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INTERNET OFFLINE SERVER DESIGN NAMED "UTAKSES" FOR UNIVERSITAS TERBUKA STUDENT LIVING IN INTERNET BLANK SPOT AREAS

Daryono [1], Onno W. Purbo [2], Della Raymena Jovanka[3], Suhartono[4], Diki[5], Adhi Susilo[6]

[1, 3, 4, 5, 6] *Universitas Terbuka (Indonesia)*
[2]*Institut Teknologi Tangerang Selatan (Indonesia)*

Abstract

Universitas Terbuka students living in remote areas of Indonesia without reliable Internet access have suffered to access UT Online. This condition creates a vast digital divide compared to their peers in the urban area. This paper reviews the opportunity to provide a local server design for wireless network systems named "UTAkses" for them. Offline Internet servers have two (2) main functions to serve the student learning process and support offline Internet network operations. The SSH, DHCP, and DNS servers are used to perform offline Internet network operations. Apache Web Server, Moodle e-Learning, Kiwix, and file sharing for online libraries to aid the student learning process. Kiwix is used to make Wikipedia accessible offline for students. Two major system requirements, namely, performance and affordability, are critical for remote students for Offline Internet operations. Following the desired performance sequence, the Internet server design can use Raspberry Pi 3 or 4, mini pc, or personal computer to serve 100 students. The project also discovered the most feasible service in term of budget, capacity and the reliability services. The compared budget for the server ranges from Rp. 700,000 to 8 million with the wifi-coverage ranges from 10 meters to 2 km. The mini PC seems to become affordable and reliable choice to be implemented for upscaling digital literacy and access for UT students in Internet blank spot areas.

Keywords: Local Cellular Network, Internet blank spot, Inclusive Online Learning.

1 INTRODUCTION

Universitas Terbuka is developing an offline Internet system for student access residing in remote areas with limited telecommunications/Internet networks. This research activity is triggered by the fact that unreliable networks are widespread, supported by data provided by the nperf.com (Daengsi et al., 2021) (Budiman et al., 2017) and the OpenSignal application.

Internet access, especially in rural/rural areas, will usually largely depend on the presence of mobile/3G/4G operators. It is clear from the data nperf.com from one of the mobile operators; there are still many blank spots in various regions in Indonesia. Consequently, Internet access in the area is also challenging.

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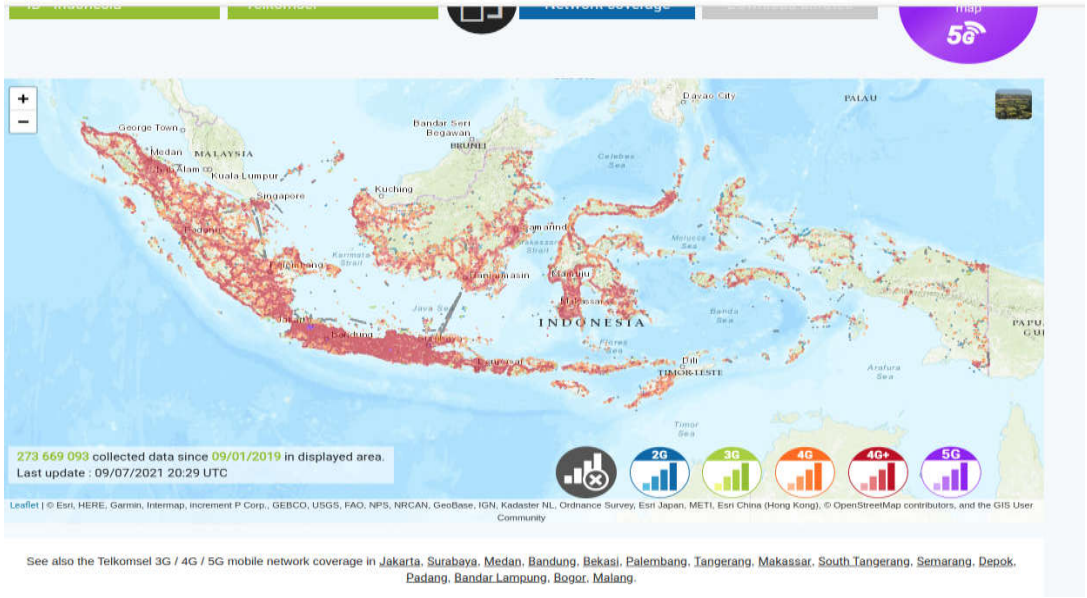

Figure 1: Telkomsel Signal Conditions throughout Indonesia.

