THE ALGORITHMIC ANALYSIS OF PRAYER TIMES ON SUNCLOCK APPLICATION

THESIS

Submitted to Faculty of Syaria and Law
In Partial Fulfilment of the Requirement for Undergraduate Degree
In Islamic Law

By:

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Demikian surat keterangan ini dibuat dan diberikan kepada yang bersangkutan untuk dipergunakan sebagaimana mestinya.

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A.n. Dekan,
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& Kelembagaan

Dr. H. Ali Imron, SH., M.Ag.

Ketua Program Studi,

Moh. Khasan, M. Ag.

MOTTO

وَاصْبِرْ لِحُكْمِ رَبِّكَ فَإِنَّكَ بِأَعْيُنِنَا ۖ وَسَبِّحْ بِحَمْدِ رَبِّكَ حِينَ تَقُومُ ﴿ ٤٨ ﴾ وَمِنَ اللَّيْلِ فَسَبِّحْهُ وَإِدْبَارَ النُّجُومِ ﴿ ٤٩ ﴾

And be patient, [O Muhammad], for the decision of your Lord, for indeed, you are in Our eyes. And exalt [Allah] with praise of your Lord when you arise. And glorify Him during part of the night and at the fading of the stars.

(Q.S. Al-Ṭūr: 48-49)

DEDICATION

This undergraduate thesis that full of blessing is dedicated to:

My beloved parents that never stop supporting me

Bapak Shodiq and *Ibuk* Hamidah

My comfort zone, sister and brothers that always spend their times to my unnecessary stories

Mbak Indah Sri Handayani, *Kak* Muhammad Khoirul Anam, and *Dek* Muhammad Zacky Alfareza

My Parents in Life Skill Daarun Najaah, that always give me guidance,

Dr. K.H Ahmad Izzuddin, M.Ag. and Aisah Andayani, S.Ag.

Republic Indonesia's Ministry of Religious Affairs that gives me chance to study in State Islamic University of Walisongo Semarang

CSSMoRA UIN Walisongo Semarang that warmly welcome me since the first meeting

Member of Gemawa'11 that always motivate me

All member of Dorm Sayyidatuna Khadijah Kubro, thank you for the time and laugh while working on this thesis

DECLARATION

I certified that this undergraduate thesis is definitely my own work. I am completely responsible for content of this thesis. Other opinions or findings in the thesis that are not from me are quoted or cited in accordance with ethical standard.

Semarang, 25 April 2021

The writer,

Umi Latifah

1702046104

TRANSLITERATION GUIDELINES

Latin Arabic Transliteration Guidelines which are the result of SKB of Ministry of Religious Affairs and Ministry of Education and Culture Number 158 of 1987 and Number: 0543b/U/1987.

1. Consonant

   The list of Aabic and the transliteration to Latin letter is:

Arabic letter	Name	Latin letter	Name
ا	Alif	Not Symbolized	Not Symbolized
ب	Ba	B	Be
ت	Ta	T	Te
ث	Ṡa	Ṡ	Es (With period above)
ج	Jim	J	Je
ح	Ḥa	Ḥ	Ha (with period below)
خ	Kha	Kh	Ka and Ha
د	Dal	D	De
ذ	Żal	Ż	Zet (with period above)

ر	Ra	R	Er
ز	Zai	Z	Zet
س	Sin	S	Es
ش	Syin	Sy	Es and ye
ص	Ṣad	Ṣ	Es (with period below)
ض	Ḍad	Ḍ	De (with period below)
ط	Ṭa	Ṭ	Te (with period below)
ظ	Ẓa	Ẓ	Zet (with period below)
ع	‘Ain	‘_	Invers Apostrophe
غ	Gain	G	Ge
ف	Fa	F	Ef
ق	Qof	Q	Qi
ك	Kaf	K	Ka
ل	Lam	L	El
م	Mim	M	Em

ن	Nun	N	En
و	Wau	W	We
ه	Ha	H	Ha
ء	Hamzah	_’	Apostrophe
ي	Ya	Y	Ye

Hamzah (ء) as the first letter follow the vocal without giving any character. If it is as the middle or last letter, so, use the apostrophe character.

2. Vocal

Arabic vocal consist of monophtong and diphtong. The characters of monophthong are:

Character	Name	Latin letter	Name
◌َ	*Fatḥah*	A	A
◌ِ	*Kasrah*	I	I
◌ُ	*Ḍammah*	U	U

The Arabic diphthong is a combination of *harakat* and letter, these are:

Character	Name	Latin letter	Name
ي + ◌َ	*Fatḥ*ah and *ya*	Ai	A and I
و + ◌َ	*Fatḥ*ah and *wau*	Au	A and U

3. Maddah

Maddah is a long vocal, the characters are:

Character	Name	Transliteration	Name
ا + ◌َ	*Fatḥah* and *alif*	ā	A and line above
ي + ◌ِ	*Kasrah* and *ya*	ī	I and line above
و + ◌ُ	*Ḍamah* and *wau*	ū	U and line above

4. Ta marbūṭah

The transliteration for *ta marbūṭah* is two, these are: *ta marbūṭah* that use *fatḥah, kasrah* or *ḍamah,* the transliteration is t. Then, the transliteration for *ta marbūṭah* that use *sukun (◌ْ)* is h. If the word ending with *ta marbūṭah* is followed by a word that uses article *al* (ال) and the reading of two word is separate, then the transliteration is h. example:

رَوْضَةُ الأَطْفَالِ : *raudaḥ al-aṭfāl*

5. *Syaddah (Tasydīd)*

Syaddah or tasydīd in Arabic is symbolized with *tasydīd* (◌ّ), the transliteration use double consonant. Example:

رَبَّنَا : *rabbanā*

If ي use *tasydīd* in the end of a word and preceded by *kasrah,* then translkteration is like *maddah* (ī). Example:

عَلِيٌّ : ‘Alī (not’Aliyy or ‘Aly)

6. Article *al* (ال)

In the Arabic language systematic, article symbolized with ال (*alif lam ma’rifah*). In this transliteration guideline, the article transliterates as “al-”, no matter it is syamsiyyah or qamariyah. The article does not follow the sound of the next letter directly. The the article is written separated from the word which follow it and connected by stripe. example:

الشَّمْسُ : *al-syamsu* (bukan *asy-syamsu*)

7. Hamzah

The rules for transliterating the letters *hamzah* into apostrophes (‘) only apply to *hamzah* that are in the middle and end of words. However, if the hamzah is located at the beginning of the word, it is not represented, because Arabic it is analif. Example:

تَأْمُرُوْنَ : *ta’murūna*

8. Typically used Arabic word writing

Transliterated Arabic words, terms or sentences are words, terms or sentences that have not been standardized. Words, terms or sentences that are commonplace and become part of the vocabulary, or have often been written are no longer written according to the transliteration method above. For example, the word *Al-Qur’an* (from *al-Qurān*), *Sunnah.* However, if tese words are part of a series Arabic texts, then

they must be fully transliterated. Example: *Fi Ẓilāl al-Qur'ān.*

9. *Lafẓ al-Jalālah* (الله)

   The word "Allah" which is presented by particles is like a letter *jar* and other letters or having the status of *muḍāf ilaih* (nominal phrases), transliteration without the letter hamzah. Example, بِاللهِ *billāh.*

ABSTRACT

The dependence of people in 20th century can't be underestimated; many aspects have progressed because of people's mission to seek convenience. Many tools are created to help the daily activities which in fact, it was. After the mundane aspects have been fulfilled, at the beginning of the 21st century, people have started to make many changes about relation between their God. One of them is by using smart phone to perform the function of prayer times notification. This kind of application can remind prayer times like *adzan*, even though in fact he is far from Muslim majority areas. One of applications that provides prayer time is Sunclock, this application was developed by a senior programmer from Germany, named Henning Benecke. The characteristic of Sunclock Application makes the rating almost perfect; it is 4,5 stars from 5. The famous word, "nothings perfect", inspire me to make a research about this application, because, Sunclock application has been downloaded by more than 500.000 users in Playstore. There are many users from Indonesia seen by the review in its comment's column that is using Indonesian language. Besides, prayer times that presented in its application is different from the usual time that used in Indonesia, for example from Website Bimas Islam. The prayer time in Sunclock 10 minutes slower than Bimas Islam. There is a possibility about the different criteria that used in this application and in Indonesia.

Based on the background, the research is formulated into two main problems, they are: algorithm of prayer times in Sunclock Application and the accuracy of prayer times on Sunclock application.

The research is a qualitative descriptive research. This kind of research is to make description systematically, factual, and accurate about an object of study. This system is useful for describing and analyzing data from the Sunclock application. This research also classified as library research, namely research conducted by examining the library materials, in the form of books, encyclopedias, journals, magazines and other sources relevant to the topic that studied in this thesis. The primary data for this research is the analysis about the data from Sunclock application and data confirmation using interviews with Henning Benecke. The data from Sunclock Application is compare to data from Indonesian Ministry of Religious Affairs as the main data from Indonesian government which has accuracy that proven by Ilmu Falak expert.

The result of this research is the algorithm of Sunclock Application to determine the Sun data is different from Ministry of Religious Affairs algorithm, but both have the close result. Although the Sun data used are close, the calculation of Sunclock prayertimes does not use *iḥtiyath* and has different Sun altitude criteria of Fajr, so the result is different up to 7 minutes at Fajr. But, in other prayer times is only 0 to 1 minute. Still in the rangeof the *iḥtiyath* that is used by Indonesian Ministry of Religious Affairs. Excepting the criteria of Fajr, the algorithm of Sunclock Application is accurate.

