rhythm Waves II ABP CUP

Fig. 6. The 15-second ECG waveforms can be accessed by pressing *f6* Rhythm.

HP PalmVue Architecture

Several key objectives drove the architectural design of the HP PalmVue system:

- Allow independent development and testing of the dispatch station and palmtop portions of the HP PalmVue software.
- Allocate processing tasks appropriately to the dispatch station and the palmtop.
- Leverage existing software for the critical care application.
- Isolate the transmission process as a subsystem to minimize regulatory concern about the specifics of the paging infrastructure.
- Develop the key software modules in the PC and palmtop to be independent of the paging technology to allow a smooth transition to alternate wireless communication technologies.

The resulting architecture provides a good solution that meets these goals and allowed for a smooth development process.

The HP PalmVue system architecture is shown in Fig. 7. The key to achieving many of the design objectives is the clinical message file. This file is a specially defined representation of the clinical patient data, together with appropriate identification and control information. It exists in the system as a standard DOS binary file. This allows the clinical message files to be created, edited, and transported using conventional PC tools. The clinical message file is provided as input to the transmission process within the dispatch station PC, and is reconstructed within the palmtop software.

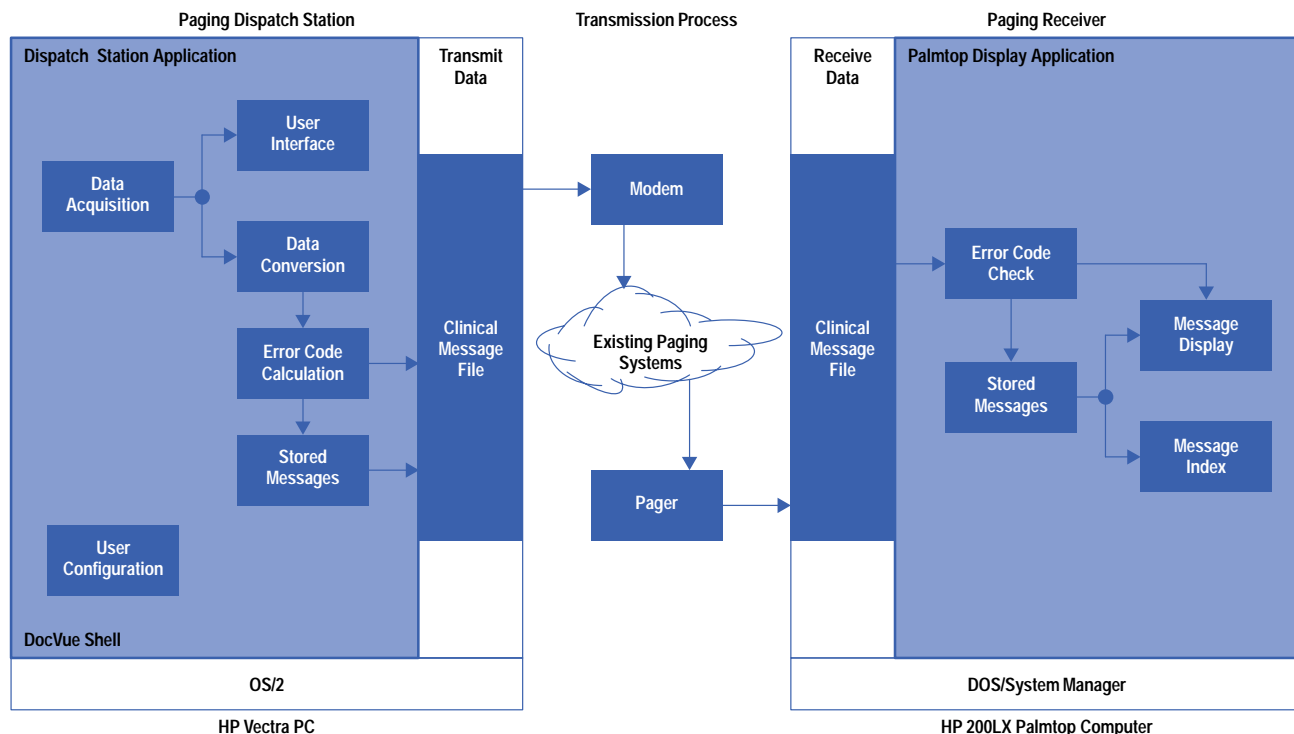


Fig. 7. HP PalmVue architecture.

This design greatly facilitates testing. Each application subsystem can be tested and verified independently by either evaluating the clinical message file as output from the PC, or by providing a valid clinical message file as input to the palmtop. The entire software system can be tested without any use of the wireless communication subsystem.

This design also resulted in optimized system performance. The bulk of the processing load, which is the transformation of waveforms into scaled display data, is handled in the dispatch station PC. The scaled waveform data that the palmtop receives in the clinical message file requires very little processing to display on the palmtop screen.

The inclusion of explicit error codes in the clinical message file allows the verification of data integrity with total independence from the transmission subsystem. This allowed the regulatory concerns for data integrity to be addressed without consideration of the specific performance characteristics of the paging systems. Both the clinical message file-based architecture and the error code implementation are capable of transparent migration to other wireless (or wireline) communication methods.