The above picture shows Telkomsel signal condition coverage throughout Indonesia, which can be accessed through the nperf.com site. There are many blank spots, especially outside Java. On the nperf.com site, we can evaluate mobile operator coverage in Indonesia with data collected by nperf.com since 2019 (Nperf, 2022, February).

Efforts to make internet access offline may not be new. Since the beginning of Internet development, some groups, especially in developing countries, have been trying to find solutions to read internet content while offline. They start from simple by backing up email, SMS, WhatsApp to more complex activities such as downloading songs, movies, files, PDFs, ebooks.

In this study, the focus was given for making educational content accessible offline. These efforts are nothing new; several steps seem to be made globally from the initiative of several state institutions and non-governmental organizations supported by various technologies that support the offline Internet. So, there are some offline Internet initiative activities, but not many. Only a handful of institutions/research in the world are trying to provide solutions for areas with scarce internet access.

2 METHODOLOGY

The study was conducted for 3 years using an action research approach. The action research is preferred to enable the experimental design in a real situation. an approach in which the action researcher and a client collaborate in the diagnosis of the problem and in the development of a solution based on the diagnosis". Action study assumes social world to be constantly changing, both, researcher and research being one part of that change.

The study was organized into several activities as follows

	Activities	2021	2022	2023
A	**Instructional Design**			
	Instructional Desain Assessment			
	Content Development			
	Small group evaluation			
	Content Deployment			
B	**Hot-Spot Infrastructure Development**			
	Pilot Target Location			
	Assessment of Existing Infrastructure			
	Equipment Procurement			
	Mockup Pilot Development (UT)			
	Mockup Trial (UT)			
C	**Hot Spot Infrastructure Installment**			
	Setting Up Hot Spot Infrastructure			
	Installation of Hot Spot Infrastructure			
	Student's testing and Feed Back			
D	**System Design and Governance**			
	Development of system design and governance – (workhsop)			
	Training (Workshop)			
	Coaching and evaluation			
E	**Evaluation and Reporting**			
	Evaluation			
	Reporting			

3 FINDINGS AND DISCUSSION

In general, OFFLINE Internet Servers can be placed in a good location, such as schools or sub-district offices. OFFLINE Internet servers are connected to local hotspot WiFi networks so that students/students around offline Internet servers can access easily (Flickenger, R.; Aichele, C. et al., 2007) (Hargreaves et al., 2015). Internet connection is "optional" only, can be done with a modem / MiFi connected to the switch/hub.

For students who are scattered within a distance that is some distance from the location of the OFFLINE Internet server can access the server, we need to establish a remote connection and then redistribute it using the local HotSpot WiFi. Long-distance connections can be made using two (2) parabolic WiFi antennas placed on a mast/tower that is relatively high (Patra, 2007) (Flickenger, R.; Aichele, C. et al., 2007) (Pietrosemoli, 2008).

At this time, some villages in the Republic of Indonesia began to create their networks using fiber optic cables (Iwata et al., 2017) (Ishizaki et al., 2011). The network setup allows a speed of about 100Mbps to 1Gbps. The necessary equipment was also not too expensive before because the price of fiber optic cables is currently around Rp 1 million per km (1000 m) (Iprice, 2021, November).

There are several initiatives at the level of institutions, both non-governmental organizations (NGOs) and state institutions, some of which are,

- ICT Centre Uganda https://sites.google.com/site/ictcentreuganda/ - ICT Center Uganda seeks to create a system so that schools can access content on the Internet offline. There appear to be several similar attempts, particularly in Africa, to create/copy Internet content to make it accessible offline.
- EduAir (formerly Kwiizi) from Cameroon is the concept's name for offering a better education digitally with or without the internet. They focus on designing portable and open media libraries in the form of solar cells that provide access to millions of educational content and offer an integrated communication system where students can make video calls in the local network used by the Box http:///www.eduairbox.com (Eduair.com,).
- Project Tawasol Tunisia - IEEE Sight in Tunisia developed a Raspberry Pi-operated device with a hard disk with relevant content such as Wikipedia pages, TED Talks, and other educational content from the Internet. They periodically update the content in the hard disk when connected to a Wi-Fi or 3G network (Mansouri, 2016).

