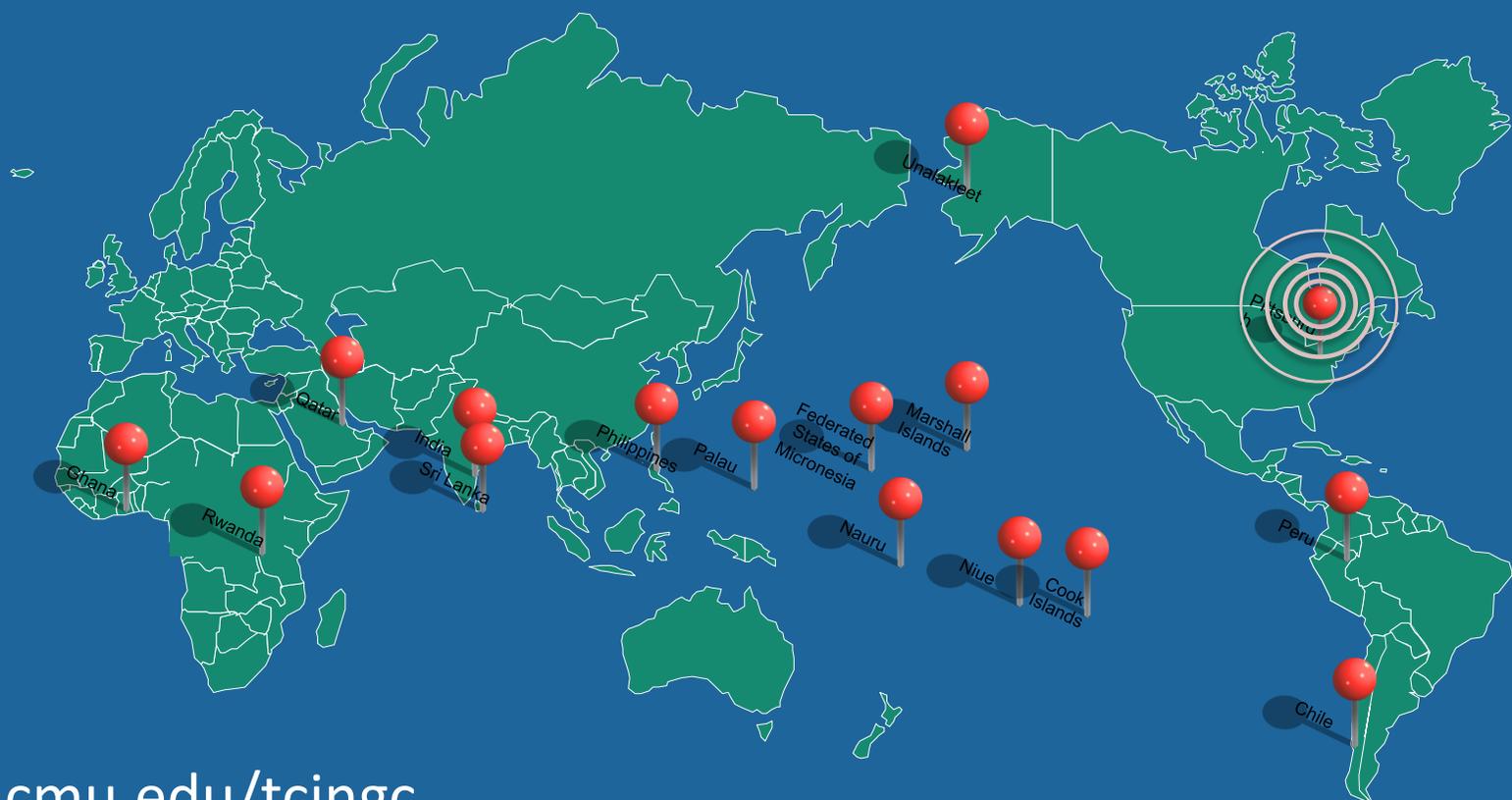


TECHNOLOGY CONSULTING

IN THE GLOBAL COMMUNITY

Final Consulting Report
Palau Community College
Fachry Rozy Oemar
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Carnegie Mellon University





Final Consulting Report

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I. About the Organization

Organization

Palau Community College (PCC) is located in the heart of Koror State of Republic of Palau. The country itself was part of Micronesia, which was administered by the United States after World War II during (1955 – 1994) as Trust Territory of the Pacific Islands. Among other countries in Micronesia, Palau is the last portion of the Trust Territory of the Pacific Islands to gain its independence. In October 1994, Republic of Palau entered Compact of Free Association with the United States that concludes Palau's transition from trusteeship to independence.

PCC's development represents the long history of Palau and it clearly reflected through out evolution of the organization. Initiated from a trade school that had its beginning in 1927 during the Japanese administration prior to World War II, known as Mokko School, the school then changed into several names such as Intermediate School – Palau District (1948 – 1955), Palau Vocational School – Palau District (TTPI) (1955 – 1969), Micronesian Occupational Center (TTPI) (1969 – 1977), Micronesian Occupational College (COM) (1978 – 1993), and finally become Palau Community College in 1993 up until present time.

PCC is persistently improving itself to become an independent college serving Micronesia. By strongly believing that education is the key to success and learning is a lifelong process, PCC clearly defined its mission to become

an accessible public educational institution helping to meet the technical, academic, cultural, social, and economic needs of students and communities by promoting learning opportunities and developing personal excellence.

PCC provides general education to give each student an opportunity to develop an integrated overview of diverse fields of human knowledge. The students are expected to become aware of skills and knowledge required to comprehend the changing world while acquiring basic principles and concepts that are part of different disciplines. Furthermore, PCC also provides education to enable students to cope with changing societies and also to prepare those interested in pursuing higher level of education beyond PCC.

During Fall 2012, there are 680 students are enrolled in different programs offered by PCC whereas 149 of them are first time students. The number of total students enrolled are slightly lower from

previous year with 742 students were enrolled in Fall 2011. The number of enrollment might be affected from number of scholarship offered so as local policy defined by other local government in some areas outside Palau.

PCC always looks to expand its programs and services as part of its effort to improve student success. In relation with that, PCC has maintained its accreditation since 1977 (initially since its name still as Micronesian Occupational Center) until present time by the Accrediting Commission for Community and Junior Colleges (ACCJC) of the Western Association of Schools and Colleges (WASC).

PCC's employees come from Palau and others may come from different islands in Micronesia. There are also some faculty members from other countries, which are assigned to particular programs or services that have been granted or hosted at PCC.

In order to maintain and enhance its programs and services, PCC tries to effectively and efficiently manage their income that came from several areas. As per fiscal year of 2012, PCC has operating budget of \$7,456,995.30 as follow details:

a. Tuition Fee	: \$2,369,816.30
b. Room	: \$ 79,191.00
c. Board	: \$ 211,366.00
d. ROP Contribution	: \$2,656,200.00
e. Restricted Appropriation	: \$ 877,112.00
f. Sale of Service	: \$ 444,023.00
g. <u>US Federal Funds</u>	: \$ 819,287.00 +
TOTAL	: \$7,456,995.30

In addition, PCC established the PCC Endowment fund that has been authorized and signed under The Republic of Palau Public Law 4-50 on May 29, 1996. The amount of fund continues to increase from \$132,273 in 1998 to become \$2,050,000 as of September 2011.

The enhancement of vocational education and services offered by PCC also effected by other factors such as a growing political awareness, development in states among Micronesia, and a strong commitment from the United States of America to accelerate Palau's education and economic development by.

In term of technology usage, PCC persistently tries to improve its network-computer environment to support its students, faculties, staff, and other business units within the college. It is clearly defined in one of its Technology Plan goals, PCC is looking to upgrade their existing college network to minimize congestion and improve network speed. This is to provide solid support of technology especially Internet connection as PCC enhances the learning process of its students through Distance Learning and Online courses. PCC also hosts a research center that invites international researchers to help local people of Palau regarding Agriculture, Natural Resources and Environment, Family and Consumer, and Expanded Food and Nutrition. Thus, connectivity to international community is strongly needed to support the college establishment. In this case, only a single semi government company, Palau National Communications Corporation (PNCC) who provides Internet connection in Palau area with relatively fair speed of access but expensive cost of service. In addition, PCC need also to improve its capability to manage and utilize its technology resources so as to use in most effective and efficient way to support PCC's mission.

Facilities

PCC is the only school of higher education in the nation. It lies on the area of 67,442 square meters, which is located in downtown of Koror State close to the business area. In general, the area of PCC may be grouped into three groups: Class rooms and Faculty area, Workshop area, and Dormitory area (See Figure 1). Further details of the buildings area are as follows:

1. Class Rooms and Faculty & Staff Area including:
 - Ukall Building
 - Miich Building
 - Dort Building
 - Ksid Building
 - Btaches Building
 - Tan Siu Liu Library Building
 - Baderirt Building
 - Dadait Building
 - Rriu Building
 - Urur Building
 - Temekai Building
 - Meluis Building
 - Sebus Building
 - Smuuch Building
 - Tekrar Building
 - Demul Building
 - Esuch Building
 - Tutau Building
 - Belochel Building
2. Workshop Area
 - Keskas Building
 - Tekuu Building
3. Dormitory Area
 - Biib Building
 - Olik Building
 - Laib Building
 - Kedam Building

Programs

PCC currently offers Certificate of Completion, Certificate of Achievement, Associate of Science, Associate of Applied Science, Associate of Technical Studies, and Associate of Arts Degree within three (3) major of schools: School of Arts and Sciences, School of Business Education, School of Technical Education.

School of Arts and Sciences offers seven (7) departments as follows:

- a. Agricultural Science (AG)
- b. Criminal Justice (CJ)
- c. Education (ED)
- d. Environmental/Marine Science (ES)
- e. Library and Information Services (LS)
- f. Liberal Arts Program (LA)
- g. Nursing Career Ladder (NU)

School of Business Education offers five (5) departments as follows:

- a. Business Accounting (BA)
- b. Business Administration (BU)
- c. Information Technology (IT)
- d. Office Administration (OA)
- e. Tourism and Hospitality Program (TH)

School of Technical Education offers nine (9) departments as follows:

- a. Air Conditioning & Refrigeration (AC)
- b. Automotive Mechanics Technology (AM)
- c. Construction Technology (CT)
- d. Electrical Technology (ET)
- e. Automotive Mechanics Technology (AM)
- f. Construction Technology (CT)
- g. Electrical Technology (ET)
- h. General Electronics Technology (GE)
- i. Small Engine and Outboard Marine Technology (SE)

In addition, PCC also offers Community Programs in forms of several programs such as:

- a. PCC Adult High School Program
The program supports adult Palauans to gain a high school equivalent diploma, preparation to continue on to higher education, so as to learn valuable occupational skills needed for employment. One of the skills offers in the program is Computer Literacy in which combine with others academic and occupational skills instruction.
- b. PCC Continuing Education Program
The program is not supported by federal funding and designed based on specific requests made by individual or groups. It is a non credit-program that may be delivered in form of workshops, seminars, one-on-one advising, counseling and or summer programs such as keyboarding, computer application and Internet exploration.

- c. Cooperative Research & Extension Program
The program collaborates with partners and community partners to generate, develop and disseminate practical and sustainable technologies and knowledge in agriculture, aquaculture, environment, food and human sciences to benefit people in the country.
- d. Operations and Maintenance Improvement Program (OMIP)
The program was designed to provide a short-term training program to up-grade government employees' competencies in the area of infrastructure operation and maintenance.
- e. TRIO Programs
The program is funded by United States Department of Education that hosted by PCC since 2002. TRIO includes eight (8) programs that owed to the passing of the Higher Education Act of 1965. TRIO was given its name because it started as a group of just three programs. In PCC, it is being delivered in form of:
 - Educational Talent Search
The program hosted by PCC from 2002 to 2016. It is to identify and assist individuals with disadvantage economic background that potentially succeed in Higher Education, complete High School and attain College Education.
 - Upward Bound Program
The program assist high school students to develop skills, knowledge, attitude and motivation needed to enroll and continue their study in college once they graduated from high school.

In order to support its students and faculty, PCC also provides services as follows:

- a. Admission Requirements & Information
PCC use EdExpress to handle admission process including financial aid for students.
- b. Registrar Office & Student Records
PCC use FxScholars to handle registration, student records, and evaluation of transfer credits and retention of students.
- c. Financial Aid Information
PCC organize scholarship, grants, and part-time employment to help students with educational expenses. As per financial year of 2011 – 2012, PCC earns in total of \$3,478,663 that are available either from federally funded (98.32%) or non-federal funds (1.68%).
 - Federal Fund
Federal Pell Grant (FPG), Federal Supplemental Educational Opportunity Grant (FSEOG), Federal Work-Study (FWS), and Student Incentive Grant (SSIG).
 - Non Federal Fund
PCC Grant-In-Aid, College Work Opportunity (CWO)
- d. Housing & Facilities
- e. Student Life
- f. Counseling
- g. Learning Resource Center
- h. Library (Tan Siu Lin Palau Community College Library)

PCC provides Library service to support academic programs with totaling over 30,000 collections. The library serves as a community resource that opens to everyone in Palau. Therefore, it also offers Library Online Catalog (Palau Union Catalog) that link with other libraries such as Elementary School libraries, Palau Public Library, Belau National Museum (funded by The Institute of Museum and Library Services (IMLS)) and Palau International

Coral Reef Center. The library also act as Republic of Palau's official depository library for all publications issued by Secretariat of the Pacific Community (SPC), United Nations (UN), World Health Organization (WHO), Food and Agriculture Organization (FAO), United Nations Education, Scientific and Cultural Organization (UNESCO).

Staff

The PCC has several business units that coordinate service to the community (See Figure 2). There are 132 full time employees (32 Faculty and 100 Administrator / Staff) and 45 limited term employees (10 Faculty and 35 Administrator / Staff) currently working at PCC. Most full-time faculty (78%) have a Bachelors, Masters, or Doctorate. In addition, more than half of them are Palauan while others are Filipino, American, FSM, Japanese, Slovak and Taiwanese. Most of the staff are relatively proficient in using Microsoft Office for administration, mostly Word, Excel, while some of them have regularly use specific applications (i.e. FxScholars, Destiny, EdExpress, and Moodle) based on their job functions. In this project, student consultants directly work with the Computing Service, who is responsible in delivering most of computer service in PCC. The unit has three (3) staffs as follows:

- **Bruce Rimirch – Director of Computer & Data Processing**

Bruce is a full time employee with under Bachelor of Art degree from Asbury College in 1986. He is responsible to manage and maintain servers and network infrastructure of PCC. He is proficient with either UNIX Operating System such as Red Hat Linux and Fedora as well or Windows platform such as Windows Server 2003 and 2008. He implements existing landline and wireless network both for internal and external that links most of computer devices (desktop and laptop) with LAN and Internet service.

- **Grace Alexander – System Analyst**

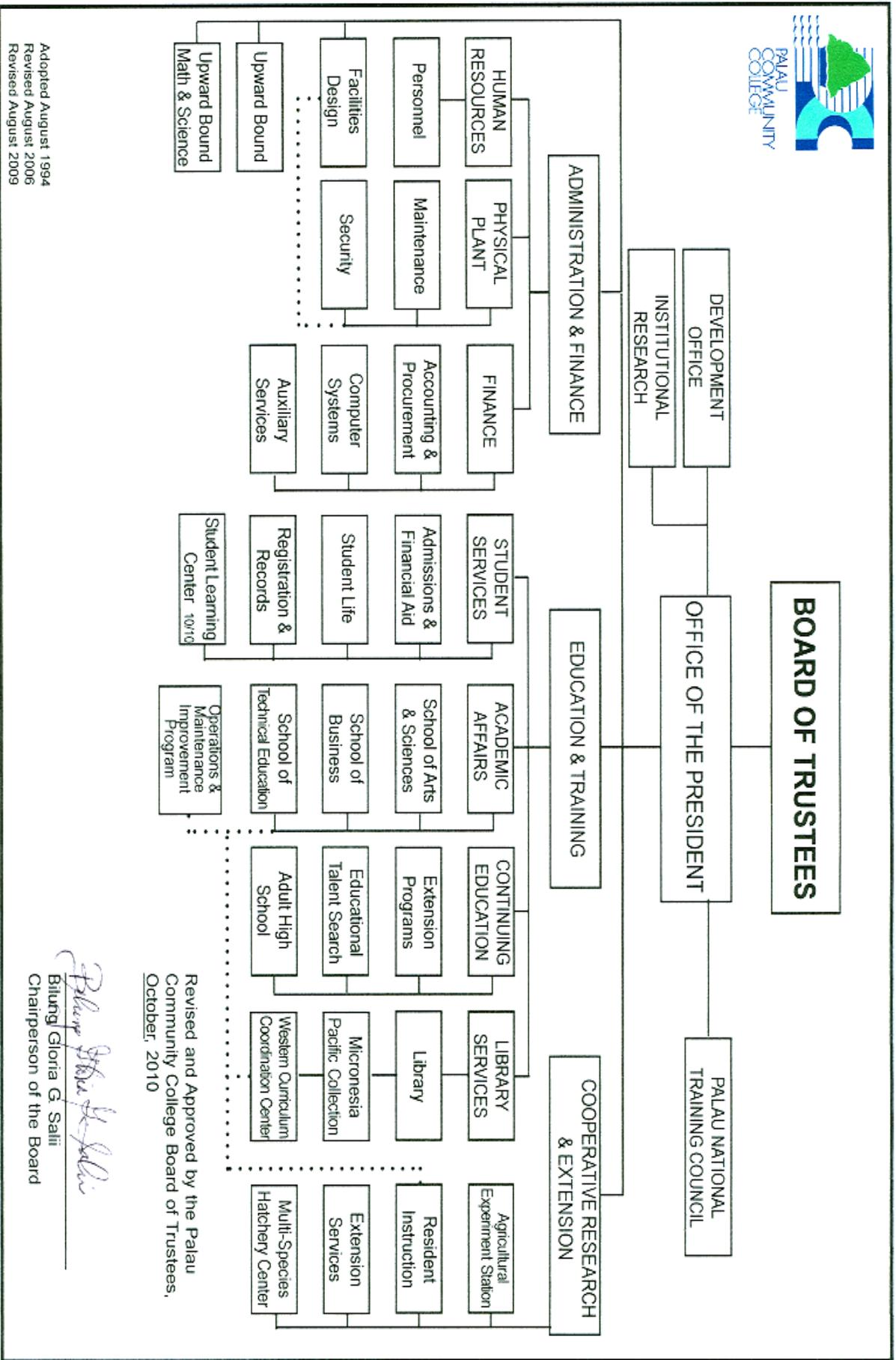
Grace is a full time employee with Bachelor of Science degree from Northern State College in 1985. She developed the current web site of PCC (www.palau.edu) and maintaining its information to be updated both for internal and external usage. She organizes any incoming calls re technical problem and coordinate with other staff to provide soonest assistance.

- **Evan – Technical Support**

Evan was a PCC Student with Associate of Science Degree for Information Technology under School of Business. He is currently taking another degree for Liberal Arts under School of Arts & Science and expecting to graduate by next Fall 2013. Evan is responsible as a 'runner' to provide technical support assistance directly to users while coordinating with Bruce and Grace at Computing Service room.

Bruce and his staff at the Computing Service responsible to maintain at least seven (7) network file servers including Windows 2003, 2008, and UNIX based server that run on Hewlett Packard and Dell Servers (Desktop and Rack). Moreover, they also also responsible for managing at least six (6) different DSL Lines to provide Internet service for every business units and its user. There are more than 40 computers connected to the network through landline, and at least 100 users connected through Wireless Access Points (WAP) around the campus area.

The existing local network is build by connecting several Layer 2 Switches and Hubs between rooms and buildings, which in some area it is expanded through WAP due to constraint of building locations and un predictive relocations of users and business units.