Background of the Product Concept

The availability of Palmtop computers, along with compatible paging devices and services, created the potential for wireless transmission of patient data to these tiny computers. The early product concept included the original Palmtop (the HP 95LX), and a paging device called the NewsStream, which connected to the serial port of the Palmtop using a cradle. The HP 95LX display allowed only coarse waveform presentation, and the combination of the Palmtop, cradle, and NewsStream was somewhat unwieldy. However, prototyping based on these concepts, using the 12-lead ECG, showed the feasibility of the product idea.

Dr. David Albert, a technology oriented physician with previous ties to the HP Diagnostic Cardiology Division, became a champion for commercialization of the product. Having formed a company (Data Critical Corporation, or DCC) to pursue building products based on this technology, he searched for partners to provide access to sources of clinical patient information as well as established marketing channels. He found an enthusiastic sponsor in Jim Cyrier, the division manager of HP's patient monitoring business. Jim had a well-developed vision of the future needs of medical professionals for access to patient data whenever and wherever they were, so he saw great promise in this product concept. Jim set in motion a process that resulted in a contract between HP and Dr. Albert's company for the joint development and marketing of the PalmVue system.

Underlying this product are two major concepts. One is the usefulness of providing complex patient data to physicians on a pocket-sized device, which is enabled by the advent of the HP palmtop, a tiny computer with a high-resolution graphics display. The other is the ability (seen by many in the paging industry as "not possible") to send large, binary information files through the standard and ubiquitous alphanumeric paging systems. Refer to "Data Through Paging Technology" above for the details of the data compression, translation, packetizing and reconstruction process used to implement this capability.

Product Development

The product definition for HP PalmVue was a joint effort of the engineering teams from the HP Patient Monitoring and Diagnostic Cardiology Divisions, working together with Data Critical Corporation. The primary design goals were to provide high quality and useful displays of patient data on the palmtop computer, to provide a very simple and intuitive user interface for the palmtop user, and to ensure the integrity of any patient data presented to the physician. The patient monitoring team developed a prototype of the palmtop displays, using Visual BASIC on a PC. These display screens were transferred to the palmtop, where they provided detailed screen formats and basic user interface controls. This proved to be a very effective method for quickly developing detailed prototype screen formats and control structures for evaluation by the development team and representative clinical users.

The development of the HP PalmVue critical care and ECGstat applications followed separate paths. The critical care product built on existing software products to provide a framework for the dispatch station application and a proven subsystem to acquire patient data from the HP CareNet patient monitoring network. The PC application to provide the HP PalmVue user interface was developed by the engineering team in the HP European Project Engineering Center by leveraging their DocVue product. Data Critical Corporation, under the development provisions of the contract, developed the transmission software for the dispatch station PC and the data reconstruction and user application software for the palmtop. The program management, system integration, testing, and product documentation were performed by the project team at the HP Patient Monitoring Division.

The development path for the HP PalmVue ECGstat product was far simpler. The HP Diagnostic Cardiology Division developed the initial product specification and Data Critical Corporation developed all of the PC and palmtop software. Substantial portions of the software (other than the PC user application) are common between the two products.

The joint development plan for these products made optimal use of the strengths of the partners. The HP patient monitoring and cardiology groups have substantial knowledge of their respective clinical application areas. They also have highly refined and formalized processes for product definition, architectural design, regulatory approval, and software quality assurance. In the case of the critical care product, existing product software from the HP European Project Engineering Center was also a key HP contribution. Data Critical Corporation provided their established Data Through Paging technology, current knowledge of paging systems and paging devices, and specific expertise in programming in the system manager environment of the HP 200LX palmtop. Substantial learning occurred by all of the partners. Data Critical Corporation was forced to conform to the rigorous testing and software QA methods required by HP's regulatory and ISO

9001 processes, while HP embraced the spirit of rapid product creation and aggressive attitudes that are the strengths of a small startup company.

The project teams needed to adapt quickly to evolving technology as the project progressed. While the early prototype was based on the HP 95LX, the HP 100LX was introduced during the early stages of the development work. By the time of product release, the HP 200LX was announced and became the platform for the initial HP PalmVue products. The paging device evolved from the bulky NewsStream to the PCMCIA-based NewsCard. The advent of the NewsCard provides the end user with a compact receiver setup that can be readily carried in a pocket or purse. A team in HP Corvallis and HP Singapore was concurrently developing interface software for the NewsCard, and they modified their software product to make HP PalmVue possible. Adapting to these changes required the development and test teams to be flexible and efficiently rework their software and test procedures to accommodate the evolving HP PalmVue product configuration.

Acknowledgments

Dr. David Albert and Aziz El Idrisi of Data Critical Corporation worked closely with our team on the development and introduction of HP PalmVue. Tim Beevers and Eric Meyers made key contributions to the formulation of early product definition, market exploration, and project planning. Thomas Kerker and Olaf Schnapper of the HP European Project Engineering Center provided the knowledge and technical capabilities for the successful development of the HP PalmVue Critical Care application based on the DocVue platform. Carla Mond, Steve Slaton, and Michelle Maietta provided the market introduction ideas and plans, and orchestrated the highly successful promotional activities. Steve deserves special mention as the originator of the idea for the user scenario at the beginning of the article. Our special thanks go to Jim Cyrier, Patient Monitoring Division general manager, for his visionary role in sponsoring the HP PalmVue project from its inception.

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