Wi-Fi and VoIP Implementation
For College Hill Presbyterian Church
By
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A Proposal Submitted to
The Faculty of the School of Information Technology
In Partial Fulfillment of the Requirements for
The Degree of Bachelor of Science
In Information Technology

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April 2014
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1. Abstract

With the expansion of the digital age, it became apparent that College Hill Presbyterian Church needed campus-wide network connectivity. The previous topology consisting of three separate access points placed across a campus of five buildings provided little-to-no coverage for patrons and staff. The offices had hardwired network connectivity; however, most of the other buildings lacked this access. Additionally, the majority of the campus is without adequate cell phone coverage due to a high degree of radio frequency interference and inductive building materials. In response, we implemented a campus-wide Wireless LAN service, offering full wireless connectivity to all five buildings. A new Voice over IP system was also integrated into CHPC’s new network in order to compensate for poor cell phone coverage in the area. This system is a hybrid of dedicated VoIP phones and softphones. With these upgrades, College Hill Presbyterian Church can better meet the needs of its members.

2. Statement of Need.

College Hill Presbyterian Church is a community worship center established in 1853. They are located at the corner of Hamilton Avenue and Groesbeck Road in the beautiful neighborhood of College Hill. CHPC’s campus began with one building (the sanctuary) at the church’s inception, but has grown over one hundred and sixty years to include an atrium, ministry center, fellowship hall, and children’s center. As the campus expanded, so did its use of technology. Now, network connectivity across the entire campus appears to be vital for church operations. The following areas were obstacles that we provided solutions for over the course of our senior project.
2.1 Wireless Internet Coverage

Wireless coverage at College Hill Presbyterian was weak and isolated before our networking project was implemented. Three access points were randomly purchased over time and placed in locations that offered minimal functionality. These APs were never designed to cover a campus of five buildings, many of which have multiple floors. They were expected to provide wireless access to those nearby who were in need. In reality, wireless access was restricted to the rooms in which each access point was placed. Some crucial locations, including but not limited to, conference rooms, offices, and the sanctuary had no access to the Internet whatsoever. Many of College Hill Presbyterian’s events, conferences, and services rely heavily on Internet access for videos and music, among other things. Sunday school teachers expressed interest in bringing iPad and laptop connectivity into their lesson plans at the children’s center located in the Barnabas building. Also, the pastor and other church speakers expressed a desire to access multimedia in the sanctuary and perhaps provide online offering services to patrons. With the previous infrastructure they were unable to do so. CHPC was simply unable to provide the quality of service that it desired.

2.2 New Telephony Environment

Cellular phone coverage on CHPC’s campus is spotty at best. Depending on the service provider, connections can range anywhere in strength from moderate to completely unreachable. Most employees felt bound to desk phones in order to make and receive calls. Staff without designated phone lines had to use their cellular devices and hope that they were in a “good spot” when making or receiving calls. Underground facilities, which include offices and conference rooms, are almost entirely disconnected from cell service, and a high degree of radio frequency interference throughout some buildings makes ground-floor cell coverage a gamble. A
significant portion of church staff are at their desks for only a fraction of the day; spending most of their time in other areas of the campus. Altogether, these issues lead to a high volume of missed calls.

2.3 New Data Environment

The previous data environment at CHPC was poorly structured and underutilized. Servers were unlabeled and underutilized due to the spotty Internet access available only to a small portion of the campus. Damaged or unused servers and switches sat unplugged in the server room collecting dust. Most Ethernet cables were unlabeled, meaning wires had to be traced manually in order to find their destinations. From preliminary traces of a few of these lines alone, wires were found to be hanging loosely from pipes or resting upon power lines, which can potentially cause signal interference.

2.4 Security

In its previous state, any user connected to CHPC’s network was able to locate and access the servers on the network. The network provided no role-based separation to prevent guests from accessing internal resources. While sensitive servers may have been password protected, the passwords were simple, and could often be found on sticky notes visibly attached to the servers and keyboards. These are serious security concerns for any type of modern network.