Adopted August 1994
 Revised August 2006
 Revised August 2009

Revised and Approved by the Palau Community College Board of Trustees, October, 2010

Bilung Gloria G. Sali
 Bilung Gloria G. Sali
 Chairperson of the Board

Figure 2 – PCC's Organizational Chart

Technology Infrastructure

Most of business units in PCC have been supported by fairly latest technology infrastructure i.e. PC Desktop, Desktop and Rack Mounted Servers, Wireless Network and Client – Server Application either running on top of Open Source (i.e. Fedora, etc.) and Licensed (i.e. Windows Family) operating system.

PCC currently has no solid network backbone to connect the area. In addition, there is a land contour constraint as the college lies in hilly area. However, PCC manage to establish a Local Area Network (LAN) that continuously expanding based on user request whereas each building in the area is connected through Category 5 cabling for landline using switches, hub and wireless access point that runs on 100 Mbps. The network currently managed to connect approximately 85% Desktops and Notebooks, while 15% stand-alone computers are without network connections.

There are currently four (5) main server-based applications uses in PCC, namely Sage IMP, a Financial Accounting System uses by Business Office unit, EdExpress uses by Admission and Financial Aid, Destiny software uses for Library Administration & Community, FxScholar application to provide admission and registration process, and Moodle Software Package specifically used for Distance Learning and Online Courses. Further details of PCC’s hardware infrastructure are as follows:

- PC Desktop

PCC currently use different types of PC Desktop from different sponsors. Some of the latest PC Desktops are equipped with Wireless Card, while some others only have Ethernet Card. Only few of them do not have any network card installed.

Table 1 – PC Desktop Inventory

<i>No</i>	<i>Item</i>	<i>Type</i>	<i>Percentage</i>
1	PC Desktop	With Network Card	85%
2		No Network Card	15%
TOTAL			100%

Source: PCC’s Computing Service – June 2013

- Network

The Computing Service on behalf of PCC currently managed six (6) different lines of DSL with various speeds of bandwidth from the only ISP (PNCC) at Palau. The reason is because different sponsor (i.e. US Federal, US Education, CRE, and IMLS – Australian Government) funds some of the DSL lines, which are separate from PCC’s regular operational budget. Therefore, the lines would only be use for that specific program and cannot be share with other users from different program. With current set up of subscription, PCC would be able to save budgets of \$4,748.4 a year for those six (6) lines compare if PCC subscribe a single line with the same number of bandwidth (See Table 3). Furthermore, there is a benefit of this set up as PCC will get six (6) IP Public for those lines compare to one (1) IP Public, which those can be utilize for external access to their network. In addition, Computer Service staffs can also switching users from one DSL Line to another when it is needed (i.e. high traffic, testing applications)

Table 2 – PCC’s DSL Lines

<i>No</i>	<i>DSL Line</i>	<i>Sponsor</i>	<i>Bandwidth</i>	<i>Monthly Fee</i>
1	Talent Search	US Federal	128 Kbps	\$379.95
2	TRIO	US Education	192 Kbps	\$529.95
3	Distance Learning	PCC	192 Kbps	\$529.95
4	Tan Siu Liu Library	Australian Gov. & IMLS	256 Kbps	\$659.95
5	Admin & Financial Aid	PCC	256 Kbps	\$659.95
6	PCC Administration	PCC	320 Kbps	\$759.95
TOTAL			1,344 Kbps	\$3,519.70

Source: PNCC and PCC’s Computing Service – June 2013

Table 3 – Yearly Cost Comparison for DSL Lines of 1,344 Kbps

<i>No</i>	<i>Cost Item</i>	<i>6 DSL Lines</i>	<i>1 DSL Line</i>
1	Installation Fee (1x)	6 x \$105.00 = \$630.00	1 x \$105.00 = \$105.00
2	Subscribe Fee per Year	12 x \$3,519.70 = \$42,236.4	12 x \$3,959.15 = \$47,509.80
TOTAL		\$42,866.40	\$47,614.8

Source: PNCC and PCC’s Computing Service – June 2013

In order to provide network connection in the college area, PCC use several devices to build their network as follow details:

Table 4 – PCC’s Network Devices Inventory

<i>No</i>	<i>Item</i>	<i>Type</i>	<i>Quantity</i>
<i>DSL Router</i>			
1	DSL Router (PNCC)	DSL 128 Kbps (US Federal)	1 Line
		DSL 192 Kbps (US Education & PCC)	2 Lines
		DSL 256 Kbps (IMLS & PCC)	2 Lines
		DSL 320 Kbps (PCC)	1 Line
TOTAL			6 Lines
<i>Switch Device</i>			
2	Access Switch – Layer 2 (Manageable)	Cisco – SG200 (8 Port)	2 Units
		Cisco – SG200 (26 Port)	2 Units
		Cisco – SG300 (10 Port)	4 Units
		Cisco – SG300 (20 Port)	3 Units
		SWR2016 (16 Port)	8 Units
		SWR2024 (24 Port)	3 Units
		Netgear FS750T2 (48 Port)	1 Units
3	Switch & Hub (Unmanageable)	N/A	7 Units
TOTAL			30 Units

**Table 5 – PCC’s Network Devices Inventory
(Continued)**

<i>No</i>	<i>Item</i>	<i>Type</i>	<i>Quantity</i>
<i>Firewall Device</i>			
4	Appliance	SonicWall 240	2 Units
		SonicWall 250N	3 Units
5	Software	Linux Firewall	1 Unit
TOTAL			6 Units
<i>Proxy Device</i>			
6	Appliance	N/A	5 Units
7	Software	Squid Proxy	1 Unit
TOTAL			6 Units
<i>Wireless Device</i>			
8	Wireless Access Point	DAP 2553AP	3 Units
		DWL 7100AP	15 Units
TOTAL			18 Units
<i>Network Monitoring</i>			
9	Software	Nagios	1
TOTAL			1

Source: PCC’s Computing Service – June 2013

- Server

In order to support its operational activities, PCC use several applications installed in their servers for different units as follow details:

Table 6 – PCC’s Server Inventory

<i>No</i>	<i>Type</i>	<i>Application</i>	<i>Quantity</i>
1	<i>Desktop Server (DELL – ProSage Family)</i>	Website & Mail Server	1 Unit
		Sage MIP (Finance)	1 Unit
		Moodle (Distance Learning)	1 Unit
		Destiny (Library)	1 Unit
		Ed Express (Admission & Fin. Aid)	1 Unit
2	<i>Rack Mounted Server (DELL – ProSage Family)</i>	FxScholars (Registration)	1 Unit
		Back Up Storage	1 Unit
TOTAL			8 Units

Source: PCC’s Computing Service – June 2013

- Operating Systems (OS) and Software

Most of PC desktop uses by PCC’s users are running on top of Windows platform, while most of the servers using Open Source OS from UNIX platform (i.e. Fedora) and only few of them using Windows Server (i.e. Windows Server 2003 and 2008). The Computer Service staff subscribes to several Open Source OS’ community that allows PCC to get update release of respective Open Source OS. Furthermore, PCC always use licensed software including for their administration (i.e. Microsoft Office, etc.) and Anti Viruses.

Table 7 – PCC’s Operating Systems & Software Inventory

<i>No</i>	<i>Item</i>	<i>Type</i>
<i>Operating System</i>		
1	Windows Family	Windows XP
		Windows Vista
		Windows 7
		Windows Server 2003
		Windows Server 2008
2	UNIX Family	Fedora
<i>Software</i>		
1	Administration	Microsoft Office
2	Design	Adobe Photoshop
		Adobe InDesign
		Adobe Illustrator
3	Anti Virus	Avira

Source: PCC’s Computing Service – June 2013

In relation with PCC’s technology infrastructure, there are several issues needs to be considered in order to improve technology utilization in the college:

- PC Desktop
 - ✓ Some of PC Desktop in PCC does not equipped with required specification to make network connection either through Ethernet or Wireless due to not having network card.
 - ✓ There is no standard specification of PC Desktop defined by PCC for students or faculty use. In addition, most of PC Desktops in PCC are coming through different funding source, which may have different agreement and standard of minimum requirement of technology infrastructure needed.
 - ✓ There is no inventory that is being updated regularly re active PC Desktops use in the college. In this case, the Computer Service staff has initiated to explore an open source inventory tools called GLPI, thus we may suggest PCC to use it and urge them to update their inventory status regularly.
- Servers
 - ✓ There is no standard specification of Server (Desktop or Rack Mounted) defined by PCC either for application (i.e. Web Server, Mail Server) or business process (i.e. Finance, Registration, etc.) use in college. In addition, some Servers in PCC are having various specifications due it came along to support different applications as part of funding or grant

package from various sponsors. Each of the applications has different minimum requirements of server's specification and PCC has to follow those requirements to run the application.

- ✓ PCC does not have redundant resource to support main servers. Moreover, some different application servers are host within a same machine server without using Virtual Machine Server (i.e. Web Server and Mail Server). Therefore, if there is a technical problem occur in one of the application, it will effect another application that is being hosted in the same physical machine.
- ✓ PCC need to update their servers inventory in the inventory tools in order to manage and maintain their servers appropriately. In this case, there is an idea to move all of the server applications from desktop to rack mounted design so as to save spaces in the Data Center. However, the decision is also depend on the sponsor's preference that provides the minimum requirement of technology infrastructure for the particular project.
- Sharing Storage
 - ✓ Some groups of users (i.e. Finance, Administration, Registration, etc.) are expecting to have sharing storage of their files to support their daily operational activities. In this case, the Computer Service Department may utilize some hard drives to create a pool storage that can be allocated to several groups of users based on their job functions.
- Internet Service Provider (ISP)
 - ✓ Currently there is only PNCC who serves entire area in Palau with fair speed and unstable connection. Therefore, any users could only rely on services provided by the ISP to connect them to Internet. Moreover, the cost to subscribe the services is very expensive compare to bandwidth's speed provided by the ISP. However, specifically for Internet connection through WAP, there is a Taiwan ISP called PMC who also provide Internet Service but limited only at certain area in Palau.
- Network Backbone
 - ✓ PCC currently does not have a solid network backbone to connect all of the users within the college area. The use of network backbone is very important to improve capability in expanding the network range while keep them in manageable administration. However, there are some considerations need to be account such as cost constraint in PCC's operating budget and availability of provider or constructor of such backbone works in the island. Furthermore, currently there is no Fiber Optic network available in Palau, which is one of the important elements in building a network backbone within an extensive area like PCC.
- Switches & Hub
 - ✓ Most of switches that build PCC's network are Layer 2 Switches, which supposed to be used as Access Switch instead of Core Switch or Distribution Switch. Therefore, PCC need to provide some Layer 3 Switches for its Core or Distribution layer and shift all of their Layer 2 Switches for Access layer. These switches would be very important in building a solid PCC's network backbone that is reliable and manageable to accommodate any network extension needed in the future.
 - ✓ PCC currently use default configuration available in their switches to build their LAN. There is an opportunity to improve existing network's security and management by re organizing its sub netting and use of VLAN and Trunking method in the network switches.
 - ✓ PCC does not have a standard network topology to map their existing network infrastructures. Even though they already use an open source Network Monitoring called

Nagios, but it would be great for them to have a standard network diagram that can be produced by using a Network Diagram Tool (i.e. Microsoft Visio, etc.) The diagram would be very useful for them to map and manage their network once there is an expansion or relocation occur in the college area.

- Wireless Access Point (WAP)
 - ✓ PCC uses different type of WAP to connect users in their network by registering MAC address of users' network card. Each user will be assigned to an IP address that is attached to the MAC address so as to connect them to PCC's LAN and Internet.
 - ✓ Some of its WAP need to be replaced with higher specification WAP so as to cover wider range and accommodate growth number of users connected through wireless network. There should be more WAPs available to reach some areas that are not feasible to be connected through cable line due to location constraints.

Technology Management

The technology implementation in PCC refers to PCC's Technology Plan that is annually reviewed and updated to ensure it is align with latest technology around. PCC has a Department of Computer and Data Processing who is responsible to manage almost all of technology infrastructure on campus. The department currently has three (3) staff including its Director, Bruce Rimirch, which the office is known as Computing Service. The office has become a single point of contact for any issue related with technology infrastructure, including management, installation, configuration, back up data, technical support and maintenance. They are also responsible to log every incoming issue but sometimes they overlook the log due to insufficient resource of people that already full hand with solving problems at users side. The Computing Service staffs solve most of problems whereas Bruce is mostly responsible for any issue related with networking and server, Grace is mostly responsible with website and software installation and Evan is mostly responsible to provide technical support directly to user side.

The Computing Service staffs regularly backing up some critical data i.e. Finance, Registration, Admission, Financial Aid and Library. They do back up all data to tape, external drive and other hard drives in daily, monthly and yearly basis. In this case, the yearly back up is kept for every 5 years period. In addition, some business units i.e. Admission and Financial Aid office do the daily back up by them self to external drive. The Computing service subscribes online update of virus definition configured in the network security device (i.e. Firewall and Proxy). However, they only updating software for daily administration use (i.e. Microsoft Office) based on need and request from users.

In order to update technology use in PCC, the Department of Computer and Data Processing mostly refer to the PCC's Technology Plan where some goals have been defined and need to be achieved in yearly basis. Most of the devices are purchased as planned in the Technology Plan while some of them may need to be obtained due to ad hoc for specific funding project.

Technology Planning

PCC currently has a Five Year Technology Plan as a framework to sustain technology enhancement that will support and promote the mission of the college. The plan is annually reviewed and updated by Technology Resources Committee (TRC) that coordinates campus-wide Computer. The TRC is

comprised of management, faculty, staff and a student leader for the Student Body Association. The plan will be used as a based to set budget or allocating PCC's information technology resources. Furthermore, the plan will act as a strategic direction that provides standards, guidelines and procedures needed to effectively implement and adopt information technology usage on campus.

Latest major goals of PCC's Technology Plan for period of 2013 – 2018 are as follows:

1. Secure funding for college technology

This goal includes some carried over tasks from previous plan such as continue to inform college community re technology need request and new added task such as monitoring technology budget.

2. Acquire software with legal license for the college use

This goal includes some carried over tasks from previous plan such as identifying needed software through annual surveys, research and make use of free or open source software and use educational discounts for any purchased software. Some new added task related with licensing, maintenance, support and upgrade fees for software used by students, faculty or staff.

3. Upgrade college Local Area Network (LAN)

This goal includes some carried over tasks from previous plan such as upgrade and network devices to improve its capability, increase campus network wide by increasing speed and number of DSL lines used in the college so as to look for network designer to design and install a solid college wide network backbone. In addition, some new tasks have been added such as involving TRC in planning process of new building and or relocation within the campus and provide training for technical support staff to overcome any issue and maintain campus' network.

4. Establish replacement of hardware on a systematic cycle

This goal includes some tasks such as upgrading and replacement of existing servers with its supporting facilities (i.e. Power Surges, etc.) that has been doing for every year.

5. Increase technology support

This goal includes some new added tasks such as providing support for web-based conferencing and back up process for existing application servers of Library, Online Lab and Specialized Program (i.e. Talent Search, Upward Bound, etc.) In addition, hiring more skillful computer technician and providing the library with more advance technology support are some of the carried tasks that still aligned with the goal.

6. Support distance education activities

This goal includes new added tasks such as aligning the distance-learning program with accreditation standards while monitoring online budget for distance education activities. Furthermore, the goal also includes regular backup and maintaining or upgrading dedicated IT resources to support online courses program. PCC currently use Moodle software to establish the online course for its students and keep on updating its support staff on using it.

7. Implement online registration for all students

This goal includes new added tasks such as exploring possibility to use an open source online registration (i.e. Quali Need Finance module for centralization) while keep on maintaining and upgrading dedicated server with its OS of Registration and Advising software.

8. Maintain an IT laboratory classroom

This goal very much related with carried out tasks such as upgrading IT resources at Library and controlling Internet connection at Library's computer lab.

9. Provide adequate technology training for appropriate personnel

This goal is related with the process of identifying and conducting appropriate trainings for faculty & staff. The trainings are defined based on the analysis of annual surveys conducted to student, faculty and staff.

10. Asses technology plan and equipment

This goal is related to regular assessment to monitor, review and update technology plan and equipment which done through surveys or direct assessment to IT resources used by faculty, staff and students.

Internal & External Communication

PCC use a domain of www.palau.edu to communicate with public through its website. The website has two versions, that is for internal users and for external users. The external version mostly uses for promoting PCC's program and on going project takes place in the college, so as to attract both candidate students and potential clients or sponsors. PCC use the internal version to disseminate any confidential information that is provided only for internal use. PCC also provides email account using the same domain to support operational activity of its faculty and staff. The website and mail domain are manage by the Computing Service staff including website's content and email account management. Both are currently running on the same physical server but set in separate port to access each of their services (Website is using Port 80 while Email is using Port 25). In addition, faculty and staff are currently not able to use Skype or accessing YouTube due to limited bandwidth available in the college.

In regards of PCC's web and mail server, there are some accessibility issues experienced by users. Some users complaining that the web site is hardly to be open from outside Palau especially when they need to open or download some information or documents available in the website. Moreover, users are having difficulty to access their PCC's email account through Internet line. This has become one of the main concerns of users in PCC that urgently needs to be resolved to avoid further held back to the operational activities in college community.

Once in the end of each year, PCC held an event gathering called PCC Thanks Giving Endowment Fundraiser to meet and acknowledge all the funders, donors, and clients that are consistently support PCC. Some of the regular funders that have been very supportive for long time received PCC's recognition during the event. In order to maintain the relationship with the funders and donors, PCC has assign the task to Development Office that will pro actively seek and maintain communication to secure as much funding as they can get only to support PCC's development. For

the last thirteen (13) years, PCC manage to maintain a growth trend of endowment funds from \$132,273 in 1998 to become \$2,050,000 as of September 01, 2011.

Information Management

Each business units has their own information that needs to be professionally managed to sustain its business process. Most of the business units currently supported with specialized software package i.e. Sage IMP for Financial & Accounting system, EdExpress for Admission and Financial Aid, Destiny for Library administration, FxScholar to manage student's admission and registration and Moodle software for Online and Distance Learning class. These software packages provided by different vendors and sponsors, thus, each of them came with specific minimum requirements of technology resource (i.e. Servers, backup, etc.) needs to be fulfilled by PCC. Even though users regularly backing up data from their specialized software, but the hardware being used does not have any backup to anticipate any technical problem i.e. Server crashed. It would be better for PCC to provide redundant resource to back up the main systems. In addition, PCC may explore to use an integrated information system that allows each business units to work in the same platform so as to reduce redundancy of data input and duplication of work. Moreover, PCC may provide sharing storage for each business units so as to allow sharing information electronically among faculty and staff at the particular business units.

Business Systems

PCC currently has Sage IMP, a financial accounting system package, being used by Business Office. The system package includes a dedicated desktop server and also training for users. People input the information into the system and retrieve some reports as needed. Every year, PCC has budget allocated to pay its annual maintenance, support and upgrade as defined in the Five Year Technology Plan. The Business Office seems comfortable using the system, but PCC also consider using an Open Source system such as Kuali for Finance (SOA platform) that allows centralization system for Finance and Human Resource. This may be a good alternative even though users may need more time to adjust and learn how to work with this open source system.

II. Implementing reliable and manageable network topology

Motivation

PCC's existing network grew in an ad-hoc manner. There is no master plan of PCC's network topology that can be use as reference to expand the network. When a new PCC program is funded, the Computing Service has to connect the site where the project is located to PCC's LAN through the closest available switch. In a situation where a funded project is phased out, all the network resources attached needs to be disabled. However, the Computing Service staff prefers to keep the line and any network infrastructures that have been installed so as to anticipate further relocation or a new project that will take place in that area. Therefore, the Computing Service is having difficulty to map their network as its topology keeps on changing without any clear direction.

Even though all internal connections are provided by the Computing Service, each funded project has a separate DSL line that can only be shared with users assigned to the particular project. Among

the six (6) DSL lines, only the line with 320 Kbps can be shared among faculty and staff, which it is also being used for PCC's website and email (See Table 2). In order to save monthly subscribing fee, PCC decided to subscribe six (6) DSL lines instead of only a single huge line (See the cost calculation in Table 3).