Keyword: Prayer times, Android Application, Sunclock

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In the name of Allah, the gracious and merciful, who always give us mercy and blessing. Peace is kindly regarded to the last Messenger, prophet Muhammad, who has brought us from the darkness to the lightness.

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Semarang, 25 April 2021

Umi Latifah

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CHAPTER I

INTRODUCTION

A. Research Backgrounds

The times demand every aspect of life to keep changing. From mundane and even religious aspects. Modern people who love practicality are very close to technology. According to Reza A. A Wattimena, "Technology is the child of science. Technology is natural engineering for the fulfillment of human interest by using science."[1]

The dependence of people in 20th century can't be underestimated; many aspects have progressed because of people's mission to seek convenience. Many tools are created to help the daily activities which in fact, it was. After the mundane aspects have been fulfilled, at the beginning of the 21st century, people have started to make many changes about relation between their God also. One of them is by using smart phone to perform the function of prayer times notification. This kind of application can remind prayer times like *azan*, even though in fact he is far from Muslim majority areas.

Ṣalat or prayer is the important form of worship and a very significant issues in Islam. Therefore, Islam places *ṣalat* as a special and fundamental thing, namely making *ṣalat* as the pillars of Islam that must be upheld. *Ṣalat* is also an obligation that must be carried out every day independently of the

[1] Reza A. A Wattimena, *Tentang Manusia: Dari Pikiran, Pemahaman, Sampai dengan Perdamaian Dunia* (Yogyakarta: Maharsa, 2016), 166.

external environment, even independently of the physical condition of humans, it is obligatory for elderly people, people who are sick or even palsied, while traveling, even in conditions of war. [2] Although the prayer times is not be mentioned clearly by Allah, but the prayer times are mentioned indirectly in Al-Quran and Hadis.[3]

Because of the important of *ṣalat*, there was a practical way to find out the schedule of prayer times with smart phone, prayer times were determined using the Sun. There are several instruments used, among them are *Istiwa'*[4] pikestaff, *Sundial*[5], *Astrolabe*[6], and *Rubu' Mujayyab*[7]. These instruments are not

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[2] Tono Saksono, *Mengungkap Rahasia Simponi Dzikir Jagat Raya* (Bekasi: Pustaka Darul Ilmu, 2006), cet. I, 99.

[3] Ahmad Izzuddin, *Ilmu Falak Praktis*, (Semarang: Komala Grafika, 2006), hlm. 78.

[4] *Istiwa'* pikestaff is an ordinary stick that is stuck perpendicular to a flat area in an open place. Its use is to determine the direction precisely by connecting two points (the distance of two points to the stick must be the same) the tip of the shadow of the stick when the Sun is in the east with the tip op the shadow after the Sun has shifted to the west. That's the exact direction for the west point. Other uses, to see the exact time of zuhr, the height of the Sun and to determine the direction of the Qibla. Look to Susiknan Azhari, *Ensiklopedi Hisab Rukyat*, (Yogyakarta : Pustaka Pelajar, 2008), cet. 3, 105.

[5] Sundial is a device used as a timestamp pseudo local by using the Sun, so that the shadow of gnomon (stem or plate whose shadow is used as a guide time). Look to Ely uzlifatul Jannah and Elva Imeldatur Rohmah, "Sundial Sejarah dan Konsep Aplikasinya", *Al-Marsyad: Jurnal Astronomi Islam dan Ilmu-Ilmu Berkaitan*, vol. 5, no. 2, 2019, 127-145.

[6] Astrolabe is an ancient tool commonly used to measuure the position of celestial bodies. Where its shape consists of a disc with a degree division scale, with a surveillance device. Look to Susiknan Azhari, *Ensiklopedi*, 36.

[7] *Rubu' Mujayyab* is a tool for calculating functions goniometris which is very useful for projecting circulation celestial bodies on a vertical circle. Look to Susiknan Azhari, *Ensiklopedi*, 182.

classic, but manual. The operator must be known about the concept of Astronomy.

Each instrument above has its own accuracy. If these tools are compared by Ministry of Religious Affairs of Republic Indonesia's method, it will get the different accuracy, for example, *Rubu' Mujayyab* its deviation is not that significant, its only 1 until 4 minutes.[8] With this level of accuracy, a lot of effort must be made. This method is ineffective if used in practical every single day.

In order to obtain accurate and practical data of prayer times, there are so many ways that be developed by Ilmu Falak expert. The most used way is mobile applications. This methode is one of the scientific formulation of falak on virtual reality.[9] One of applications that provides prayer time is Sunclock, this application was developed by a senior programmer from Germany, named Henning Benecke. As the named implies, this application is an application that provides information about the sundial. However, in this application there is a prayer times feature for Muslim. For Muslim communities living in the majority areas do not experience the urgency of this application. But, in the minority areas, where the *aẓan* is difficult to hear, this application means a lot to facilitate the implementation of worship in the correct time.

[8] Moelki Fahmi Ardiansyah, "Assessment Tool of Hisab Rukyat Archipelago (Rubu 'Mujayyab and Astrolabe in Calculating the Start Time of Prayer)", *Bimas Islam,* vol.8, no. 1, 2015, 1-30.

[9] Achmad Mulyadi, "The Science of Falak on Virtual Reality", *Al-Hilal: Journal of Islamic Astronomy,* vol. 2, no. 1, 2020, 63-98.

In addition to Muslims who live in minority areas, this application also means a lot for travelers who are not familiar with prayer times in their stopover areas. Because the movement of the Sun which determines prayer times is very depend on the latitude of the observer. In theory, when the 21st June, the apparent part of the Sun or commonly known as the declination of the Sun, is close to the North Pole, which is 23º27'. It makes the daylight of Artic region and surrounding area longer than the night. At the same time, in the conditions in the South pole is opposite, the day is shorter than the night. There are even some days that are filled with dark nights. The situations were reversed on December 22 when the apparent motion of the Sun was closer to the South pole. Declination value -23º27'. At that time, the South Pole region experienced a day that is longer than the night. On the other hand, the north pole and its surroundings experience a night that is longer than its day. [10] This issue is discussed in the book of Slamet Hambali. In that book written that in some place that haven't the certain time to pray because of the Sun movement, they can follow the prayer times of Saudi Arabia or place nearest from their place.[11]

The characteristic of Sunclock Application makes the rating almost perfect; it is 4,5 stars from 5. The famous word,

[10] Auzi'ni Syukron Kamal Ahmad, "Analisis Perbedaan lintang Terhadap Lama waktu *Salat*", *Undergraduate Thesis* UIN Walisongo Semarang (Semarang, 2018), 65-66.

[11] Slamet Hambali, *Ilmu Falak 1: Penentuan Awal Waktu Shalat & Arah Kiblat Seluruh Dunia*, (Semarang: Program Pascasarjana IAIN Walisongo Semarang, 2011), 138.

"nothings perfect", inspire me to make a research about this application, because, Sunclock application has been downloaded by more than 500.000 users in Playstore. There are many users from Indonesia seen by the review in its comment's column that is using Indonesian language. Besides, prayer times that presented in its application is different from the usual time that used in Indonesia, for example from Website Bimas Islam. The prayer time in Sunclock 10 minutes slower than Bimas Islam. There is a possibility about the different criteria that used in this application and in Indonesia.

Seeing this reason, this application must be examined, because it closely related to compulsory worship. There are many forbidden times for prayer where prayers may be established because of inaccurate schedules or even many people have difficulty recognizing prayer times in new places because they are unfamiliar with the movement of the Sun. As an Ilmu Falak student, I have a responsibility to examine about what happen to this kind of phenomena to improve the science.

B. Research Problems

The research will be formulated into some main problems in the following form of several questions below:

1. How is algorithm of prayer times in Sunclock Application?
2. How is the accuracy of prayer times on Sunclock application?

C. The Purpose and Benefit of the Research

1. The purposes

The aims of research are:

a. To know the algorithm of prayer times in Sunclocck application
b. To know the accuracy of prayer times on Sunclock application.

2. The benefits

The benefits of research are:

a. Inform one of the processing data and study about prayer times that developed in the world
b. Give information about calculation system of prayer times and data that used in Sunclock application
c. Inform about the accuration of prayer times in Sunclock application
d. Enrich an astronomy science, especially in programing the prayer times.

D. Literature Review

One of my purpose to write and make a research about this title is to enrich the science, especially Islamic Astronomy (Ilmu Falak), hence the originality is the basic to realize the aim. But this research is not the new one. There were the previous researches about prayer times and analysis about application of prayer times that trigger my idea to make this research. But there are many differences about the object of study. Some of the research are:

The Undergraduate Thesis of Rizaluddin, *Comparation Analysis of Slamet Hambali and Rinto Anugraha Prayer Times Calculation Algorithm*. This study resulted in

two findings. *First,* the both algorithms different in using the Sun's declination data and equation of time, the altitude of the sun, refraction values for *Isya* and *Fajr* and consistency within spot height correction. *Second,* the advantages and disadvantages of both algorithms. The advantages of Slamet Hambali algorithm are easy and fast calculations, in calculator program, minimal human error potential and systematic calculation flow. While the disadvantage is the data rounding and cannot used for all over the world. While the Rinto Anugraha algorithm has advantages such as the absence of rounding data, the excel program and systematic calculation. The disadvantages it has is inconsistency using height correction, it is difficult to do manual calculations, potential human error is big and cannot use for all over the world.[12]

The Undergraduate Thesis of Bangkit Riyanto, *Analysis Study of Digital Falak Application Prayer Times by Ahmad Tholhah Ma'ruf,* from this study it was found that the Digital Falak application is quite accurate when compared to the Winhisab of Ministry of Religious Affairs of Republic Indonesia. Considering that Winhisab is made and use by Ministry of Religious Affairs of Republic Indonesia, its accuracy value in calculations must be considered carefully. Although in the result of the comparison between the Digital

[12] Rizaluddin, "*Comparation Analisys of Slamet Hambali and Rinto Anugraha Prayer Times Calculation Algorithm," Undergraduate Thesis* UIN Walisongo Semarang (Semarang, 2016).