2.5 Expandability

The campus network topology was built and expanded as an afterthought when additional buildings were constructed. Any upgrades or additional maintenance had to be built on top of the existing network while some old portions needed replacing. Reconstructing the network to be ready for any future upgrades or extensions greatly extended its lifetime.
3. Solution

3.1 Course of Action/Solution

We have installed eleven wireless access points across the five buildings within the CHPC campus. Through these hotspots, we provided universal indoor campus coverage for both patrons and employees. The network is now divided into three SSID’s with different levels of security and access. The first SSID is a public network for members and guests solely to connect to the Internet. This network is on a separate VLAN that has no access to internal resources on the church network. As the number of guests on campus can reach well beyond one hundred, this network has been throttled to 1.5 MB/s per user. The second SSID, CHPC Staff, is designated for use by staff laptops and tablets. Our team has removed all of the Cisco access points from the previous wireless network used by staff and created an SSID dedicated for their use only. This network has access to the internal servers and uses a password known only to the employees. Because staff activity takes precedence over the guest network, the CHPC Staff SSID is throttled to 5 MB/s per user. The third SSID is a hidden network designed for use by SIP VoIP clients only. All of the traffic on this SSID is funneled through the Ruckus access point controller to ensure that sufficient quality is maintained. This network also has access to internal resources and is throttled to 5 MB/s. This configuration guarantees a near-seamless transition for the campus staff with minimal technical training.

We also put in place an Allworx VoIP phone system that integrates desk phones and SIP mobile Reach clients. The Reach client allows smartphones to connect over Wi-Fi as softphones. The new phone system has given greater mobility to the staff. It has also lowered the monthly long-distance and international rates the church paid previously. With the voice over IP installation/configuration, issues regarding cell coverage have diminished while employees and
staff are on-site. Calls can be made and received from anywhere on the property, as long as they are within CHPC’s Wi-Fi range. Employees are no longer tied to their desks and instead can answer calls from the Reach app on their smart phones. Even when off-campus, Reach clients can still function over 4G data or local Wi-Fi. Since these systems are new and complex, our chosen vendor, PowerNet Global, is providing on-going training to staff and members.

3.2 Discussion of User Profiles and Design Protocols

The church staff is comprised of teachers, pastors, and deacons, as well as the Finance, Accounting, and Administration teams. Though there are many different roles as a staff member at College Hill Presbyterian Church, all staff members will likely utilize the network in relatively similar manner. Staff will be able to accomplish the following tasks: access the Internet, make and receive VoIP calls, access the file server, and authenticate into the network.

Staff will likely use the network on a daily basis; whereas members will only use it once or twice a week. Guests will use it even more infrequently. Members and guests will have the ability to authenticate into the network and agree to terms of use.
**User Profile Form**

<table>
<thead>
<tr>
<th>Application:</th>
</tr>
</thead>
<tbody>
<tr>
<td>College Hill Presbyterian Access Point and VoIP Install</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Potential Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff of CHPC, church members, and guests</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Software and Interface Experience:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Users should have a basic understanding of Internet and phone usage.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Experience with Similar Applications:</th>
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</thead>
<tbody>
<tr>
<td>Home networks, connecting to a Wi-Fi network.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Task Experience:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Web Browsing</td>
</tr>
<tr>
<td>2. Receiving VoIP calls</td>
</tr>
<tr>
<td>3. Managing the network (securing, monitoring)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency of Use:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Church staff will likely make use of the network every day. Members would likely use it once a week.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key Interface Design Requirements that the Profile Suggests:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Secure internal network for staff</td>
</tr>
<tr>
<td>2. Easy access, open network for members</td>
</tr>
<tr>
<td>3. Allworx SIP mobile phone client</td>
</tr>
</tbody>
</table>
4. Heat Map Diagrams

To decide upon the placement of our wireless access points, our team used a heat mapping tool known as Tamograph Site Survey, created by TamoSoft. This software came highly recommended from PowerNet Global and proved invaluable during the planning phase of our project. With this software and a battery-powered AP, we were able to create visual representations of the signal strength and penetration in locations across the campus that we believed to be optimal. These locations generally offered the most amount of indoor coverage while remaining a short distance from the nearest switch closet. The battery-powered AP was mounted on an extendable pole that could reach the ceiling in order to simulate precisely where the final AP would be mounted. If the placement of a particular access point provided inadequate coverage, we were able to quickly adjust its placement and map out its signal again from a new location.

CHPC only had a floor plan available for the ground level. Basement and second floor levels use this same image, so areas without any signal measurements do not correspond to actual indoor areas on those levels. The preliminary heat mapping is the only exception to this rule. Areas without any measurements in this instance are areas in which no signal was found. Note that larger versions of the following images are available at the end of this document.

