MANAGING WIRELESS FIDELITY SECURITY AND BANDWIDTH IN PUBLIC AREA BY IMPLEMENTING QUICK RESPONSE CODE AND CAPTIVE PORTAL

Muhammad Adam Nugraha[1], Nyoman Bogi Aditya Karna[2], Ridha Muldina Negara[3]
[1,2,3]Telecommunication Engineering, School of Electrical Engineering, Telkom University
[1]adamanugeraha@telkomuniversity.ac.id, **[2]aditya@telkomuniversity.co.id**,
[3]ridhanegara@telkomuniversity.ac.id

Abstract
Internet of Things (IoT) enables various devices to communicate with one another without the obligation of using old-fashioned communication styles such as data cable, external flash drive, and disks. These days, people connect their smartphones to the Wireless Fidelity (Wi-Fi) in a public area by manually typing the Wi-Fi password to their smartphones, which is considered as a hassle, especially when the password is lengthy and complex. This paper demonstrates the effectiveness of using Quick Response (QR) code and Captive Portal for protecting the Wi-Fi password and also to prevent an unwanted user from abusing the public area Wi-Fi, respectively. The public area Wi-Fi user has to scan it to obtain the information that they needed, in this case, the Wi-Fi password. The Captive Portal is a router gateway server that does not permit any internet connection before the user gets identified. Thus, simulation and experimentation are required by using ZXing QR code generator application for obtaining the Wi-Fi's QR code. Furthermore, devices with a QR code scanner are required to scan the code. As a result, the security of the public area Wi-Fi is safe as the password is not leaked to the user.

Keywords: QR code, Wi-Fi, IoT, Captive Portal

1. Introduction

Nowadays, wireless technology is leading than wired technology and has become the first selling point of transmission technology all over the world. The best reason is due to the flexibility of accessing Internet of Things (IoT) with devices by using Wireless Fidelity (Wi-Fi) provides efficiency for people to connect their devices to the internet to access online entertainment, education, and social networking with different people all over the world. Wi-Fi hotspots are an important part of the wireless infrastructure and are aimed at improving user experiences. Wi-Fi hotspot no longer restrict themselves to regular top locations, like airports or hotels, and it quickly moves to neighborhood retail stores, parks, restaurants, and shopping centres [1].

Although Wi-Fi is beneficial for everyone that uses its service, this is not entirely the case for the provider of the public area Wi-Fi. Especially for places like restaurant, hospitals, campuses, and museums. In the case of a restaurant, many customers who come to a restaurant buy only one or two cheap food or drink for the sake of getting the free Wi-Fi service of the restaurant. These customers later then take for granted and decide to stay over in the restaurant for more than the average duration of typical restaurant's customers. This situation leads to a loss for the restaurant business as those customers take the seat of the next customer of the restaurant.

Wi-Fi is set by a password to provide security for its connection. However, this is not wholly a proper solution as costumers are able to use the loophole by asking one of them to buy cheap food or drink to obtain theWi-Fi password and then share the password to the other customers in the group. Although the Wi-Fi password able to save complicated numerical, alphabetical letters, it is still insufficient. Previously, there was an arrangement attempt to dispose of the weakness on any pre-shared data between the Access Point (AP) and the customer gadget to actualize security. Existing WPA2-PSK convention is changed to produce an Instantaneous Session Key (ISK) between the customer and the AP through verified Diffie Hellman key trade along these lines disposing of the reliance on a pre-shared key [2]. The prevention that is suggested in this thesis is by enforcing bandwidth limitation and implementing Quick Response (QR) code. Bandwidth limitation is done by Captive Portal feature and is built for those customers who stay for too long inside the restaurants and prevent them from abusing the internet connection speed that makes the other customers have slow internet connection speed. The other technology called QR code is capable to safely provide the password of the restaurant's Wi-Fi to the customers' smartphones securely. The QR code is a

technology that using two-dimensional (2D) barcode that is going to be scanned by the camera of a smart device to provide faster action for almost anything. Currently, the QR code reaches high acceptability quickly. This technology is being used every day by massive numbers of people. One of the reasons why it is rapidly growing is because the QR code smartphone users increase across the globe, and sellers use QR code for mostly connecting with the mobile consumer [3]. Thus, the usage of the QR code and Captive Portal are capable to help significantly to prevent losses for businesses in a public area that have Wi-Fi.