Falak and Winhisab there is a difference, the difference is very small, it was in second level.[13]

The Undergraduate Thesis of Novi Arijatul Mufidoh, *Calculation System of Website Program Bimbingan Masyarakat Islam's Prayer Times by Ministry of Religious Affairs of Republic Indonesia.* This study found two result, *first,* the prayer times calculation system in the Bimbingan Masyarakat Islam website program is one of the basic programs of Modern Astronomy, the calculations refer to Jean Meeus's book Astronomical Algorithms which supports the display of the result of prayer time calculation. The computation system used refers to the system for calculating the prayer times of Muhyiddin Khazin in the *Ilmu Falak dalam Teori dan Praktek* book, with used the input data from Ephemeris data. *Second,* based on the analytical result of the Islamic Bimas prayer times using calculation of Slamet Hambali's book and the Accurate Times computation system, this program can be said to be inaccurate for determining the time of *Fajr, Fajr,* Sun rise, and *Magrib* as long as it has not taken into account of the height of the place in the calculation. Therefore, the author concludes that this program cannot be used comprehensively as a reference in determining the 5 prayer times throughout Indonesia, especially in determining

[13] Bangkit Riyanto, *"Analysis Study of Digital Falak Application prayer Times by Ahmad Tolhah Ma'ruf," Undergraduate Thesis* UIN Walisongo Semarang (Semarang, 2016).

prayer times which are strongly influenced by the calculation of the altitude of the Sun.[14]

Also, some research about prayer times, such as a journal from Hossein Aghighi, Abbas Ali Muhammadi, and Mohammad Sadeghi Ghahareh, in title *Prayer Times Modeling with GIS: A Case Study for Iran and Its Surrounding*. This research discusses about the use of GIS in computing prayer times for Iran and its surrounding. The result is that applying the GIS in computing prayer times is clear and evident and it is suggested the scientific authorities of Muslim and non-Muslim countries –who are responsible for such calculations- apply GIS in computing prayer times.[15]

Maqsood Alam and Rbia Tabassum, *Astronomical Improve Model of Prayer Timing with Error Analysis*. In this research, the astronomical improve mathematical models of *salat* timing are developed in line with the major school of thought of Islam jurisprudence. The tracking of a true Sun, for calculating the *hour angles* on *ecliptic* at five different places and developing the models of *Zuhur* and *Asar Salat* timing according to Syafi'i and Hanafi school of thought are the key objectives of this research. There are various astronomical measures like astronomical Islamic Twilight (AIT), depression

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[14] Novi Arijatul Mufidoh, "*Calculation System of Website Program Bimbingan Masyarakat Islam's Prayer Times by Ministry of Religious Affairs of Republic Indonesia,"* Undergraduate Thesis UIN Walisongo Semarang, (Semarang, 2018).

[15] Hossein Aghighi, Abbbas Alimohammadi& Mohammad sadeghi Ghahareh, "Prayer Times Modelling with GIS: A Case Study for Iran and It's Surrounding", *Journal of Compuer science)*, vol. 4, no. 10, 2008, 807-814.

angle, declination of Sun and equation of time are used in this study to construct the model outcomes using SOSS 19 will be presented.[16]

E. Research Methodology

1. Kind of research

   The research is a qualitative descriptive research. This kind of research is to make description systematically, factual, and accurate about an object of study. This system is useful for describing and analyzing data from the Sunclock application.

   This research also classified as library research, namely research conducted by examining the library materials, in the form of books, encyclopedias, journals, magazines and other sources relevant to the topic that studied in this thesis.

2. Data sources and types

   This study used two data sources, primary data and secondary data.

   a. Primary data is a data source that is directly collected by me from the main source. The primary data for this study is the analysis about the data from Sunclock application and data confirmation using interviews with Henning Benecke.

[16] Maqsood Alam and Rabia Tabassum, "Astronomical Improve Model of Prayer Timing with Error Analysis", *Conference Paper* of 12th International Conference on Statistical Sciences (Univercity of Karachi, March, 2014), 107-120.

b. Secondary Data

Secondary data or secondhand data is not directly obtained by me from the object of research. I obtain this data from library research, sourced from journals, books that discuss the prayer times and application programing, paper, sources from archives, dictionaries, encyclopedias, internet and books related to this research supplementary data from this research.

3. Method of collecting data

a. Interview

I interviewed the programmer of Sunclock application, Henning Beneck, about the programing system of Sunclock application, and some of Ilmu Falak experties to know more about their opinion of prayer times. The interview techniques are very important because the main data of the study is the result of interview process.

b. Documentation

The documentation as a data collection technique will be done by collecting some information about data and facts related to the problem and the purpose of study. The data can be in the form of writings, various books, journal, articles, and sources from the internet, as well as the scientific data that are related to previous research.

4. Data analysis method

I collected data obtained from the result of documentation and interviews, then analyzed by using a qualitative

approach with descriptive evaluative. Descriptive method uses to describe the results of my analysis that did by collecting related data with the calculation of prayer time in application Sunclock.

F. Systematic of Writing

In an outline, this study is written by compiled in each chapter. Consist of five chapters,

Chapter I Introduction. This chapter contains about background of the reserarch, identification of the problems, the aims of research, the benefit of research, literature review, research methodology and systematic of writing.

Chapter II Prayer times theories. This chapter contains the prayer times normative law from al-Qurān, Hadīts, prayer times according to *Fiqh* and Astronomy, data components to compute prayer times, the calculation of prayer times according to *hisab* expert from Indonesia and the argument from *Ilmu Falak* experties.

Chapter III Sunclock Application. This chapter contains about the biography of Henning Benecke, the Sunclock application detail, and the algorithm of prayer times in Sunclock Application.

Chapter IV Algorithmic analysis of prayer times on Ssunclock Application. This chapter contains about the main research, they are about algorithm of prayer times in Sunclock application, my critics and how is the accuracy of prayer times Sunclock application.

Chapter V Closing. The last chapter contains about the conclusion of research, suggestion, and closing words.

CHAPTER II

PRAYER TIMES THEORY

A. The Law of Prayer Times

Prayer (*salat*) in etymology is from an Arabic word - صَلَّى يَصلِّى – صَلاَةً that has mean الدعاء (pray). Like what said in Al-Quran At-taubah verse 103:

وَصَلِّ عَلَيْهِمْ ۖ إِنَّ صَلَاتَكَ سَكَنٌ لَهُمْ ۗ وَاللَّهُ سَمِيعٌ عَلِيمٌ[1]

"and pray for them. Your prayer is comfort for them. God is Hearing and Knowing."

In terminology, prayer is a greeting and activity that begins with *takbīratul iḥrām* and ends with greetings (*salām*).[2] The word salat is an uptake of Arabic which according to KBBI is defined as the second pillar of Islam, in the form of worship to Allah SWT., it must be done by every post puberty Muslim, with conditions, harmonious, and certain reading, started by *takbīr* and ended by *salām*.[3] In English, *ṣalat* is the Muslim act of praying five times a day, one of the Pillars of Islam.[4]

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[1] Departemen Agama RI, *Al-Qur'an dan Terjemahnya* (Jakarta Timur: CV Darus Sunnah, 2015), cet. 18, 204.

[2] Syaikh al-Islam Zakariyya al-Anshari, *Tuhfatu al-Ṭullāb,* (Surabaya19. Maktabah Hidayah, tth), 19.

[3] Tim PenyuSun Kamus Bahasa Indonesia, *Kamus Bahasa Indonesia*, (Jakarta: Pusat Bahasa, 2008), 1249.

[4]Oxford University Press, "Oxford learner's Dictionary Online", https://www.oxfordlearnersdictionaries.com/, accessed on January 14 2021 M./ 30 Jumadil Akhir 1442 H.

Ṣalat is prescribed in Islam in the month of Rajab in the 11th year of prophecy when Raslullah was in *Isra' Mi'rāj*[5] to *Sidratil Muntahā*. Prayers are compulsory for Muslims in a day and night for five times, namely Fajr, Zuhur, Asar, Magrib, and Isya'.[6] These five prayer times have their own time. As mentioned in the Al-Qur'an and Hadis.

1. Al-Quran
   a. An-Nisā' verse 103

فَاِذَا قَضَيْتُمُ الصَّلٰوةَ فَاذْكُرُوا اللّٰهَ قِيَامًا وَّقُعُوْدًا وَّعَلٰى جُنُوْبِكُمْ ۚ فَاِذَا اطْمَاْنَنْتُمْ فَاَقِيْمُوا الصَّلٰوةَ ۚ اِنَّ الصَّلٰوةَ كَانَتْ عَلَى الْمُؤْمِنِيْنَ كِتٰبًا مَّوْقُوْتًا[7]

> *"When you have completed the prayer, remember God, standing, or sitting, or on your sides. And when you feel secure, perform the prayer. The prayer is obligatory for believers at specific times."*

Al-Zamakhsyari in his *Tafsīr* interpreted this verse that people should not end the time or give precedence to prayer time at will, whether it is safe or afraid.[8] The word "*kānat"* indicates about something that is

[5] Isra' is the journey of Prophet Muhammad from the Grand Mosque to the Al-Aqsa Mosque. Then, Mi'raj is the journey from Al-Aqṣa Mosque to *Sidratil Muntahā.*

[6] Ahmad Musonnif, *Ilmu Falak: Metode Hisab Awal Waktu Shalat, Arah Kiblat, Hisab Urfi dan Hisab Hakiki Awal Bulan,* (Yogyakarta: Teras, 2011), 59.

