Development of a Wireless Network and Report Building Program for Children's Hospital

By

Nicholas A. Vernon

Submitted to
the Faculty of the Information Engineering Technology Program
in Partial Fulfillment of the Requirements for
the Degree of Bachelor of Science
in Information Engineering Technology

University of Cincinnati
College of Applied Science

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Abstract

Wireless Network and Report Builder Program

The use of a wireless network and a Report Builder serves one purpose: to make difficult tasks easier. Currently the facility manager at Children's Hospital of Cincinnati has to generate a daily report on the previous day's minimums, maximums, and averages for all of their boilers, chillers, electric use, and steam production. At this time, the manager runs queries through an MS SQL Server database, and then manually inputs the data into an Excel spreadsheet. This process typically takes two hours every morning. The more efficient Report Builder program utilizes ASP and HTML to automatically run these queries, generate the output, and print the tables every morning at 12:10am. The reports are available in his printer tray when he comes to work in the morning saving him two hours of work. The Report Builder can also be used throughout the day to monitor these measurements for abnormalities. The wireless network allows Fosdick and Hilmer to connect to their client, Children's Hospital, without using a slow and unreliable dial-up connection or continually paying for a leased T1 connection. As long as line of sight is maintained between the two buildings, this configuration will provide them with a direct connection up to 11Mbit of through put. The wireless network will allow Fosdick and Hilmer engineers to monitor and update the integrated controls in a quick and efficient manner. The paper summarizes the steps necessary to plan, budget and implement wireless network, and how ASP and HTML programming can automate daily tasks.

Development of a Wireless Network and Report Building Program for Children's Hospital

1 Statement of the Problem

The design engineers for Fosdick and Hilmer typically spend three to five hours, two to three days a week maintaining the integrated controls program for Children's Hospital. This requires either sending personnel to the client's control room, or using a modem and dial-up connection to the client's network. It is difficult to get the right person free long enough to send him/her over to the client's facility. Making changes over the dial up connection is slow and not always reliable. Fosdick and Hilmer need a faster and more reliable connection to the client's network from the office.

Another reason to be connected to Children's Hospital's network is for a report-building program that is custom-tailored to our client's needs. Fosdick and Hilmer want to use HTML and active server pages (ASPs) to write this program for two reasons. First they already own licensed copies of Microsoft Visual Studio, which includes Microsoft Interdev, and Notepad. As a result, there is no additional software that needs to be purchased by them. Secondly the web pages can be installed on the client's server and then be viewed immediately. The client is not required to purchase any special software to view the reports. This reporting program gathers data about the previous day and shows the usage or production of electricity, steam, and chilled water. The integrated control software comes with a reporting function, but it has multiple steps and cannot be automated. Fosdick and Hilmer want to design our report-builder to automatically

generate a report, based on the previous twenty-four hours of activity, every night at 12:10AM. The report will be printed and available to the facility manager at the beginning of each workday.

1.1 Wireless Network Prerequisites

Using wireless technology is not new to Fosdick and Hilmer. Their branch office is located in Ft. Thomas, KY, and is connected to the main office in Cincinnati via wireless network. This wireless network was installed in 1998, when the fastest transmission rate was 4Mbps; even quicker than today's fastest dial up modem. This system has operated flawlessly through all types of weather. Another way of connecting to the client's network would be to rent a T1 connection from the phone company. However, Fosdick and Hilmer believe they will be working for the Hospital long enough to make it more cost effective to install an $5000 wireless network than to pay $200 - $500 per month for the T1 line. Wireless technology has progressed considerably since 1998. Now transmission rates are up to 11Mbps, and more security has been built into the wireless protocol. A few basic requirements must be met before we can consider using a wireless network. First the mounting locations must have line-of-sight with each other, and there must be a suitable location for mounting the antenna. Both of these basic criteria are met so Fosdick and Hilmer could proceed with designing a wireless network. (1)

2 Description of the Solution

2.1 User Profile

The users at Children's Hospital will be facility managers. These users are whom the report builder is designed to assist. They are either mechanical or electrical engineers. They want a program that is very user friendly and does not require them to make many decisions on how the program works. They do want the ability to make choices on which type of report they get, and the period of time the report covers. For the most part they do not posses any programming skills.

The users at Fosdick and Hilmer are also mechanical and electrical engineers. These users are the primary users of the wireless network. The design engineers for Fosdick and Hilmer typically spend three to five hours, two to three days a week maintaining the integrated controls program. The wireless network will allow them to be able to quickly identify and troubleshoot any problems that Children's Hospital may encounter. These users have programming skills and are able to adjust the programs code so it fits the needs of the client.