2. System Design

The current method to connect to a public Wi-Fi is normally done by manually typing the Wi-Fi password onto the customer's smartphone. The weakness of this method is that the customer is able to know the Wi-Fi password and is shareable to the other customers. In this thesis, the implementation of the QR code and Captive Portal are prepared to provide a solution for the weakness stated above. The QR code uses the model 2 type as it is the most efficient QR code type amongst the others with its ability to store embedded information and to provide a smooth reading to the QR code scanner regardless of its position and the distortion of the image. The Captive Portal feature is already applied to the router Tenda W15E AC1200. This feature provides the authentication of the customers so that they are able to connect to the public Wi-Fi service and the bandwidth limitation to throttle the internet speed of the Wi-Fi to prevent any customer from abusing the Wi-Fi.

In general, there are two parts that are going to be planned for this thesis; design of hardware and software device. In the hardware device planning, the QR code model 2 is readily stored with the Wi-Fi password that is going to be used to login on the Captive Portal page. Then followed by a smartphone with ZXing barcode scanner installed to read the QR code. In the software device planning, https://speedof.me is used to ensure that the internet speed of the Wi-Fi is already limited or not. If the speed is the same as the desired and configured output speed, then the bandwidth limitation is successful. Then followed by the Captive Portal configuration of the router Tenda W15E AC1200 through the router's IP address.

2.1 Hardware and Software

In this thesis, the QR code model 2 is selected as the type of QR code that is to be scanned by a QR code reader application. The QR code model 2 features a more stable and fluid reading of its code; nevertheless, the distortion, condition, and the angle of the printed code [3]. Tenda W15E AC1200 is a router intended for the wireless connection of small offices, internet cafes, big houses etc. The wireless speed complies with the standard 802.11a /n / ac and is up to 1200 Mbps. Provides an external power amplifier and Captive Portal to boost wireless device efficiency and ensure highly skilled Wi-Fi connectivity [4]. The configuration of the Captive Portal is shown in the Fig. 1.

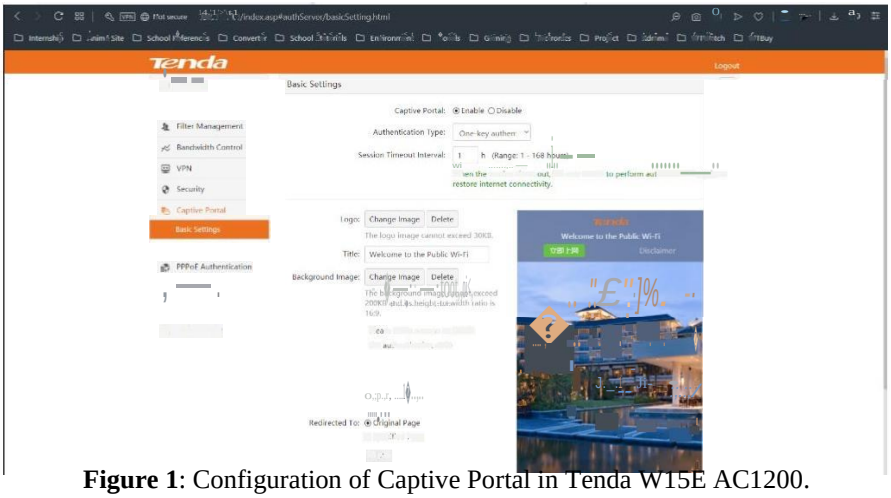

Figure 1: Configuration of Captive Portal in Tenda W15E AC1200.

The QR code is a useful technology that can immediately be used to connect device to device or device to service. However, not all smartphones are able to use the QR code [5]. Smartphones that use android version 6 and below and unable to install QR code reader applications

are not able to use the QR code technology due to the limitation of the software and outdated support for using the application of QR code reader [6]. ZXing QR code reader is going to be used in this thesis for the simulation and experimentation. The aim is to scan and decode the QR code via the device by using the built-in camera on smartphones, with or without communicating with a server [7]. The bandwidth limitation done by the Captive Portal feature is to be confirmed by accessing https://speedof.me. In this thesis, the bandwidth is set to 700KBps or 5.6 Mbps of downloading and 300 KBps or 2.4 Mbps of uploading.