[7] Departemen Agama RI, *Al-Qur'ān dan Terjemahannya* (Jakarta Timur: CV Darus Sunnah, 2015), cet. 18, 96.

[8] Al-Zamakhsyari, *Tafsīr Al Kasyaf* Juz 1 (Beirut: Daar Al-Fikr, 1997), 240.

continuity, its mean the determination of prayer times will never change as said by Al-Husain bin Abu Al-'Izz Al-Hamadaniy.[9]

b. Ar-Rūm verse 17-18:

فَسُبْحٰنَ اللّٰهِ حِيْنَ تُمْسُوْنَ وَحِيْنَ تُصْبِحُوْنَوَلَهُ الْحَمْدُ فِى السَّمٰوٰتِ وَالْاَرْضِ وَعَشِيًّا وَّحِيْنَ تُظْهِرُوْنَ[10]

> *"So glorify God when you retire at night, and when you rise in the morning. His is the praise in the heavens and on earth, and in the evening, and when you reach midday."*

The *Ulamā'* understand the verse above as a sign of prayer times starting with Asar and Magrib which are indicated by the word تُمْسُوْنَ, namely when the Sun is just about to set and / or moments after setting, followed by the dawn prayer which is indicated by the word تُصْبِحُوْنَ then the Isya prayer which is indicated by the word عَشِيًّا and the midday prayer which is indicated by the word تُظْهِرُوْنَ. For those who understand the above verse to talk about prayer, they understand the word

[9] Al-Husain bin AL-'Izz Al-Hamadaniy, *Al-ghārib fī I'rāb Al-Qurani* Juz 1 (Qatar: Daar Al-Tsaqafah), 788.

[10] Departemen Agama RI, *Al-Qur'ān,* 407.

سبح الله in the sense of the command to pray, because *tasbīh* and purification and *tahmīd* are part of prayer.[11]

c. Al-Isra' ayat 78:

اَقِمِ الصَّلٰوةَ لِدُلُوْكِ الشَّمْسِ اِلٰى غَسَقِ الَّيْلِ وَقُرْاٰنَ الْفَجْرِۗ اِنَّ قُرْاٰنَ الْفَجْرِ كَانَ مَشْهُوْدًا[12]

"Perform the prayer at the decline of the Sun, until the darkness of the night; and the Quran at dawn. The Quran at dawn is witnessed."

The verse explains that Muslims are instructed to perform the five prayers in a day and night as a duty, while at that time the delivery of the Prophet was only verbal and the times for its implementation were not listed in the Koran, until finally the verse came down.[13]

2. Hadits

a. Hadis narrated by Jabir bin Abdullah, Shahih Bukhari: 547

حَدَّثَنَا مُحَمَّدُ بْنُ بَشَّارٍ، قَالَ حَدَّثَنَا مُحَمَّدُ بْنُ جَعْفَرٍ، قَالَ حَدَّثَنَا شُعْبَةُ، عَنْ سَعْدٍ، عَنْ مُحَمَّدِ بْنِ عَمْرِو بْنِ الْحَسَنِ بْنِ عَلِيٍّ، قَالَ قَدِمَ الْحَجَّاجُ فَسَأَلْنَا جَابِرَ بْنَ عَبْدِ اللَّهِ فَقَالَ كَانَ النَّبِيُّ صلى الله عليه وسلم يُصَلِّي

[11] M. Quraish Shihab, *Tafsīr Al-Miṣbāh* vol. 11 (Jakarta: Lentera Hati, 2005), cet. 4, 26.

[12] Depertemen Agama RI, *Al-Qur'an,* 291.

[13] M. Quraish Shihab, *Tafsīr Al-Miṣbāh* vol. 8, 525.

الظُّهْرَ بِالْهَاجِرَةِ، وَالْعَصْرَ وَالشَّمْسُ نَقِيَّةٌ، وَالْمَغْرِبَ إِذَا وَجَبَتْ، وَالْعِشَاءَ أَحْيَانًا وَأَحْيَانًا، إِذَا رَآهُمُ اجْتَمَعُوا عَجَّلَ، وَإِذَا رَآهُمْ أَبْطَؤُا أَخَّرَ، وَالصُّبْحَ كَانُوا ـ أَوْ كَانَ النَّبِيُّ صلى الله عليه وسلم يُصَلِّيهَا بِغَلَسٍ.

"Has told us Muhammad bin Basyar, Narrated Jabir bin `Abdullah: The Prophet used to pray the Zuhur at midday, and the `Asar at a time when the Sun was still bright, the Magrib after Sunset (at its stated time) and the `Isya at a variable time. Whenever he saw the people assembled (for `Isya' prayer) he would pray earlier and if the people delayed, he would delay the prayer. And they or the Prophet used to offer the Fajr Prayers when it still dark."[14]

b. Hadis narrated by Salama, Sahih Bukhari: 548

حَدَّثَنَا الْمَكِّيُّ بْنُ إِبْرَاهِيمَ قَالَ: حَدَّثَنَا يَزِيدُ بْنُ أَبِي عُبَيْدٍ عَنْ سَلَمَةَ قَالَ كُنَّا نُصَلِّي مَعَ النَّبِيِّ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ الْمَغْرِبَ إِذَا تَوَارَتْ بِالْحِجَابِ.

"Has told us al-Makiy bin Ibrahim, he said: has told us yazid bin Abi 'Abid, Narrated Salama: We used to pray the Magrib prayer with the Prophet when the Sun disappeared from the horizon."[15]

[14] Abdul Qadir Syaibah al-Ahmad, *Al-Jāmi' Shahīh lil Bukhāri* (Riyadh: National Library of King Fahd, 2008), 192.

[15] *Ibid.*

c. Hadis narrated by Abdillah bin Umar ra, Sahih Muslim: 173

وَحَدَّثَنِي أَحْمَدُ بْنُ إِبْرَاهِيمَ الدَّوْرَقِيُّ حَدَّثَنَا عَبْدُ الصَّمَدِ حَدَّثَنَا هَمَّامٌ حَدَّثَنَا قَتَادَةُ عَنْ أَبِي أَيُّوبَ عَنْ عَبْدِ اللَّهِ بْنِ عَمْرٍو أَنَّ رَسُولَ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ قَالَ: ((وَقْتُ الظُّهْرِ إِذَا زَالَتِ الشَّمْسُ وَكَانَ ظِلُّ الرَّجُلِ كَطُولِهِ مَا لَمْ يَحْضُرِ الْعَصْرُ وَوَقْتُ الْعَصْرِ مَا لَمْ تَصْفَرَّ الشَّمْسُ وَوَقْتُ صَلاَةِ الْمَغْرِبِ مَا لَمْ يَغِبِ الشَّفَقُ وَوَقْتُ صَلاَةِ الْعِشَاءِ إِلَى نِصْفِ اللَّيْلِ الأَوْسَطِ وَوَقْتُ صَلاَةِ الصُّبْحِ مِنْ طُلُوعِ الْفَجْرِ مَا لَمْ تَطْلُعِ الشَّمْسُ فَإِذَا طَلَعَتِ الشَّمْسُ فَأَمْسِكْ عَنِ الصَّلاَةِ فَإِنَّهَا تَطْلُعُ بَيْنَ قَرْنَيْ شَيْطَانٍ)).

"Has told me Ibrahim ad-Dauraqiy, has told us Hammam, has told us Qatadah from Abi Ayyub from Abdullah bin 'Amr reported: The Messenger of Allah (may peace be upon him) said: The time of the noon prayer is when the Sun passes the meridian and a man's shadow is the same (length) as his height, (and it lasts) as long as the time for the afternoon prayer has not come; the time for the afternoon prayer is as long as the Sun has not become pale; the time of the evening prayer is as long as the twilight has not ended; the time of the night prayer is up to the middle of the average night and the time of the morning

prayer is from the appearance of dawn, as long as the Sun has not risen; but when the Sun rises, refrain from prayer for it rises between the horns of the devil."[16]

From the script of Hadits, it can be concluded that the determination of early Isya and Fajr prayer times can be done through observing natural signs in the form of disapperarance of *syafaq* and the appearance of *fajr ṣadīq*.[17]

B. Determining of Prayer Times on *Fiqh* and Astronomical Perspective

In Islamic law perspective, the mandatory prayers (*maktubah*) have determined times (so that they are defined as *muwaqqat*[18] worship). Although not clearly explained, but in implicit way, Al-Quran has determined it. Detailed descriptions of prayer times are explained in the *Hadīts*. From the *hadīths* for prayer times, the *fuqahā* set the time limits for prayers in various ways or methods. There are some of them who assume that the way to determine the time of prayer is by looking directly at the natural signs as textually in the Prophet's *hadits*, such as using the equiptment of the *istiwā'* stick, or *miqyās*, or hemisperium. This is the method or ways used by

[16] Abi Husain Muslim bin Hajjaj, *Ṣahīh Muslim* (Saudi Arabia: Dar Mughni, 1998), 308.

[17] M. Syaoqi Nahwandi, "The reformulation of Algorithm for Calculating Star's Position as the Sign of Isya and Fajr Prayer Times", *Al-Hilal: Journal of Islamic Astronomy*, vol. 1, no. 1, 2019, 53-86.

