PCS Data Knowledge Site

Wireless IP - A Case Study

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Introduction

What if field workers of a public utility had online access to inventory databases, work orders, maps and other essential information from anywhere? What if crew chiefs had access to e-mail and schedules without having to return to their offices? This is the vision that the City of Seattle Public Utilities is making a reality in a project spearheaded by its Information Technology Division. This case study shows not only the issues the utility has faced and the solutions it has found; but, more importantly, how the lessons learned can be applied by almost any organization today to make wireless data an effective and successful tool.

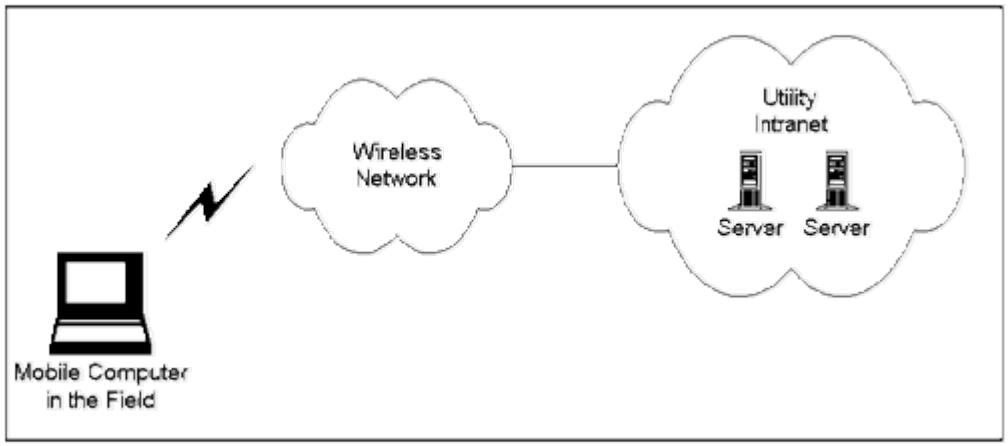

Figure 1: The utility plans to make applications and information on its intranet available to field workers.

The applications the utility is extending to its mobile workers include both work management and office applications, a combination common to many organizations. Developing wireless networking solutions requires special considerations. The utility has identified effective approaches, is about to proceed with a pilot program, and has a plan that accommodates the inevitable changes in applications, platforms and wireless

technologies.

This case study is organized as follows:

Goals

The utility's work and inventory management application is MAXIMO*, a system that uses an Oracle database, developed by PSDI (Bedford, MA, http://www.psdi.com/). Since MAXIMO is developed for specific types of job functions, it can be considered a vertical market-type application. From the point-of-view of providing wireless access to an enterprise database, however, it is similar to any number of other applications based on SQL (Structured Query Language), one of the most common protocols used today for client/server applications.

The office-based applications that the utility intends to extend to the field include Novell's GroupWise* and Web-hosted applications on the utility's intranet. These are horizontal market applications in that their use is not restricted to any particular job function or type of industry. In addition, the utility plans to make a GIS (graphical information system) available eventually, though it realizes that current wireless networks are not well-suited for such intensive graphical content. The goal for all these applications is to provide reliable remote operation with preferably the same user interface as a direct LAN connection. Though slower response times are acceptable and somewhat inevitable, applications must operate in a reliable and effective manner.

The utility has two types of remote workers who will use the wireless system: leads that will use MAXIMO primarily and crew chiefs that will use the office applications in addition to MAXIMO. Because it is difficult to predict what applications may be needed in the future, a key goal is to provide a flexible wireless architecture that allows new applications to be added easily.

Another goal is security. Wireless connections should be no less secure than existing remote access methods based on dial-up connections. Finally, while the utility is willing to commit to a particular wireless technology in its initial deployment, it wants an approach that allows it to migrate easily to other wireless technologies in the future.

Choosing the Computing Platform

The utility recently adopted the Microsoft Windows* 95 platform across multiple departments. For the wireless IP project, it needed to decide whether to use Windows 95 notebook computers or to consider a somewhat more specialized platform such as Windows CE.

Though MAXIMO client software is not available for Windows CE, Windows CE was an option because Syclo Corporation (Barrington, Illinois) supplies middleware that enables Windows CE computers to access MAXIMO databases through a gateway. Using Windows CE would have provided advantages such as lower device cost, greater portability and longer battery life.

Despite some of the advantages of Windows CE, the utility was concerned about the range of applications it could deploy on the platform. Because the utility expects the requirements for mobile workers to evolve over time, and for the types of work performed in the field to expand, it needs the greatest degree of flexibility possible for the types of applications it can deploy. For this overwhelming reason, the utility chose Windows 95 over Windows CE. In addition, because the computers are mounted in the vehicles and not used outside the vehicles, the extra portability Windows CE was not a factor. Finally, there are a number of ruggedized laptops available that can address the demanding field conditions that utility workers encounter.