2.2 Block Diagram System

The Fig. 2 represents the block diagram of the system. The system starts when the customer is provided with a QR code model 2, which contains the password to be used later on the Captive Portal authentication. The customer uses a smartphone that has ZXing QR code reader application installed to scan the QR code and obtain the password. The customer is then redirected to the Captive Portal web for the process of authentication done through the router Tenda W15E AC1200. If the verification is successful, the customer is then granted the Wi-Fi internet access with the provided three different bandwidth speeds according to what the customer wants. If the verification via Captive Portal failed, the customer's smartphone is rejected from connecting to the public Wi-Fi.

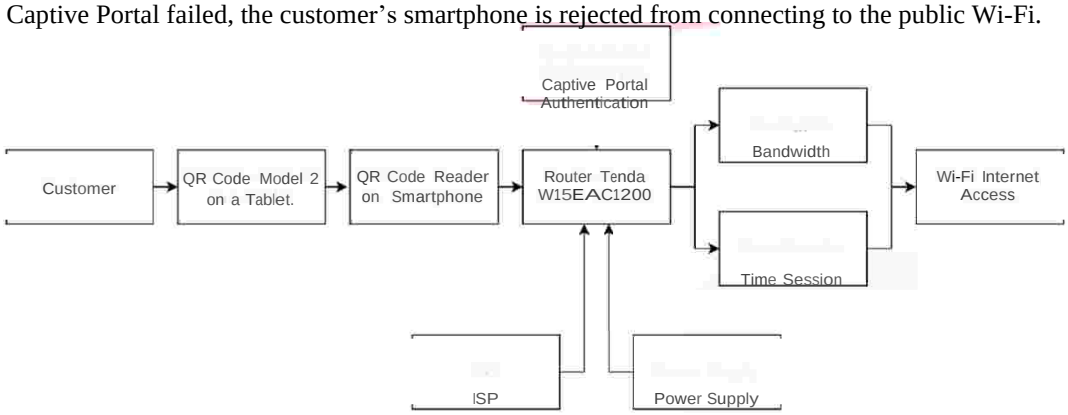

Figure 2: Block Diagram System.

2.3 System Work Flowchart

Fig. 3 shows the flowchart of the system. In this case, there are two situations:

1. Customer buys Wi-Fi service.
   The Wi-Fi QR code is given to the customer, and the customer is able to use the smartphone to scan the QR code by using the ZXing QR code scanner application. The customer's smartphone is then obtained the public area Wi-Fi username and password effortlessly. Then, the customer is redirected to the Captive Portal login page and does the authentication process. After the duration of one hour is reached, the Wi-Fi connection on the customer's smartphone is terminated. If the customer still wants to use the Wi-Fi service, the customer needs to repurchase the Wi-Fi service.
2. Customer does not buy Wi-Fi service.
   The Wi-Fi QR code containing the username and password is not given, and the customer unable to connect the smartphone to the Wi-Fi service.

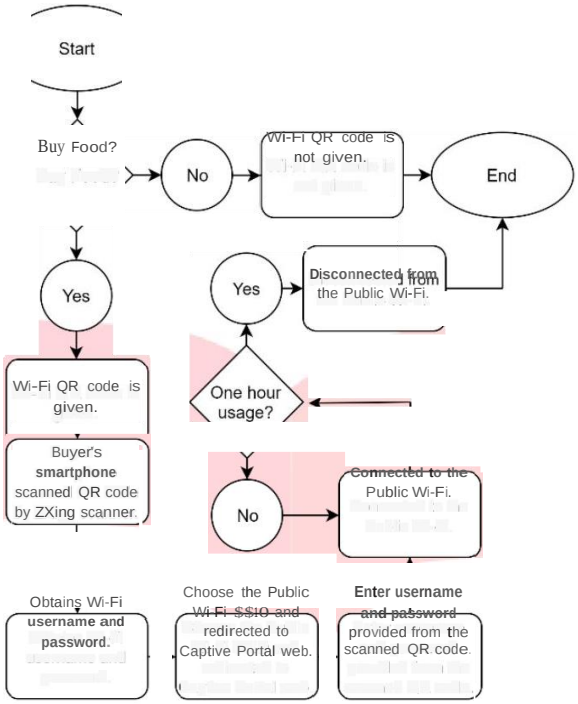

Figure 3: Flowchart of QR code and Captive Portal Implementation.

3. Testing Results and Analysis

The testing experiment in this research is divided into several stages. Those stages are by finding the optimal distance and average time are taken for scanning the QR code. Followed by the optimal angle to scan the QR code horizontally (X-Axis) and vertically (Y-Axis). After that the successfulness of Captive Portal authentication usernames and passwords. Lastly, the download and upload speed of the Wi-Fi after the bandwidth is limited to 700KBps or 5.6 Mbps and 300 KBps or 2.4 Mbps, respectively.