As mentioned in the Five Year Technology Plan, PCC is looking to improve its college LAN by exploring some efficient ways to increase speed and number of DSL lines for its users. In addition, PCC expects to redesign its network by utilizing a solid college wide network backbone. Therefore, PCC needs to map and assess existing technology resource, mainly the network infrastructure, by closely reviewing its capability, capacity and current usage. Based on that, PCC may initiate to reorganize existing topology and then followed by a future network design with solid backbone. It can be set up to be achieved through several stages considering their operation budget and available resource of technology in Palau. The future network design will lead PCC to have more manageable technology infrastructure to achieve its mission. In addition, the backbone design will help PCC to manage and expand the network in the most efficient and well planned approach.

Based on above, student consultant is highly motivated to assist PCC's in following areas:

1. Identifying current network topology to provide clearer view of network's development in the college area.
2. Assessing the utilization of existing network resources and Internet service by considering number of users connected, type of network devices (i.e. Layer 2 or Layer 3, Manageable or Unmanageable devices) and its placement, year of usage of each devices, and bandwidth of each DSL line available in the network.
3. Developing a network drawing that acts as a guidance to improve current PCC's network management, security, and utilization.
4. Implementing the early stage of network and Internet service improvement based on the drawing. This may includes repositioning and reconfiguration existing Switches, WAP, network security devices (i.e. Firewall and Proxy), DHCP server, DNS server, network management tool (i.e. Nagios), and bandwidth management of each DSL lines.
5. Developing a blue print of PCC's Network Backbone Design for future implementation.

Outcomes

In the very beginning, student consultant initiate to identify the current issues and complaints related with existing network and Internet connection. It is done by interviewing users from different business units, reviewing PCC's technology plan, so as observing how the Computing Service staff handling daily issues re the network and Internet connection. During the process, student consultant found some facts asp below:

1. There are different policies of accessibility for several groups of users. For example, not all users are allow to access social media site i.e. Facebook. Only particular business units or projects i.e. Student Life, Talent Search, or computer labs that have the access to that particular site. In addition, the Computing Service is strongly encourage users not to make any streaming connections i.e. YouTube considering the speed of available bandwidth.

- Some DSL lines are exclusively use only for particular business units (see Table 8). Thus, the Computing Service cannot evenly distribute the bandwidth to all users.

Table 8 – PCC’s DSL Lines Utilization

<i>No</i>	<i>DSL Line</i>	<i>Bandwidth</i>	<i>Concurrent Users</i>
1	Talent Search	128 Kbps	Talent Search (< 20 Users)
2	TRIO	192 Kbps	UBMS Lab (< 20 Users)
3	Distance Learning	192 Kbps	Online Course (< 30 Users)
4	Tan Siu Liu Library	256 Kbps	Computer Tech Lab (< 25 Users)
5	Admin & Financial Aid	256 Kbps	Executive Mgmt. (< 25 Users)
6	PCC Administration	320 Kbps	Faculty & Staff (< 50 Users)

Source: PCC’s Computing Service – June 2013

- The Computing Service implements DHCP Static based on Users’ MAC Address to register them into the local network with specific gateway for Internet connection.
- The Computing Service are planning to use manageable switches in each nodes of the network. Thus, they have decided to replace the unmanageable switches (see Table 4) that have been used for more than 10 (ten) years so as to improve future network monitoring and management.
- Most of cabling are Cat 5 or Cat 5e that being used for more than 10 (ten) year. Only one line from Distance Learning to Nursing Office (approximately 100 feet) use Cat 6.
- Due to the old age of PCC’s building, the management strongly encourage not to drill any holes on its wall. Therefore, each building in PCC does not have any special LAN outlet for the network arrangement. In addition, most of access switches are currently being placed at public area (i.e. on top of user’s desk or shelves) without any specific case or rack.
- Due to inavailability of Fiber Optic network in the island, PCC is currently having problem to expand the network as they need to connect users at different buildings within the wide range of college area. In addition, there is a distance constraint (<100 feet) to connect one node to another using network cable i.e. Cat5e, Cat6a. Thus, the Computing Service has to connect switches from one building to another in order to connect all users into PCC’s campus network.
- Most of the issues are related with the Internet speed connection experienced by faculty and staff who used the same DSL Line of 320 Kbps.
- The community partner has developed its legacy network topology (See Appendix A) and DSL Lines - Server Diagram (See Appendix B) using Microsoft Excel. The documents help them to map existing network resources and being used as a reference to do troubleshooting and monitoring.

Based on those preliminary facts, there are some outcomes achieved related to the task:

1. Re draw PCC's Existing Network Topology

Student consultant and community partner surveyed all network resources location and their inter connectivity to define existing network topology. Most of network devices are located as described in the drawing (See Appendix A), only two (2) unmanageable switches are found in Learning Resource Office that are not appear in the drawing. Those unmanageable switches have been installed by outsource vendor that had been hired by the related business units without informing the Computing Service.

In this case, student consultant re produce the initial network topology using Microsoft Visio to give better view and understanding of existing LAN in the college (See Appendix C).

Throughout the process of improvement, student consultant assist the community partner to utilize Microsoft Visio to update the initial drawing of PCC's network topology. Based on the new drawing, student consultant and community partner managed to define several major issues asp below:

- a. The switch device at Business Office, Registrar Office and Adult Office plays very critical role for inter connectivity of the existing network topology. In this case, the switch at Business Office become the central of the whole PCC's local network. The other switches at Registrar Office and Adult Office expand the network into different part of PCC's area (See Appendix C) .
- b. All of the switches works as access switches as some end users also connected directly to the them.

2. PCC's Current Network Backbone Design (Master Plan) – Cable

Based on above findings, student consultant recommends a Network Backbone Design that can be used as a master plan to improve PCC's existing network (See Appendix D & E). The network backbone is designed to use network cable (i.e. Cat 6a and Cat 5) due to inavailability of fiber optic network in Palau.

According to Cisco Network Topologies and LAN Design (www.ciscopress.com), there are three (3) different network topology models as follows:

a. Hierarchical Models

It is adopting the concept of Open System Interconnection (OSI) reference model that allowing users to choose the right systems and features for each layer.

b. Redundant Models

It is suitable for organization who has critical system, service or network paths that needs assurance of zero network failure.

c. Secure Models

It is often designed by using several layers of security device (i.e. Firewall) to protects internal network form another untrusted network.

PCC's Future Network Backbone with Fiber Optic network is designed to adopt the three models (Hierarchical, Redundant, Secure) to improve reliability and performance of PCC's network (See Appendix K). However, due to current network infrastructure availability (no fiber

optic network) in Palau and the consideration of PCC's operational budget, student consultant recommends to adopt Hierarchical combined with Security models as short term solution, which enables PCC to have secure internetworks design into layers. Some benefits of using hierarchical models are as follows:

a. Cost savings

The modular nature of the models enables flexible use of bandwidth resource within each layer to reduce wasted capacity. In addition, network load will no longer be concentrate in a single switch device.

b. Easy to understand

The approach to keep each layers in simple and small design facilitates ease of understanding for network administrators. Management responsibility and network management systems can be distributed to the different layers among Network Administrator and Network Technical Support.

c. Flexible for network growth

The hierarchical models carries modularity approach to facilitate easy network growth. It allows creating design elements of layers that can be replicated as the network grows, thus the cost and complexity of making the upgrade is contained to a small subset of the overall network.

d. Improved fault identification and isolation

The small, easy-to-understand structure of network facilitates improvement in fault isolation. Network administrators can easily understand the transition points in the network to identify failure points.

The hierarchical models has there layers: Core, Distribution and Access. Each layer provides necessary functionality to the network which do not need to be implemented as distinct physical entities. However, the hierarchy should always be maintained for optimum network performance.

The core layer is the high-speed switching backbone of the network that enable inter-communication among several sites of network within the organization. According to Cisco Network Topologies and LAN Design (www.ciscopress.com), the core layer should have the following characteristics:

- Offer high reliability
- Provide redundancy
- Provide fault tolerance
- Adapt to changes quickly
- Offer low latency and good manageability
- Avoid slow packet manipulation caused by filter or other processes
- Have a limited and consistent distance between routers

In this case, PCC has several campus area in Palau (PCC's main campus area, PCC's Multi Species Hatchery, and PCC's Cooperative Research and Extension) that can be connected

between core layers. For the main campus area in Koror, the core switch located in the Data Center at the Computing Service area (See Appendix E).

The distribution layer in the model is the demarcation point between the core and access layer of the network. According to Cisco Network Topologies and LAN Design (www.ciscopress.com), the distribution layer can have many roles and not limited only to implement the following functions:

- Implementing network policy in forwarding different traffics from different interfaces.
- Security
- Address or area aggregation or summarization
- Departmental or workgroup access
- Broadcast/multicast domain definition
- Routing between virtual LAN's (VLANs)
- Media translations
- Redistribution between routing domains
- Demarcation between static and dynamic routing protocols.

In this case, student consultants recommends PCC to have nine (9) distribute switches in the layer as follow:

a. Data Center

The distribution switch is placed in PCC's Data Center at the Computing Service Office. It will control routing from and to application servers located in the Data Center.

b. Zone I

The distribution switch is placed in Sebus Building. It will control routing from and to the area of distribution in Zone I, which include users at:

- Sebus Building – Nursing Class Room
- Smuuch Building – Science Class Room
- Demul Building – Child Care Center
- Tekrar Building – OMIP Computer Lab, Electronics Class Room, AC & Refrigeration, Electrical Shop
- Keskas Building – Cooperative Research Extension (CRE), Maintenance Workshop, Classrooms.
- Tekuu Building – Automotive Shop and Small Engine Shop.

c. Zone II – A

The distribution switch is placed in Vice President Office at Ukall Building. It will control routing from and to the area of distribution in Zone II - A, which include users in Business Office, HR Office, Vice President Office, and President office at Ukall Building.

d. Zone II – B

The distribution switch is placed in Adult Education Office at Dort Building. It will control routing from and to the area of distribution in Zone II - B, which include users in Adult Education, Development Office, Institutional Research, Learning Resource, and Conference Room at Dort Building.

e. Zone II – C

The distribution switch is placed in Distance Learning Lab at Btach Building. It will control routing from and to the area of distribution in Zone II - C, which include users at:

- Btaches Building – Computer Lab Rooms and Distance Learning program
- Temekai Building – Ex-Faculty Office and Agriculture Office
- Meluis Building – UBMS Lab

f. Zone II – D

The distribution switch is placed in the Academic Affair Office (2nd Floor) at Tan Siu Lin Library. It will control routing from and to the area of distribution in Zone II - D, which include users at:

- Tan Siu Lin Library Building – Library Tech Lab, Faculty Offices, and Academic Affair Office.
- Baderirt Building – Talent Search
- Dadait Building – ALO Office

g. Zone II – E

The distribution switch is placed in Registrar Office at Miich Building. It will control routing from and to the area of distribution in Zone II - E, which include users in Registrar, Financial, Student Life, and Continuing Education at Miich Building and Ksid Building.

h. Zone III

The distribution switch will be placed in one of the faculty room at Esuch Building. It will control routing from and to the area of distribution in Zone III, which include users of PCC's Tourism School at Esuch Building.

The access layer provides access for users at each of local segment on the network. The layer is characterized by switched and shared bandwidth LANs in each segment. This is the closest location of switches from users which can be extended either through cable LAN or WAP. Some of the buildings at PCC's area may have several access switches due to user's location.

3. Implementation of PCC's Current Network Backbone Design

As the consulting partner agreed to adopt the PCC's Current Network Backbone Design recommended by student consultant, the implementation has achieved several progress as below:

a. Build PCC's Core and Distribution Layer

In order to build the Core and Distribution Layer, PCC need to provide Layer 3 (L3) switches that are capable of running routing protocols and communicating with neighboring

L3 switches. According to Cisco Network Topologies and LAN Design (www.ciscopress.com), the L3 switches perform the functions of both data link layer switches and network layer routers. Each port interfaces are grouped into broadcast domains (subnets) and a routing protocol is selected to provide network information to other L3 switches and routers.

As this report was compiled, PCC has just purchased 3 (three) new Layer 3 (L3) Switches – Cisco Catalyst 3560 V2 10/100. One (1) of the L3 switches has been successfully installed by the community partner in Core Layer at the Data Center (See Appendix E & F) to replace the unmanageable Layer 2 (L2) switch and take over the ‘role’ of L2 switch at Vice President Office (See Appendix C).

The community partner has also successful installing another two (2) L3 switches in Distribution Layer at Registrar Office for distribution area of Zone II – E (See Appendix E & I) and Adult Education Office for distribution area of Zone II – B (See Appendix E & G). The L3 switches replaces the previous L2 switches at Registrar Office (Cisco SG 200-26) and Adult Education (Cisco SG 300-10). The technical justification to prioritise these switches to be replaced was because these two nodes appear as critical point in expanding existing network (See Appendix E). The distribution switch of Zone II – E connects another distribution switches of Zone I and Zone II C with core switch. While the distribution switch of Zone II – B connects the core switch with distribution switch of Zone – D.

b. Implement PCC’s Network Design in Data Center

Due to the limited resource (i.e. Switch and Cat6a Cable) available in Palau, student consultant and consulting partner decided to gradually implement the network master plan and starting it from Data Center. The implementation process goes smoothly as designed in PCC’s Network Design for Data Center (See Appendix F). The community partner has put one (1) access switch that connects all the servers (i.e. Back Up, Business Office and DHCP Server). In addition, the community partner were also removing all of legacy Cat5 Cables and replaced them with Cat6 Cable. Thus, all devices in Data Center are currently connected with Cat6 Cable as planned in the design and being labelled accordingly to ease maintenance and monitoring.

c. Reorganize switches placement

Student consultant recommends PCC to reorganize some switches in order to optimize existing infrastructures. The technical approach used is to utilize L3 switches in Core and Distribution Layer and L2 switches within Access Layer. However, due to resource limitation available in PCC, the approach slightly modify by placing at least the most advance type of available switches (either L2 or L3) in Distribution Layer and gradually replace the unmanageable switches with the manageable L2 switches. During the process, student consultant provides hands on assistance to the community partner to reposition some switches asp details in Table 9 below. In addition, the Computing Service receive no complaints from users after the reposition. On the other hand, some of users from Business Office and Financial Office admitted that there is a significant improvement of connection to the server application after replacing the unmanageable switches.

Table 9 – Switches Repositioning

<i>No.</i>	<i>Area</i>	<i>Layer</i>	<i>Location</i>	<i>Before</i>	<i>After</i>
1	Data Center	Distribution	Data Center (Ukall Building)	N/A	L2 – Cisco SG 300-20
		Access		L2 – LinkSys SWR 2024	L2 – Cisco SG 200-26
2	Zone I	Distribution	Nursing Office (Sebus Building)	L2 – LinkSys SWR 2024	L2 – Cisco SG 300-10
		Access	OMIP Comp. Lab (Tekrar Building)	L2 – LinkSys SWR 2024	L2 – Cisco SG 200-26
			CRE Office (Keskas Building)	Dlink DSS (Unmanageable)	L2 – LinkSys SWR 2024
			Small Engine	Hub (Unmanageable)	L2 – Cisco SG 200-10
		Auto Mechanic (Tekuu Building)	Hub (Unmanageable)	N/A	
3	Zone II – A	Access	Business Office (Ukall Building)	Netgear DS108 (Unmanageable)	L2 – LinkSys SWR 2024
4	Zone II – B	Distribution	Adult Education (Dort Building)	L2 – Cisco SG 300-10	L3 – Cisco Catalyst 3560 V2
5	Zone II – D	Distribution	Library 2 nd Floor (Tan Siu Lin)	L2 – LinkSys SWR 2024	L2 – Cisco SG 300-10
		Access	Library 3 rd Floor (Tan Siu Lin)	L2 – LinkSys SWR 2024	L2 – Cisco SG 200-26
6	Zone II – E	Distribution	Registrar Office (Miich Building)	L2 – Cisco SG 200-26	L3 – Cisco Catalyst 3560 V2
		Access	Financial Office (Miich Building)	Netgear FS516 (Unmanageable)	L2 – LinkSys SWR 2024
			Financial Office (Miich Building)	Netgear FS516 (Unmanageable)	L2 – LinkSys SWR 2024

Source: PCC’s Computing Service – July 2013

d. Reorganize IP Subnetting of Network Devices in each layers (Core, Distribution, Access)

PCC’s Current Network Backbone Design allows the network administrator to re organize IP Subnetting of network devices for management and monitoring purpose. Based on the legacy topology, the network administrator arrange the IP subnetting based on type of device (i.e. Switches, Wireless Access Point) and its vendor (i.e. Cisco, LinkSys). In this case, student consultant and the community partner agreed to modify the IP subnetting based on layers (i.e. Core, Distribution and Access) within each zone (i.e. Zone I – III). Based o that, the community partner has updated all IP’s of the switches in the network to follow the current setup as follow:

Table 10 – IP Resubnetting of Network Devices

<i>Legacy Setup</i>	<i>Current Setup</i>
<ul style="list-style-type: none"> ▪ <i>Switches</i> Cisco Series: 182.10.20.XXX LinkSys Series: 182.10.16.XXX ▪ <i>Wireless Access Point (WAP)</i> 182.10.10.XXX 	<ul style="list-style-type: none"> ▪ <i>Core & Distribution Layer:</i> 182.10.30.XXX ▪ <i>Access Layer (Switches & WAP):</i> 182.10.40.XXX

Source: PCC’s Computing Service – July 2013

e. Reconfigure Content Filter Service of Firewall Appliances

In order to secure PCC’s local network that is connected to Internet through 6 (six) DSL lines, the network administrator installed Network Layer Firewall in form of 4 (four) Firewall Appliances of SonicWall Series (e.g. SonicWall 240 and 250N) and 2 (two) Firewall Software of Linux platform. Network Layer Firewall operate at a relatively low level of the TCP/IP protocol stack by restricting packets to pass through firewall unless they match the establishes rule set by the network administrator.

For the future use, the network administrator has decided to deploy only Firewall Appliances to secure PCC’s network. Existing firewall appliance from SonicWall provide several comprehensive security services (See Appendix L) i.e. Content Filter, Client Anti-Virus Enforcement, Gateway Anti-Virus, Intrusion Prevention (IP), Anti-Spyware, Geo-IP Filter and Botnet Filter.

In this case, student consultant and the community partner agreed to focus in reconfiguring the Content Filter Service rules based on Content Categories (See Appendix M) for each group of users (See Table 12). Some of the rules are as follows:

- Only certain group of IP Addresses (i.e. Student’s Computing Lab and Talent Search) are allow to access Social Networking site (i.e. Facebook, etc.)
- All users are not allow to access any URL in Nudism and Pornography category.
- All users are not allow to access any URL in Gambling category.

f. Bandwidth Management through Firewall Devices

As currently there are 6 (six) DSL Lines used by different users in PCC, the Computing Service consider to implement bandwidth management through firewall devices that attach to each DSL Lines. In relation to that, only 4 (four) DSL lines that goes through SonicWall Firewall Appliances, while the others goes through Firewall in Linux platform. In this case, student consultant and the community partner agreed to implement bandwidth policy below (based on group of users) and starts with the DSL lines that goes through Firewall Appliances. In this process, the community partner will implement the policy to one appliance at a time. He will then monitor the result before deciding to implement it to all of the Firewall Appliances.

Table 11 – Bandwidth Management in Firewall Appliances

<i>No.</i>	<i>Group of Users</i>	<i>Guaranteed Bandwidth (% of Total Bandwidth)</i>	<i>Maximum Bandwidth (% of Total Bandwidth)</i>
1	Computer Lab	30	100
2	Faculty & Counselor	30	100
3	Staff	20	100
4	Administrative Secretary	30	100
5	Executive Management	50	100

Source: PCC's Computing Service – July 2013

g. Reconfiguration of VLAN

The Computing Service currently use only default VLAN configuration in each of the switches. Therefore, all users are able to access any resources (i.e. Application Servers, etc.) as long as they are assigned in the same subnet of network. In this case, student consultant recommends the community partner to configure some VLAN's based on the application used by users (i.e. FxScholar, Business Office, Destiny, Sage MIP, Moodle, Ed Express). At the time this report was compiled, the student consultant assist the network administrator to use Cisco Packet Tracer 5.3.3 in order to simulate the VLAN configuration before finally implement it in the current network. Due to time constraint and learning process of the community partner, the VLAN implementation will not take place during the project. The Computing Service need to explore more about several alternatives of VLAN implementation using the Cisco Packet Tracer, and then implement them as required.

h. Reconfigure IP Static distribution in DHCP Server

The network administrator currently deploy different DHCP servers for users that is connected through Land Line and WAP. Both of the servers assigns static IP Address to a specific MAC Address of user's devices.