Choosing the Wireless Network

The utility faced a bewildering situation when it began evaluating the wireless networks available. There was the analog cellular network, new digital cellular and PCS technologies, and four wireless packet networks with service in the Seattle area.

The utility decided to base their applications on TCP/IP communications, so this quickly disqualified the BellSouth Wireless Data and ARDIS networks which do not directly support TCP/IP. Moreover, the utility believed that a packet-based approach would better support the frequent communications that workers in the field require. This requirement eliminated circuit-switched cellular connections. Since packet-based services are not yet available for digital PCS networks, the remaining choices were CDPD and the Metricom Ricochet* network. CDPD and Metricom Ricochet* are both IP-based packet networks. However, data services for GSM and CDMA digital PCS networks are expected to be deployed in the 1999 time frame and so may be candidates in the future.

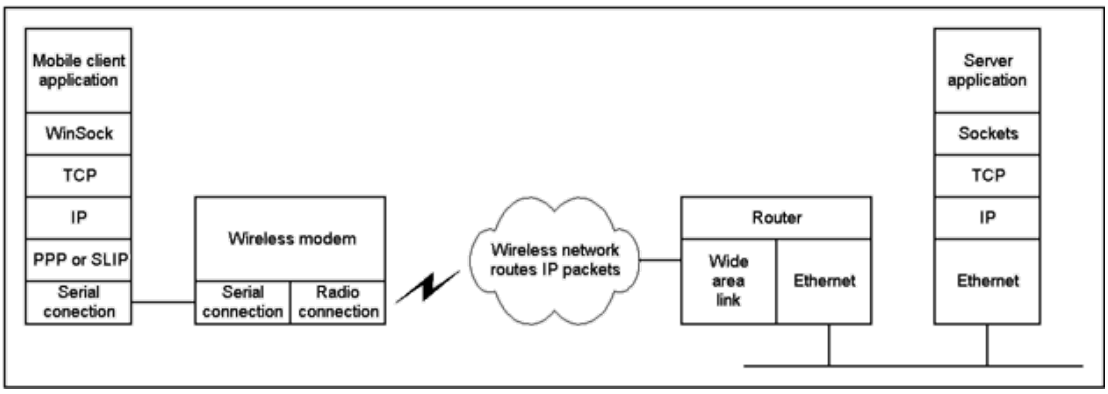

Figure 2: The utility chose a wireless network that is IP-packet based for greatest flexibility.

Since wireless data services are evolving rapidly, the utility decided to implement an architecture that insulates its applications from the actual network used to the maximum extent possible. Using an IP-based approach, where applications make no assumptions about the nature of the physical connection, achieves this goal. This is not unlike Internet-based communications, where packets may flow across copper cable, one moment; fiber optic cable, the next; and a satellite. It should be possible to deploy applications using one wireless network; and with minimal effort, migrate the application to another wireless network in the future, should that network become more desirable.

Migrating between network types is indeed possible, though some adjustments may be necessary for each network. For example, CDPD uses fixed IP addresses and Metricom Ricochet uses dynamically assigned addresses. This difference could affect how firewalls are configured. The effective throughput rates of Ricochet and CDPD also differ, with Ricochet operating at 20 to 30 Kbps and CDPD at about 10 Kbps.

Software Approaches

In an ideal world, a computer connected over a wireless network would work just like a computer on a LAN. But wireless networks operate at lower speeds with higher latency, and connections can be lost at any moment, especially when mobile. The utility has considered a number of software approaches, seeking to strike a balance among these factors: ease of use, performance, reliability, and cost of deployment. To complicate matters, it discovered that the best approach for supporting one application is not always the best approach for another.

The first approach is to use all applications in their native form, with client software installed on the mobile computer and communicating using TCP/IP protocols. Because some workers will be working with the same applications both in an office environment

and in the field, the advantage of this approach is that the user interface stays the same in both environments. Also, IT managers can set up mobile computers in the same way as desktop computers. A disadvantage is that this approach does not address some of the connectivity issues associated with wireless, such as throughput and latency. Another disadvantage is the requirement for software installation on field computers, which can add to maintenance and support.

Another approach is to use Citrix MetaFrame* (combined with Microsoft Terminal Server), where applications run on an application server at a central location, and mobile nodes operate as terminals (thin clients). The utility has already deployed Citrix MetaFrame to support dial-up users. The advantage of this approach is that installing and maintaining mobile computers is simplified because they only need the Citrix client software to access multiple applications. The disadvantage is that Citrix MetaFrame has some significant limitations when operating over wide area wireless connections. We learn about these limitations in the next section when we look at test results.