4.1 Preliminary Heat Mapping

A floor diagram of just the first floor was taken for this particular survey.
Before any placement testing was conducted, we took a preliminary heat mapping of the existing wireless coverage on CHPC’s campus. There were three existing wireless access points on campus. Two were Cisco small business access points; the third was a Netgear wireless router that had not been properly configured and was interfering with the DHCP server. This router was found hanging by its Ethernet cord from the ceiling in the basement.

The survey showed compelling evidence that the previous access points were not ready to serve any users trying to access the network from beyond the rooms the APs were installed in, let alone the entire campus. Signal barely penetrated through a couple of walls and connections were slow, dropping frequently. The old APs have been removed from the new network, labeled and stored away.

4.2 Predicted Heat Mapping

*Floor diagrams, from left to right: basement, first floor, and second floor.*

The three diagrams in this section were created by placing a test access point in the locations that we felt were optimal. Since we only had one test AP to work with, an individual survey had to be conducted from each location. The individual surveys were later combined into three diagrams and sorted by floor.

The results suggested the proposed wireless topology would provide full coverage to each of the buildings on CHPC’s campus. Tamograph rated most coverage as -55db (light green) or stronger, which is ideal. Our team noted that there were a few areas of -65db (yellow) or weaker
(orange to red). At the time these areas were certainly points of concern. However, it was important to keep in mind two facts:

1.) The test access point we were given was an older Ruckus model that has been replaced by newer models on the market. The current models that were later installed had notably stronger signal strength and range. Utilizing a weaker access point for the initial survey made identifying potential weak points easier to locate visually.

2.) The two weakest areas of the initial survey were located in the sanctuary (top-right) and the Fellowship Hall (bottom-center). These two locations received the ZoneFlex 7982 model access points, which are considerably larger and more powerful than the traditional ZoneFlex 7372 models which were installed throughout the rest of campus. The 7982 models are designed to cover a much broader range and support more users than the 7372. This meant that the weak signal in these areas would be compensated for after installation.

4.3 Implementation Heat Mapping

Floor diagrams, from left to right: basement, first floor, and second floor.

The three diagrams in this section represent the wireless coverage of the final implementation of the wireless access points across campus. This survey shows coverage significantly stronger than what the initial survey predicted. All but one room showed signal strength of -55db (green) or stronger. The balcony (top-right area of floor 2) dipped into the -65db (yellow) range, which is still reliable signal strength. Though our team would prefer better
coverage in this area, the space is rarely used by any significant number church members. Any other areas of the survey that dip below -55db (green) are software-predicted areas of signal strength outside of the buildings. Our final Tamograph survey concludes that the newly installed wireless topography offers complete and reliable coverage to every building on campus.

4.4 Additional Survey Results

The above diagram shows the number of access points that a device is able to connect to in a given area. If there are more APs available in specific area, there is greater potential for load balancing and redundancy. A large portion of campus has five or more APs (represented by dark blue) within reach at any given time. The Sanctuary and Care Center are covered by two APs (yellow), which can still offer some form of load balancing and redundancy. The only areas with access to just one AP (red) are either outside of the building or on the far corners of a few classes.
in the top-left. Users will almost always have more than one AP in their location, which guarantees that traffic in their area will be load balanced, and jumping between APs when they move between spaces will be a seamless transition.

The above diagram demonstrates the theoretical maximum distance that each access point will allow before its connection is dropped due to range, showing that a large majority of the external grounds have coverage in addition to the buildings themselves. These grounds include parking lots and external paths between buildings. Should they need it, staff and guests will be able to work and convene on a majority of the church grounds and remain connected to the wireless network.
5. Technical Elements

5.1 Ruckus Technical Specifications

The hardware requirements for the Wi-Fi network differ from room to room. In the office, the number of users per access point remains fairly consistent. Rooms like the Sanctuary and Fellowship Hall must have the ability to handle large groups (anywhere from 5 to 500) when a conference or large meeting requires participants to have network connectivity. Working with PowerNet Global, our senior project team priced out equipment to meet these requirements.

We decided upon hardware from Ruckus Wireless to implement the WLAN at CHPC. Founded in 2004, Ruckus Wireless is known for creating the first generation of Smart Wi-Fi products that extend the range of signal and actively adapt to changes in environment. Ruckus’ flagship product that we ultimately decided on was the ZoneFlex access point. The ZoneFlex 7982 access point boasts of three stream MIMO 3x3:3, 450 Mbps per radio, and has 6 decibels of signal-to-interference ratio and noise improvement. It also has 15 decibels of interference mitigation. We installed the ZoneFlex 7982 in the Sanctuary and Fellowship Hall because this access point model is capable of supporting an ultra-high user density which we expect to place a heavy load on the network in these areas.