Currently, the network administrator arrange the IP Static distribution based on area where user is located and the DSL Line use as their Internet connection gateway. In this case, while referring to the DSL Line as the gateway, student consultant recommends the community partner to reconfigure existing IP Static distribution refer to the group users as describes in Table 12. The implementation has not taken place yet due to the community partner is currently assessing which group of users that is going to be the pilot project. In addition, implementation will occur at one group of users at a time. He will then monitor the result before deciding to implement it to all of group of users.

Table 12 – IP Static Reconfiguration

<i>Legacy Setup</i>	<i>Current Setup</i>
<ul style="list-style-type: none"> ▪ 192.168.55.XXX for: OMIP Lab, Workshop, CE Lab ▪ 192.168.168.XXX for: Administrator, Executive Management, Development, Student Life, Student Service, UBMS, Faculty, Tan Siu Lin Library ▪ 222.123.224.XXX for: Staff’s Personal Device ▪ 222.123.225.XXX for: Library Computer Lab ▪ 222.123.226.XXX for: Talent Search, Guest ▪ 192.168.231.XXX for: Online Lab (WAP Users) 	<ul style="list-style-type: none"> ▪ 222.123.221.XXX Computer Lab ▪ 222.123.222.XXX Faculty & Counselor ▪ 222.123.223.XXX Staff ▪ 222.123.224.XXX Administrative Secretary ▪ 222.123.225.XXX Executive Management

Source: PCC’s Computing Service – August 2013

i. Recabling using Cat6

PCC’s Current Network Backbone Design (See Appendix E) required the backbone line and nodes in each layers to be connected by Cat 6a Cable 100BASE-T, 1000BASE-TX (Gigabit Ethernet) for all Layer. Only those connections from Access Switch to users that may use Cat 5e Cable 10BASE-T, 100BASE-TX (Fast Ethernet).

In this case, due to inavailability stock of Cat 6a Cable in Palau, the current recabling process can only be done in Data Center area. The community partner has ordering the Cat 6a Cable from local supplier and will continue the recabling once it available. Thus, the whole recabling process is expected to be done only after the project is finished.

4. Blue Print of PCC’s Future Network Backbone Design – Fiber Optic

Even though currently there is no Fiber Optic network available in Palau, but PCC need to have a Blue Print of Future Network Backbone Design that will utilize Fiber Optic infrastructure once its available. Therefore, student consultant recommends the PCC’s Future Network Backbone Design – Fiber Optic that adopt Secure and Redundancy in Hierarchical Models to connect all users across PCC’s area, including those who are located at Esuch Building in Zone III (See Appendix J).

The main feature of the future design is that each Distribution Switch can be connected directly to the Core Switch (See Appendix K) in single line of Fiber Optic. In this case, the Fiber Optic omits the distance limitations exist in current topology using network cabling (i.e. Cat5, Cat6a).

In addition, the future design has two (2) redundant Core Switch in the Core Layer to ensure network availability and maintain traffic routing performance. The design will allow redundant routes as all of the Distribution Switches will be connected to both Core Switches. The redundant routes has two (2) purposes: load balancing and minimizing down time. The load balancing depends on which switching mode is used on the Core and Distribution Switches. While the redundant routes will also minimize the effect of link failures as multiple equal-cost paths to a destination network exist.

In this design, each of the Distribution Switch is also connected to its neighbour Distribution Switch providing alternative paths to destination. Furthermore, it is also feasible to have 'back up' routes from any switches in the Access Layer to switch in Distribution Layer using the Fiber Optic.

Recommendations

In order to maintain the sustainability of the solution that has been initiated during the project, student consultant recommends short term actions plan below as a reference to carry on the improvement in PCC's networking:

Table 13 – Actions Plan to Improve PCC’s Networking Period of 2013 - 2014

<i>No.</i>	<i>Period</i>	<i>Action</i>	<i>Reasons</i>	<i>References</i>
1		Replacing all Cat5 Cables with Cat6 STP (Shielded Twisted Pair). It should starts with the Backbone Line from Core Layer to Distribution Layer	<ul style="list-style-type: none"> ▪ Existing Cat5 Cables have been used for > 10 years ▪ Some of the existing cable routings are not aligned with the Current Network Design ▪ STP Cable will reduce interferences during packet transmission 	<ul style="list-style-type: none"> ▪ PCC’s Current Network Backbone Design (Appendix E)
2		Perform best practices of installation for cabling including Labelling and Grounding	<ul style="list-style-type: none"> ▪ Ease for maintenance and troubleshooting ▪ Support safety and security for users and the devices 	<ul style="list-style-type: none"> ▪ http://www.brocade.com/downloads/documents/best_practice_guides/Cabling_Best_Practices_GA-BP-036-02.pdf
3	3 rd Quarter – 2013	Circulate minimum specification for Personal Computer (PC) Desktop that compatible with network requirement	<ul style="list-style-type: none"> ▪ Some of PCC’s business units may invest for PC Desktop, thus the Computing Service need to provide guideline to ensure those will compatible with the existing network requirement. 	<ul style="list-style-type: none"> ▪ PCC’s Technology Plan ▪ Minimum specification for PC Desktop: <ul style="list-style-type: none"> ✓ Operating System: Windows 7 SP3 ✓ Processor: Intel i5 DualCore ✓ RAM: 2 GB ✓ Harddisk: 320 GB ✓ VGA Card: 1 GB ✓ LAN Card: Gigabit Port ✓ Wireless Card: 802.11g
4		Continue replacing all of unmanageable switch	<ul style="list-style-type: none"> ▪ Ease monitoring and troubleshooting ▪ Some users from Financial Office and Business Office admitted that they experienced faster connection after the replacement of legacy unmanageable switch with the manageable one. 	<ul style="list-style-type: none"> ▪ PCC’s Current Network Backbone Design (Appendix E)

5	Provide dedicated PC Desktop for network and server monitoring tool	<ul style="list-style-type: none"> ▪ The current PC Desktop available in the Computing Service is not suitable to run the web-based management console of the switches and the network and server monitoring tool (Nagios). ▪ The current PC Desktop available in the Computing Service is not suitable to run the latest version of Microsoft Visio 2013 for updating the PCC's Network Backbone Drawing. 	<ul style="list-style-type: none"> ▪ PCC's Technology Plan ▪ Minimum specification of PC Desktop for Network and Server Monitoring: <ul style="list-style-type: none"> ✓ Operating System: Windows 7 SP3 ✓ Processor: Intel i7 DualCore ✓ RAM: 4 GB ✓ Harddisk: 500 GB ✓ VGA Card: 4 GB ✓ LAN Card: Gigabit Port ✓ Wireless Card: 802.11g
6	Provide case / rack for switches placement	<ul style="list-style-type: none"> ▪ Most of access switches are currently placed in public area that is insecure and not safe both for the users and the devices ▪ Some of the switches are hardly to reach for troubleshooting or maintenance 	<ul style="list-style-type: none"> ▪ PCC's Technology Plan
7	Google Apps Training for Computing Service Staff	<ul style="list-style-type: none"> ▪ It is a new solution being used by the Computing Service Staff. ▪ Google Apps for Education offers lots of feature that are suitable for Distance Learning and Online Course. ▪ More schools and universities use Google Apps for Education 	<ul style="list-style-type: none"> ▪ PCC's Technology Plan ▪ http://www.google.com/apps/intl/en-GB/edu/
8	Consistently update PCC's Network Drawing using Ms. Visio	<ul style="list-style-type: none"> ▪ Ease network monitoring, maintenance and troubleshooting ▪ Manage the expansion of the network ▪ Supports the implementation of PCC's Technology Plan 	<ul style="list-style-type: none"> ▪ PCC's Technology Plan ▪ PCC's Current Network Backbone Design (Appendix E)

9	1st Quarter – 2014	Gradually invest three (3) units full featured L3 Switches and two (2) full featured L2 Switches with Gigabit Port	<ul style="list-style-type: none"> Continue to build the PCC's Network Backbone with L3 Switches in Core and Distribution Layer, and L2 Switches in Access Layer 	<ul style="list-style-type: none"> PCC's Technology Plan PCC's Current Network Backbone Design (Appendix E)
10		Provide two (2) units of Firewall Appliances (i.e. SonicWall)	<ul style="list-style-type: none"> Replace the Linux Firewall Ease for network security and bandwidth management 	<ul style="list-style-type: none"> PCC's Technology Plan PCC's Current Network Backbone Design (Appendix E)
11		Review Bandwidth Usage	<ul style="list-style-type: none"> Optimize cost investment for monthly subscribe of DSL Lines based on users' needs 	<ul style="list-style-type: none"> PCC's Technology Plan
12		Asses for alternative Internet Service Provider	<ul style="list-style-type: none"> Current monthly subscription fee is very costly considering the amount of bandwidth available Compare Internet service performance 	<ul style="list-style-type: none"> PNCC PMC
13	Networking Training for Computing Service Staff	<ul style="list-style-type: none"> Improve knowledge of the community partner about network cisco device configurations Improve knowledge of the community partner about network management, monitoring and troubleshooting Future need to expand the network 	<ul style="list-style-type: none"> PCC's Technology Plan http://www.cisco.com/web/learning/index.html 	
14	Consistently update PCC's Network Drawing through Ms. Visio	<ul style="list-style-type: none"> Ease network monitoring, maintenance and troubleshooting Manage the expansion of the network Supports the implementation of PCC's Technology Plan 	<ul style="list-style-type: none"> PCC's Technology Plan PCC's Current Network Backbone Design (Appendix E) 	

15		Gradually invest two (2) units full featured L3 Switches and two (2) full featured L2 Switches with Gigabit Port	<ul style="list-style-type: none"> Continue to build the PCC's Network Backbone with L3 Switches in Core and Distribution Layer, and L2 Switches in Access Layer 	<ul style="list-style-type: none"> PCC's Technology Plan PCC's Current Network Backbone Design (Appendix E)
16	2 nd Quarter – 2014	Increase Bandwidth for Main DSL Line	<ul style="list-style-type: none"> Increasing number of Users use the main DSL Line. Users' traffic of uploading and downloading attachment in email correspondence 	<ul style="list-style-type: none"> PCC's Technology Plan Bandwidth Management in Firewall Device Packet Shaper Tool
17		Consistently update PCC's Network Drawing through Ms. Visio	<ul style="list-style-type: none"> Ease network monitoring, maintenance and troubleshooting Manage the expansion of the network Supports the implementation of PCC's Technology Plan 	<ul style="list-style-type: none"> PCC's Technology Plan PCC's Current Network Backbone Design (Appendix E)
18		Gradually invest two (2) units full featured L3 Switches and two (2) full featured L2 Switches with Gigabit Port	<ul style="list-style-type: none"> Continue to build the PCC's Network Backbone with L3 Switches in Core and Distribution Layer, and L2 Switches in Access Layer 	<ul style="list-style-type: none"> PCC's Technology Plan PCC's Current Network Backbone Design (Appendix E)
19	3 rd Quarter – 2014	Installed more WAPs in the Access Layer	<ul style="list-style-type: none"> Users are located in different building Ease to expand the network (Access Layer) Management's policy is not allowing to drill holes in any building. 	<ul style="list-style-type: none"> PCC's Technology Plan PCC's Current Network Backbone Design (Appendix E)
20		Consistently update PCC's Network Drawing through Ms. Visio	<ul style="list-style-type: none"> Ease network monitoring, maintenance and troubleshooting Manage the expansion of the network Supports the implementation of PCC's Technology Plan 	<ul style="list-style-type: none"> PCC's Technology Plan PCC's Current Network Backbone Design (Appendix E)

Source: Student Consultant – Augustus 2013

In addition, student consultant also recommends PCC to build PCC's Wide Area Network (WAN). Currently, PCC has three main areas for student and faculty activities in Palau:

- PCC's main campus area at Medelai, Koror
- PCC's Multi Species Hatchery at Ngermetengel, Ngaremlengui
- PCC's Cooperative Research and Extension at Ngermeskang, Ngaremlengui

Those areas relates to each other to support student activity both theoretical and practical approach. Therefore, it is required to have those areas be connected in PCC's Wide Area Network (WAN). PCC's Multi Species Hatchery currently has Internet connection that is provided by grant from Japanese government. On the other hand, the PCC's Cooperative Research and Extension currently does not have any Internet connection due to its remote location. PNCC, the sole Internet provider in Palau, still not have any network service to reach the area. Therefore, Internet access via satellite might be one of the best solution to be used at PCC's Farm and Research Center.

While the report is being prepared, PCC just received a support from Australian government to make use of Internet connection using Satellite through the small dish installed at Ukall Building. According to the technician who installed the dish, the Internet speed will be 256 Kbps for uploading and 128 Kbps for downloading. However, the satellite connection is very depend on the weather, which is very unpredictable here in Palau.

Both student consultant and the network administrator have checked its connection and found it is not as fast as the current connection available in PCC main campus. Moreover, the dish might got heavy interferences during transmitting the signal, as there are several bigger size dishes (belongs to PNCC) that are installed near by it. PCC may consider to have the dish installed for PCC's Cooperative Research and Extension instead, considering less interference and unavailability of PNCC's landline network at Ngermeskang area.

III. Implement reliable and accessible email system

Motivation

PCC currently provide email service using domain of palau.edu. The email server is using Postfix Email Server that is hosted in the same machine of PCC's website server, but in the separate port of access (Website using port 80 while Email using port 25). Both the servers are being accessed through DSL Line of 320 Kbps, which is the same line that being use by faculty and staff to access Internet.

Email communication has become one of the most important ways for PCC's faculty and staff to communicate with others party outside the college. In some funded project hosted at PCC, local researchers are relying on their email to communicate and collaborate with other researchers outside the island. Some instructors of Distance Learning and Online Course also use their email to communicate with the students, especially related with assignments submission.

Currently, the Computer Service staffs receives at least one complaint a day from users reporting that they are having difficulty to send and receive email from the domain of palau.edu. In some cases, users unable to download some attachments in the message from mail server of palau.edu.

Other complaints related with either incoming or outgoing messages that are bounce back by the server. For later issue, the student consultant found that some of the issues occurred due to ISP's DNS Server blocks the messages. The Computer Service staffs have reporting this issue to PNCC and found that other subscribers of PNCC also having the same issue.

In addition, there is another issue about availability of Internet connection in Palau. Currently, not all area in the island has Internet connection. The speed is considerably very slow and not stable, whereas some areas still only have Dial Up connection. In addition, Internet connection cost is considerably very expensive. Therefore, the Computer Service staff suggests users to access their official email (palau.edu) via email client such as Microsoft Outlook or Mozilla Thunderbird to minimize connection time to Internet so as to save connection cost. Users will only connect to Internet when they need to download the incoming messages to their Inbox Mail. Once it's done, users can disconnect the Internet and continuing to draft the reply email or composing new messages. After that, they re connect again to the Internet when they are ready to send those messages and disconnect again once they are sent. However, currently there is a problem with PCC's email domain (mail.palau.edu) that in different situation cannot be retrieve using email organizer such as Mozilla Thunderbird or Microsoft Outlook. Moreover, the email can only be access using PCC's LAN, thus users will not be able to read their email when they are not in main campus area. It is very important for PCC to find a workaround to overcome this issue as faculty and staff relying to this mean of communication. Temporary solution is to forward all incoming message to personal email account (i.e. Gmail, Yahoo, etc.) of users, but still they are having problem when they need to send email using their official email of PCC (palau.edu). There are some alternatives of open source and or free hosting email server (i.e. Zimbra and GoogleApps for Education) that can be consider as a solution. However, it might requires PCC to re configure its email routing and meet the minimum requirement resources (i.e. configuration, bandwidth, OS, and server specifications) to implement the solution.

Based on above, student consultant is highly motivated to assist PCC's in following areas:

1. Identifying issues with current email service both in server and user side.
2. Assessing for open source and or free hosting email server to be implemented as a sustain solution for email service in the college. Some of main considerations are its accesibility both through Internet and Intranet, service reliability, user management, and interoperability with different type of email client (i.e. Microsoft Outlook, Mozilla Thunderbird).
3. Develop a migration process of email server from legacy system into the new one. It is also includes the procedure to integrate the new email system to existing email client at each of users side, so as to ensure smooth transition process.
4. Implementing the new email system and foresee any issues or challenges during the process.

Outcomes

In the very beginning, student consultant try identify the current issues and complaints related with email service. It is done by interviewing users from different business units, so as observing how the Computer Service staff handling daily issues re email services. During the process, student consultant found that PCC is urgently requiring reliable and accessible email system to support daily tasks of faculty and staff.

The reliable email system means that it can assure that any email sent by users will be delivered to the recipient in a timely manner. The email server in the legacy email system often stopped transmitting outgoing emails due to a bottleneck resulting from emails with attachments. Those emails 'pile up' in the server at the Data Center and required the Computing Service staff to send them one by one after office hours. This is the reason why there were delays, which might take more than half a day, from the time a user sent the messages and received them at destination. The issue also occurred when a user expected to receive emails from other users. In addition, most users use an email client system (i.e. Mozilla Thunderbird, Microsoft Outlook, Eudora) to access their email as the web interface of the legacy email system was disabled by the Computing Service due to a bandwidth issue.

The accessible email system means that users' inboxes can be accessed from anywhere and at any time. Using the legacy email system, users experienced 'unreachable inboxes' as incoming or outgoing messages were often 'bounced back' by the server. Further investigation revealed that in some cases, the ISP's DNS Server (PNCC) blocks the messages due to 'unclear' security reasons. The issue has been raised to PNCC and found that other subscribers of PNCC's service also have the same issue. In addition, users can only access their inboxes via PCC's LAN at the main campus area. If one of the faculty or staff has to go off-island, the Computing Service staff has to configure the email server to forward the incoming emails from the inbox in mail.palau.edu to the inbox of their personal email account (i.e. gmail, yahoo, etc.). The Computing Service staff will then disable the forwarding once the faculty or staff is back to the island and access their inboxes via PCC's LAN at the main campus area.

Based on those findings, there are some outcomes achieved related to the task:

1. Research for suitable open source and/or free email system

Initially, the student consultant tried to gather information about the latest configuration of PCC's email server managed by the Computing Service. In this stage, the student consultant assessed the capacity and capability of the legacy email system by having registered as one of the users. From this point, the student consultant managed to undergo any challenges from the user side and grasp most of the users' expectations to the email system.

Based on the experience above, the student consultant explored several options of solutions including some of the open source and/or free email systems as follows:

- a. Optimizing existing email system of PostFix

The legacy email system of PostFix running on a UNIX-based server that shared with the web server. The current server does not have an adequate size of storage to keep users' inboxes. In this case, the community partner has tried to create a new mail system in a different server. However, the accessibility issue still occurs due to the available bandwidth does not adequately accommodate users' inbound and outbound traffic to and from the email server. In addition, only Bruce, Director of the Computing Service, who is familiar with the UNIX environment. Therefore, there is a lack of knowledge to maintain and secure the email system if they decided to keep it running from local infrastructure at PCC's Data Center.

- b. Zimbra Collaboration Server

Zimbra Collaboration Server (ZCS) is an enterprise-class email, calendar, and collaboration solution, built for the cloud both public and private. There are several versions of ZCS including ZCS Network Edition, ZCS hosted email by a Zimbra Partner, and ZCS Open Source Edition (free). The ZCS has a browser-based interface that offers innovative messaging

experience to connect end users to the information and activity within organization's clouds. There are some benefits of using Zimbra:

- Innovative Features

The ZCS offers full-featured email, calendar and collaboration solution that enables end-users to securely and seamlessly connect to their personal clouds with POP / IMAP. Its innovative AJAX experience puts Windows, Mac and Linux end-users at complete feature parity. In addition, its highly scalable open source technology provides simple, web-based administration tools that reduce maintenance and support costs. However, ZCS runs only on Linux or Mac OS X commodity servers.