The third approach is to use wireless middleware (specialized software installed on a mobile computer and on a centralized server that acts as an intermediary between client applications and server processes) to optimize communications. The utility has looked at wireless middleware designed specifically for MAXIMO, as well as general purpose middleware that optimizes IP communications over wireless links. The advantage of wireless middleware is it allows applications to run with much better response times and much greater reliability, however, it increases complexity and adds cost.

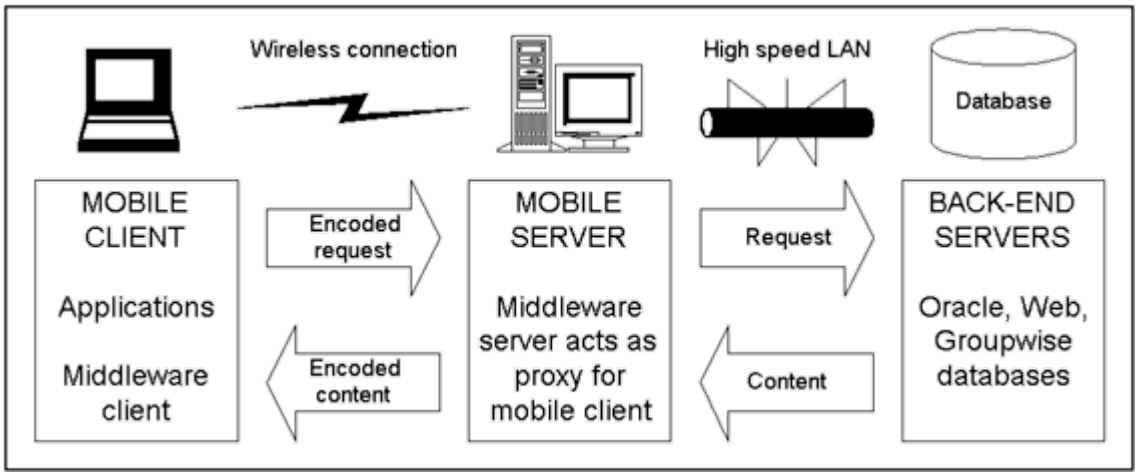

Figure 3: Wireless middleware adds a mobile server that handles transactions on behalf of the mobile client.

Because wireless coverage is not always available everywhere the workers spend time, an approach also considered was Oracle Lite where workers can download a subset of the database they need, operate on it locally during the day, and then synchronize at the end of the day. This approach reduces the demand for wireless connectivity, but it is not as

flexible as the other approaches where field workers remain in constant communications during the day and can respond quickly to changing circumstances.

By using a flexible computing platform such as Windows 95 on a laptop, the utility realized it could also consider a mix of approaches. Perhaps one application would work best in its native form, and another would work best using a thin-client approach. This indeed was the case as we see next.

Test Results

Whereas architecting different wireless approaches on paper may be an entertaining diversion, it is difficult to predict how the approaches will actually perform until tested in the real world. The utility has tested the architectures discussed earlier with results that did not always match expectations. For instance, the utility expected that an IP-based client would perform reasonably well over a wireless IP connection. This was the case for certain applications but not for others, which performed better using a different approach. Testing emphasized three scenarios:

1. Given the slower speed of wireless connections, what are the issues when starting (and restarting) sessions and applications?
2. How do applications perform once started, under normal operating conditions?
3. What happens when a connection is lost due to driving outside a coverage area or to strong interference?

Interestingly, every application and every software approach performed somewhat differently under the three different test scenarios.

Here are the various configurations and how they performed.

Remote IP-based Clients

The first configuration tested was with remote clients, specifically MAXIMO and Web browser clients installed on laptops using TCP/IP communications. The version of GroupWise used at the time did not provide a TCP/IP client, so GroupWise could not be tested using this configuration.

Because both Metricom Ricochet and CDPD are based on IP, the applications operate in the same fashion as if installed on LAN-based workstations using TCP/IP protocol stacks. What is different, of course, is the slower speed of wireless connections. Also, the mobile nodes are not necessarily always in wireless coverage. The first comprehensive series of tests used the Metricom Ricochet network. Compared to CDPD, Ricochet has higher average throughput but it does not support seamless hand-offs between base stations. This means that active applications may lose their connections when the vehicle drives out

of range of the original base station.

In looking at the first test scenario (how applications started), Web applications experienced no problems. But MAXIMO would sometimes require more than five minutes during the logon process. Subsequent research revealed that because MAXIMO is an Oracle database application, large data dictionaries are downloaded at startup. This is clearly not acceptable in a field environment. Fortunately, it is possible to cache local versions of these dictionaries on a local hard disk. Such up-front synchronization is common to many applications and is often a performance issue for wireless communications.