3.1. Optimal Distance and Average Time Taken

The testing experiment finding the optimal distance of scanning the QR code is done by providing a range of distance from 0 cm to 160 cm. Meanwhile, the average time taken is earned after the sum of a repetition of three times of taking the time taken to scan the QR code in every tested distance divided by three. The Fig. 4 shows the setup of the devices during the testing experiment of finding the optimal angle and average time taken.

Figure 4: Optimal Distance and Average Time Taken Testing Experiment.

Table 1: The Successfulness of Scanning QR Code to Find the Optimal Distance and Average Time Taken.

Dislanee (<111)	Time Taken I (ms)	Time Taken 2 (rm)	Time Taken J (ms)	A"era∳e Time 'foken (ms)	SUI'CCSS
0	-	-	-	-	No
5	-	-	-	-	No
10	-	-	-	-	No
15	-	-	-	-	No
20	157	145	134	145.4	Yes
25	145	132	160	145.7	Yes
30	161	165	138	154.7	Yes
35	164	162	225	183.7	Yes
40	141	264	148	184.4	Yes
45	143	162	212	172.4	Yes
50	204	143	160	169	Yes
55	180	186	193	186.4	Yes
60	148	173	145	155.4	Yes
65	173	178	188	179.7	Yes
70	211	151	135	165.7	Yes
75	115	163	191	156.4	Yes
80	172	173	195	180	Yes
85	209	180	216	201.7	Yes
90	160	155	195	170	Yes
95	173	185	188	182	Yes
100	178	195	196	189.7	Yes
105	170	163	210	181	Yes
110	232	190	200	207.4	Yes
115	284	253	242	259.7	Yes
120	437	611	512	520	Yes
125	348	521	283	384	Yes
130	342	150	202	231.4	Yes
135	2788	1027	1462	1759	Yes
140	1201	943	2301	1481.7	Yes
145	3126	1155	6969	3750	Yes
150	-	-	-	-	No
155	-	-	-	-	No
160	-	-	-	-	No

The Tab. 1 shows the data obtained after testing the implementation of scanning the QR code through a range of distance and average time taken by a smartphone with ZXing Barcode Scanner installed. The result of scanning the QR code from range 0 cm to 15 cm is unsuccessful due to the location of the QR code is too closed with the smartphone used to scan. Meanwhile, from the range distance of 20 cm to 145 cm, the testing is successful. However, the result obtained at 145 cm; 3750 ms, is rejected nevertheless of its successfulness. This is because the desired average time taken for the scanning the QR code has a maximum value of 2 s or 2000 ms; any time taken longer than 2 s or 2000 ms is rejected. Based from the Tab. 1, the optimal distance to scan the QR code is at 20 cm with an average time taken of 145.5 ms for scanning the QR code.

3.2. Optimal Angle Horizontally and Vertically

The testing experiment finding the optimal angle of scanning the QR code is done by providing a range of angle horizontally (X-Axis) and vertically (Y-Axis) from 0° to 360°, respectively. The Fig. 5 shows the setup of the devices to obtain the optimal angle in horizontal X-Axis. Based on the Tab. 2, the optimal angles to scan the QR code within the distance 20 cm are from range 0° to 50° and 310° to 360° horizontally and vertically. Other than these mentioned angles, the result of scanning the QR code is unsuccessful.

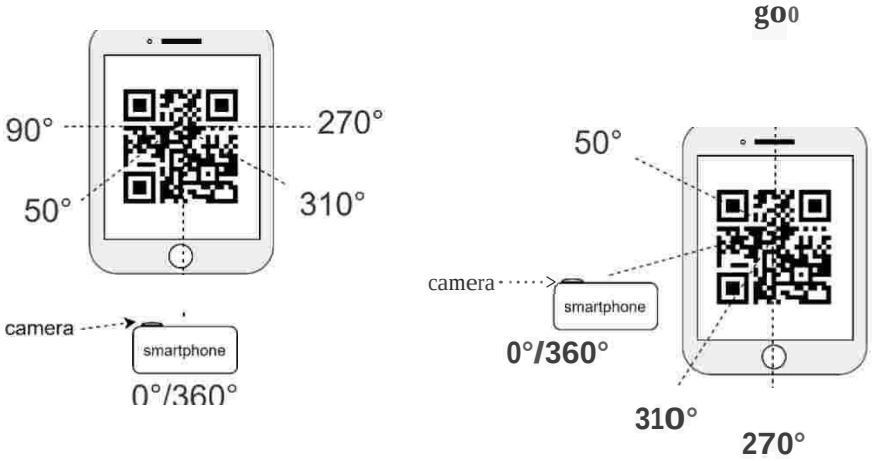

Figure 5: Optimal Angle in X and Y-Axis Testing Experiment.