2.2 Design Protocols

2.2.1 Wireless Network

The wireless network will consist of two networks that are not physically connected, but will able to communicate via the wireless bridge. I will have Bridge_1 on Fosdick and Hilmer's network that is set as the root bridge. When you have two or more bridges on a network one of them has to be set as root and all other bridges set as non-root. Bridge_2 will be on Children's Hospital's network and set as a non-root bridge. The

two bridges will need IP addresses assigned to them. I will use available IP's from Fosdick and Hilmer's network and install the remote bridge at Children's Hospital so that their router will allow a Fosdick and Hilmer user to access their network. There are many ways to connect the bridges to a network. We will be using shielded CAT5 Ethernet cabling. Here is an illustration of the wireless bridge that I will be using.

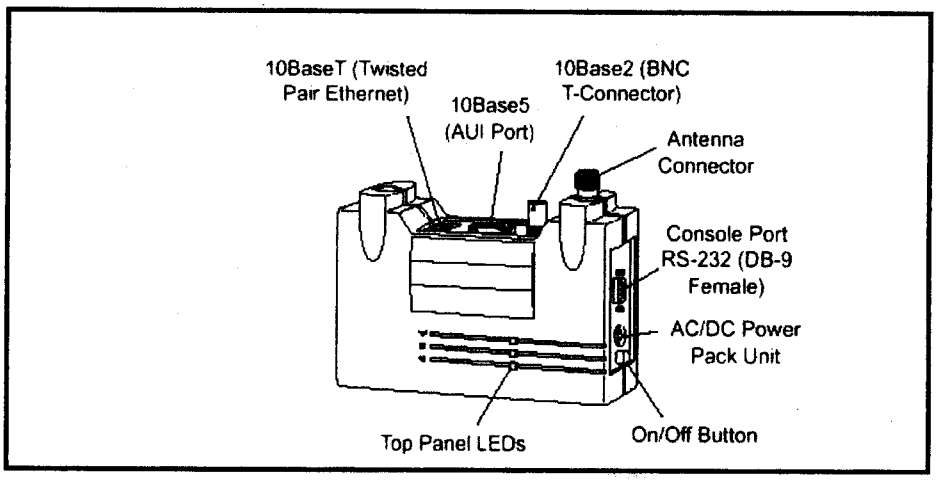

Figure 1: Cisco 342 wireless bridge (1)

These bridges are very versatile and can be connected to many types of network cabling. There is a port for 10BaseT standard Ethernet cabling, for 10Base5 Thicknet cabling, and for 10Base2 Thinnet cabling. There is an antenna connector where you can either install the included 4-inch rubber antenna or connect a more powerful mast mounted antenna.

The following is a schematic of the wireless network between Fosdick and Hilmer and their client.

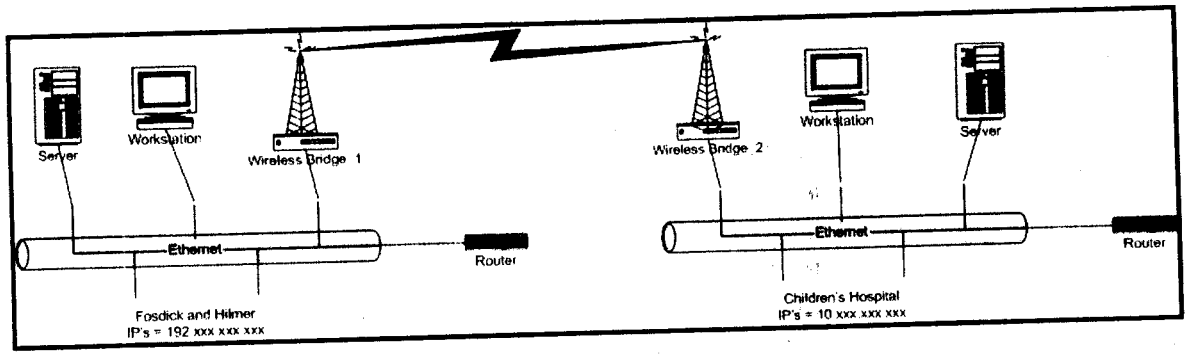

Figure 2: Wireless network diagram

The bridges are configured using Hyper Terminal separately before connecting them to the network. The wireless network that the bridges belong to is given a name, such as "F&H_to_CHMC_WLAN". The bridges convert this name into a Service Set Identification (SSID) and will only accept packets for this network. (1) There are many options that need to be set on the bridges like data transfer speeds, approximate distance between bridges, and Ethernet packet size. Once the basic configuration is setup the bridges are able to communicate with each other and any final changes could be made by typing the bridges IP address into Internet Explorer, which brings up a web version of the configuration menus.

I have been able to configure the bridges so that we can install them in their prospective networks, have their long range antenna's installed and start communicating with them. However, due to a down sizing in our company we no longer have a building that has line of sight with Children's Hospital. We are keeping the equipment because we can see one of our other clients and we are considering creating a wireless network

between them. Then from their building we could connect to Children's Hospital. So for now we will keep the bridges and use this information on our next wireless network.