There is no detailed technological information from the various initiatives above. Interestingly, Project Tawasol Tunisia uses a cheap Raspberry Pi. We cannot compare UTAkses OFFLINE Internet with the above initiatives because UTAkses OFFLINE Internet is functionally much more complex. After all, it also provides e-learning services, online learning evaluation, and various references in digital libraries to make it easier for students to get a Bachelor's Degree.

In terms of technology, some exciting technologies are partly also used in UTAkses Offline Internet system; at a glance, the technology includes

- SolarSpell - SolarSpell - Library powered by Raspberry Pi, with Access Point Wifi http://solarspell.org/ (SolarSPELL, 2021)
- Kiwix - is a free app that lets us search and read Wikipedia without an internet connection. Available for Android, iOS, Windows, MacOS, and Linux http://www.kiwix.org/ (Kiwix, 2021) (Lin, 2015, June) (Purbo, 2019)
- Wikipedia and Wiktionary
- Open content repository

Indeed, not many patents have been written on Offline Internet technology, some of which are,

- Jay F. McLain, "Offline view of internet content with mobile devices", Assignee Microsoft Technology Licensing LLC, US Grant US6493758B1, 1998 (McLain, 1998).
- Robert Shaver, William Clogston, "Systems and methods for providing the same offline viewing experience of online website content", Assignee University of Texas System, Oath Inc., U.S. Grant US8001471B2, 2006 (Shaver et al, 2006a).
- Robert Shaver, William Clogston, "Systems and methods for a single integrated online and offline content development tool provide the same viewing experience", Assignee Oath Inc., U.S. Grant US8015491B2, 2006 (Shaver et al, 2006b).

The above initiatives are mainly in developing Internet OFFLINE technology. Thus, people may easily access the knowledge. There are not many initiatives similar to the Universitas Terbuka as open university undertaken, where lecture access is done offline, including digital libraries and even the student evaluation process.

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3.1 General Design of offline internet in general

In general, a relatively complete OFFLINE Internet access network may be described as shown in the following Picture.

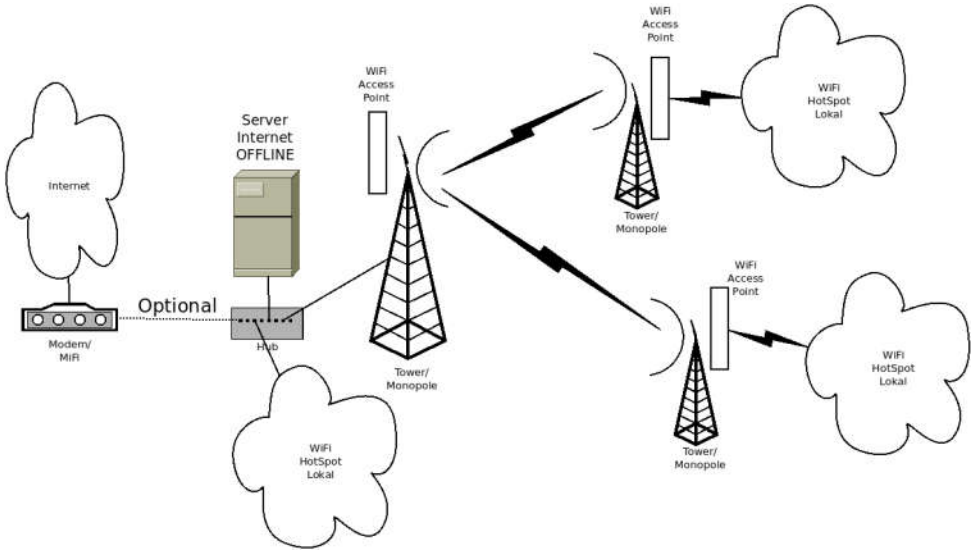

Figure 2: Offline Internet System Design.

3.2 OFFLINE Internet Server Design

A IT network technician can easily create offline Internet systems. It would be easier if the network technician knew more about the Linux operating system (Ward, 2021) (Prasetya et al., 2021) (Jaiswal, 2021) and server administration (Choi, 2021) (Westfall, 2021).

Some assumed server parameters in developing OFFLINE Internet systems are,

- Operating System - Ubuntu 20.04 or Debian 11, or most recently.
- 32bit or 64bit computer.
- 4G or 8G RAM Memory.