Table 2: The Successfulness of Scanning QR Code to Find the Optimal X and Y-Axis Angle.

Angle (X & Y-Axis)	Success	Angle (X & Y-Axis)	Success
0	Yes	190	No
10	Yes	210	No
20	Yes	220	No
30	Yes	230	No
40	Yes	240	No
50	Yes	250	No
60	No	260	No
70	No	270	No
80	No	280	No
90	No	290	No
100	No	300	No
110	No	310	No
120	No	320	Yes
130	No	330	Yes
140	No	340	Yes
150	No	350	Yes
160	No	360	Yes
170	No		Yes
180	No		

3.3. Captive Portal Authentication

The testing experiment for the successfulness of the authentication for the Captive Portal is required to make sure that the username and password generated by the QR code are possible to be used by the customers for login. In the Fig. 6, the customer failed to login through the Captive Portal authentication as the username and password are entered incorrectly. In order to let the customer gets the correct username and password, the customer has to buy the service from the public area such as food or drink. Then the customer gets a generated QR code containing the valid username and password that is to be scanned by the application ZXing barcode scanner

While, in the Fig. 7, the customer is able to login through the Captive Portal authentication since the customer uses the provided and correct username and password generated by the QR code after scanning it with the ZXing QR code. The customer then gains an internet access for browsing, downloading, and uploading from the public area Wi-Fi for an hour long duration. After one hour of Wi-Fi usage, the customer gets disconnected from the Wi-Fi as the customer exceeded the time limit set from the configuration of the Captive Portal in the Tenda router. To obtain the internet access again, the customer has to buy the service again.

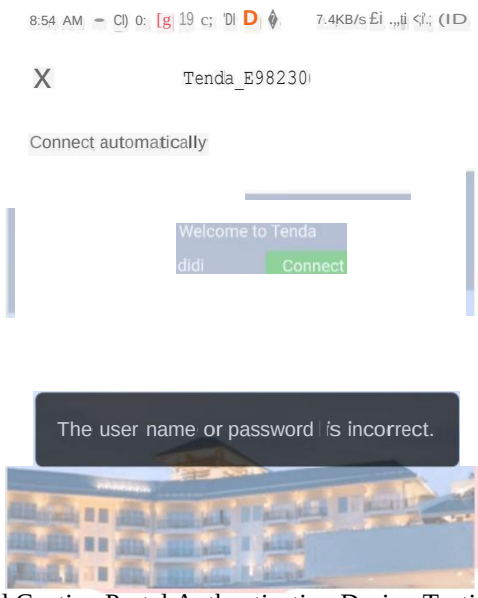

Figure 6: Failed Captive Portal Authentication During Testing Experiments.

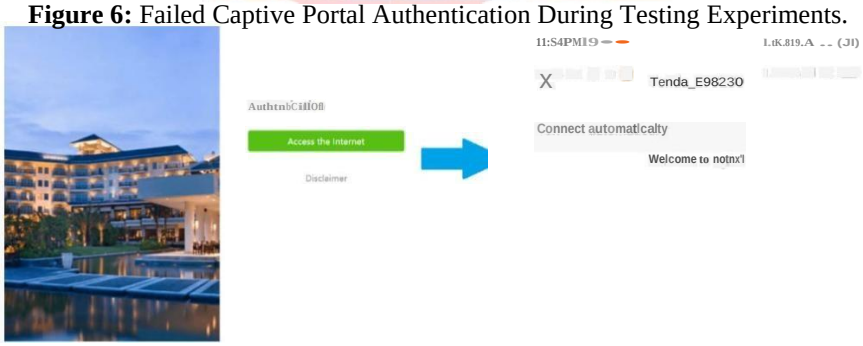

Figure 7: Succeeded Captive Portal Authentication During Testing Experiments.

