TECHNOLOGY CONSULTING
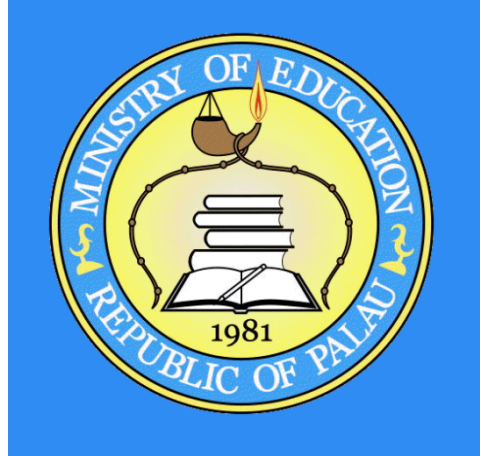## IN THE GLOBAL COMMUNITY

Final Consulting Report

Palau Ministry of Education

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August 2021

Carnegie Mellon University

cmu.edu/tcingc

Ministry of Education, Republic of Palau Executive Summary

Student Consultant, Meghna Chhabra
Global Community Partner, Edwel Ongrung

I. About the Organization

The Ministry of Education is one of the nine departments of the Executive Branch of the National Government of the Republic of Palau. It is responsible for the education of Palau's children ages 6-17.

The ministry is headed by a cabinet level position, the Minister of Education. It implements its strategies and goals through two bureaus, **Curriculum and Instruction** and **Education Administration.**

Direct services to children are delivered through eighteen public and six private elementary and high schools. The ministry operates the public schools. The private schools are independently operated under charter from the ministry.

The mission statement of the organization is as follows-

> *"In partnership with parents and community, is to ensure that our children and youth preserve Palauan culture and become contributing citizens and productive workers in a changing world."*

The vision of the ministry is *"Our students will be successful in the Palauan society and the world."*

II. Migration of Services to the Cloud

Recently, MOE has changed the technical infrastructure. Previously, all the 20 campuses were connected to central office which was further connected to the internet. Thus, communication to the outside world was being handled by the central office. Currently, every campus is connected to the internet, and it has improved the communication however, the campuses still use the intranet to access certain apps such as-

- Apps running on Apache/PHP Server with MySQL database at the backend.
- Ruby on Rails App with MySQL database at the backend

Outcomes of the project include:
- Provide the flexibility and agility that the MOE needs as it increases its use of technology in the coming years.
- Migrating these services to the cloud and making them accessible over internet instead of intranet would reduce the bandwidth cost at central office as the schools will be able to connect directly to the cloud.
- Eliminate the need of not only hardware like servers but also admin of such hardware at the MOE.
- It would mean that the ministry would not have to look for someone to maintain the hardware server and provide management onsite. It would open up MOE's options to hire contractors on a small-term basis.

Outputs of the project include:

- Apache/PHP Apps with MYSQL backend is established in the cloud. It hosts MOE Website and 2-3 small Webapps.
- Ruby on Rails App with MySQL backend is set up in the cloud. It includes Student Information System, Requisitioning System and Teacher Evaluation System which can be migrated to the cloud.
- Effective Communication from different schools of Palau with low latency and high response time.
- The UniFi® Controller which is a wireless network management software solution from Ubiquiti Networks needs to run on the server. Ever since 22 campus have been connected to the Internet directly it is not possible to manage Internal Wifi due to each campus having its own router and Wifi. This solution offers a way to manage the school's Wifi over the internet.
- NGINX which is used as reverse proxy to hide internal webservers from outside users also need to be migrated. Due to limited security skills, this is required so that there is just a single entry point and traffic can be monitored.

Recommendations:

- Choosing a cloud provider based on multiple factors like cost, accessibility, support etc
- Secure a domain name for IP address of the final cloud server which will be decided.
- Basic Security such as blocking all the IP's other than those from Palau and setting up firewall security..
- Using database as a service offered by the cloud after evaluation.
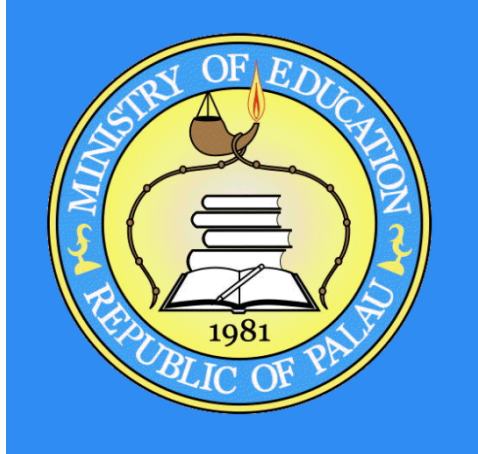
Consulting Partner

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Ministry of Education, Republic of Palau Proposal

Student Consultant, Meghna Chhabra
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Organization

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Palau National Code (PNC) specifies the role of ministry as follows –

- set up public elementary and high schools.
- manage public elementary and secondary schools.
- operate public elementary and secondary schools.
- promote public elementary and secondary schools.
- develop educational curriculum and standards.
- implement educational curriculum and standards.