- Reliable

The ZCS provides migration tools, clustering, full backup and restore, extensive command line interface (CLI) and AJAX Admin Console to give more security and span-of-control. In addition, it also integrates with Microsoft Outlook, Active Directory and Exchange for split deployments or gradual migrations.

- Accessible

Zimbra offers a rich browser-based experience on any xHTML-capable device that support POP / IMAP and iCal / CalDav. It provides synchronization to iOS, Windows, Android-based smart phones and tablets, or even Blackberry smartphone. Thus, it provides the users to access their email from anywhere, anytime and with various type of mobile devices.

- Cost Effective

Zimbra supports both multi-tenancy, as well as hierarchical storage management that optimizes storage cost through tiered storage. In addition to that, it is designed for virtualization to deliver faster provisioning and easier administration with built-in support for high availability, disaster recovery, backup and lifecycle management using VMware vSphere. Its simple web-based administration reduces maintenance and support overhead. In this case, PCC need to invest new server and storage for this email system, as it requires 64-Bit server machine with Linux OS (i.e. Red Hat Enterprise Linux, SUSE Linux Enterprise Server, or Ubuntu LTS Server Edition) and dedicated storage server.

c. Google Apps for Education

Google Apps for Education is a free suite of hosted email and collaboration application exclusively for schools and universities. It is just one way of Google's contribution to educational community, as Google was founded by a research project at Stanford University. There are some benefits of using Google Apps:

- Reliable

Google Apps for Education provides critical security features that specifically designed by Google Engineers to keep users' data safe, secure and fully control. Users' message is guaranteed to be received by partner in securely and timely manner. Users are entitle to utilizy exactly the same service as provided by Google in Gmail. All data is automatically backed up on Google servers, thus when accidents happen i.e. computer

crashes or laptop gets stolen, users can up and running again in seconds. Furthermore, Google guarantee 99.9% uptime and build-in robust disaster recovery, so users does not have to worry about system failure caused by natural disasters.

- Accessible

Google Apps for Education is an email system based on web using Google's Data Center. The Data Center network provides exceptional security and guarantees reliable access to users' data at any time, even on leap years (24x7x365.25). In addition, just like Gmail, users' email saved in the cloud and allow them to access it at anytime, anywhere and on almost any device that can be connected to Internet (including mobile device or tablet). Users can directly go to URL of mail.palau.edu and or www.gmail.com to access their email (See Appendix O). By enabling IMAP feature in the users' account (See Appendix P), it is easy to synchronize their mobile device with the main email server, as the system works the same way wherever and from whatever device you use to access it. Moreover, Google Apps offers an extra layer of security with two factor authentication and encrypt browser session with SSL for Apps users. It is greatly reduces the risk of hackers stealing usernames and passwords.

- Cost Saving

Google Apps for Education is free not just the service, but also the infrastructure to have the service up and running. Thus, PCC does not have to buy or maintain any servers and client software to provide mail.palau.edu service. As the Google Apps is updated automatically, the Computing Service does not have to worry about downloading and deploying patches or facing the security risk of delayed updates. The Computing Service does not have to invest any infrastructure of storage for the email system, whereas each user has 30 GB of storage for Google Drive, Gmail and Picasa Web Albums, 10 GB Google Video, and 100 GB Google Sites for free. In addition, the collaborative tools such as video chat and shared documents help users to to feel in the same room (See Appendix Q). This would be suitable to support users interaction, especially the distance learning course in PCC .

- Easy to manage and monitor

The cloud service of Google Apps for Education allows the Computing Service to spend less time managing the IT infrastructure of its email system. In addition, its single administration console enables email administrator to easily manage the email system, including the users' management, users' inbox, sharing policy, reports, apps usage, etc. (See Appendix N). The number of users that PCC can have on Google Apps for Education is limitless as long as it is not generated from spam. Google does not require the administrator to delete inactive users.

Besides phone support and priority email line, the Computing Service staff can utilize the Google Apps Administrators Help Center whenever they need resource to troubleshoot any problems occur.

2. Migrating from legacy to the new email system

After intense research and brainstorming for the most suitable email system solution for PCC's users, the community partner decided to adopt Google Apps for Education as their new email system. The main reason is because it does not requires PCC to invest any infrastructure to

implement the new email system, which is very reasonable considering limited operational budget to improve IT service in the community college.

The next stage was to migrate from legacy to the new email system. The student consultant and the community partner agreed to perform the migration process during Summer weeks considering less traffic as most of users are off island. In relation to that, there are some stages that were perform asp below:

a. Sign Up and Verify Domain for Google Apps for Education

The student consultant assist the community partner to sign up for Google Apps for Education. In relation to that, the community partner has to verifying domain ownership of www.palau.edu within 21 days after signing up to activate the services. Among several ways to verify the domain, the community partner decided to add a <meta> tag to PCC's website (www.palau.edu) which took about an hour to get verified by Google.

b. Setup Google Apps Core Features

In this stage, the community partner use the easy-to-use setup wizard provided by Google. This include running a pilot to test and get hands on experience of the new email system among the Computing Service staff. The community partner are willing to activate most of Google apps to be available for users' use. However, in order to maintain users' learning curve of the new email system, the community partner then decided to temporarily deactivate Google Drive and Google Site. Further discussion will take place together with the Distance Learning instructors to utilize these features.

c. Migrating users

Each user in domain mail.palau.edu has to have user account that provides users with a name password for signing in to their email address, as well as the Google Apps. In this case, the email administrator may create accounts to use as mailing lists and also give users additional email aliases if necessary.

The student consultant assist the community partner to use the setup wizard in migrating users from the legacy email system. There are several options available to creating user accounts, depending on organization's size and structure. As the number of users in the PCC's legacy email system is considerably small (< 100), the community partner decided to upload a CSV (Comma Separated Values) file to add several users at once. In order to minimize confusion at user's side, the community partner will creates exactly the same username as it was in the legacy system.

In addition to that, the community partners decided to maintain several groups of users based on business units in PCC asp follows:

- academicaffairs@palau.edu - Group of staff in Academic Affairs
- counselors@palau.edu - Group of counselors in Student Service
- pccasc@palau.edu - Group of PCC's Accreditation Steering Committee
- pcciac@palau.edu - Group of PCC's Institutional Steering Committee
- pcclib@palau.edu - Group of staff in PCC's Library
- pccusers@palau.edu - Group of all users in mail.palau.edu

- registrar@palau.edu - Group of staff in Registrar Office
- studentservice@palau.edu - Group of staff in Student Service
- techsupport@palau.edu - Group of staff in the Computing Service

d. Reroute the DNS for mail.palau.edu

In order to redirect all email for users of mail.palau.edu in Gmail platform, the community partner has to point Mail Exchange (MX) records to Google mail servers first. MX records of mail.palau.edu is configured in its domain host of www.educause.edu. In relation to that, multiple MX records can be defined to direct email to multiple servers for a domain with a different priority (lowest number is highest priority). That way, if one server is down, mail can be routed to another server instead to ensure any emails will always get delivered. The changes of this configuration may take up to 72 hours before they are propagated, depending on the TTL that was configured in PCC's MX records. Thus, until records have been updated worldwide, PCC users will still receive email through the legacy email server.

e. Installing the new email in users' email client

After all the setup in email server has settled, student consultant and the community partner running several tests in sending and receiving emails with and without attachments. Once it is done, student consultant assist the community partner to integrate the new email system to several email clients used in users' desktop or laptop i.e. Mozilla Thunderbird, Outlook Express, and Apple Mail. In general, the configuration should be fill up with the following information:

- Incoming Mail (POP3, IMAP, HTTP) server: imap.gmail.com or pop.gmail.com
Port: 993 (IMAP) or 995 (POP3)
- Outgoing Mail (SMTP) server: smtp.gmail.com
Port: 465

3. Educating users to use the new email system

It took almost a week to install and introduce the new email system to most of PCC's users. There is no significant different in the way of user sending and receiving emails as they still using the same username as they have in the legacy email system. In relation to that, there are some improvements offers by the new email system that needs to be introduce to users:

1. Access the email through web browser

As mentioned before, the Google Apps for Education offers web based interface (See Appendix R) to allow users accessing their inbox from anywhere at anytime. All users positively welcomed this improvement as now they can intensively correspond using official email of mail.palau.edu. One thing that user should understand is that the inbox that can be accessed via URL: mail.palau.edu or www.gmail.com (See Appendix O) will always be more update than those in the email client at their desktop or laptop. Due to bandwidth limitation at PCC, users should expect delayed for the email client to download all the new email from Google servers, especially those that come up with attachments.

Ever since the new email system been fully implemented, the Computing Service receive no complaints about the email service and users looks comfortable to use it in daily basis.

2. Access the email through email client (i.e. Mozilla Thunderbird, Outlook Express)

Most of PCC's users already use either Mozilla Thunderbird or Outlook Express to access the legacy email system. In this case, there is no different for them to access the new email system with those existing email client. The main different is that there might be delayed in downloading incoming emails with attachment from Google server. This issue actually also occurred in the local email server, whereas the community partner need to manually remove the bottleneck in the local email server by sending them one by one.

3. Using Gtalk Chat

In addition to the features offers by Google Apps for Education, users may also use Gtalk Chat to establishe one-to-one communication with other users. In this case, they may send files using the Gtalk, which is another alternative for them to overcome any issue in sending emails with attachments due to bandwidth limitation. Most of staff now has Gtalk installed in their PC Desktop and use it regularly to communicate with others. In several testing, student consultant and the community partner found that sending attachments via Gtalk is faster than common email communication. Thus, users can utilize the Gtalk if they need to send files with other users. Some of its limitation are that Gtalk can only be use among Gmail users and the receiver has to accept file transmission before the transmission started.

Recommendations

In order to maintain the sustainability of the new email system of Google Apps for Education, student consultant recommends below short term action plan to carry on the improvement:

1. Collaborate Google Apps for Education to enhance PCC's Distance Learning Course

As mentioned before, Google Apps for Education offers several features to provide fast and easy collaboration among users (See Appendix Q). Google Site and Google Docs offer real-time editing, powerful sharing controls and seamless compatibility, which is very suitable for distance learning environment.

Google Chat with video and Google Docs supports group study across distance in real time. Whether near or far, students and faculty or instructors can arrange impromptu video chats right from mail.palau.edu inbox or jump into the same document. They can edit it together as if they are sitting at the same computer and sharing the same screen i.e. Microsoft Word, Microsoft Excel, Microsoft Power Point, etc. Every student within a class has access to the right version of any document, spreadsheet or presentation. It can help streamline academic tasks like essay writing and class scheduling. No more back-and-forth email attachments and versions that user cannot keep track of.

The Distance Learning Instructors may coordinate with the Computing Service to collaborate Moodle Software System with Google Apps for Education. In relation with that, PCC has to ensure that there will be reliable Internet bandwidth available to support the distance learning course. Moreover, the Computing Service staff need to attend training to improve their knowledge of utilizing the features of Google Apps for Education.

2. Provide Email Accounts for Students and PCC's Part Time Staff

The ease of user management in Google Apps for Education allows PCC to add unlimited number of users. Thus, it is a great opportunity to provide email accounts for students and PCC's Part Time Staff.

There will be advantages for students if they can join in the PCC's community using Google Apps for Education. Students can consultate with the conselors through Gtalk at any time and they can discuss homework online through Google Docs with the instructors. As there is no limitation for number of users in Google Apps for Education, all faculty and staff of PCC now should be able to be connected via available apps provided by Google.

In this case, Technology Committee should work together with Registrar and Records office and Human Resource to define the procedure in registering student and part time staff into the new email system. This will also encourage all faculty and staff to stop using public email account i.e. Gmail, Yahoo, etc. and use only mail.palau.edu for official correspondence in PCC.

About the Consultant

Fachry Rozy Oemar is a senior in Information Systems Management at Carnegie Mellon University. He is working as a System Architect at Indonesian Customs under the Ministry of Finance of Republic of Indonesia. He is taking part in the Technology Consulting in the Global Community internship over the summer and return in the fall to gain the Master Degree on December 2013.

Appendix A.

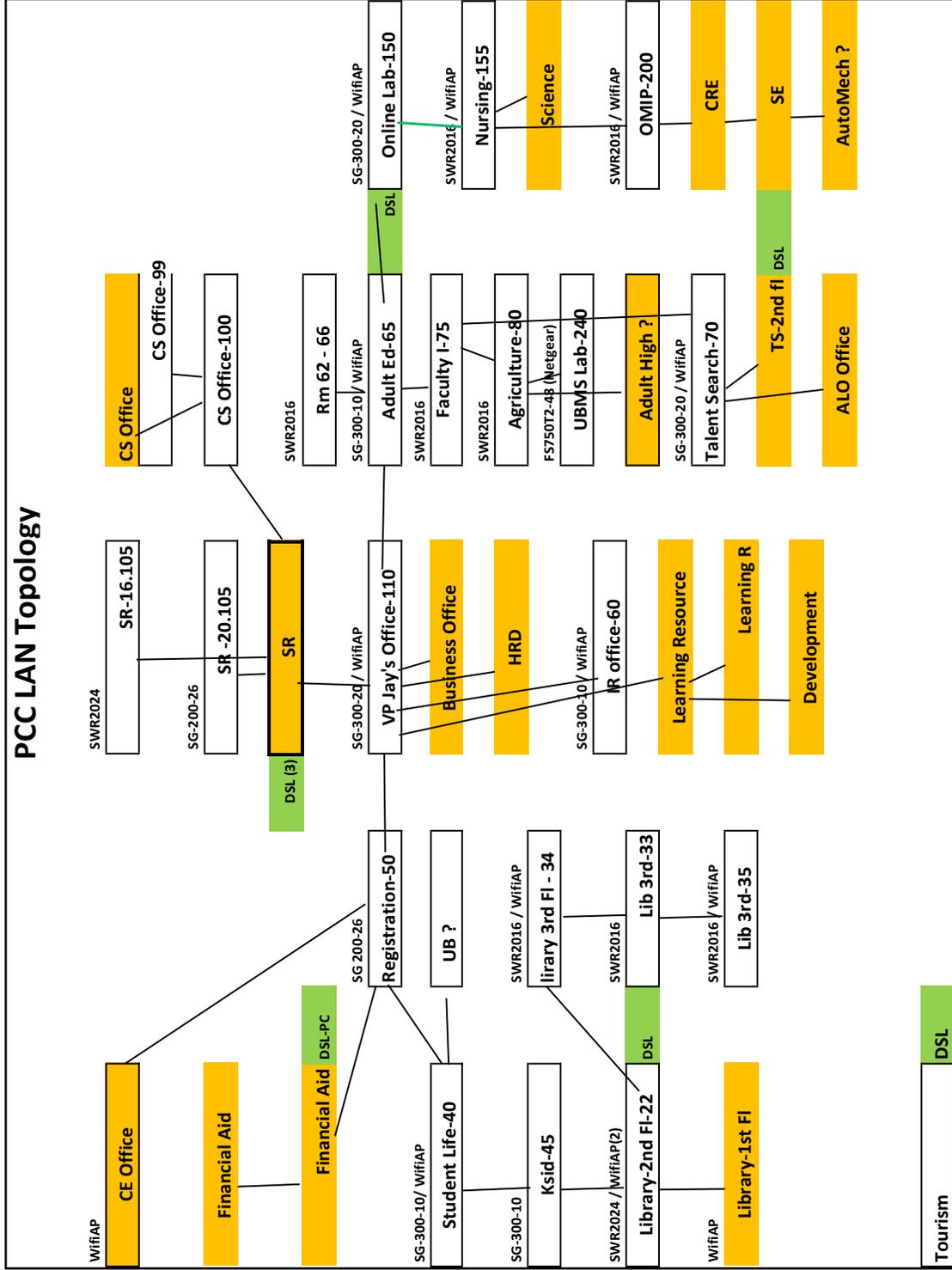


Figure 3 – PCC's Existing Network Topology Drawing

Appendix B.

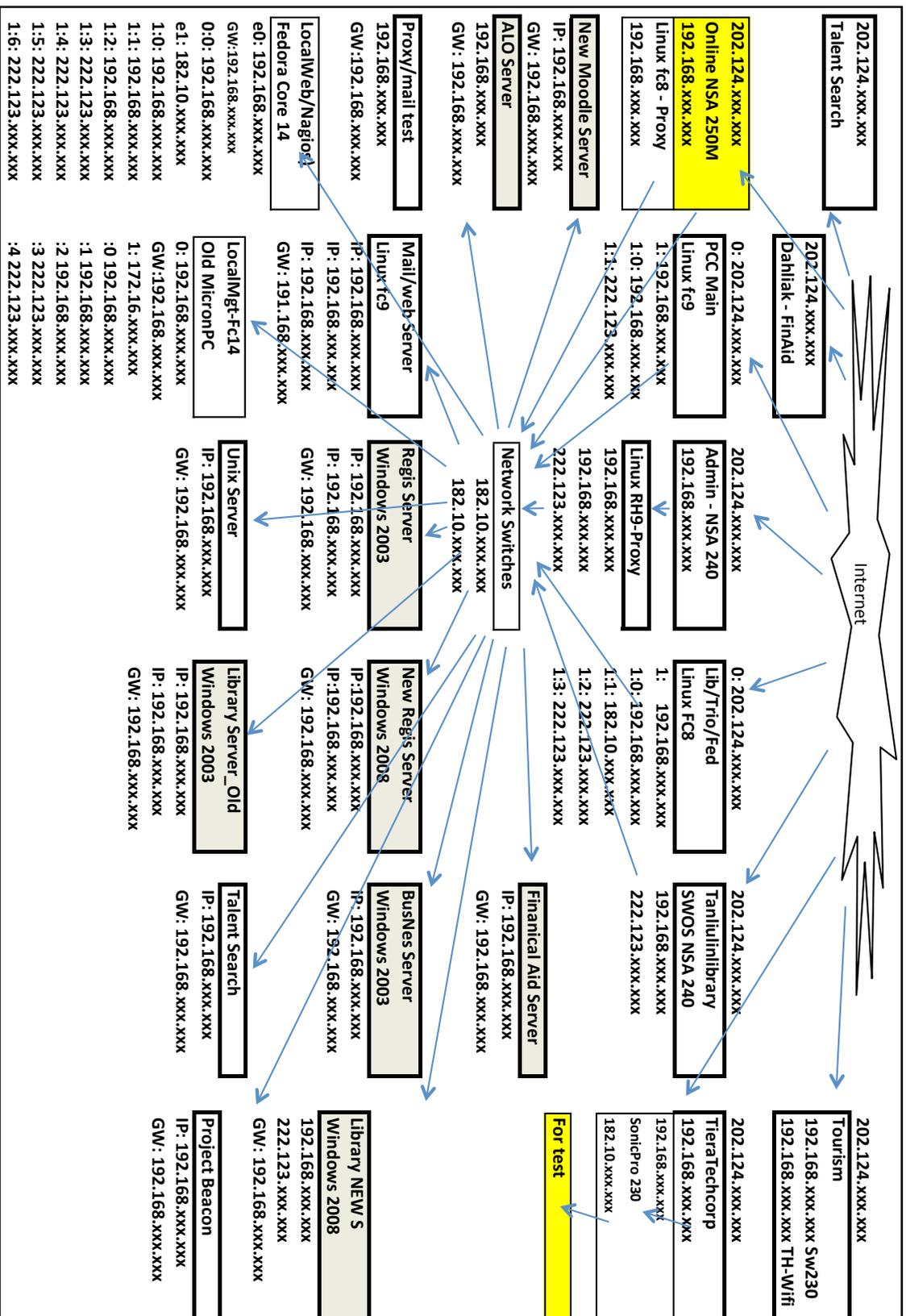


Figure 4 – DSL Lines & Server Diagram

Appendix C.