The ZoneFlex 7372 access point is capable of two stream MIMO 2x2:2, 300 Mbps of throughput, 128 unique antenna patterns per band, 4 dB of signal-to-interference and noise improvement, and 15 dB of interference mitigation. This is the access point that was installed throughout the remainder of the campus. Both access points are capable of supporting over 500 users at a time. These APs also have beam-forming technology; they detect the location of devices connected to them and are able to transmit a stronger signal in that direction.
The ZoneDirector 1100 is the access point controller selected by our team and CHPC to control and configure the access points. The ZoneDirector 1100 comes with step-by-step wizards that make configuration easy. It also offers a wide variety of innovative features. Ruckus advertises that this controller can be configured by non-IT staff. With this in mind, now that we have installed and configured the network, Greg Fischer, CHPC’s facilities manager, should be able to maintain and configure the controller without the need for technical support. The controller has the ability to detect when interference is occurring and command the access points to dynamically switch to another channel. It is also possible to set traffic thresholds for specific SSIDs ensuring throughput is purposefully distributed. For instance, setting a threshold on the guest network would prevent guests from using all of the available bandwidth when staff need to connect to make VoIP calls.

5.2 Ruckus Comparison

The Center for Convergence and Emerging Networking Technologies conducted a study in 2012 on the quality of service available from the top distributors of wireless technologies. The study evaluated Aerohive, Aruba Networks, Cisco, Meraki, and Ruckus Wireless. Assessments were completed in Hinds Hall at Syracuse University, home to the School of Information Studies. Before testing, the existing wireless network was shut down, and the environment was tested to ensure there were no radio signals which could cause interference. Equipment from each vendor was put through a series of three tests, and throughput of both 2.4 MHz and 5MHz was measured to determine which vendor had the most reliable equipment. In the first test, throughput was measured between one AP and one client from several locations. As the client moved away from the AP, the throughput of each vendor’s hardware dropped to some degree; however, Ruckus Wireless’ equipment ranked highest of the five vendors.
In the second test, throughput was measured between each vendor’s AP and groups of thirty clients in rooms located at increasing distances from the access point. In this test, throughput dropped as the distance from the access point increased, but the Ruckus ZoneFlex access point still offered the most throughput of all five vendors. Meraki’s equipment completely failed to provide service to one room, located fifty-five feet from the server. Aruba and Ruckus provided the most throughput to the furthest room. But of all the vendors, Ruckus Wireless boasted of dropping the least number of clients during this test.

The third evaluation was considered the most ambitious. In this evaluation, throughput was measured in an environment comprised of multiple access points and multiple clients. This test was designed to measure how well each product could mitigate interference and perform fault tolerance and load balancing. One hundred and twenty clients were placed across four classrooms, with one access point per classroom and two additional access points in nearby empty classrooms. The access points were statically assigned channels to prevent issues with interference caused by channels changing dynamically. Cisco and Ruckus showed the highest throughput when testing all APs and clients simultaneously.

This study demonstrates that Ruckus Wireless’ hardware was able to penetrate much greater distance than its competition. These facts became a major determining factor when we were deciding upon AP manufacturers. (Center for Convergence and Emerging Networking Technologies) Ruckus hardware offers several improvements over comparable Cisco equipment. With Ruckus’ hardware, the access point controller can crash, and all of the access points will still be able to function. High-level features such as interference mitigation might no longer function, but the access points will remain usable. Using Cisco’s equipment, if the access point controller fails, all of the access points fail and become completely unusable. On a Cisco
wireless network, all traffic is funneled through the access point controller, which can potentially be a bottleneck on the network. With Ruckus hardware, the Network Administrator can configure whether or not traffic from the access points is funneled through the controller.

Ruckus’s hardware is designed with a simplistic interface that is easier to configure. We chose Ruckus Wireless because their hardware consistently outperformed those of its top competitors. Also, for the quality of service, Ruckus’s hardware is far more cost-efficient than the equivalent hardware of top competitors.