- other related matters.

Facilities

The primary MOE office is located west of downtown Koror and is 9 m above mean sea level. The first floor of the office holds some conference rooms, the server room and the office of the Minister of Education. The second floor of the building is divided into two sides based on the bureaus – curriculum and administration. The upper floors have cubicles for staff and offices for department chiefs, directors, and receptionists. All offices and work areas inside the Ministry are air conditioned. The building parking lot has had solar panels installed since 2010 which theoretically provide up to 51 kW in electricity.

There are government-provided cars for the employees to carry out MOE related work and to visit schools in different districts, when needed. The Ministry also owns three speedboats for traveling to schools on other islands like Peleliu, Angaur, or Kayangel. There is a small maintenance department behind the Ministry that is in charge of maintaining all the cars, but boats need external servicing.

Programs

The MOE manages 17 elementary schools and one high school. The high school is located in Koror, whereas the elementary schools are scattered throughout the 16 states. There are 2 private elementary and 4 private high schools that run under a charter granted by the Ministry, but they are in charge of their own operations outside of a triennial Ministry inspection.

All the programs run by the MOE aim at improving the schools and the quality of education. MOE has collaborated with TCinGC for past several years and some of the initiatives are as follows-

Student Partner	Year	Project and technology used
Joe and Sam	2015	PHP app for capturing electricity consumption data and report consumption rates
Daniel	2017	Ruby on Rails App for Teacher Evaluation System
Jeevika and Pavan	2019	New Requisitioning App with new ERD and front-end using Ruby on Rails
Vrinda and Caitlyn	2020	New Student Information System which manages the information of the schools using Ruby on Rails.

Staff

The Ministry is headed by the Minister of Education which is yet to be appointed by the President. The ministry is currently under the President after the term of the last Minister of Education expired.

Around 430 people are employed by and at the MOE, including the teaching and administrative staff at the schools. All schools have principals as heads, and three schools also have vice principals. There are around 2100 students in the schools with the biggest school having 600 and the smallest school having 7. The primary client partner for this engagement is:

Edwel Ongrung, Administrative Services Manager - Edwel oversees Support Services for the Ministry. He is also the person responsible for server maintenance and managing all the technology related things going on at the MOE. I will be working with him to analyze the problem, discuss the feasibility of the solution, understand the compatibility of the solution with the existing infrastructure. Edwel is well versed with SQL, Ruby on Rails, Apache as per training he received during previous projects. He is also familiar with Linode which is American based cloud hosting company which will be used for the POC(Proof of Concept) this summer. He will be responsible for maintaining the project in the future.

Technology Infrastructure

The technology infrastructure of the central office and the schools MOE is responsible for is listed in the table below-

Category	Specification
OS	MacOS
Hardware	- Macbook or similar Apple Computer in the central office 2000 Android Tablets for students 200 iOS Tablets for students - Windows, Mac, Linux desktops for Office workers in the schools
Internet Connection	- undersea fiber-optic cable - wireless access points offering broadband-level speed (4 Mbps) throughout Koror that anyone can connect to after purchasing the card with access code - WPA2 protected moewifi network is accessible anywhere inside the building and is extremely fast (speed was measured at 47 Mbps down and 9 Mbps up)
Software	MS Office Suite

Initially the schools were connected to the central MOE office which was then connected to the internet but now each school is directly connected to the internet except three schools which lie in the remote areas. Efforts are being made to bring electricity to those areas by installing Solar Panels which will lead to them eventually having an internet connection.

Technology Management and Planning

Management of technology is divided across two units. One unit provides the support services and manages the IT and the other unit is responsible for implementation of instructional technology in the curriculum. The IT unit is responsible for the technology infrastructure and providing services and technical support to MOE users. The most prominent problems that the IT support team tackles are maintenance of equipment, mainly copiers and printers and network problems throughout the school system. Edwel serves as the head of IT and has two staff members working under him, Bal Ongrung and Aberlynn Ngirous. Bal is the technician and Edwel is responsible for servers and backend services. Bal mainly works on fixing hardware problems for laptops and replacing faulty parts. Edwel focusses on keeping the servers up and running and fixes any network problems that occur in the ministry and the schools. Aberlynn mainly takes care of providing support on the instructional side to the teachers and staff.