[18] Determined the time. See Mahmud Yunus, *Kamus Arab Indonesia*, (Jakarta: Mahmud Yunus Wa Dzurriyah, 2007), 504.

the Rukyah school in the matter of determining prayer times. So that the specified prayer time is called *al-Awqāt al-Mar'iyyah* or al-*Waktu al-Mar'y*[19]. Determining the beginning of the prayer time is part of astronomy whose calculations are determined based on the Sun's orbit or research on the position of the Sun on the Earth.[20] To know the beginning of prayer times, Allah sent Jibril to give direction to the Prophet Muhammad about the times of prayer with reference to the Sun and the phenomenon of sky light which incidentally is also caused by the Sun's rays. So actually the first indication of knowing the prayer times is by looking at (*rukyat*) the Sun.[21]

While some others have a contextual understanding, in accordance with the intent of the texts, where the beginning and end of the prayer time is determined by the position of the Sun seen from a place on Earth, so the method that is used is calculation. Therefore, the essence of prayer times calculation is calculating when the Sun will occupy positions for prayer times based on the *al-Qurān* and *Hadīts*. So that this opinion is used by the school of calculating in the matter of determining prayer times. And it's prayer time by *fiqh* scholars is called *Riyādhy*[22] time. In this way, the existence of the eternal prayer

[19] Ahmad Izzuddin,M.Ag., *Ilmu Falak*, 78-79.

[20] Encup Supriatna, *Hisab Rukyat dan Aplikasinya*, (Bandung : PT Refika Aditama, 2007), 15.

[21] Ahmad Musonnif, *Ilmu Falak*, 58.

[22]It can be determined by calculating the altitude of the Sun, while the time of Mar'iy can be obtained by looking at the Sun. Both are intermediaries to determine syar'i time.

time schedule or the prayer schedule of all time will be born.[23] But, the discussion about these two arguments do not bring the crucial problems.[24]

The arguments about prayer times not only about when is the beginning. But, also how many times of prayer that must be done by Mouslem. As an implication, there are differences in determining the beginning of prayer times. The first group mentions that the beginning of prayer times are three. The second group mentions that the beginning of prayer times are five.[25]

The development of a stronger opinion in Indonesia is the second typology, namely prayer consisting of five times.[26] Five prayer times in Indonesia have a stable schedule because the position of Indonesia is crossed by the equator, as this affects the day / night arc length difference. In theory, the length or shortness of the day / night arc is much influenced by the latitude where the area is located and the position of the Sun towards the equator. The farther the place and the Sun are from the equator, the greater is the difference of the day and night arc length. The closer the Sun is to the equator, the smaller the

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[23] Ahmad Izzuddin, M.Ag., *Ilmu,* 79.

[24] Ahmad Izzuddin, *Fiqih Hisab Rukyat: Menyatukan NU dan Muhammadiyah dalam Penentuan Awal Waktu Ramadhan, Idul Fitri dan Idul Adha,* (Jakarta: Erlangga, 2007), 39.

[25] Susiknan Azhari, *Ilmu Falak Perjumpaan khazanah Islam dan Sains Modern,* (Yogyakarta: Suara Muhammadiyah, 2011), 64.

[26] Obi Robi'a Al-Aslami, "Aplikasi Jadwal Waktu Salat dengan Standar Jam Atom BMKG Berbasis Android", *Undergraduate Thesis State Islamic University of Walisongo Semarang* (Semarang, 2019), 24.

difference in day and night arcs. Each prayer time has different effects, *first,* for Zuhur and Asar times, the further south the latitude is, the longer the prayer time will be. *Second,* Magrib prayer, the closer to the equator, the shorter the prayer time. *Fourth*, the length of the Isya prayer will get shorter the more it goes south. The last, Fajr, the closer to the equator, the shorter it will be, conversely, the closer to the poles, the longer it will be.[27] Therefore, from the above texts developed the prayer times used in Indonesia.

1. Zuhur

   The beginning of Zuhur is the movement of the Sun from its culmination to the West clearly with increasing the shadow length of an object.[28] The movement process from this culmination is only momentary.[29] What needs to be understood is that during Zuhur, the value of Solar angle is 0º and at that time it is 12 o'clock according to the Solar astronomic time.[30] However, there were instances where the Rasulullah had prayed in a state of shadow that was as long as himself. This may be due to the position of Saudi Arabia which lies

[27] Auzi'ni Syukron Kamal, "Analisis Perbedaan Lintang terhadap Lama Waktu Salat", *Undergraduate Thesis Islamic State University of Walisongo Semarang* (Semarang, 2018), 68.

[28] Ahmad Ghazali Muhammad Fathullah, *Irsyadul Murīd,* (Sampang: Lafal, 2005), 29.

[29] Biasanya posisi ini diambil sekitar 2 menit lewat tengah hari. Saat berkulminasi atas pusat busur Matahari berada di Meridian. Slamet Hambali, *Ilmu Falak 1,* (Semarang: Program Pacasarjana IAIN Walisongo Semarang), 2011, 127.

[30] Izzuddin, *Ilmu Falak*, 85.

about 20º-30º North. When the Sun slips, the length of the shadows can reach even more length. This situation can occur when the Sun is positioned far south, which is around June and December.[31]

The situation above is a scientific explanation of the differences in opinion of the Islamic Scholars. The four scholars do not have different opinions regarding the beginning of Zuhur. However, disagreements occur when discussing the end of Zuhur. Imam Malik, Shafi'i, and Daud argued that the end of Zuhur is when the shadow length of an object exceeds just a little of the length of the object.[32]

The uncertain movement of the Sun is felt at 12 o'clock when this culmination is influenced by the equation of time. That is why, the formula of the meridian pass is MP = 12- the equation of time. From the calculation of this Meridian pass, 2 minutes according to Slamet Hambali is added, as the start of Zuhur time.

2. Asar

The definition of when is the beginning of Asar is uncertain among *fuqahā*. This is because the phenomena on which they are based are not clear or seem as they are.[33] The notion that is often used for the beginning of Asar time is that Zuhur time expires and the shadow of the stick is

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[31] *Ibid.,* 83.

[32] Muhammad bin Ahmad bin Muhammad bin Ahmad ibnu Rusyd al-Qurtuby, Bidayah al-Mujtahid wa Nihayah al-Muqtasid, Juz II, (Baerut: Dar al-Kutub al-Ilmiyah, 1996), 116.

[33] Slamet Hambali, *Ilmu Falak 1*, 127.

equal to the length of the stick.[34] However, this opinion can have a ambiguous meaning because there is a difference of opinion by Islamic Scholars in interpreting the end of Zuhur. This phenomenon is closely related to the position of the Sun and the location of the observer, for example like what explain above, in winter it can be achieved at Zuhur time, maybe even never happened because the shadow is always longer than the object.[35]

According to Imam Malik, the end of Zuhur is *musytarak* time (time for two prayers). Meanwhile, Imam Syafi'i, Abu Tsaur, and Dawud argue that the end of Zuhur is Asar, which is when the shadow of an object exceeds the length of the actual object. Than, Abu Hanifah argues that the beginning of Asar is when the shadow was twice.[36]

3. Magrib

The beginning of Magrib is the end of Asar, namely by sinking the entire arc of the Sun and disappearing under the horizon.[37] The Sun can be said to have set if in the eye the disc of the Sun has touched the horizon. Time of Magrib in astronomy means when the Sun sets, meaning that the entire disk of the Sun is not visible to the observer. The solar disc has a diameter of 32 arc minutes, half of which means 16 arc minutes, besides that near the horizon there is a refraction which causes the

[34] Ahmad Ghazali Muhammad Fathullah, *Irsyadul*, 31.
[35] Slamet Hambali, *Ilmu Falak 1*, 127.
[36] Syamsudin Sarakhsi, *Kitab Al-Mabsūṭ*, Juz I, (Beirut: Darul Kitab Al-Ilmiyah), 143.
[37] Ahmad Ghazali Muhammad Fathullah, *Irsyadul*, 32.

Sun's position to be higher than it is actually estimated at about 34 minutes.[38]

Astronomically, the Sun sets when the center of the solar disk touches the horizon. Meanwhile, the Sun setting according to *fiqh* is when all the disks of the Sun have Sunk from the horizon. Consequently, the Sun's altitude when Sunset (0°) must be reduced by half of the unset Sun's disc (0° 16 '). In addition, there are also two other factors that affect the Sunset time, namely the place altitude and refraction. The place altitude affected to the observer's horizon, it can be calculated with the formula Dip = 0° 1,76 'x √H (H = altitude of place). Meanwhile, refraction is the refraction of Sunlight from the Sun because the Sun is not in an upright position, the highest refraction is when the Sunset is 0°34'25. Meanwhile, the end of Magrib time is when loss of red cloud.[39]

In the Syafi'i shcolar, there are two opinions regarding the time of Magrib. According to the first opinion, it is found in *qaul qadīm*, that the time of Magrib is from Sunset until the red cloud or *syafaq* disappears. As for the second opinion, it is found in *qaul jadid*, that Magrib time is only a short time since the Sun sets.[40]

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[38] Slamet Hambali, *Ilmu Falak 1*, 131.

[39] Slamet Hambali, *Ilmu Falak 1*, 131-132.

[40] Arwin Juli Rakhmadi Butar Butar, *Pengantar Ilmu Falak* (Depok: Rajawali Press, 2018), 35.