5.3 PowerNet Global Comparison

PowerNet Global was suggested as an option by College Hill Presbyterian Church. CHPC has utilized their services before, and the company advertises itself as a Christian organization, which is extremely important to the church. Though favored by CHPC, there were several reasons why we chose them as our preferred vendor. PowerNet Global had experience working with other Senior Design Projects from the University of Cincinnati. They also offered pricing options that were attractive to both us and the church. We priced out other competitors such as Cincinnati Bell and Time Warner Cable, but the options we were presented with were limited. For example, Time Warner quoted us with campus wide coverage for $61,200.00 for a three year agreement, but at the end of that deal, CHPC would have to renew their lease or return all of the equipment. PowerNet offers a lease-to-buy options that is about one-third the price of Time Warner’s option.
6. Budget

6.1 Wireless Installation Project

After deciding to use Ruckus equipment, an initial budget was drawn up to accommodate the hardware needs of the initial survey. The following table is a breakdown of the items and costs of the wireless network upgrade installation and configuration.

<table>
<thead>
<tr>
<th>Ruckus Wireless Equipment / Support</th>
<th>Quantity</th>
<th>Price</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZoneDirector 1100</td>
<td>1</td>
<td>$1,337.50</td>
<td>$1,337.50</td>
</tr>
<tr>
<td>ZoneFlex 7982 dual-band Wireless Access Point (3x3:3 streams)</td>
<td>2</td>
<td>$735.00</td>
<td>$1,470.00</td>
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<tr>
<td>ZoneFlex 7372 dual-band Wireless Access Point (2x2:2) streams)</td>
<td>7</td>
<td>$435.00</td>
<td>$3,045.00</td>
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<tr>
<td>PowerNet Global &amp; WatchDog Support (3 years)</td>
<td>1</td>
<td>$1,142.50</td>
<td>$1,142.50</td>
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<tr>
<td>Cabling</td>
<td></td>
<td>$200.00</td>
<td>$200.00</td>
</tr>
</tbody>
</table>

**Total Wireless Project Physical Cost:** $7,195.00

Included in the preliminary budget plan were installation and configuration fees. With our group’s involvement in the project, the following budget section has been made irrelevant. Our team took care of the initial site survey, and handled any installation (including running cable between floors and buildings) and configuration that was necessary.

<table>
<thead>
<tr>
<th>Wi-Fi Site-Survey and Installation</th>
<th>Quantity</th>
<th>Price</th>
<th>Total</th>
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<tbody>
<tr>
<td>Initial site survey</td>
<td>1</td>
<td>$395.00</td>
<td>$395.00</td>
</tr>
<tr>
<td>Access Point Installation / Configuration</td>
<td>9</td>
<td>$85.00</td>
<td>$765.00</td>
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<tr>
<td>Controller Installation / Configuration</td>
<td>1</td>
<td>$395.00</td>
<td>Included</td>
</tr>
</tbody>
</table>

**Total Installation Savings:** $1,160.00
6.2 Voice over IP Installation Project

The voice over IP budget was drafted and approved during fall semester 2013-2014. This budget included the physical devices and supporting equipment, as well as provision of service and configuration. The following table is a breakdown of the items and costs of the VoIP installation and configuration.

<table>
<thead>
<tr>
<th>Allworx Phone System Bundle</th>
<th>Quantity</th>
<th>Price</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allworx 6x Phone System (Bundle Price)</td>
<td>1</td>
<td>$1,595.00</td>
<td>$3,540.00</td>
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<tr>
<td>Call Assistant Software Option</td>
<td>1</td>
<td>$330.00</td>
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<tr>
<td>Conference Center Software Option</td>
<td>1</td>
<td>$330.00</td>
<td>Included</td>
</tr>
<tr>
<td>Mobile Link Software Option</td>
<td>1</td>
<td>$125.00</td>
<td>Included</td>
</tr>
<tr>
<td>Allworx 9212L VoIP phone</td>
<td>10</td>
<td>$250.00</td>
<td>Included</td>
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</table>