Together, the team is responsible for tackling IT related issues for nearly 2,200 students and 430 staff. The MOE also hires local IT vendors to help them with various projects and for maintenance of hardware. The IT unit is also responsible for all the information security of the Ministry. All the PCs use a free open source antivirus system called Avast. However, any Macbooks (or personal laptops) do not have antivirus software downloaded as they already have built-in anti-malware functionality. In order to block harmful websites and mitigate threats from incoming and outgoing network traffic the department relies on firewalls setup on the network servers.

Communication

Most communication at the office is carried out in person, with people walking to the office of the person they want to talk to or using phones to dial each others' extensions. All files and information are shared through email. Employees have emails ending with '@palaumoe.net' that they use for official communication. For faster responses, people text each other using iMessage as most of them have Apple computers. With the remote nature of this year's TCinGC project, communication between us and the client have shifted to Slack, Google Drive, Zoom, and iMessage.

The MOE's website continues to provide information for external parties; it also hosts an intranet server containing educational content for internal use along with some past reports and documents. The schools are directly connected to the internet with the exception of 3 which are in remote areas.

Information Management

Enumerated below are major information management systems that are in use by the Ministry of Education.

1. Expenditure Tracking Information System
    It recently became a priority for the Ministry to better understand and track expenditure and student success. In having the ability to electronically track expenditure and student success, the MOE will be able to evaluate and report key performance indicators internally and externally to UNESCO and The United Nations with better ease. Spreadsheets and log books have been in use at the Ministry since the 1980s, so they became the de facto method of tracking expenditures as the MOE looked for a technological replacement. Attempts were made to use the Excel

logbooks to figure out and provide evidence of teachers getting materials they needed, but it was prohibitively difficult to conduct and report summative evaluations for reports such as the APR or MAP.

2019 project delivered a Ruby on Rails application hosted on the MOE intranet server that has four modules corresponding to the four defined functions of the MOE's expenditure process. Edwel mentioned that although implemented and functional, there is still work to be done to improve the functionality of the expenditure tracking system. Particularly, Requisitioning was completed, tested, and put to production by the previous team. Receiving was completed, but was not tested or deployed to production. Inventory was only partly wire-framed and reporting is still to be addressed. Edwel currently handles the maintenance of this project.

2. Student Information System

The SIS for the elementary schools was completely redone as a part of last year's TCinGC project. Previously, both the high school and elementary schools had an online Student Information Systems (SIS), the result of projects starting in 2005 and fully up and running in 2009. This application ran in PHP with a MySQL backend. Both the high school and elementary schools' SIS's collect data. In the past, teachers in high school used computers in their department offices to enter student data and school staff in elementary schools with access to computers were designated as the data entry person.

Now, each teacher has a computer to enter grades. This system is able to track gpa and absences, as well as create report cards. Output of the new SIS system included-

- Management of classes, enrollments/registrations, students, and academic years
- Report card generation
- Batch processing of student grades based on workbooks mandated by the MOE
- Data validation
- Authorization and Authentication

3. Reporting Information System

The MOE is responsible for utilizing the data in databases to construct standard quarterly or yearly reports. In order to get the data to write these reports, Edwel backs up the database, runs some SQL tests to confirm the accuracy of the data, and then runs SQL queries. Then, the data is handed over to an expert in Excel who compiles each report in its own spreadsheet. This process to complete the annual report takes around two weeks. Edwel mentioned that an additional consideration with reporting is accuracy and relevancy of the data. As mentioned earlier, the existing student information data has inconsistencies due to the fact that the data is manually entered. In reporting, those who work with the data often find these inconsistencies and contact the school systems to confirm the error. However, instead of permanently fixing the error in the database, many times the error is just fixed locally in the spreadsheet for the report. Edwel mentioned that there is currently a process for fixing these inconsistencies properly through a database manager, but this process is rarely followed.