Based on the basic theory of the beginning of prayer time, *fuqahā* agree that the beginning of the Magrib is when the Sun sets. However, in determining the end of time, there are different opinion among the *fuqahā*. According to the majority of *fuqahā*, including *the qaul jadīd* of Syafi'i, the end of Magrib is when *Syafaq* (cloud) disappears. The difference of opinion among them is due to the difference in text between Jabir bin Abdulloh's *hadits* and Abdulloh bin Umar's hadith.[41]

The information about the short time of the Magrib prayer is likened to when people peal the *adzan*, do *wudu'*, cover their *aurat* (dress), perform Magrib prayer, and perform five cycles of Sunnah.[42] According to Imam Asy-Syafi'i, the time of Magrib is only one, that is finished when people done their three *raka'at* of prayer.[43]

4. Isya

In *fiqh* perspective, *syafaq* literally means reddening and contextually is remarked as the sky condition at western horizon related to the determination of the ending of Magrib and the beginning of Isya. There are two types of sky condition of *syafaq* have been defined

[41] Halimi Firdausi, "Uji Akurasi Perhitungan Awal Waktu Salat dalam Digital Falak LED Karya Ahmad Tholhah Ma'ruf", *Undergraduate Thesis* Islamic State University of Walisongo Semarang (Semarang, 2019), 27.

[42] Al-Qurtuby, *Bidāyah*, 206.

[43] Syamsudin Sarakhsi, *Kitab Al-Mabsūṭ* (Beirut Libanon: Darul Kitab Al-Ilmiyah. t.th.), juz 1, 144.

by *fuqahā* i.e. *syafaq al-ahmar* and *syafaq al-abyad.*[44] The time of Isya begins with the appearance of a red light or *al-syafaq al-ahmar* (this is the new opinion of Syafi'i) in the western part of the sky, which is a sign of the entry of dark night.[45] Once the Sun sets on the western horizon, the Earth's surface does not automatically darken. This happens because there are particles in space that refract the Sun, so even though the Sun's rays are not hitting the Earth, there is still a bias of light from the particles. In astronomy it is known as twilight.[46]

In particular, astronomy divides twilight into 3 stages relatively depends on solar depression angle irrespective of the influence factors. Civil dusk is refers to the ending time of evening after Sunset until solar depression is geometrically 6º below the horizon. During this dusk, terrestrial objects and the horizon is clearly can be distinguished, the brightest stars are visible to the naked eye as well as well as the extended sources of planets such as Venus and Saturn, thus, outdoor activities still can be curry on during this civil dusk without any artificial sources of light.[47]

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[44] Muhammad Abdul Niri, etc, "Astronomical Determination for Begining Prayer Times of Isya'", *Middle-East Journal of Scientific Research,* vol. 12, No. 1, 2012, 101-107.

[45] Slamet Hambali, *Ilmu Falak 1,* 132.

[46] Muhyiddin Khazin, *Ilmu falak: Dalam Teori dan Praktik,* (Yogyakarta: Buana Pustaka, tth), 91.

[47] Muhammad Abdul Niri, etc, "Astronomical Determinations", 103.

Nautical dusk is defined as the ending time of evening when solar depression is geometrically between 6º to 12º below the horizon. At the time of nautical dusk, the horizon is clearly not distinguIsyable to the naked eye, general outlines of some terrestrial objects still can be discerned but some of smaller ground objects no longer can be recognized. Any outdoor activities therefore required artificial sources of light.[48]

When the center of the Sun is geometrically between 12º to 18º below the horizon, it is defined as astronomical dusk. End of astronomical dusk is remarked as the beginning of night. At the stage of astronomical dusk in the evening, the sky is mostly dark and the Sunlight is so faint that it is practically imperceptible to naked eye due to the Sun does not contribute to sky brightness. During this astronomical dusk, the point sources like stars and zodiac light are perceptible to the naked eye. Instead, faintest and dimmest objects such as nebulae, galaxies and the stars above the sixth magnitude only visible to naked eye when solar depression angle is above 18º, which is after the astronomical dusk.[49]

The phenomenon of light above can be seen with naked eyes if when the sky is clear and with minimal pollution, so that Islam has made it a benchmark since the beginning of prayer as a *syaria.* However, the detection of this light can be assisted by developments in existing

[48] *Ibid.*
[49] *Ibid,* 103.

technology. Observation with naked eyes also needs equipment. The most accurate equipment to collection process in order to gain data that is precise and accurate this time is SQM-LE.[50] An Isya time research with this instrument has been done, and the result is, while the Isya prayer time the Sun is at the 17º below the west horizon and the sky magnitude was 20,09 mag/m2.[51]

According to Slamet hambali when the time of Isya, the Sun is located 18° below the western horizon (Horizon) or if the zenith distance of the Sun = 108°.[52]

There are other opinions about the altitude of the Sun as the beginning of Isya's time:

a. According to the Egyptian General Authority of Survey, they thought that the altitude of the Sun at the time of Isya was 17.5° below the horizon,
b. According to the Muslim community in the United States called as Islamic Society of North America (ISNA), the altitude of the Sun when entering Isya time is 15º below horizon.

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[50] AW. Raihana, K. Norihan, M. Muhammad Hazwan, "Issues on Determination of Accurate Fajr and Dhuha Prayer Times According to Diqh and Astronomical Perspectives in Malaysia: A Bibliography Study", *Conference Proceedings,* (Bali, Oct 13-14 2016), 675-680.

[51] Siti Asma' Mohd Nor, Mohd Zambri Zainuddin, "Sky Brightness for Determination of Fajr and Isya Prayer by Using Sky Quality Meter", *Internasional Journal of Scientific and Engineering Research,* vol. 3, No. 8, (August, 2012), 1-3.

[52] Slamet Hambali, *Ilmu Falak 1,* 132.

c. According to Imam Abu Hanifah, when the white light disappears, that is, the Sun's altitude is 19º below the horizon.[53]
d. According to Syiah Itsna Ashari (Jaafari), the altitude of the Sun during Isya time is 14º below the horizon.
e. According to Muslim World League (WML), the altitude of the Sun during Isya is 17º below the horizon.
f. According to University of Islamic Sciences Karachi and Malaysia, the altitude of the Sun during Isya is 18º below the horizon.[54]

These prayer times have a long span, but there are differences of opinion about their ending. The value of the Sun's angle seen from the twilight based on observations using the Sky Quality Meter (SQM) shows that the light is fluctuating and not constant. Among these opinions are: *First*, some scholars argue that the time of Isya prayer only lasts a third of the night. This opinion was held by Imam Syafi'i in his new opinion / *qaul jadīd*, Abu Hanifah, and Malik. *Second*, the second opinion states that the end of the Isya is in the middle of the night, which occurs at approximately 24.00. *Third*, the final opinion states that the end of Isya's until dawn of *Ṣadiq*. The latter opinion is

[53] Ahmad Ghazali Muhammad Fathullah, *Irsyadul*, 35.
[54] Siti Asma' Mohd, "Sky Brightness for", 1.

more global and has a long span. The dawn of *ṣadiq* is a sign of the beginning of Fajr.[55]

5. Fajr

Fajr begins when the time of Isya ends with the appearance of dawn *ṣadiq*, and Indonesian astronomers argue that the height of the Sun at dawn is -20º.[56] *Fajr ṣadiq* in astronomy is known as astronomical twilight, this light begins to appear on the Eastern horizon before Sunrise when the Sun is about -18º below the horizon (zenith distance of the Sun = 108º). Other opinions says that the dawn of the *shodiq* begins when the Sun is 20º below the horizon or the distance of the Sun = 110.[57] From the research using SQM, the altitude of Sun during Fajr prayer is 20º below the east horizon and the magnitude of the sky was 20mag/m2.[58]

In other studies, there is an additional factor that affects the colour of the sky at dawn, it is humidity. The higher humidity, the twilight sky colors became orange-reddish. Also, visibility was influenced by the level humidity. The beginning of Fajr prayer can be derived by

[55] Encep Abdul Rojak, Amrullah Hayatudin& Muhammad Yunus, "Koreksi Ketinggian Tempat terhadap Fikih Waktu Salat: Analisis Jadwal Waktu Salat Kota Bandung" *Al-Ahkam Journal,* vol. 27, No. 2, (October, 2017), 252-253.

[56] Ahmad Ghazali Muhammad Fathullah, *Irsyadul,* 38.

[57] Slamet Hmbali, *Ilmu Falak 1,* 124.

[58] Siti Asma' Mohd Nor, "Sky Brightness for", 2.

averaging solar elevation angle of defined the true dawn was -18º39'29.4".[59]

Indonesia uses the opinion of -20º as the beginning of dawn. One of the astronomers who corroborates this opinion is Saadoeddin Djambek. He argues that *Fajr* begins with apparently dawn below the eastern horizon and ends with the rising of the Sun. according to astronomical calculations, the position of the Sun is 20º below the east horizon.[60]

From a *fiqh* perspective, islamic scholars agree that the beginning of Fajr is the dawn of *Shodiq.* Imam Maliki, Imam syafi'I also in another narration from Imam Hambali stated that the Fajr prayer should be done when it is still dark. According to Imam Hanafi, the Fajr prayer is carried out between dark and light. If dark time has disappeared, then light time is better than dark, except when in muzdalifah which should be done when it is still dark.[61]

The differences in the criteria for prayer times described above still have tolerances within reasonable limits. However, there are two other prayers whose criteria for the altitude of the

[59] Nihayatur Rohmah, "The Effect of Atmospheric Humidity Level to the Determination of Islamic Fajr/Morning Prayer Time and Twilight Appearence", *Conference Paper of International Symposium on Sun, Earth, and Life* (Bandung, 3-4 June, 2016) 3.

[60] Saadoeddin Djambek, *Shalat dan Puasa di daerah Kutub* (Jakarta: Bulan Bintang, 1974), 45.

[61] Imam pamungkas, Maman Surahman. *Fiqih 4 madzhab* (Jakarta: al-Makmur, 2015), 77.