2.2.2 Report Builder

The layout of the Homepage of the report-builder starts with a list of power plants at Children's Hospital. Then there is date fields where the user can specify which days the report is to be based on. The date field automatically enters the date of the previous day. Drop down menus are used so the user can set the date they want the report based on, and only allows the date to be entered in the correct format. After completing their selections the user will click the Submit button that will send the users input to the correct active server page. The start page is laid out in frames so the report will appear in one window and the selection boxes will still be visible. This allows the user to generate a different report without returning to the homepage. It sometimes takes a minute or so for the active server page to generate the report so a pop-up window is shown that informs the user that their request is being processed and to wait patiently.

The homepage has a white background with the image of the Children's Hospital logo on it. The active server pages already take a full minute to generate the tables from the raw data, so they do not have any pictures or very much formatting. Plus there is a script that runs the active server pages every night at 12:10am that reports the activities of the prior day. This report is filed and needs to be in a concise format. The tables will have alternating white/gray lines to make it easier to read the data. They will also have bold headings to ease use. Here is a flow chart of the report builder program.

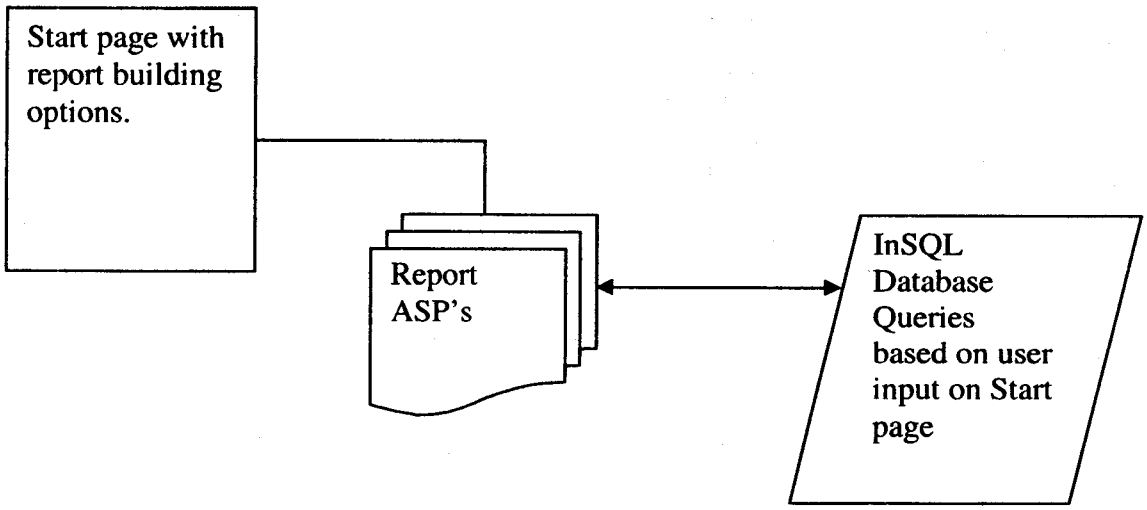

Figure 3: Report Builder program flow chart

When we installed the program we ran through its capabilities with the facility managers at Children's Hospital and answered any questions they had about it. The start page has headings over the input boxes that instruct the user what they are used for. At this time no help file is intended for the report builder program. If Children's Hospital wants to make changes to the program they are able to contact Fosdick and Hilmer easily via email and phone calls. Fosdick and Hilmer will be maintaining this program and also plan to use it for other clients. So I have been trying to write the code so it is easy to change variables and parameters to meet different clients' needs.

3 Deliverables

3.1 Wireless Network

Following is a list of the networking deliverables for the project complete.

Item	Delivered	Notes
1. Configure Cisco wireless bridges	Yes	
2. Connect wireless bridges to perspective networks	No	Not delivered because of company downsizing caused loss of line of sight.
3. Install antenna's	No	Due to the loss of line of sight antennae location cannot be determined.
4. Establish a connection between two networks	Yes	

Figure 4: Wireless network deliverables

3.2 Report Builder Program

Here are the Report Builder program's deliverables needed to make this portion of the project complete.

Item	Delivered	Notes
1. Html start page divided with two frames	Yes	
2. A drop down menu listing power plants	Yes	
3. A drop down menu for choosing a report date	Yes	
4. Error checking and validation on user input	Yes	
5. Generated active server pages based on the input from the user	Yes	

Figure 5: Report Builder program deliverables

4 Design and Development

4.1 Budget

Fosdick and Hilmer are currently contracted to Children's Hospital to upgrade their current integrated controls system as well as designing the new systems for buildings that are under construction. Money was allocated from this project to purchase the wireless network equipment. If you are interested in the prices of each piece of equipment please see the table in Appendix 1. There you will find an itemized list of expenditures. Fosdick and Hilmer will save money in the long run by having a wireless network connecting them to their client. The time that is spent driving, parking going through security at the Hospital will be saved and can be used on other projects.