Business Systems

As briefly mentioned in the Programs section, the Ministry of Finance (MOF) is the agency authorized to budget and spend government funds. The MOE remains under the MOF umbrella, and is constructing more detailed data capture systems to support data-driven management. Once the MOE's budget is allocated by the Legislature, all expenditure requests follow a specific process. Items are requested by different units and must be approved before a purchase order is issued. After the vendor fulfills the order, the items are picked up by Saburo (the receiving staff) and verified before he distributes them to their recipients. Inventory management used to have no formal system in place; after repeated failed inventory tests that once forced the Ministry to pay multiple audit exemptions costing up to $45,000 each, the MOE hired an inventory custodian and reports no issues since. This official, Adeline, maintains a master list of all assets within the MOE. Twice each year, she receives inventory lists from each unit (department and school) within the Ministry and verifies their status against her master list. If any items are damaged or were not delivered, she makes a note of this before exporting a list of all fixed assets (costing more than $5000) that she has her bureau's directors sign before forwarding it to the Palau Procurement Office for record keeping. This entire process is conducted by hand, resulting in a list of a few hundred assets that has to be manually verified twice every year. No greater analysis is done on these records, but they are constantly maintained by Adeline. The MOE also has its own inventory tracking system, that contains significantly less records and is more detailed than the inventory system used by the MOF. This tracking system is used primarily for assets such as laptops and tablets.

II. Migration of Services to the Cloud

Motivation

Recently, MOE has changed the technical infrastructure. Previously, all the 20 campuses were connected to central office which was further connected to the internet. Thus, communication to the outside world was being handled by the central office. Currently, every campus is connected to the internet, and it has improved the communication however, the campuses still use the intranet to access certain apps such as-

- Apps running on Apache/PHP Server with MySQL database at the backend: Examples of such applications include MOE website which consists of certain webpages where data comes from the database such as student-teacher ratio. There are also small webtools which are used internally like an application that tracks and records the fuel consumption. Whenever someone wants to get fuel, they take a form which is required to be filled by the attendant. Then MOE staff enters it into the app which helps in budgeting of fuel.
- Ruby on Rails App with MySQL database at the backend: Recent TCinGC teams have been building applications using Ruby on Rails which need to be hosted on a Web Server. Example of such an application is Student Information System developed by Caitlyn last year which helps to manage information of the school.

Migrating these services to the cloud and making them accessible over internet instead of intranet would reduce the bandwidth cost at central office as the schools will be able to connect directly to the cloud. Servers which are used to host these applications break down every two years and lots of time and effort is spent in restoring the system to its previous running state. They need capital to purchase new servers and days are spent in setting them up. Making these services accessible on the cloud

would also make them easier to maintain as Edwel would not have to worry about the hardware or the necessary patches to the software. Linode was chosen as a cloud provider based on some of the advantages it had over its competitors' like AWS, Azure, Digital Ocean like flat pricing and free support. A list of the differences can be seen in the Appendix.

Outcomes

A 4GB Linode plan with docker setup was purchased which offered upto 80 GB of storage for this project. Docker is an open platform for developing, shipping, and running applications. Docker enables you to separate your applications from your infrastructure so you can deliver software quickly. Docker's container-based platform allows for highly portable workloads. Docker containers can run on a developer's local laptop, on physical or virtual machines in a data center, on cloud providers, or in a mixture of environments.

Docker's portability and lightweight nature also make it easy to dynamically manage workloads, scaling up or tearing down applications and services as business needs dictate, in near real time thus offering agility and flexibility. The following applications were developed locally and then deployed to the cloud-

1. Apache/PHP Apps with MYSQL backend is established in the cloud. It hosts MOE Website and 2-3 small Webapps.
2. Ruby on Rails App with MySQL backend is set up in the cloud. It can be used as a base and apps like Student Information System, Requisitioning System and Teacher Evaluation System can be migrated.
3. The UniFi® Controller which is a wireless network management software solution from Ubiquiti Networks is running on the server. Ever since 22 campus have been connected to the Internet directly it is not possible to manage Internal Wifi due to each campus having its own router and Wifi. This solution offers a way to manage the school's Wifi over the internet.
4. NGINX which is used as reverse proxy to hide internal webservers from outside users has been migrated and set up. Due to limited security skills, this is required so that there is just a single entry point and traffic can be monitored.

One of the applications that was deployed on the cloud was the timeclock application which had Apache/php server and MySQL backend. This had been running smoothly on the cloud for about a week and has utilized just 2% of the CPU. It is used by 70 employees 4 times a day and seems to be more responsive than the MOE server.

The current organizational structure of MOE does not have a big software engineering team managing or developing new software, and Edwel will be the one that is going to maintain the solution after the project ends. Therefore, I made sure that Edwel also understands the solution in order to maintain it in future. Edwel is an experienced Administrative Services Manager who was able to understand the solution and quickly learn. MOE can also easily hire an independent contractor to help maintain the solution remotely or on an hourly basis instead of employing someone full-time if required.