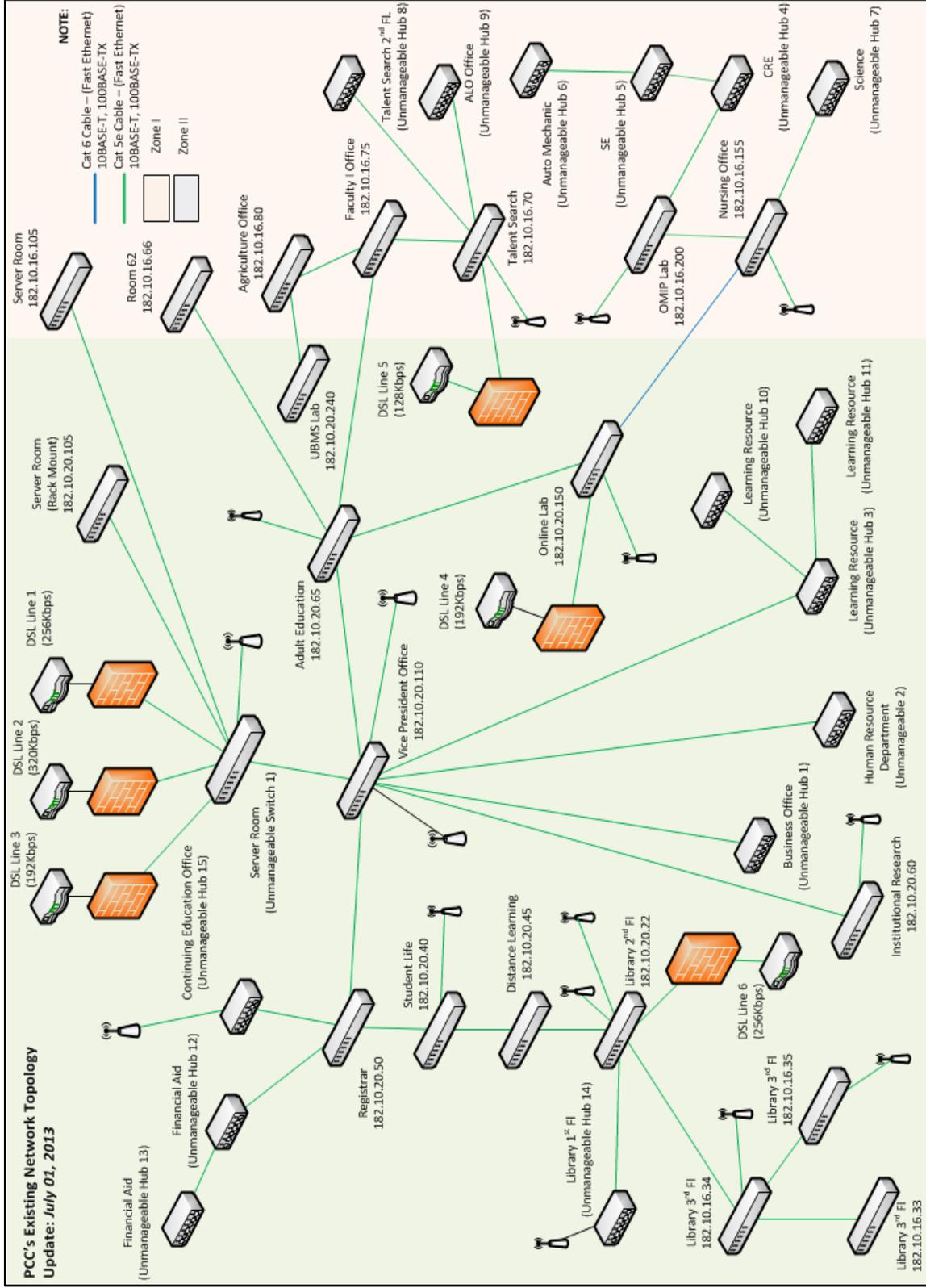


Figure 5 – PCC's Existing Network Topology – Re Drawing

Appendix D.

PCC'S NETWORK BACKBONE DESIGN – CABLE (Cat6a – 100BASE T, 1000BASE-TX)

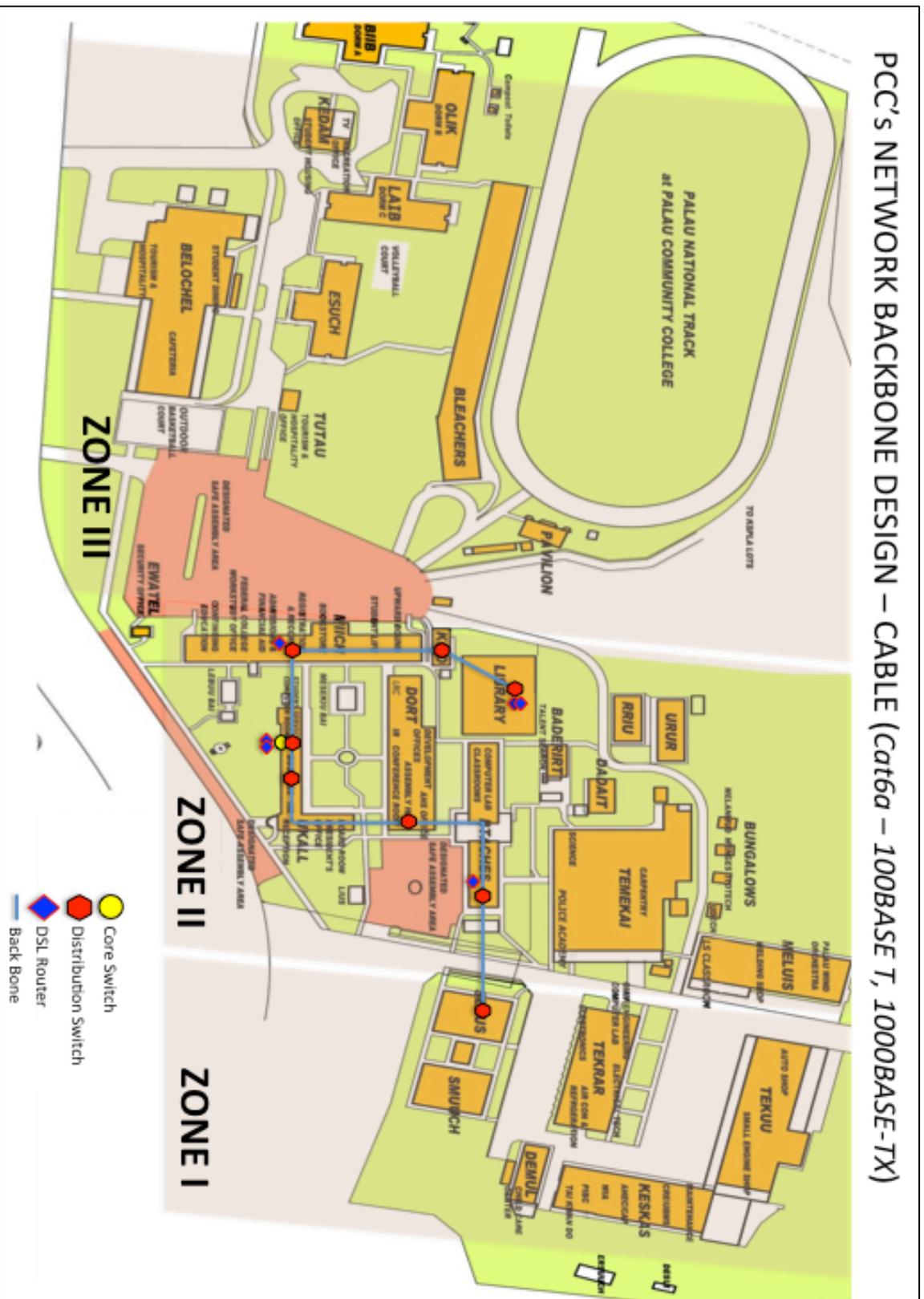


Figure 6 – PCC's Existing Network Backbone Design – Cable

Appendix E.

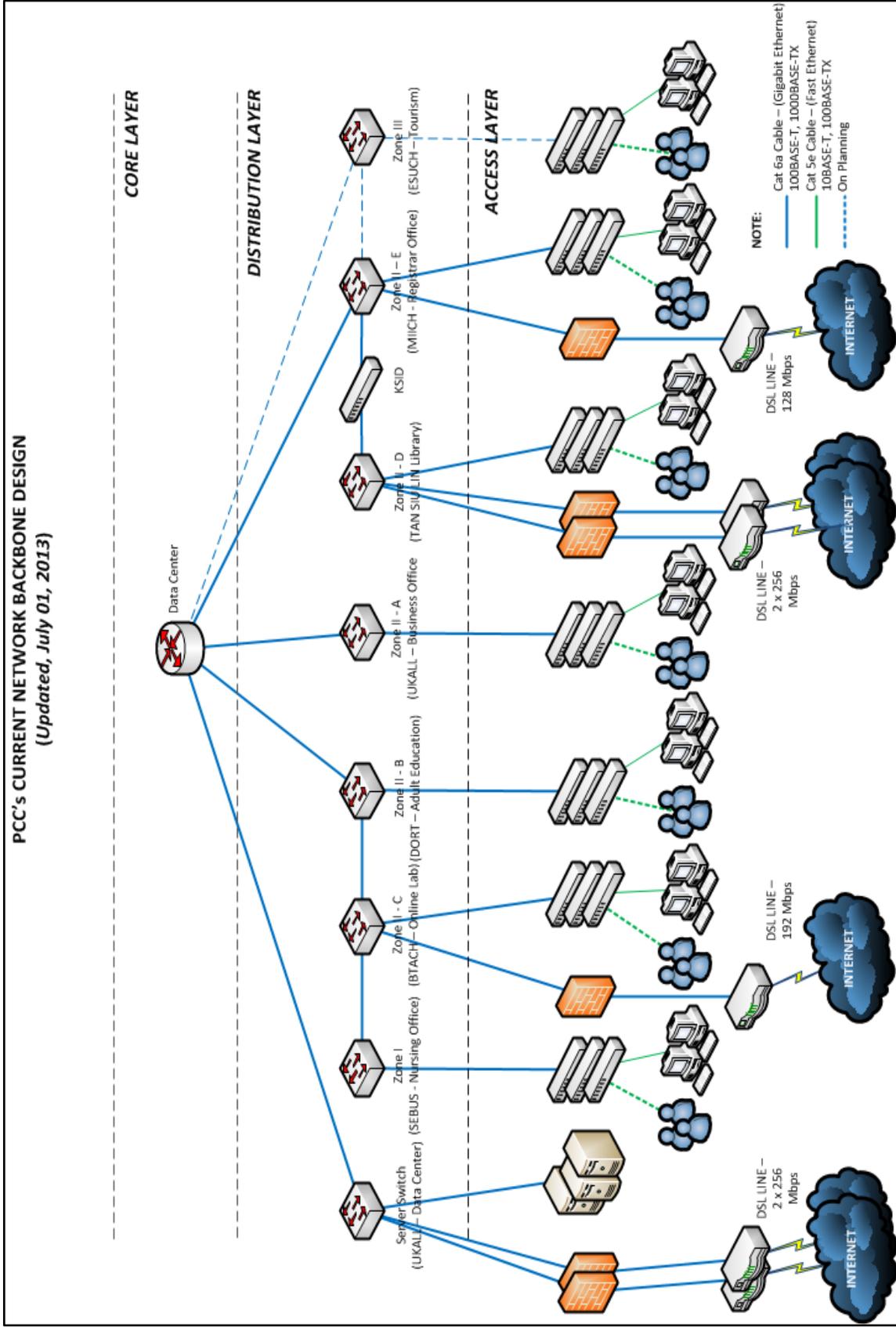


Figure 7 – PCC's Existing Network Backbone Design (Master Plan)

Appendix F.

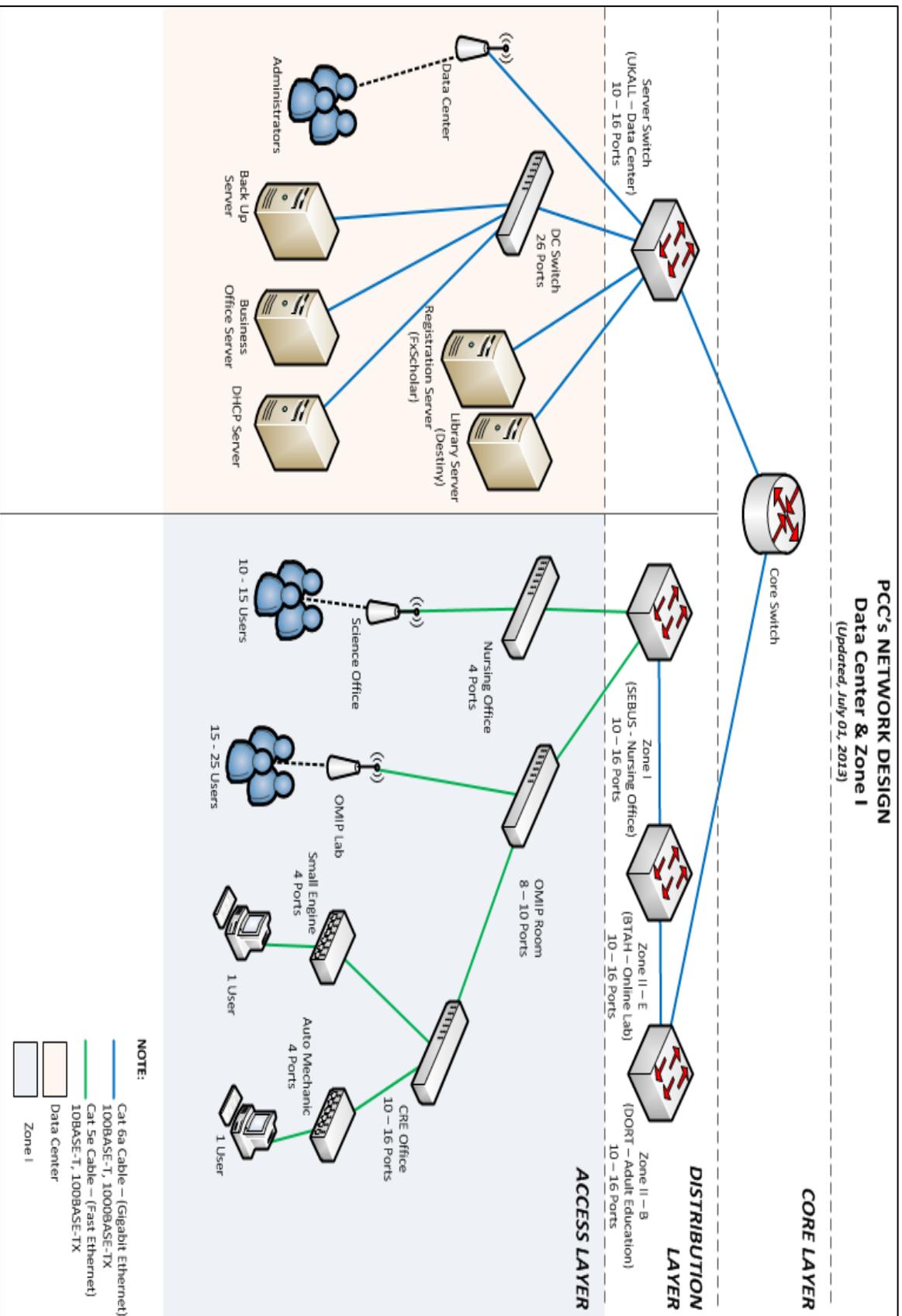


Figure 8 – Network Design for Data Center & Zone I

Appendix G.

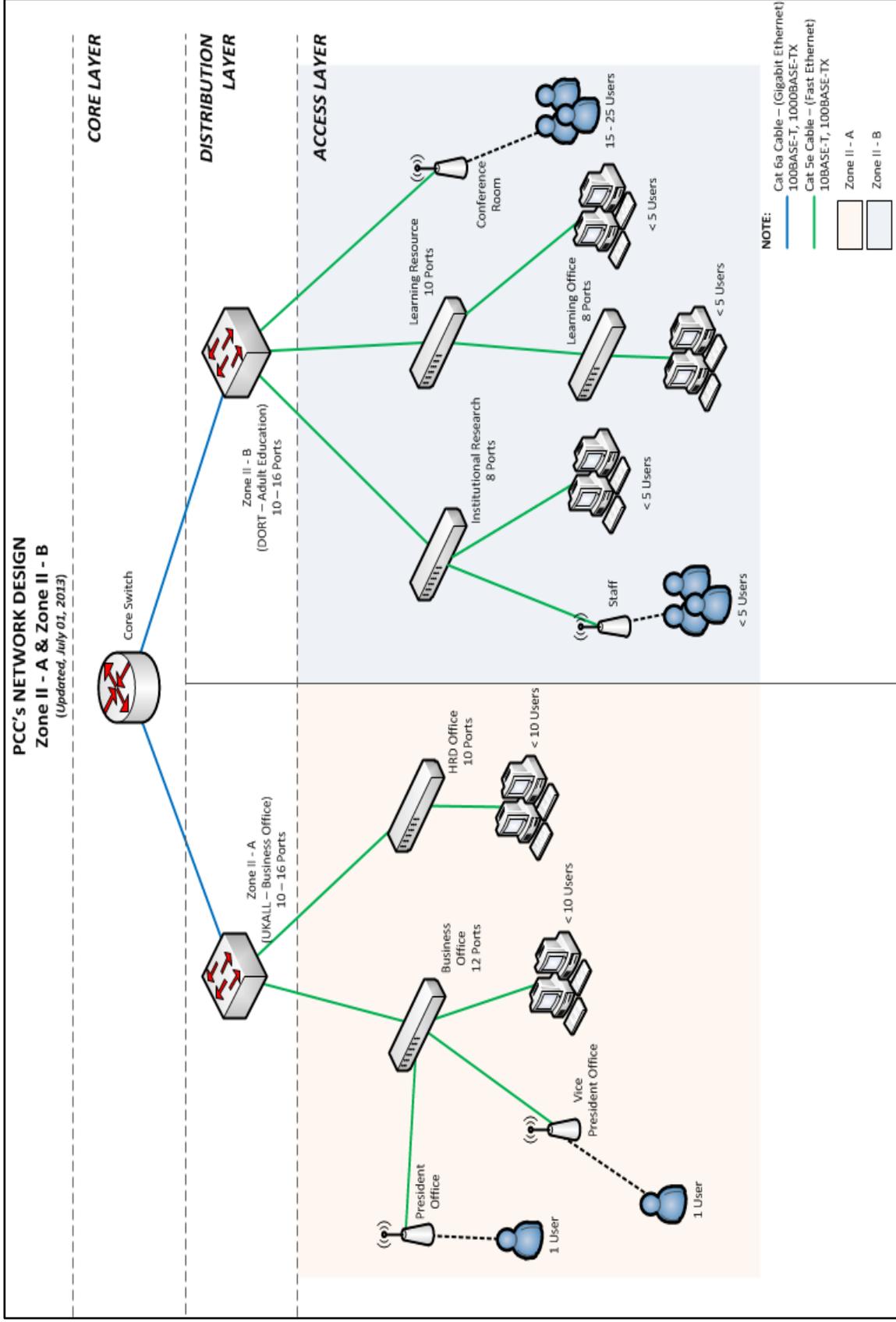


Figure 9 – Network Design for Zone II-A & Zone II-B

Appendix H.