4.2 Timeline

Time for this project was not an issue because Children's Hospital was building several new buildings on their campus and I would be using one of the new buildings as the location of my antenna. Once the building we plan to use is completed we will be able to install the antenna. If a person had the time to devote to this project, it could be completed in about one month. There is a table in Appendix 2 that shows the break down of approximately how long each step took me.

4.3 Wireless Network Equipment

Here is a list of the required equipment needed to build a wireless network.

Quantity	Description
2	Wireless Bridges

2	Antenna
1	Router (2)

Figure 6: Equipment list

We chose Cisco wireless bridges and Aironet antennas. Aironet is a company that specialized in wireless antennas and where recently bought by Cisco. We are already using Aironet equipment for some of our networking needs. The type of antenna you choose will depend on the distance you are trying to bridge, and the transmission rate you desire. See Appendix 3 for the specifications on the antenna's we decided to use. The first step of setting up the wireless network is to set the basic configurations. To do this you need to connect a serial cable from the bridge to an available serial port on your workstation. Create a HyperTerminal connection that has these settings: **Set the terminal to** 9600 **baud,** 8 **data bits,** No **parity,** 1 **stop bit, and** Xon/Xoff **flow control.** This HyperTerminal connection will bring up the Main Menu. See the illustration below.

```
                Configuration Menu
    Option          Value       Description
1 - Radio         [ menu ]    - Radio network parameters
2 - Ethernet      [ menu ]    - Ethernet configuration
3 - Ident         [ menu ]    - Identification information
4 - Console       [ menu ]    - Control console access
5 - Stp           [ menu ]    - Spanning Tree Protocol
6 - Mobile-IP     [ menu ]    - Mobile IP Protocol Configuration
7 - Time          [ menu ]    - Network Time Setup
8 - Dump                      - Dump configuration to console

Enter an option number or name, "=" main menu, <ESC> previous menu
>_
```

Figure 7: Wireless bridge configuration - Main Menu

The first setting that needs to be set is in the Radio menu, so type a 1 and press Enter. In the Radio menu there is a SSID option. Here you need to give the wireless network a

name. The bridge will convert name to a unique identifier and only allow packets of data with this identifier to enter the network. Record the name you use because you will need to give the same name to the second bridge.

The next step is assigning an IP address to the bridge. Press the Esc key until you are back to the Main menu. From the Main menu you need to enter a 3 so that you go to the Ident menu. In the Ident menu there are these options that need to be set, the INADDR option that assigns an IP address, the INMASK option to define the Internet subnet mask, and the GATEWAY option to define the gateway address, if appropriate.

Now we need to set the root configuration. The default setting is root = yes. When you have a wireless network one of the bridges must be designated as root and the other as not the root. From the Main menu, type 1 and press Enter to go to the Radio menu. In the Radio menu you set root = yes/no.

With these settings applied your bridges are configured enough that they can locate and talk to each other. You can now exit the HyperTerminal connection and remove the serial cable. From now on you can make configuration changes over the Internet by typing in the bridges IP address.

Here is an illustration of what the configuration menu looks like through Internet Explorer.