3.4. Internet Speed and Devices Connected

The testing experiment finding the behavior of the Wi-Fi internet speed connection after the bandwidth is limited through the configuration in the Tenda router, and the number of devices connected is increased. The testing is divided into two scenarios; download speed comparison during browsing only and downloading a file and upload speed comparison during browsing only and uploading a file. When the Wi-Fi is only served for browsing only; not downloading, the internet speed remains the same of 700 KB/s regardless of the number of devices connected. However, when the Wi-Fi is used for downloading, the internet speed of the Wi-Fi decreases as the number of devices connected increases. When the number of devices connected is ≤ 10. The average download speed for downloading remains ≈ 700 KB/s. But when the number of devices connected is 50, the average download speed is 269.5 KB/s as shown in the Tab. 3. When the Wi-Fi is only served for browsing only; not uploading, the internet speed remains the same of 300 KB/s regardless of the number of devices connected. However, when the Wi-Fi is used for uploading, the internet speed of the Wi-Fi decreases as the number of devices connected increases. When the number of devices connected is ≤ 10. The average upload speed for uploading remains ≈ 300 KB/s. But if the number of devices connected is 50, the average upload speed is 240.8 KB/s as shown in the Tab. 4.

Table 3: The Average Download Speed with Respect to the Number of Devices Connected.

Download Speed = 700 KB/s		
Number of Devices	**Average Download Speed (KB/s) Browsing only**	**Average Download Speed (KB/s) Downloading**
0	700	700

10	700	700.5
20	700	632.3
30	700	479.4
40	700	343.8
50	700	269.5

Table 4: The Average Upload Speed with Respect to the Number of Devices Connected.

Download Speed = 300 KB/s		
Number of Devices	**Average Upload Speed (KB/s) Browsing only**	**Average Upload Speed (KB/s) Uploading**
0	300	301.2
10	300	301.2
20	300	288.5
30	300	273.4
40	300	343.8
50	300	269.5

4. Conclusion

The usage and function of QR code and Captive Portal are just like what had been expected, the Wi-Fi username and password for the Captive Portal authentication are provided to the customer, and the Captive Portal successfully prevent anonymous people from connecting to the Wi-Fi and limit the bandwidth of Wi-Fi internet speed connection. Implementing the QR code and Captive Portal features are proved to improves the security and bandwidth parts of the Wi-Fi. Based on the results of the figures above, the optimal distance and angle to scan the QR code via ZXing barcode scanner is 20 cm, with an average time taken of 145.4 ms, 0° – 50° and 290° - 360° in the x-axis and y-axis respectively. The internet speed of the Wi-Fi is inversely proportional to the number of devices connected and used the Wi-Fi actively for downloading. The ZXing barcode scanner is only compatible with android devices starting android versions five and above. A software that scans the QR code and records the time taken to scan the QR code is required as it reduces the human error. The current Tenda router is only applicable for 50 connected devices. A router that provides twice or thrice of the existing Tenda router is required for larger public areas.

References:

[1] D. Arora, S. W. Neville, and K. F. Li, “Mining wifi data for business intel-ligence,” in 2013 Eighth International Conference on P2P, Parallel, Grid, Cloud and Internet Computing, Oct 2013, pp. 394–398.

[2] A. E. Redondi, M. Cesana, D. M. Weibel, and E. Fitzgerald, “Understanding the wifi u-sage of university students, ” in 2016 International Wireless Communications and Mo-bile Computing Conference (IWCMC), Sep. 2016, pp. 44–49.

[3] S. Tiwari, “An introduction to qr code technology,” in 2016 International Conference on Information Technology (ICIT), Dec 2016, pp. 39–44.

[4] Tenda, AC1200 Wireless Hotspot Router W15E User Guide, 2017 (accessed Novemb-er 5, 2019). [Online]. Available: https://gzhls.at/blob/ldb/e/e/9/8/407d3ed2892923da60-7ab50c4335c3029b1b.pdf

[5] R. Tulloh, R. M. Negara, Y. E. Y. Prasetya, and S. Saputra, “ Hero: Maximizing stude-nt potential to mobilize community empowerment activities around campus, ” in 2019 International Conference of Artificial Intelligence and Information Technology (ICAII-T), March 2019, pp. 431–436.

[6] R. M. Negara, R. Tulloh, N. Hadiansyah, and R. T. Zahra, “My locker : Loaning locker system based on qr code,” IJEAT, 2019.

[7] M. Zaslavsky, About ZXing, 2010 (accessed April 1, 2019). [Online]. Available: https: stackoverflow.com/tags/zxing/info