For the purpose of designing the content and learning management systems, we need to install some of the main applications supporting learning services, such as,

- Apache web server, mariadb database server, and PHP
- Moodle for e-learning

- Kiwix for offline wikipedia

As well as intranet network operations, such as,

- bind dns servers
- Server SSH
- DHCP Server
- SAMBA File Sharing server if needed.

Details of the installation and configuration of various server applications on OFFLINE Internet systems will be published in the form of handbooks to help hundreds of thousands of schools in Indonesia.

3.3 OFFLINE Internet Server Application Planning

The primary purpose of offline Internet systems/servers is to help students, especially those in the area, learn online without the Internet. For the system to be implemented reliably and cheaply by schools, open-source applications are used.

Raspberry Pi 3 or 4 servers may be suitable for small remote schools with small numbers of students. The Raspberry Pi may use the moodlebox operating system. The moodlebox is complete with e-learning can be implemented to operate directly at schools (Ndassimba, 2021) (Ncube, 2020). For schools or larger groups may use a computer or mini pc. The main application that must be installed on the server are

- E-learning application, using moodle which is the best and open-source e-learning application. (Rice et al., 2006) and (Simanullang et al., 2020)
- Kiwix application to create a copy of Wikipedia to be accessible offline (Kiwix, 2021) (Lin, 2015, June).
- Digital Library applications can be built from folders on a regular web server (Udosen, 2018).

These three applications can only run well if supported by the following applications,

- Web Server, there are three main options, namely, Apache, Openlitespeed, Nginx. Apache (Mustafa et al., 2019), although the slowest of the three, is relatively easy and quite widely used for moodle e-learning applications (Rice et al., 2006) (Simanullang et al., 2020) (Zabolotniaia et al., 2020).

- Database server, there are three main options, namely, MySQL, MariaDB or Percona. In this study, it was suggested to use MariaDB (Kenler et al, 2015) (Bartholomew, 2014) (Prebensen, 2019), which is relatively more straightforward than MySQL (Converse et al., 2004) (Prebensen, 2019) and Percona (Prebensen, 2019).
- Php last version.

For operating system support for the network to run correctly, we need to install some additional applications that are all open source, that is,

- SSH Server so that admins can easily log into the server safely. The application used is OpenSSH-server (Venkatachalam, 2007).
- DHCP Server, so that if there is no router on the network, the OFFLINE Internet Server can provide an IP address for the client/user/student who accesses the system. The application used is isc-dhcp-server (Dinu et al., 2014, May).
- DNS Server, so that users can access the server using a domain name, such as utakses.ac.id. The application used is bind (Liu et al., 2006).
- Agreement in IP Address and domain name used.

On offline internet systems operated at the Open University (UT), it is agreed that

Ubuntu LTS 20.04 Operating System (or later version)

Utakses.ac.id server	name, utakses.id
Server IP address	192.168.88.8
IP Address	192.168.88.0/24
Gateway IP address	192.168.88.1 (Default microtik 192.168,.88.1)

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The hardware and software configurations are presented in the following picture.

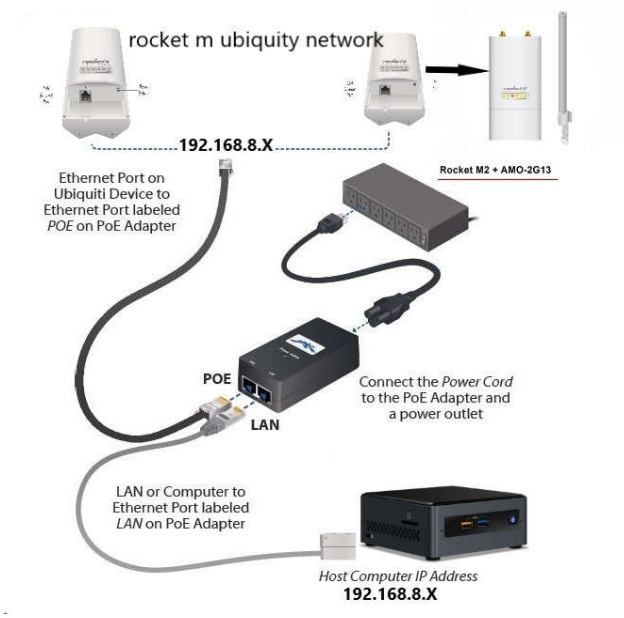

Figure 3. Internet Offline Hardware and Software Configuration

3.4 Server Capacity Analysis

One of the biggest problems in determining a server is ensuring that the server we set up is enough to handle the desired workload. Especially for e-learning applications using moodle, some notes about the planning of moodle e-learning servers scattered on the Internet can be summed up as follows.