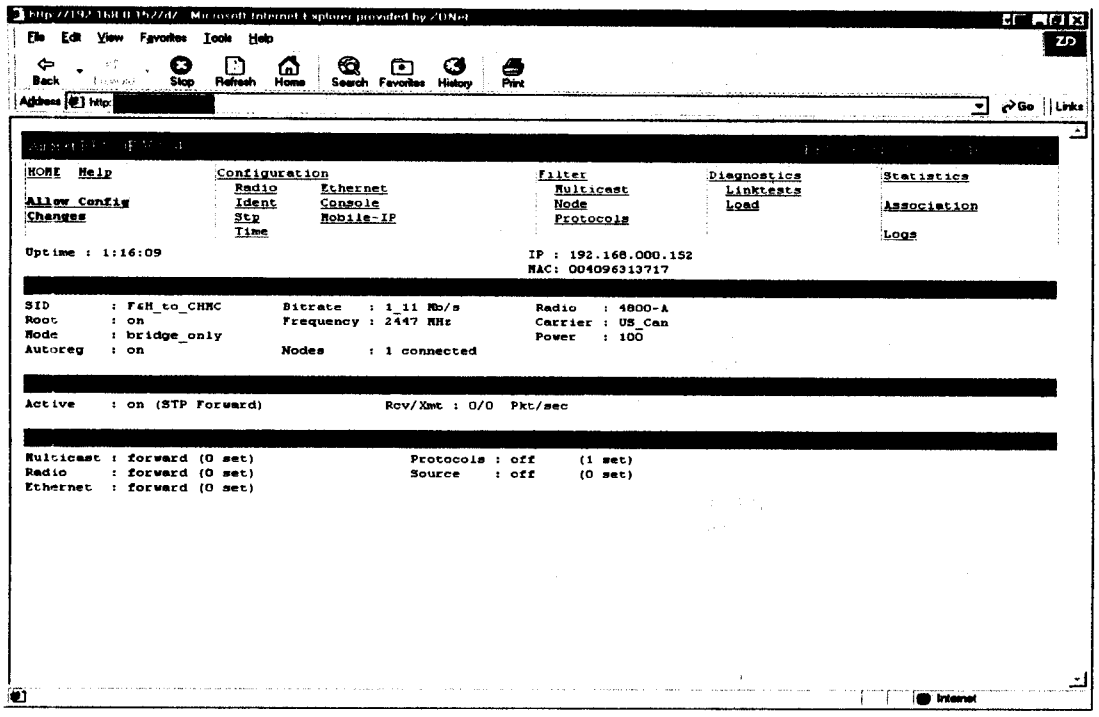

Figure 8: Configuration menu from Internet Explorer

From the web based configuration menu you can finish your setup. There are many more settings that you can choose to set if your situation requires it. Some of these settings are bit-rate, distance between bridges, console users and passwords, and adding more wireless components.

4.4 Report Builder Program

I started working on the Report Builder program first because this was something the facility managers needed immediately. I talked with the facility manager at Children's Hospital to discuss what he needed the program to do. He showed me how he was currently creating the daily reports. He could use the integrated controls software to run queries and retrieve the information he needed, but he then had to manually input the information into an Excel spreadsheet. This typically took him two hours every morning to complete. The database that the integrated controls software uses to store its data is an

industrial version of Microsoft SQL it is called InSQL. It uses similar query structures as MSSQL with just a few slight variations. Here is a sample of the code I used to setup the connection to the database. (3, 4)

```
Dim WWENDDATE
Dim WWDURATION
Dim WWROWCOUNT
WWENDDATE = """ & strChartDate & """
WWDURATION = "(minute,1440)"
WWROWCOUNT = 1441
Dim rstData          'Collects Chiller Data (reads every minute) and puts it into
RawMinuteData Table
Dim rstHour          'Organizes the HourlyData Table by Hour
Dim rstSummary       'Summarizes the Days Min's, Max's, Totals, and Avg's
Dim rsTables  'As adodb.recordset
Dim dbconn           'My ADO Connection
Dim strRowColor
Const Gray="#E0E0E0"
Const White="#FFFFFF"

'Set up connection to database
        set dbconn=server.createobject("ADODB.CONNECTION")
        dbconn. ConnectionString =
"DSN=InSQL;UID=wwAdmin;PWD=wwAdmin"
dbConn.CursorLocation = 3 'Client
        dbconn.Open
        dbConn.execute " Use RunTime "
        dbconn.execute " set wwEndDate " & WWENDDATE
        dbconn.execute " set wwDuration " & WWDURATION
        dbConn.execute " set wwRowCount " & WWROWCOUNT
```

As you can see there are a few unique syntax requirements for InSQL, like the "WW" prefix.

I decided to separate the start page in two sections using frames. This way I could have the user input fields in the top frame and the data that is gathered from the queries displayed in the lower frame. I felt this would be best because then the user could enter new dates or choose a different plant to run the queries on without having to go back to

5 Proof of Design

To prove that I have setup and configured the bridges correctly I took a screen shot of Network Neighborhood showing both Comp_A and Comp_B.