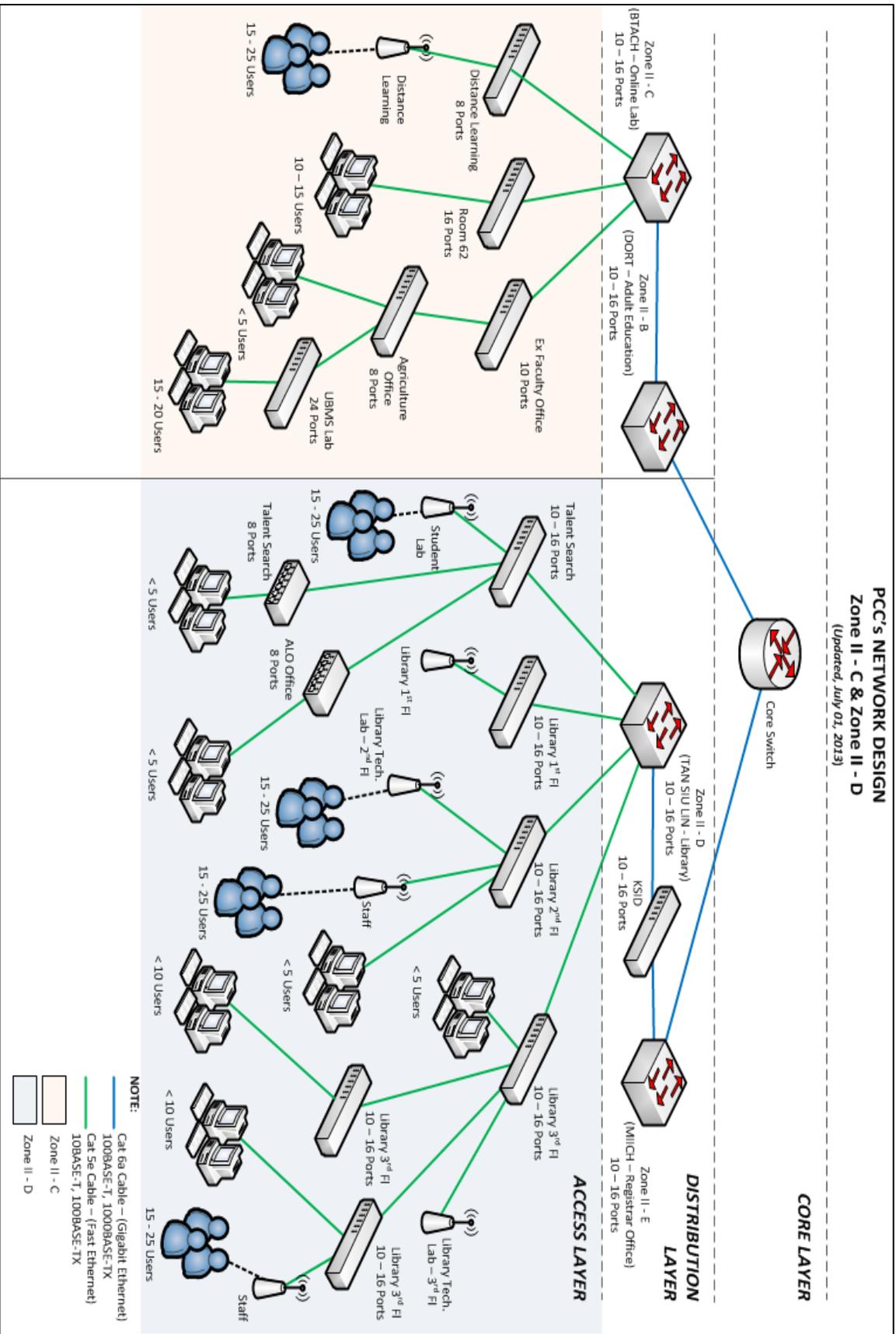


Figure 10 – Network Design for Zone II-C & Zone II-D

Appendix I.

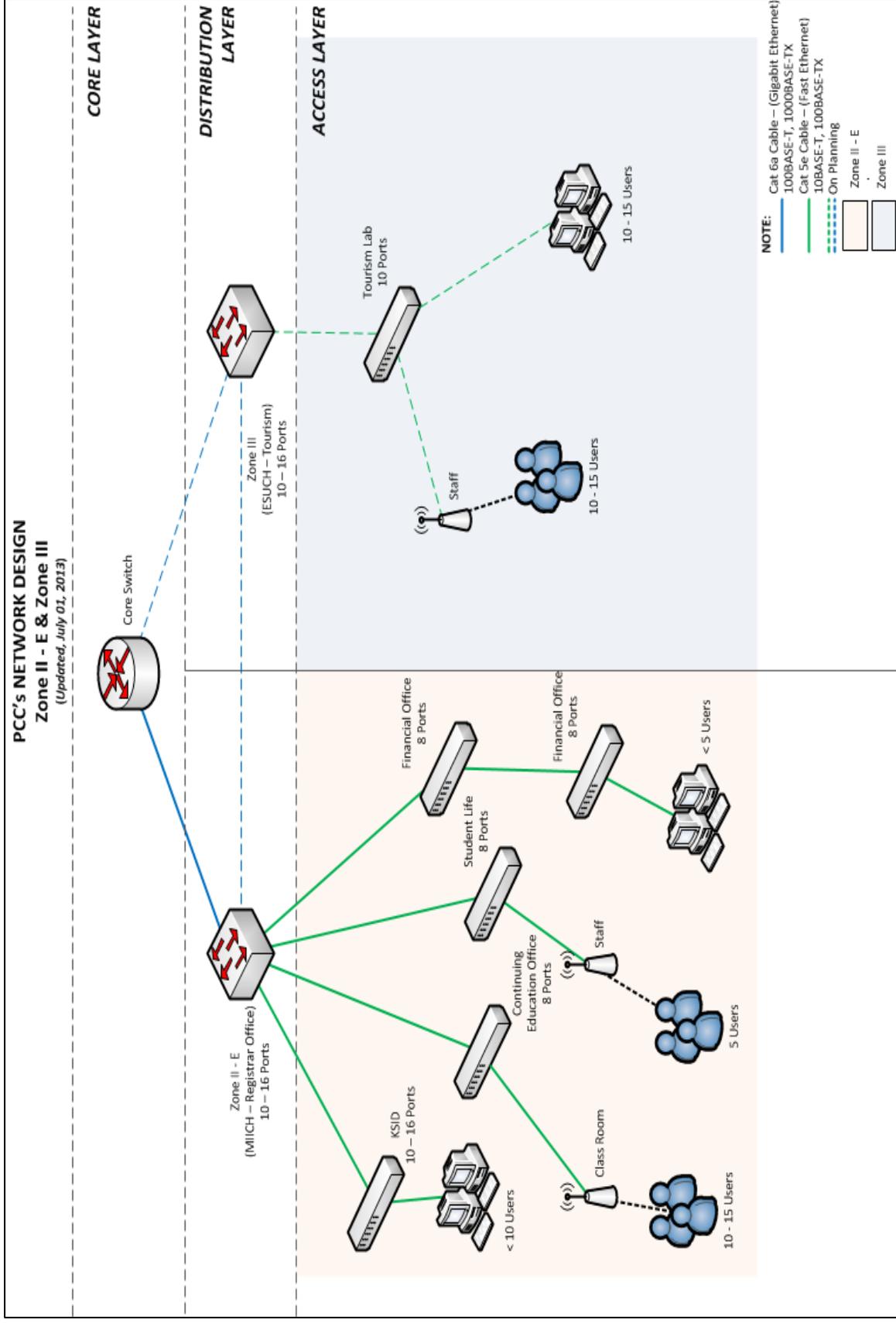


Figure 11 – Network Design for Zone II-E & Zone III

Appendix J.

PCC'S NETWORK BACKBONE DESIGN – FIBER OPTIC

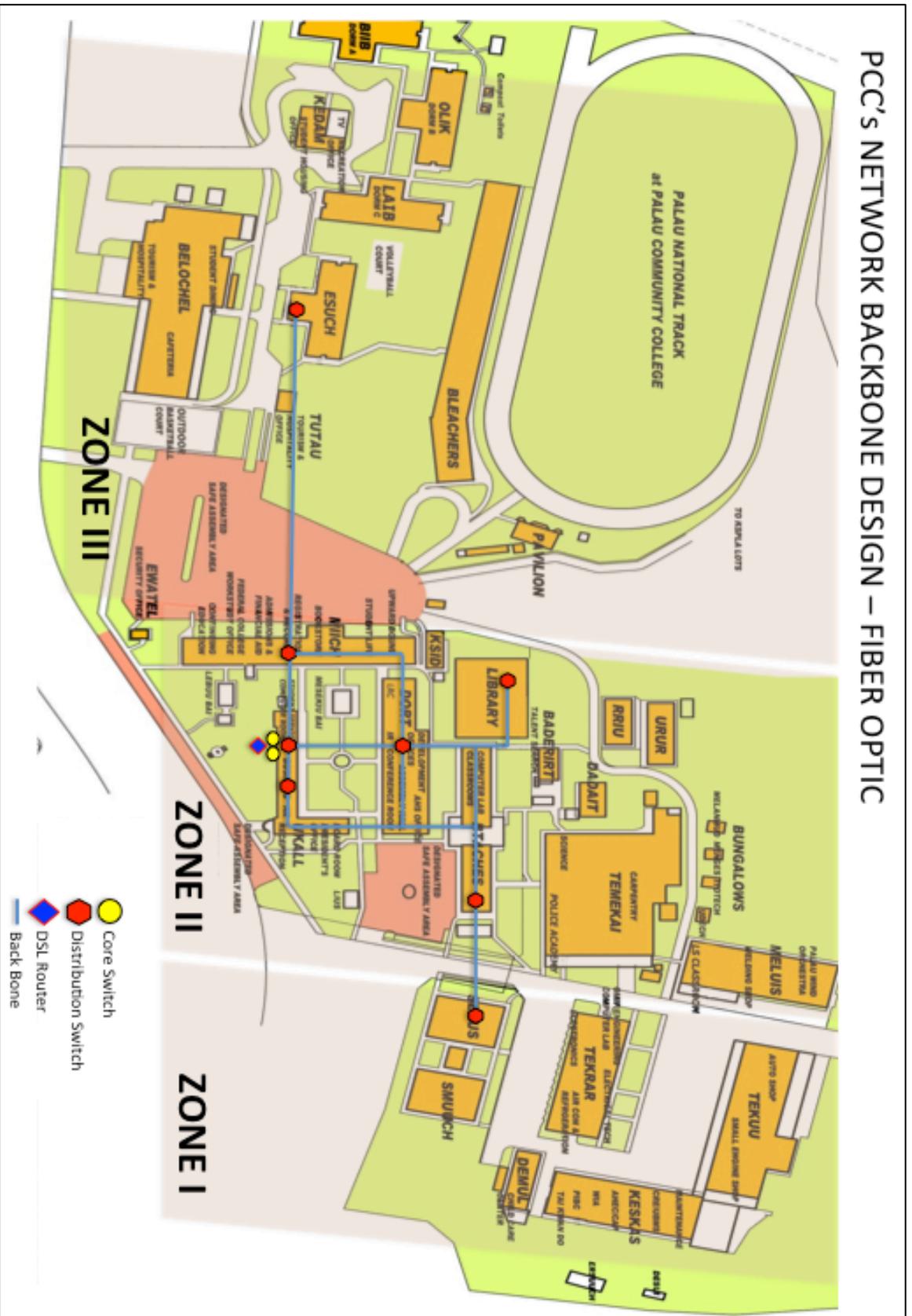


Figure 12 – PCC's Future Network Backbone Design with Fiber Optic

Appendix K.

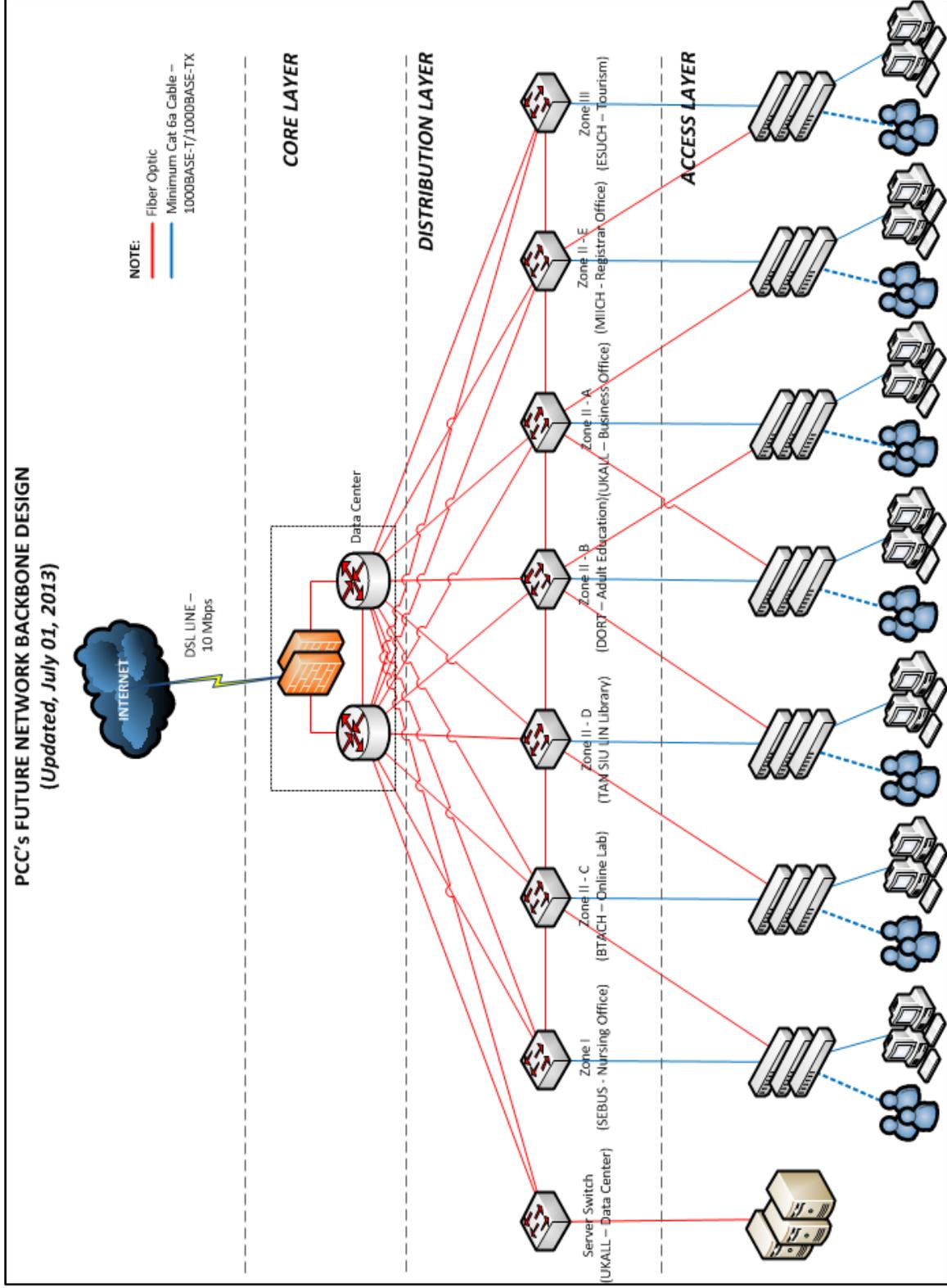
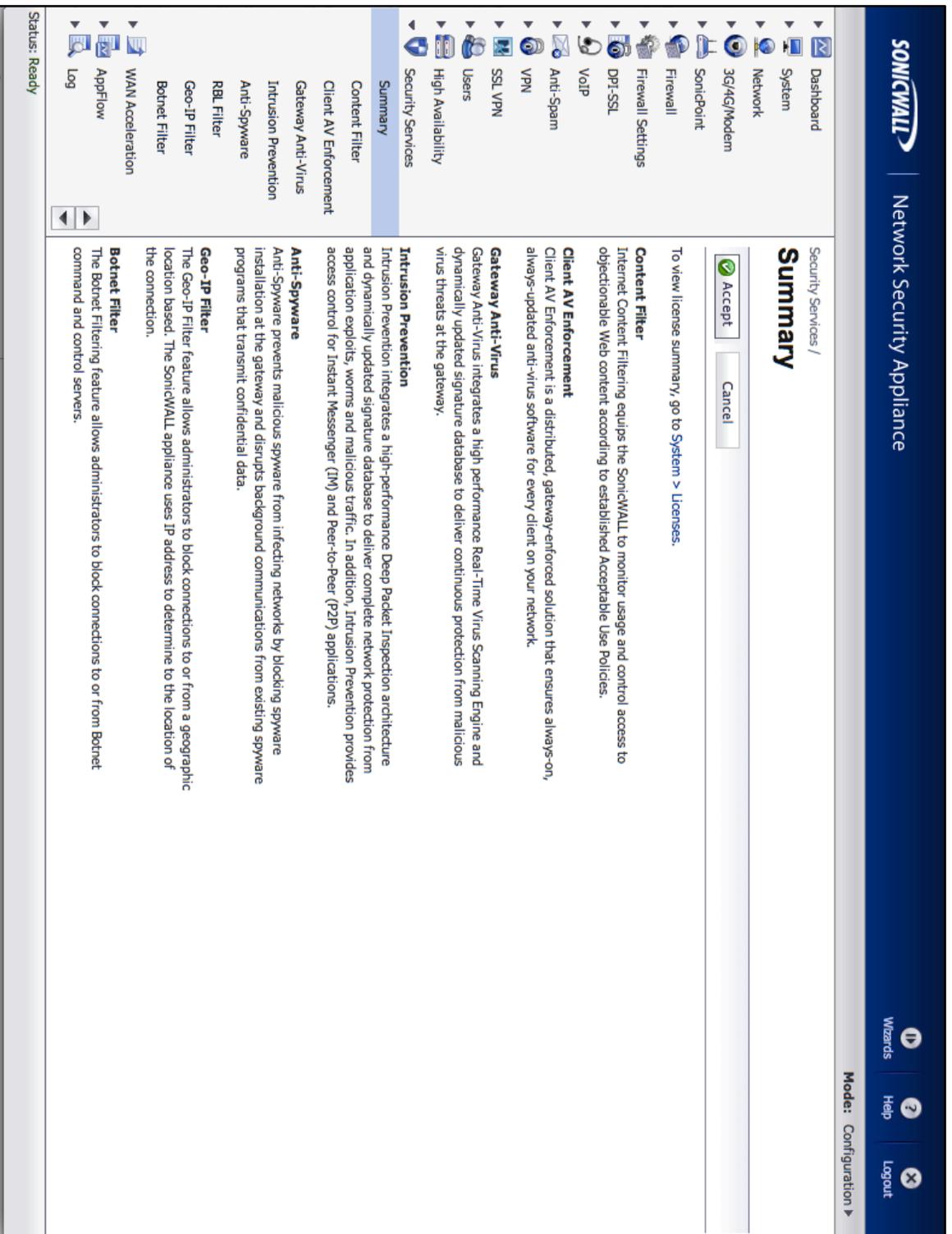


Figure 13 – PCC's Future Network Backbone Design - Fiber Optic

Appendix L.



The screenshot shows the SonicWALL Network Security Appliance interface. The top navigation bar includes the SonicWALL logo and the text "Network Security Appliance". On the right side of the navigation bar are links for "Wizards", "Help", and "Logout". Below the navigation bar, the page title is "Security Services / Summary". There are "Accept" and "Cancel" buttons. The main content area contains several sections: "Content Filter", "Client AV Enforcement", "Gateway Anti-Virus", "Intrusion Prevention", "Anti-Spyware", "Geo-IP Filter", and "Botnet Filter". Each section has a brief description of its function. The status bar at the bottom left indicates "Status: Ready".

SONICWALL Network Security Appliance

Wizards Help Logout

Mode: Configuration

Security Services /

Summary

To view license summary, go to System > Licenses.

Content Filter
Internet Content Filtering equips the SonicWALL to monitor usage and control access to objectionable Web content according to established Acceptable Use Policies.

Client AV Enforcement
Client AV Enforcement is a distributed, gateway-enforced solution that ensures always-on, always-updated anti-virus software for every client on your network.

Gateway Anti-Virus
Gateway Anti-Virus integrates a high performance Real-Time Virus Scanning Engine and dynamically updated signature database to deliver continuous protection from malicious virus threats at the gateway.

Intrusion Prevention
Intrusion Prevention integrates a high-performance Deep Packet Inspection architecture and dynamically updated signature database to deliver complete network protection from application exploits, worms and malicious traffic. In addition, Intrusion Prevention provides access control for Instant Messenger (IM) and Peer-to-Peer (P2P) applications.