Sun have been hotly debated to date and have vast differences. The two prayers are Fajr and Isya. From the explanations above, this prayer also has varying criteria. However, recently there was a very heated discussion from an expert, namely Prof. Dr. Tono Saksono about the start of evening prayer and Fajr prayer in Indonesia which is not the right time. Based on research conducted using SQM, the DIP numbers obtained were -13.4º for dawn and -11.5º for Isya. There are several other scientific facts. Classical scholars in medieval times generally received a Dip of -18º for dawn and -16º for Isya for the Middle East region. The tools they use are generally astrolabe for measurement, while the Rubu Mujayyab is used for processing. Supposedly, in nominal equator areas, the Dip rate is lower. Therefore, according to this opinion, the Fajr prayer time in Indonesia is 26 minutes too early, and the Isya prayer time too late 26 minutes.[62]

The new edict came from Muhammadiyah at the end of December 2020. Muhammadiyah, which initially used the Sun's altitude 20º below the horizon, changed it to -18º below the horizon. This criterion means that the dawn prayer schedule is postponed to 8 minutes later. This is based on the latest findings from the Islamic Science Research Network (ISRN) UHAMKA, Ahmad Dahlan University Astronomy Center

[62] Adiv Ammar, "Prof. Dr Tono: Indonesia Sholat Fajr Terlalu Awal 26 Menit, Isya Lambat 26 Menit", https://www.voa-islam.com/read/tekno/2018/01/17/55577/prof-dr-tono-indonesia-sholat-Fajr-terlalu-awal-26-menit-isya-lambat/, accesed on 8 February 2021 M./ 26 Jumadil Akhir 29 1442 H

(Pastron UAD), and the Science Observatory of Muhammadiyah University of North Sumatra (OIF UMSU). However, this issue is answered by the Ministry of Religion which uses 20 degrees below the horizon. The Ministry of Religion still holds this opinion based on research conducted by the Ministry of Religion Falakiyah Team consisting of experts from the National Aeronautics and Space Agency (Lapan), the Meteorology, Climatology and Geophysics Agency (BMKG), and Islamic universities throughout Indonesia, as well as astronomical experts from PBNU, Persis, PUI, and Al-Irsyad. This criterion is based on the results of observations made in Labuan Bajo in 2018, as well as observations of dawn in Banyuwangi.[63]

C. The Calculation of Prayer Times

I define the calculation process into three steps. *First*, input data, *second* processing data, *third*, output data.

1. Input data

   The data that need to be input are:

   a. Geographic Coordinates

      There are two kinds of geographic data that is neded in this calculation, that are Latitude and Longitude.

[63] Saifan Zaking, "Soal Waktu Fajr Salah, Kemenag Bantah Klaim dari Muhammadiyah", https://www.jawapos.com/nasional/21/12/2020/soal-waktu-Fajr-salah-kemenag-bantah-klaim-dari-muhammadiyah/, accessed on 8 Februari 2021 M./ 26 Jumadil Akhir 29 1442 H.

The latitude of a place is defined as the distance along the Earth's meridian measured from the equator to a place in question. Latitude at least 0º and maximum 90º. Places in the Northern Hemisphere are given a positive sign (+) while those in the Southern Hemisphere are given a negative sign (-). In Arabic, latitude is termed *Urd al-Balād*. This is to[64]

Place longitude is the distance measured along the equatorial arc from longitude through the city of Greenwich to longitude through the place or country in question. In Arabic, the longitude of the place is termed as *Thūl al-Balād*, while Siradj Dahlan is the term "Moedjoer". The astronomical notation used is lambda (λ).[65]

The way to get both of these data is by opening software that is connected to the internet such as Google Earth which provides the Latitude and Longitude coordinate data of the Place at the place shown on the screen. There is also a tool called GPS (Global Positioning System), this tool can scan latitude, longitude, and altitude. Where this tool is located with the help of several satellites.

b. Time

In the book of Astronomical Algorithm of Jean Meeus, the primer data to calculate Solar declination

[64] Susiknan Azhari, *Ensiklopedi Hisab Rukyat,* (Yogyakarta: Puataka Pelajar, 2012), 134.

[65] Susiknan Azhari, *Ensiklopedi,* 47.

and equation of time is date, month and year which is desired.[66] I input the variable hours to get the solar declination value and the equation of time at the desired hour. While the time zone variable is needed to convert GMT time to the desired time, for example Indonesia, for WIB the time zone = +7, for WITA the time zone = +8, and for WIT the time zone = +9. But, in this thesis, I use the data that provided in Ephemeris Hisab Rukyat of Ministry of Religious Affairs of Indonesia.

c. Equation of Time

Equation of time in Indonesian can be interpreted as *perata waktu*, while in Arabic it is *Ta'dīl al-Waqt*, which is the difference between the culmination time of the true Sun and the time of the mean Sun.[67] This is because Earth is moving along the ecliptic. While the core is an ellipse. So because of the Keppler II law (map area law) to fulfill the provisions of this law, the speed of the Earth in evolution will vary from place to place, the rotational speed is also the same. From this effect it also affects changes in prayer times, this is due to changes in the declination and equation of time every day.[68] This data is usually

[66] Jean Meeus, *Astronomical Algorithm* (Virginia: Willman-Bell, 1991),cet. 1, 60-61.

[67] Susiknan Azhari, *Ensiklopedi*, 62.

[68] Slamet Hambali, *Pengantar Ilmu Falak*, (Banyuwangi: Bismillah Publisher, 2012), 204-205.

represented by a lowercase character "e" and is required in calculating the initial prayer times.

d. The Solar's declination

The Sun's declination is the distance formed by the Sun's path to the equator. The declination in the northern hemisphere is positive (+), while in the south it is negative (-). When the Sun crosses the equator its declination is 0º. [69] The maximum value of the declination is 23º 27 '. If the slope of the angle formed reaches this value, a turning point will occur. The equinox occurs around 21 June, and the south on 22 December. The declination of the Sun is usually given the notation δ_o in calculations.[70]

e. Place's altitude

Altitude, like elevation, is the distance above sea level. Altitude data is needed to distinguish the time of Sunset at different places. This altitude is calculated from sea level, and is very influential on the time of Magrib and dawn.

2. Processing Data

a. The Zenith Distance

The zenith distance is the distance calculated from the Sun to the zenith. The notation used for zenith distances is zm (solar zenith). The size of the zenith distance is determined by the size of the declination and the latitude of the place, and negative or positive

[69] Slamet Hambali, *Ilmu Falak 1*, 55.
[70] Slamet Hambali, *Pengantar*, 204.

is determined by the declination and latitude of the place. If the declination and place light are both positive (+) or both negative (-), then the zenith distance is the difference between the two, conversely if the declination and place light are different, i.e. positive and negative, then the zenith distance or zm is the sum of both. The zm result has no effect, it only shows if the result is (+) means the Sun is to the North of the zenith point and if the result is negative (-) shows the Sun is south of the Zenith point.[71]

The formula that is used to calculate Zenith distance is:

zm (jarak zenith) $= \delta^o - \phi^x$

b. Sun's Depression Angle (DIP)

DIP is closely related to the horizon. The horizon is a large circle that divides the celestial sphere into two equal parts (the visible part of the sky and the invisible part of the sky). This circle is the limit of someone's perspective. each person in a different place, also different horizons. While, the horizon is divided into three, they are *ufuk haqīqī* (true horizon), *ufuk hissī* (sensible horizon) *and ufuk mar'i* (visible horizon).[72]

Dip is the difference in position between the actual horizon or the true horizon and the visible

[71] Slamet Hambali, *Ilmu Falak*, 56.
[72] Susiknan Azhari, *Ensiklopedi*, 223.

horizon (*ufuk mar'i*) of an observer. This difference is represented by the magnitude of the angle.[73]

In astronomical terms, the determination of the initial time of prayer is basically determining the position of the Sun, which is based on the direction of the Sun, whether it is above the horizon or below the horizon.[74] Altitude has an effect on the low horizon which in turn has an impact on the position of the Sun. The prayer time most affected by the DIP is the Magrib prayer time. Magrib time is the time when the Sun sets. In astronomy, at this time the position of the Sun is about -1º from the horizon. This is the prayer time where the Sun's position is closest to the horizon, so the effect of the altitude that will impact the DIP is very large.

In areas with a higher geographical level, DIP correction is very influential, one example is the Bandung area. Bandung has an average altitude of 768 msl. At this height, there is a significant difference between DIP correction and not correction. The difference in Magrib prayer time is about 4 minutes. The time of four minutes cannot be underestimated, remembering Magrib time is the most awaited moment during the month of Ramadlan, and whether fasting is complete or not at this time. If there is a minute error

[73] Susiknan Azhari, *Ensiklopedi*, 47.