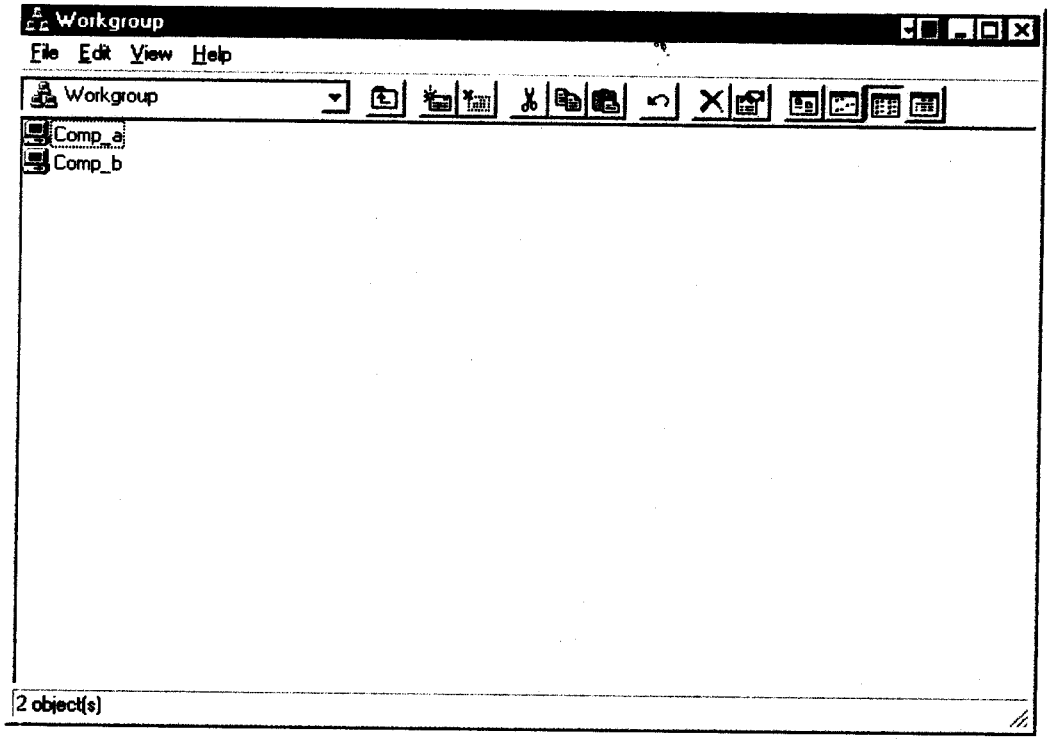

Figure 9: Network neighborhood list

For the Report Builder program I also took screen shots of the web pages.

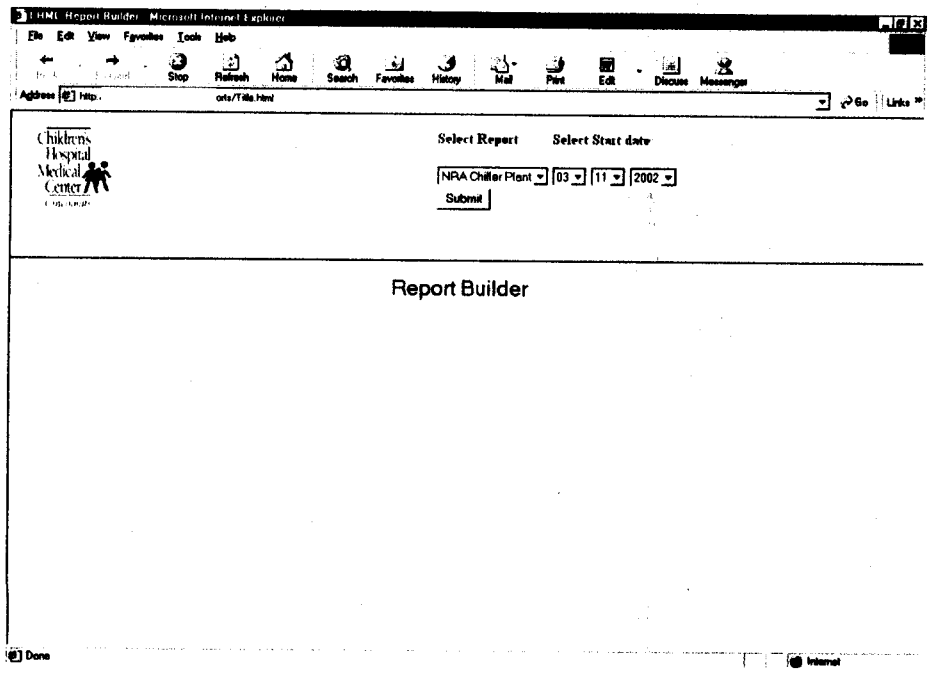

Figure 10: Report Builder start page

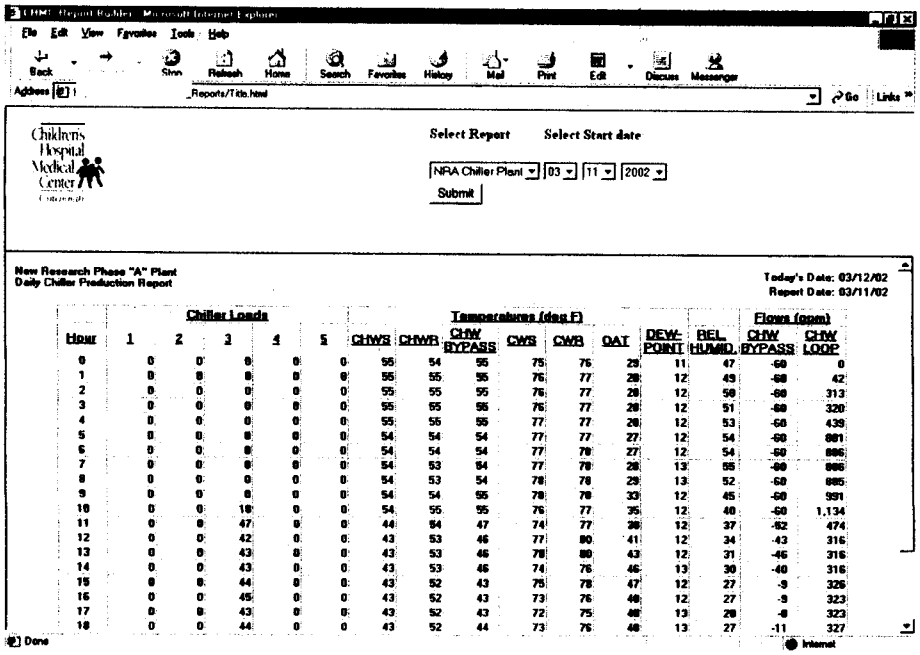

Figure 11: Daily report

See Appendix 4 for the printed version of these reports.