<table>
<thead>
<tr>
<th>Allworx Phone System Options</th>
<th>Quantity</th>
<th>Price</th>
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<td>Allworx 6x System upgrade</td>
<td>1</td>
<td>$665.00</td>
<td>$665.00</td>
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<tr>
<td>Allworx 6x 5 Year Maintenance</td>
<td>1</td>
<td>$495.00</td>
<td>$495.00</td>
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<tr>
<td>Allworx 9204 VoIP phone - 4 button (non-programmable)</td>
<td>2</td>
<td>$220.00</td>
<td>$440.00</td>
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<tr>
<td>Allworx 9212L VoIP phone - 12 button (programmable)</td>
<td>15</td>
<td>$250.00</td>
<td>$3,750.00</td>
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<tr>
<td>Allworx 9224 VoIP phone - 24 button (programmable)</td>
<td>1</td>
<td>$267.50</td>
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<tr>
<td>Allworx TX 92/24 24 button expander</td>
<td>1</td>
<td>$100.00</td>
<td>$100.00</td>
</tr>
<tr>
<td>Additional Equipment</td>
<td>Quantity</td>
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<tr>
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<td>----------</td>
<td>---------</td>
<td>--------</td>
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<tr>
<td>Allworx Phone AC Adapter</td>
<td>5</td>
<td>$7.50</td>
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<td>Netgear 24-Port 10/100 Switch with PoE</td>
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<td>$400.00</td>
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<tr>
<td>APC BACK-UPS CS 500VA 120V 6-Outlet</td>
<td>1</td>
<td>$125.00</td>
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</table>

**Total VoIP Project Physical Cost:** $9,820.00

Included in the Voice over IP budget is an installation and training budget. In this case, installation and training will be handled by PowerNet Global.

<table>
<thead>
<tr>
<th>Installation &amp; Training</th>
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<th>Price</th>
<th>Total</th>
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<td>Basic Installation / Configuration Package:</td>
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<td>$1,395.00</td>
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<tr>
<td>- Pre-Install consultation with engineer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Configuration of Allworx PBX + 10 Phones</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- End user training session</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Additional Phone Install / Configuration</td>
<td>18</td>
<td>$40.00</td>
<td>$720.00</td>
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**Total Installation Savings:** $2,115.00

The overall financial figures for our senior design project are calculated below.

<table>
<thead>
<tr>
<th>Total Combined Project Cost:</th>
<th>$17,015.00</th>
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<tbody>
<tr>
<td>Total Combined Project Savings:</td>
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</tr>
</tbody>
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7. Gantt Chart

The following Gantt chart was established in order to ensure that all deliverables were met within a reasonable time frame, and that they have been properly configured and integrated into existing systems.

7.1: Man-Hours

A total of roughly 750 hours were put into this project. Of those hours, 150 were dedicated to preliminary planning, initial surveying, and meeting and collaborating with vendors and church officials. The remaining 600 hours were spent on installation, configuration, and testing.
8: Recommendations

The wireless install has opened many new doors for the church to explore. Our project team has offered CHPC staff numerous suggestions that could further improve the usability and functionality of the wireless network. A few suggestions include:

- Installing wireless cameras throughout the campus. Currently, there are only a select number of cameras located in the atrium area. They are hard-wired to the security server located there, and were only able to be installed as far as cables could be run practically. With a secure, reliable wireless network, new cameras can be installed to cover all of the entrances to every campus building, as well as in sensitive areas such as server rooms or financial offices. This would provide a higher degree of physical security for both the network and the church as a whole.

- A campus-wide paging system could be integrated using either wireless connection, or via connections to the newly-implemented switches. This way, important messages could be broadcast throughout the entire campus. Medical emergencies and security concerns are not uncommon events at the church, so a new paging system could prove to be greatly beneficial.

- With Internet access now provided to the sanctuary, the projectors and audio/video equipment can be used to a much greater capacity. Online church-related literature, songs, and videos can be brought in to services instantly. Additionally, much of the equipment has online features that can now be utilized.

- SharePoint was provided to the church a number of years ago. It has since gone unutilized due to a lack of network usage and understanding among staff with regard to the abilities of SharePoint. With the new network in place, it would be beneficial to receive training on the benefits and proper utilization of SharePoint. The interface could also be customized to maximize comfort and ease-of-use in a church environment.
REFERENCES

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Additional Image Resources

Before and After Network Diagram

Before

The Internet

Cincinnati Bell DSL Modem

Cisco Firewall

Switch

Fiber connection

AD and File Server

Ministry Center (Church Office)

Barnabas Center

HVAC Server

Care and Outreach Office

After

The Internet

Time Warner Cable Modem

Switch

Fiber connection

9 VoIP Phones

AD and File Server

Ministry Center (Church Office)

Barnabas Center

HVAC Server

Care and Outreach Office

4 AP’s

Zone Director

4 AP’s

AP
Previous Wireless Survey: Floor 1
Proposed Wireless Solution: Floor 1
Final Wireless Solution: Floor 2
APs in Area
Theoretical Maximum Distances
Miscellaneous work photos