Anti-Spyware
Anti-Spyware prevents malicious spyware from infecting networks by blocking spyware installation at the gateway and disrupts background communications from existing spyware programs that transmit confidential data.

Geo-IP Filter
The Geo-IP Filter feature allows administrators to block connections to or from a geographic location based. The SonicWALL appliance uses IP address to determine to the location of the connection.

Botnet Filter
The Botnet Filtering feature allows administrators to block connections to or from Botnet command and control servers.

Dashboard
System
Network
3G/4G/Modem
SonicPoint
Firewall
Firewall Settings
DPI-SSL
VoIP
Anti-Spam
VPN
SSL VPN
Users
High Availability
Security Services

Summary
Content Filter
Client AV Enforcement
Gateway Anti-Virus
Intrusion Prevention
Anti-Spyware
RBL Filter
Geo-IP Filter
Botnet Filter
WAN Acceleration
AppFlow
Log

Status: Ready

Figure 14 – Firewall's Security Services

Appendix M.

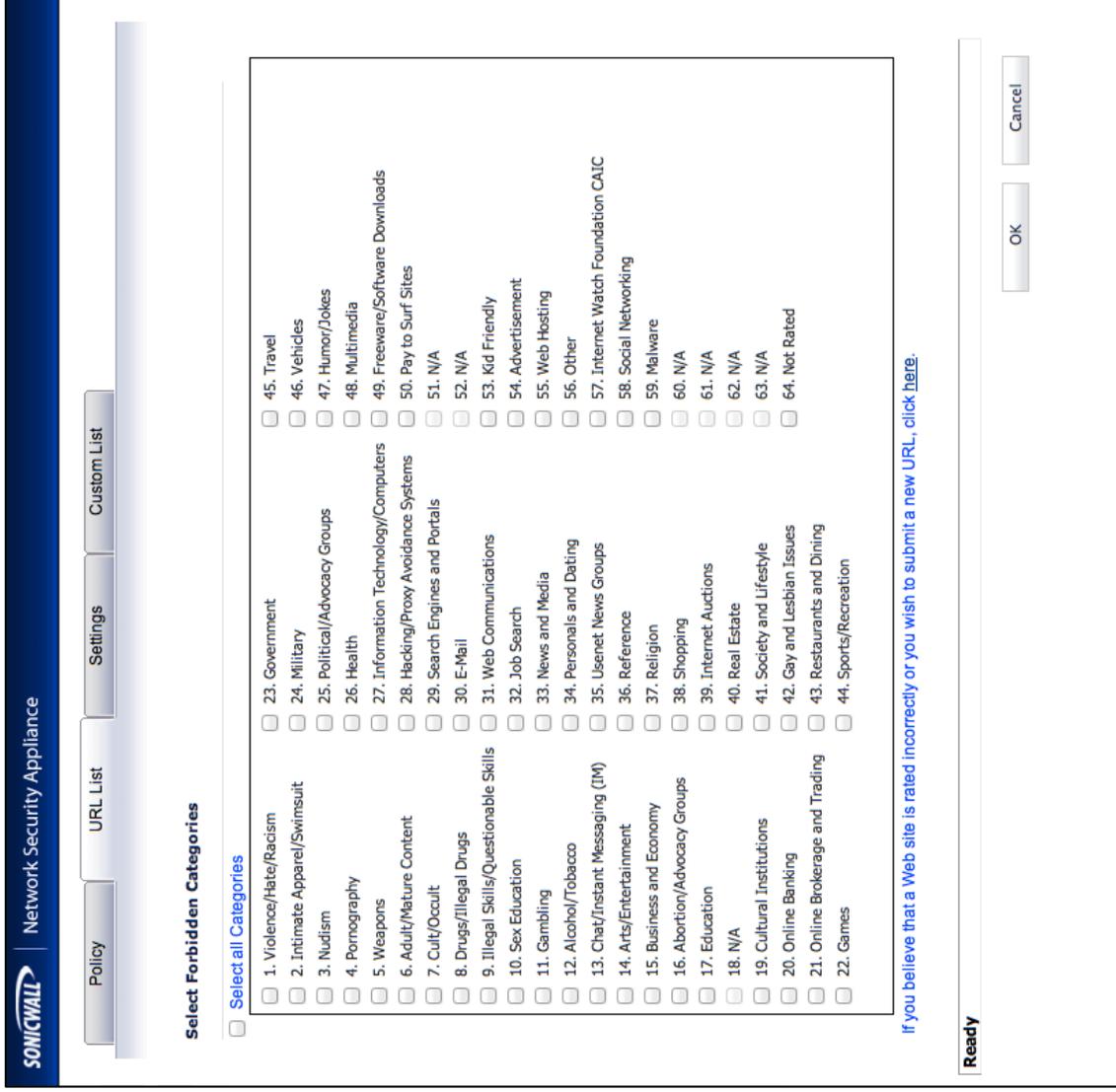


Figure 15 – Forbidden Categories

Appendix N.

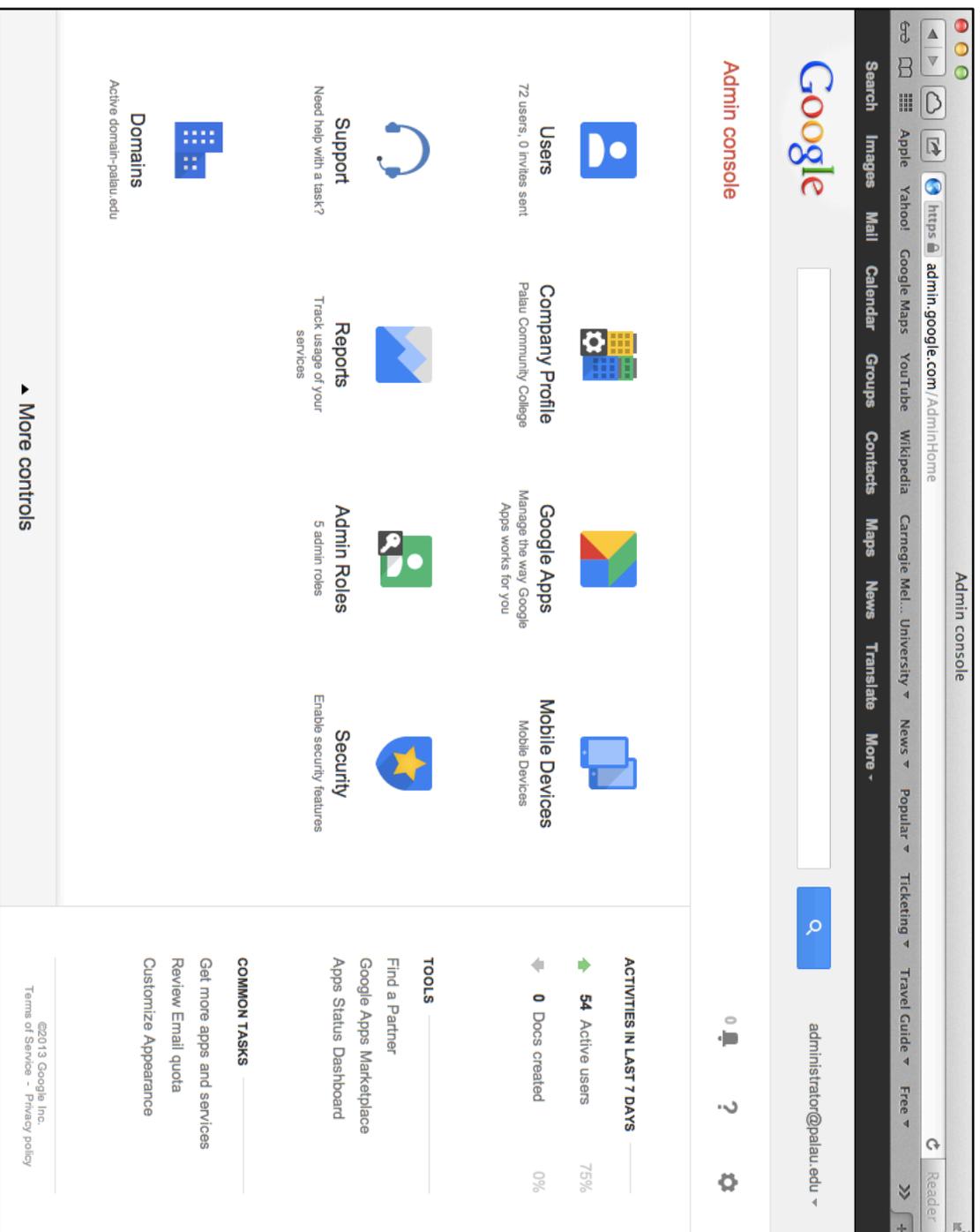


Figure 16 – Google Apps Admin Console

Appendix O.



Figure 17 – Google Apps User Login

Appendix P.

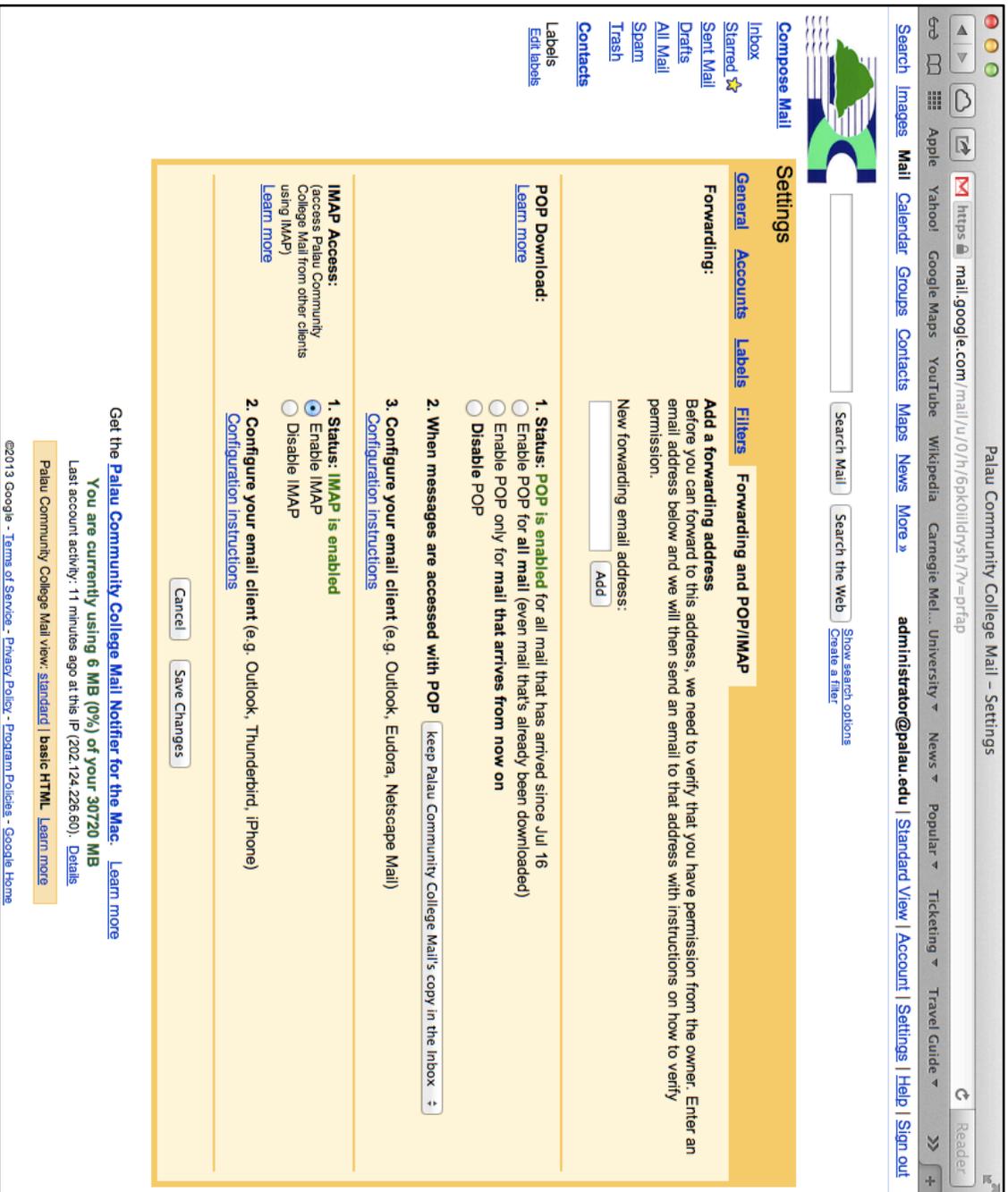


Figure 18 – Google Apps Users' Account Setting

Appendix Q.

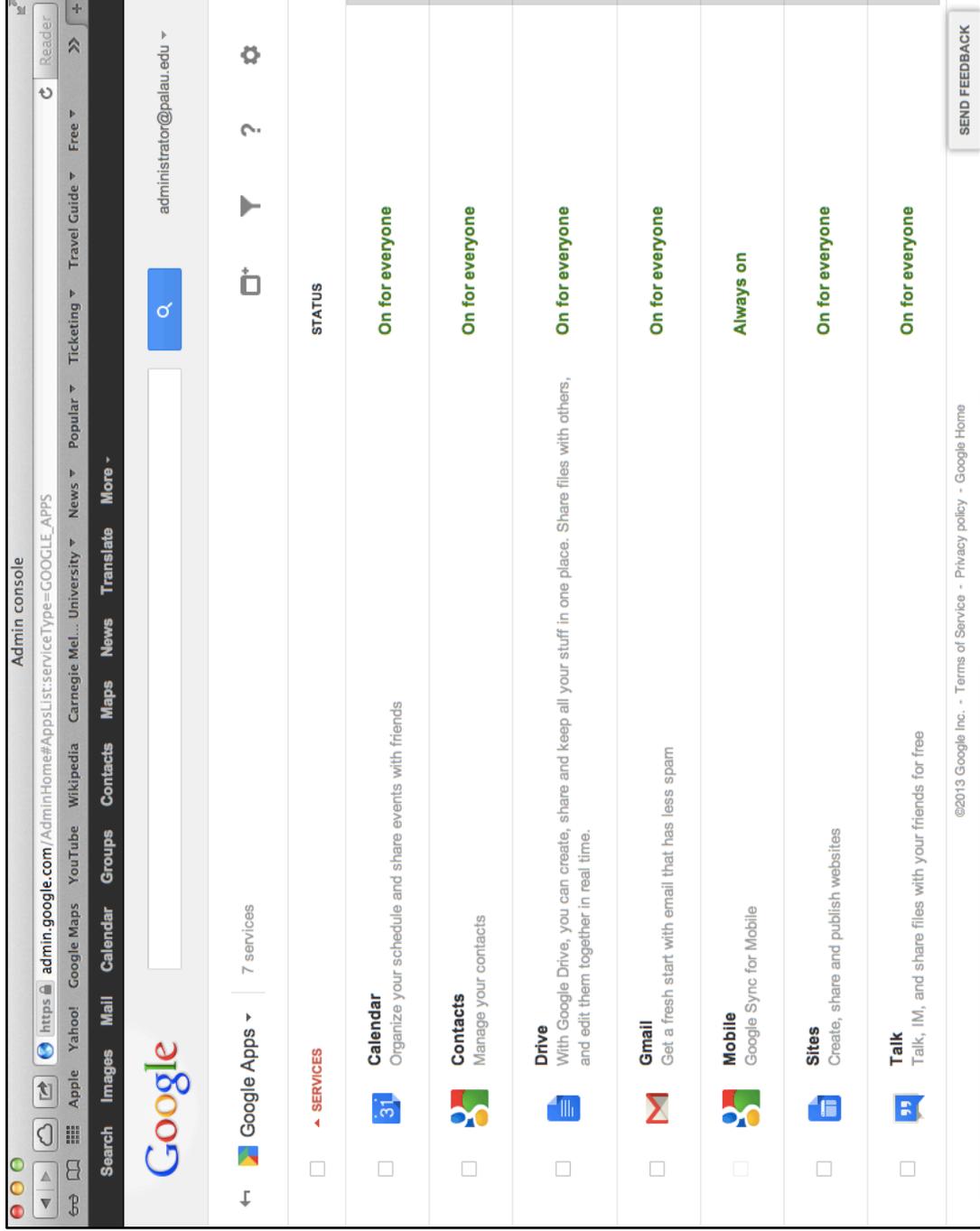


Figure 19 – Google Apps for PCC’s Users

Appendix R.

Palau Community College Mail - Inbox

Search Images Mail Calendar Groups Contacts Maps News More » administrator@palau.edu | Standard View | Account | Settings | Help | Sign out

1 - 50 of about 60 Older >

Archive	Report Spam	Delete	More Actions...	Go	Refresh		
<input type="checkbox"/>						Bruce, Jay (2)	IMPORTANT !! ... PCC's New Email System - Of course, I have no idea what you are talking Jul 17
<input type="checkbox"/>						FACHRY ROZY OEMAR	Test - Test Jul 16
<input type="checkbox"/>						Hilda Ngralman	Test From Hilda Account - Test PCC Jul 10
<input type="checkbox"/>						FACHRY, Lourdes (2)	Test from Fachry Account - Well received on Wed Jul 10 On 7/2/2013 9:37 AM, FACHRY ROZY Jul 10
<input type="checkbox"/>						Shelley, me (4)	Test from Outlook - On 7/8/2013 4:17 PM, Administrator PCC wrote: > Well Received to new Jul 8
<input type="checkbox"/>						Tchuzie Tadao	Re: Test from Adminst - Well received and try to reply On 7/8/2013 3:02 PM, Fachry R Oemar Jul 8
<input type="checkbox"/>						FACHRY, Jay (2)	Email Administrator Test - On 7/8/2013 2:26 PM, FACHRY ROZY OEMAR wrote: > Dear Jul 8
<input type="checkbox"/>						Vernice, me (2)	Test From Vernice Account - Test Received On 7/8/13, Vernice Y wrote: > Test > > Jul 8
<input type="checkbox"/>						me .. Yerra, Lauran (5)	Random Email Testing - Aili Bruce/Administrator, thanks, I hope I can keep getting my Jul 6
<input type="checkbox"/>						Jay, me (2)	Re: Test - Reply from admin On 7/4/13, Jay Olegierill wrote: > On 7/4/2013 5:05 PM, Fachry R Jul 4
<input type="checkbox"/>						Maurine Alexander	Test from Maurine - Test Jul 4
<input type="checkbox"/>						Jay, me (2)	Test From Jay - Well received from admin On 7/4/13, Jay Olegierill wrote: > This afternoon > Jul 4
<input type="checkbox"/>						me, Flora (3)	Test - On 7/4/2013 3:33 PM, Administrator PCC wrote: > Test ok! Jul 4
<input type="checkbox"/>						Harline	RE: aili - Re Test Jul 4
<input type="checkbox"/>						Harline Haruo	Test to Admin - Test Jul 4
<input type="checkbox"/>						Norma Etibek	testing from Norma @ Front Office - testing 123 Jul 4
<input type="checkbox"/>						Patrick, me (2)	test from new Pres email - Well received again On 7/4/13, Patrick Tellei wrote: > testing 123 > Jul 4
<input type="checkbox"/>						Patrick, me (2)	testing from Pres Eudora - Well Received On 7/4/13, Patrick Tellei wrote: > Testing 123 > Jul 4
<input type="checkbox"/>						Human Resource - PCC	Re: Air-Conditioning Instructor - test from old server of hr Jul 4
<input type="checkbox"/>						Human Resource - PCC	Re: Librarian Position - Test from old message Jul 4
<input type="checkbox"/>						Pioria Faunгы	Test from Pioria @ Library - Testing 1 2 3. Jul 4
<input type="checkbox"/>						Tchuzie, me (2)	Test from Tchuzie - Well received yesterday.. sorry for late reply :) On 7/3/13, Tchuzie Tadao Jul 3
<input type="checkbox"/>						Shelley, me (2)	Testing from Shelley - Well received yesterday... sorry for late reply :) On 7/3/13, Shelley Ueki Jul 3

Figure 20 – User's Inbox (mail.palau.edu)