This is the pop-up window that opens when the user submits their request. It is designed to open up in the middle of the screen and close as soon as the all the data is retrieved from the database and starts to be printed to the screen.

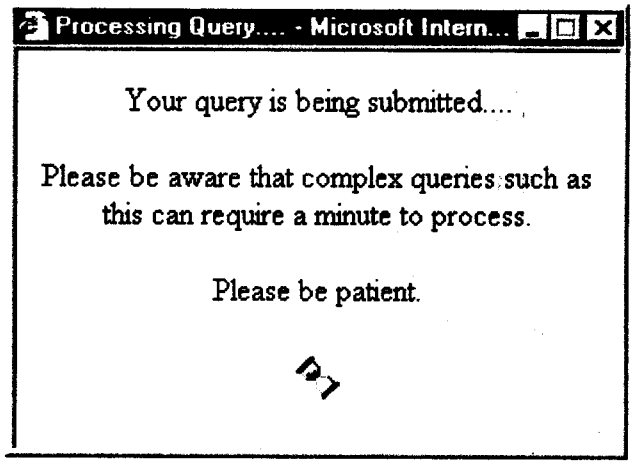

Figure 12: Pop-up window

6 Conclusions and Recommendations

This wireless network will allow me to connect our network to our clients in a cost effective way. It will allow the engineers at Fosdick and Hilmer to easily and efficiently moderate the control systems at the Hospital. It is flexible enough that we could move or add to it without difficulty. Fosdick and Hilmer have other clients in the Cincinnati metro area. We can install antennas on their buildings and wireless bridges on their networks using information we have learned from this project. Being connected to our clients allows us to quickly answer and correct any problems that our clients may encounter.

The Report Builder is a program that automated a task that use to take two hours. It has been designed so it can be tailored for many different clients without much

changing to the core code. Children's Hospital is currently adding on to their campus. This means there will be future plants that need reports. Adding them to the Report Builder will be as done by reusing the existing code and changing the table fields appropriately. The data needed for the tables has been the same for years so that part of the code will remain the same.

Appendix

1 Budget

QTY	Description	Price
1	Microsoft Visual Studio Package	**$1499.00**
1	Cisco Solid Parabolic Dish Antenna	**$789.16**
1	Cisco Yagi Mast Mount Antenna	**$289.92**
2	Cisco 340 DSSS Wireless Bridges	**$2892.18**
2	Cisco Lightning Arrestor Kits	**$339.64**
	Various Mounting Hardware (Such as: bolts, masonry anchors, drill bits, 2 foot piece of angle iron, 2 inch diameter x 15 foot pipe for mast extension)	**$200.00**
	Total	**$6009.90**

Figure 13: Budget

2 Timeline

Date	Description	≈Hours
6/29/01	Setup Workstations	4
7/2/01	Setup and Configure Bridges	8
7/6/01	Setup and Configure Bridges	6
7/23/01	Re-Setup and Configure Bridges (Had to relocate to a new location)	8
7/27/01	Design/Code Start page	8
8/3/01	Design/Code Start page	8
8/6/01	Design/Code Start page	8
8/7/01	Design/Code Start page	8

Date	Description	≈Hours
8/10/01	Design/Code ASP pages	8
8/13/01	Design/Code ASP pages	8
8/17/01	Design/Code ASP pages	8
8/20/01	Design/Code ASP pages	8
8/24/01	Design/Code ASP pages	8
2/11/02	Configure Wireless Bridges	3
2/13/02	Configure Wireless Bridges	2

Figure 14: Timeline

3 Antenna Specifications

Cisco System's product specification sheets

Description	Yagi mast mount	Solid dish
Gain	13.5 dBi	21 dBi
Approx. range at 2Mbps	6.5 miles	25 miles
Approx. range at 11Mbps	2 miles	11.5 miles
Beam width	30°H 25°V	12.4°H 12.4°V
Cable length	1.5 ft.	2 ft.
Dimensions	Length: 18 in. Diameter: 3 in.	Diameter 24 in.
Weight	1.5 lb	11 lb
Size	6.30 in. (16 cm) wide x 4.72 in. (12 cm) deep x 1.45 in. (3.7 cm) high	
Status indicators	On the back panel: A barrel power connector (plug-in AC adapter) for a regulated 5V input and an RJ-45 jack for Ethernet connections.	
Connectors	Power pack. The power pack is either 120VAC/60Hz or 90-264VAC/47-63Hz; whichever is appropriate for country of use.	
Operating temp	32°F to 122°F (0°C to 50°C)	
Weight	Less than 1 lb (0.45 kg)	
Power output	30 mW	
Frequency	2.400 to 2.497 GHz (Depending on the regulatory domain in which the bridge is installed)	
Modulation	Direct Sequence Spread Spectrum	
Data rates	1, 2, 5.5, and 11 Mbit/s	

Compliance	Operates license-free under FCC Part 15 and complies as a Class B computing device. Complies with DOC regulations. Complies with ETS 300.328, FTZ 2100 and MPT 1349 standards (and others).