Recommendations

When the services will be migrated to the cloud, it will not only eliminate the need of hardware like servers but also admin of such hardware at the MOE.A comprehensive list of hardware that can be eliminated is provided in the appendix. It would mean that the ministry would not have to look for someone to maintain the hardware server and provide management onsite. It would open up MOE's options to hire contractors on a small-term basis. For example- they can hire someone for a few hours a week instead of hiring someone as a full-time employee. What's more, they would not have to be situated at Palau to maintain the servers. It would also lead to a reduction in the cost of replacing the broken servers as they would not have to worry about the physical servers.

The ministry would also have to make a choice regarding the choosing a cloud provider based on multiple factors like cost, accessibility, support etc. A comparison of various cloud providers is also provided in the appendix. The next step should be to secure a domain name for IP address of the final cloud server which will be decided. Basic Security such as blocking all the IP's other than those from Palau and setting up firewall security on the instance would vary from cloud to cloud provider.

Another recommendation would be looking into database as a service. The term "Database-as-a-Service" (DBaaS) refers to software and/or services that enables users to set up, operate and scale databases without the need for setting up physical hardware, installing software or configuring for performance. All of the administrative tasks and maintenance are taken care of by the service provider so that all the user or application owner needs to do is use and access the database.

About the Consultant

Meghna Chhabra is a graduate student in Information Systems Management at Carnegie Mellon University. She will be taking part in the Technology Consulting in the Global Community internship over the summer and return in the fall to study for another semester at the university.

Appendix

Table-1

List of all the servers that could be relieved by cloud migration.

Hardware and OS	Age	Init Cost	Purpose	Cloud	Remarks
Macmini 2012 and MacOS X 10.9	9	$1,500	Database Server	Yes	
Macmini 2012 and MacOS X 10.9	9	$1,500	Unifi Controller	Yes	
Dell PowerEdge 110 II 2013 and Linux 7.2	8	$3,000	Web Server	No	
Dell PowerEdge 110 II 2013 and Linux 7.2	8	$3,000	Experimental Projects Server	Yes	
HP Proliant Micro Server 2010 and Linux 6.9	11	$1,500	Web Server	Yes	
HP Proliant Micro Server 2010 and Linux 6.9	11	$1,500	Mail Server	No	Used for internal file sharing up to 40Mb files. At least 400 users.
HP Proliant Micro Server 2010 and Linux 6.9	11	$1,500	Backup Database Server	Yes	
HP Proliant Micro Server 2010 and Linux 6.9	11	$1,500	Redundant Hardware, Misc backup storage	No	Need to have replacement hardware available for the mail server.

Comparison of various cloud providers

DigitalOcean vs Linode

FEATURES	DigitalOcean	Linode
Cloud GPUs	✖	✔
Latest AMD CPUs	✔	✔
Outbound Transfer Speed	Max 2 GBps	1-12 GBps
Free Cloud Firewall	✔	✔
Free DDoS Protection	✖	✔
Bare Metal Cloud Servers	✖	Coming soon
Managed Kubernetes	✔	✔
Managed Database	✔	Coming soon
High Memory VM's	✔	✔
App Marketplace	✔	✔
100% Free Human Support	✖	✔
1000+ Documentation Library	✔	✔
Developer Focused	✔	✔
Free Bundled Transfer	✔	✔
API, CLI, and user friendly Cloud Interface	✔	✔
Flat predictible pricing	✔	✔

AWS vs Linode

FEATURES	AWS	Linode
Cloud GPUs	✅	✅
Free Cloud Firewall	✅	✅
Free DDoS Protection	✅	✅
Bare Metal Cloud Servers	✅	✅
Managed Kubernetes	✅	✅
Local SSD	✅	✅
High Memory VM's	✅	✅
App Marketplace	✅	✅
100% Free Human Support	❌	✅
1000+ Documentation Library	✅	✅
Simple API, CLI, and user friendly Cloud Interface	❌	✅
Flat predictible pricing	❌	✅
Free Bundled transfer	❌	✅
Same Price Across Every Data Center	❌	✅

Azure vs Linode

FEATURES	Azure	Linode
Cloud GPUs	✅	✅
Free Cloud Firewall	✅	✅
Free DDoS Protection	✅	✅
Bare Metal Cloud Servers	✅	✅
Managed Kubernetes	✅	✅
Local SSD	✅	✅
High Memory VM's	✅	✅
App Marketplace	✅	✅
100% Free Human Support	❌	✅
1000+ Documentation Library	✅	✅
Simple API, CLI, and user friendly Cloud Interface	❌	✅
Flat predictible pricing	❌	✅
Free Bundled transfer	❌	✅
Same Price Across Every Data Center	❌	✅