Once connected (the second test scenario), the Web client performed acceptably as long as the content was more textual than graphical. MAXIMO, in contrast, ran extremely slowly. Opening new modules (e.g., the inventory module or the work-order module) within MAXIMO would take 60 to 90 seconds. Once a module opens, a screen update (such as looking at a new order) would take about 30 seconds. It is easy to understand why operations were so slow. Oracle transactions, based on SQL, involve a considerable amount of back-and-forth traffic. The slow screen updates make a remote MAXIMO client practically unusable. However, users entering text in either application posed no problems.

The last operating scenario examined the effect of lost connections. The Web client was highly tolerant of intermittent connections, which was expected since HTML applications are stateless; each page entails a new TCP connection. With MAXIMO running, a dropped connection would generate an error message for transactions in process and result in the module closing; but the overall session is maintained. If no transactions were in progress, MAXIMO readily tolerated the underlying connection being lost and regained.

Citrix MetaFrame

The second software scenario tested was the thin-client approach using Citrix MetaFrame. Starting a remote MetaFrame session over a wireless connection took about 60 seconds. Once the session was started, application startup was not an issue at all, which was expected since the applications run on an application server that has a high speed LAN connection to back-end services. Screen updates for all applications tested (MAXIMO, Web client and GroupWise) ranged from 10 to 15 seconds. This was about the same speed as a remote Web client but significantly faster than a remote MAXIMO client.

The biggest problem with using MetaFrame, however, is that it is not tolerant of intermittent connections. Even in the absence of any application processing, driving out of range of the Metricom base station would terminate the MetaFrame session as well as all the application sessions. With this architecture, text input proved very slow for all applications—not surprising since every character typed by the user would have to be

echoed over the wireless link by the application server.

Wireless Middleware

The last architecture tested was wireless middleware. The particular middleware chosen for testing was Smart IP* from Nettech Systems, Inc. Smart IP has a number of different capabilities, but the one of greatest interest is its ability to make IP communications more efficient over wireless networks. It achieves its efficiency through a number of mechanisms, including compression as well as replacing TCP with its own wireless-optimized transport protocols. These transport protocols are used over the wireless connection between the middleware client software that is installed on the mobile computer and the mobile server as Figure 3 shows. The net result is transmission of fewer and smaller packets.

Actual test results with Smart IP showed noticeable data transfer gains. Using a browser application, Smart IP reduced the time required to download pages by an average of about 25%. For example, a page that took 20 seconds to download without Smart IP would on average take 15 seconds with Smart IP. The utility tried to configure Smart IP to operate directly with MAXIMO, but tests were postponed due to configuration difficulties.

The utility found that different applications worked better using different approaches. Only through testing could the utility determine how their applications would function in a wireless environment. Though applications generally ran slower than over dial-up modem connections, with the right approach, applications run well enough to be deployed in the field. The utility also found that the number of software approaches available increased during the course of its project.

The Changing Application Landscape

Computer technology continues to evolve rapidly, as software vendors keep revising and improving their applications. The utility experienced a number of changes that had implications on their wireless strategy. In particular, the number of software approaches available to support wireless networking expanded.

The utility upgraded from GroupWise version 4.1 to version 5.2. With the older 4.1 version there was no easy way to provide remote access other than by using Citrix MetaFrame. But version 5.2 includes TCP/IP support as well as a Web browser client thus adding two new paths for providing remote wireless access. The most attractive approach appears to be the TCP/IP client; testing is under way to confirm this.

Another change involves PSDI, the maker of MAXIMO. Realizing the importance of wireless communications for field service workers, PSDI began to architect their next

generation of software to better support wireless networking. In the new version, MAXIMO offers a Web-based interface to mobiles using HTML protocols. HTML is a far more efficient approach than extending the SQL database protocols all the way to the mobile computer. This new "wireless friendly" version of MAXIMO is release 4 and the utility plans to upgrade from release 3. Once it does, the Web interface to MAXIMO will probably be the preferred approach for mobile field workers.

As the utility proceeds with its deployment, and as it expands the number of field workers using wireless networking, it will need to rely on a hybrid set of approaches to address their application needs. In some cases, the utility will run applications in their normal LAN-based or modem-based modes. In other cases, the utility will take advantage of wireless middleware products. And for other applications, a thin-client software approach may be the most effective.

By using a strategy that includes an IP-based communications infrastructure and a flexible computing platform, combining the various software approaches is completely feasible. Such a strategy provides the utility, and any organization for that matter, maximum flexibility when supporting both field workers with specific job functions and office workers with more generalized computing needs.

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