Figure 15: Antenna Specifications

4 Report Program printouts

New Research Phase "A" Plant
Daily Chiller Production Report

Today's Date: 03/03/02

Report Date: 03/01/02

	Chiller Loads					Temperatures (deg F)								Flows (gpm)	
Hour	1	2	3	4	5	CHWS	CHWR	CHW BYPASS	CWS	CWR	OAT	DEW-POINT	REL. HUMID.	CHW BYPASS	CHW LOOP
0	0	0	37	0	0	44	44	45	73	75	35	11	44	-59	1,389
1	0	0	36	0	0	44	44	45	72	74	34	11	44	-59	1,389
2	0	0	36	0	0	44	45	45	72	73	34	11	44	-59	1,389
3	0	0	36	0	0	44	45	45	73	74	34	11	44	-59	1,391
4	0	0	36	0	0	44	45	45	72	74	34	11	44	-59	1,391
5	0	0	28	0	0	45	45	46	72	72	33	11	46	-59	1,391
6	0	0	0	0	0	50	50	51	73	74	32	11	43	-60	1,392
7	0	0	0	0	0	54	54	54	73	74	32	11	44	-60	1,392
8	0	0	0	0	0	55	55	55	74	74	33	12	42	-60	1,392
9	0	0	34	0	0	52	55	54	75	77	36	12	39	-60	1,363
10	0	0	49	0	0	45	48	47	75	78	39	14	36	-60	1,522
11	0	0	44	0	0	45	47	47	78	80	42	15	34	-60	1,444
12	0	0	46	0	0	45	47	47	74	77	45	14	31	-60	1,529
13	0	0	47	0	0	45	47	48	74	78	46	14	28	-60	1,568
14	0	0	48	0	0	45	47	48	75	78	48	13	27	-60	2,171
15	0	0	51	0	0	46	48	49	75	79	49	13	27	-60	2,288
16	0	0	51	0	0	46	48	49	74	78	50	13	26	-60	2,309
17	0	0	51	0	0	46	48	49	76	79	49	12	25	-60	2,301
18	0	0	48	0	0	45	47	48	74	77	48	13	27	-60	2,266
19	0	0	46	0	0	45	47	48	75	78	47	14	30	-59	2,229
20	0	0	46	0	0	45	47	48	75	78	46	14	31	-60	2,205
21	0	0	44	0	0	45	47	48	73	76	45	14	32	-60	2,182
22	0	0	44	0	0	45	47	48	76	79	44	14	33	-59	2,169
23	0	0	44	0	0	45	47	48	72	75	45	13	30	-60	2,177

Figure 16: Report Builder printout 1

Hospital Tower Plant
Daily Chiller Production Report

Today's Date: 03/03/02
Report Date: 03/01/02

	Chiller Loads	Temperatures (deg F)							Flows (gpm)	
Hour	3	CHWS	CHWR	CWS	CWR	OAT	DEW-POINT	REL. HUMID	CHW AHU	CHW LOOP
0	0	58	60	75	74	35	11	44	49	0
1	0	58	60	75	74	34	11	44	48	0
2	0	58	60	75	74	34	11	44	48	0
3	0	58	60	75	74	34	11	44	48	0
4	0	58	60	75	74	34	11	44	48	0
5	0	58	60	75	74	33	11	46	48	0
6	0	57	60	75	74	32	11	43	48	0
7	0	57	60	75	74	32	11	44	48	0
8	0	58	60	75	74	33	12	42	48	0
9	0	58	60	75	74	36	12	39	48	0
10	0	58	61	76	74	39	14	36	49	0
11	39	47	50	81	85	42	15	34	2,629	0
12	43	45	48	81	87	45	14	31	2,809	0
13	43	45	48	82	87	46	14	28	2,815	0
14	46	45	49	82	87	48	13	27	2,810	0
15	46	45	49	81	87	49	13	27	2,810	0
16	47	45	49	82	87	50	13	26	2,805	0
17	47	45	49	82	87	49	12	25	2,804	0
18	45	45	49	81	87	48	13	27	2,801	0
19	44	45	49	81	87	47	14	30	2,799	0
20	44	45	48	82	87	46	14	31	2,800	0
21	44	45	48	81	87	45	14	32	2,804	0
22	43	45	48	82	87	44	14	33	2,798	0
23	43	45	48	81	87	45	13	30	2,803	0

Figure 17: Report Builder printout 2

Notes

References

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