The specifications of the processor used can vary depending on the load to be handled. For a small number of students, an arm processor machine such as Raspberry Pi 3 or 4 can be used. Raspberry Pi 3 has the lowest capability. Mini PC ASUS mobile processor with 2G RAM has the ability two-three times Raspberry Pi 3. A computer or mini pc that has capabilities far above the Raspberry Pi 3 (Purbo, 2020). For offline Internet server purposes with hundreds of students in POKJAR, computers or mini PCs with i3 to i7 processors can be used (Purbo, 2020). A high-load server for a large school or campus with thousands of students will need a server with a Xeon class processor (Cadambi et al., 2013) (Loghin et al., 2015).

The amount of RAM is the most decisive component in handling the load on the moodle e-learning server (Guo et al., 2013) (Jayakody et al., 2016). In general, the formula used is as follows,

Concurrent User Max = RAM (GB) * 50

Approximately. Max Browsing User = about max. concurrent user * 5

So, for example,

Moodle server with 4GB of RAM

Max. Concurrent user = 200

Max. Browsing user = 1000

Some tips to make the small servers work,

- Images, Videos, documents/files/pdf, etc., not on moodle servers, but elsewhere, such as youtube, google drive, etc. It may be good to set up its digital library server to accommodate various images, videos, documents, etc.
- Moodle servers should be prioritized for handling exams/ quizzes, especially if we adopt the pattern of exams that can be repeated for one semester. The ability to take exams on moodle servers becomes very special in offline Internet systems because the learning evaluation process is a core component/life of offline Internet systems.

In summary, a computer with an i5 or i7 processor with 4G RAM capacity will be sufficient for POKJAR with up to 50 students. For schools in areas / rural areas with students of 300-500 people would be better off using more RAM, for example, 8Gbyte.

3.5 Procurement Budget Analysis

We need to choose equipment for (1) offline Internet servers and (2) local HotSpot networks in schools. In this paper, we will not describe long-range wireless networks.

The choice for offline Internet servers depends on the number of students who access simultaneously, with alternative options and prices,

- RaspberryPi 3 or 4, for 10-20 students/ students. Estimated price rp. 700,000-1.2 million.
- Used desktop, for 200-300 students / students. An estimated price of Rp. 1-2 million

- Mini PCs, physically small and low power, may serve 200-300 students. The estimated price is Rp. 8-15 million, depending on the configuration.
- Server, for thousands of students. The estimated price is Rp. 10-20 million depending on (Iprice, 2021a, November) configuration.

WiFi equipment to create local hotspots for students to access using their gadgets is easy to obtain in online stores. They are starting from fairly cheap, like tp-link, to good ones like Microtik and Linksys. HotSpot WiFi equipment that is simple but adequate can be obtained at prices between Rp. 200-400,000,-. Usually, equipment with a higher price will be more durable for long-term use.

Operating support equipment that is no less important is (1) Uninterruptible Power Supply (UPS) can usually be used to provide electricity on offline Internet systems when PLN electricity for a period of not long between 15-30 minutes only. The estimated price of UPS is around Rp. 1-2 million, and (2) alternative sources of electricity using solar power. This option needs to be chosen if you want to operate the system in a region where there is no electricity.

4 CONCLUSION

Half of the Indonesian nation today lives in rural areas with very limited telecommunications and Internet infrastructure. Knowledge access inequality may be reduced by implementing offline Internet systems in schools/campuses located in areas that have internet access difficulties. The design of servers for OFFLINE Internet systems on UTAkses in study groups (POKJAR) has been discussed.

Offline Internet servers run two (2) main functions: to serve the student learning process and support offline Internet network operations. To help the student learning process used Apache Web Server, Moodle e-Learning, Kiwix, and file sharing for online libraries. Kiwix to make Wikipedia accessible offline. Several servers, such as SSH, DHCP, and DNS servers, need to be installed to serve offline Internet network operations.

For offline Internet purposes in POKJAR with 100 students can use a computer or mini pc process i7 with 8G RAM. The estimated budget is around Rp. 8 to 15 million for mini pc with maximum capability with 8G byte SSD memory RAM hard drive. For small schools can use moodlebox in raspberrypi 3 or 4 with a budget of around Rp. 700,000, - so it is very affordable for most schools and universities that want to provide knowledge for students and students with Internet problems.

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