[74] Slamet Hambali, *Aplikasi Astronomi Modern* (Semarang: FSH IAIN Walisongo, 2012), 24.

in calculating the prayer time, then many people eat in the wrong time, the fast will be broken. Because, most people will immediately break the fast according to the Sunnah taught by the Prophet apart from as a necessity.[75]

The formula to calculate DIP is DIP = 0º1'. 76*√H. H is the location altitude from sea level.

c. The Solar Altitude

The Solar altitude is the arc distance along a vertical circle from the horizon to the Sun. In Falak Science it is called *Irtifā' al-Syams* which is usually given the notation h_o. The Sun's height is positive (+) when the Sun is above the horizon. Likewise, there is a negative sign (-) when the Sun is under the horizon.[76]

1) The Solar altitude of Fajr

   h_f = -20 – (dip + ref + sd)

   Eksplanation:

   Ref= refraksi = 0º34'

   Sd = Solar's semi diameter = 0º16'

2) The Solar altitude of Sunrise

   h_s = - (dip + ref + sd)

3) The solar altitude of Asar

   h_a = $1/\tan^{-1}$(tan zm + 1)

4) The Solar altitude of Magrib

   h_m = - (dip + ref + sd)

5) The solar altitude of Isya'

[75] Encep Abdul Rojak, *"Koreksi Ketinggian",* 256-258.
[76] Muhyiddin Khazin, *Ilmu Falak*, 80.

h_i = -17º - (dip + ref + sd)

d. The Sun Hour Angle

The Sun hour angle is the arc along the daily circle of the Sun calculated from the top culmination point until the Sun is located. Or the angle at the South or North celestial pole flanked by the Meridians and the circle of declination that the Sun passes through. In the science of falak it is called *Fadl al-Dāir*.[77]

The calculation of the time angle starts with the upper meridian and ends at the lower meridian. Thus, time is divided into two parts, namely the western part of the sky and the eastern part of the sky.[78]

Time angle value 0º to 180º. The time angle value of 0º is when the Sun is at the top or right of the celestial meridian, while the value of 180º is when the Sun is at the lower culmination point.[79] The total amount of time is 360 °, taken by the Sun for 24 hours, thus:

1h = 15

4m = 1

1m = 15 '

4d = 1 ', and so on.[80]

If the Sun is next to the meridian or in the western sky, the time angle is positive (+). If the Sun

[77] Muhyiddin Khazin, *Ilmu Falak*, 81.
[78] Slamet Hambali, *Ilmu Falak 1*, 63.
[79] Muhyiddin Khazin, *Ilmu Falak*, 81.
[80] Slamet Hambali, *Ilmu Falak*, 63-64.

is in the eastern meridian or in the eastern sky, the time angle is negative (-).[81] The formula is

$$\text{Cos } t_o = \text{Sin } h_o \div \cos \phi^x \div \cos \delta^m - \tan \phi^x \cdot \tan \delta^m$$

e. Prayer Times Formula

1) Zuhur $= WH - e + 0^j 3^m$
2) Asar $= 12 + t_a$
3) Magrib $= 12 + t_m$
4) Isya $= 12 + t_i$
5) Fajr $= 12 + t_f$

f. Time Zone correction

The result obtained from the above calculation is real time, so, if the result is to be converted to regional time, there is a correction by adjusting the longitude of the place and the longitude of the area. Indonesia divides the territory into 3 parts of time zones, WIB for Western Indonesian Time (105º), WITA for Central Indonesian Time (120º) and WIT for Eastern Indonesian Time (135º). How to set it aside is to use the formula: Time Zone $= (\lambda^d - \lambda^x) : 15$

3. Output Data

Output data is the result of prayer time calculation. The results of this prayer time calculation are displayed in hour and minute form. To display the calculation result in hours and minutes, the number of seconds must be rounded to the number of minutes with the condition: if the number

[81] Muhyidddin Khazin, *Ilmu Falak,* 81.

of seconds is more than 30, it is rounded to 1 minute, if it is less then it is omitted.

The result above calculations are added with *iḥtiyāṭ*, which is defined as "safety" is a step in the initial calculation of prayer time by adding or subtracting 1 to 2 minutes of time from the actual calculation results, for zuhur, the addition is 3 minutes after the midday. This effort is intended:

1) So that the calculation results can cover the surrounding areas, especially those in the west. @minutes = ± 27.5 km.
2) Make the rounding in the smallest unit in minutes of time. So that its use is easier.
3) To provide corrections for errors in calculations, in order to increase confidence that prayer times have actually entered, so that the prayer services are actually carried out on time.[82]

Iḥtiyāṭ for Zuhur, Asar, Magrib, Isya and Fajr prayers uses the concept of addition, where the subtraction concept is used for time of Sunrise. Because, this time is the time of forbidden to pray. This is the realization of safety.

Thomas Djamaluddin argues that pertains to the effort that is correlated with the *iḥtiyāṭ* and correction of altitude, where this altitude correction is only used in certain areas, when the prayer times are circulated, the elevation data is

[82] Muhyiddin Khazin, *Ilmu Falak*, 82.

flat. However, this *iḥtiyāṭ* is only used for general regional conditions. Special areas are excluded from the calculation, for example, if there are hills on the west and east horizons that cause the horizon to be higher, then it will have a consequence that Magrib prayers will be faster and dawn will be slower. This causes the elevation correction to be unable to use general formulas and the effort correction using those estimated to adjust empirical data on local area elevations.[83]

[83]Imam Baihaqi, "Annalisis Perhitungan Awal Waktu Salat Thomas Djamaluddin", *Undergraduate Thesis of Islamic State University of Walisongo Semarang*, (Semarang, 2017), 92-93.

CHAPTER III
SUNCLOCK APPLICATION

A. Biography of Henning Benecke

Henning Benecke was born on April 4th 1961, in Writtingen Germany. His specialization in MINT was already evident in the eighth grade when he chose mathematics and physics. Six years later, in 1980, He graduated from high school in mathematics and physics. In 1986 I graduated as a Dipl.-Ing. Electrical engineering. He started developing graphics hardware that also required a bit of programming. Over time, he changed from a hardware developer to a software developer.[1]

For a long time, astronomy was only one of many branches of physics during his training. That changed when he moved from Bonn in Germany to Dornach in Switzerland at the end of the 1990s. He attended the seminar "Fundamentals of Geometric Astronomy" by Dr. Renatus Ziegler and was fascinated how he traced the geocentric movement of e.g. the sun and the moon for summer and winter and for different latitudes in the air with an outstretched arm.

[1] Henning Benecke, "*interview*, Gmail, 5 February 2021 M./ 22 Jumadil Akhir 1442 H.

Dr. Renatus Ziegler taught him that abstract mathematics and physics can also be represented vivid. He, Henning Benecke, want something like that as a watch was his thought. He had a knowledge of clocks and mechanics, a little free time and the necessary stamina. At the end of 2003 he had finished the prototype and a normal quartz movement drove the astronomical gear so that a pointer in space pointed to the sun and the moon.[2]

He thoght that he was lucky enough to receive a thorough mathematical and natural science education (theory), know a good programming language like the back of his hand (tools), and had enough opportunity to realize exciting projects from A to Z (experience). So he was able to realize his ideas as freely as possible. A high degree of freedom can be experienced when programming.[3]

With these motivations and goals, he succeeded in his career in programming. He has been using Jave programming language for about 25 years. The content was about user interfaces: How does he present the data to the user- be it Computer-aided desighn (CAD) data[4], share portopholios,

[2] *Ibid.*,
[3] *Ibid.*,
[4] Computer-aided design (CAD) is a system of hardware and software used by design professionals to design and document real-world objects. AutoCAD and MicroStation are two widely used general-purpose CAD platforms. These systems are designed to accommodate a wide range of applications. Organizations

insurance data, music metadata or astronomical data such as sunrise or prayer times. He has been developing exclusively for Android since around 2010. That means with the programming language Java for the platform Android. Before that, since around 2000, it was also the programming language

involved in the engineering, architecture, surveying, and construction industries use them to provide a variety of services. ArcGIS Pro, "CAD Data", https://bit.ly/2OnW2Ea, accessed on 11 February 2021 M./ 29 Jumadil Akhir 1442 H.

Java, but for other platforms such as MIDP[5], J2SE[6] and Applet[7] and before that C[8] and C ++[9].

With the expertise and experience he has, he creates Sunclock which is actually a Christmas gift for his daughter who lives in Australia. So she could see at any time whether

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[5] Mobile Information Device Profile (MIDP) is a specification published for the use of Java on embedded devices such as mobile phones and PDAs. MIDP is part of the Java Platform, Micro Edition (Java ME) framework and sits on top of Connected Limited Device Configuration (CLDC), a set of lower level programming interfaces. MIDP was developed under the Java Community Process. The first MIDP devices were launched in April 2001. Wikipedia, "Mobile Information Device Profile", https://en.wikipedia.org/wiki/Mobile_Information_Device_Profile, accessed on 11 February 2021 M./ 29 Jumadil Akhir 1442 H.

[6] J2SE is a collection of Java Programming Language API (Application programming interface) that is very useful to many Java platform programs. It is derived from one of the most dynamic programming language known as "JAVA" and one of its three basic editions of Java known as Java standard edition being used for writing Applets and other web based applications. J2SE is a collection of Java Programming Language API (Application programming interface) that is very useful to many Java platform programs. It is derived from one of the most dynamic programming language known as "JAVA" and one of its three basic editions of Java known as Java standard edition being used for writing Applets and other web based applications. Roseindia, "What is J2SE", https://www.roseindia.net/whatis/J2SE.shtml, accessed on 11 February 2021 M./ 29 Jumadill Akhir 1442 H.

[7] In computing, an applet is any small application that performs one specific task that runs within the scope of a dedicated widget engine or a larger program, often as a plug-in. Wikipedia, https://en.wikipedia.org/wiki/Applet, , accessed on 11 February 2021 M./ 29 Jumadill Akhir 1442 H.

[8] C is a high-level classical type programming language that allows you to develop firmware and portable applications. Guru99, "Difference Between C and C++", https://bit.ly/2Np6gUc, accessed on 11 February 2021 M./ 29 Jumadill Akhir 1442 H.

[9] C++ is a computer programming language that contains the feature of C programming language as well as Simula67(a first object Oriented language). *Ibid.,*

it was day or night in Europe.[10] Because in contrast to Europe which celebrates Christmas in winter and snow, Autralia celebrates Christmas in summer.

When the I interviewed him, he was almost 60 years old, but still had a lot of passion for developing things. He has a strong motivation to make a program, those are:

1. He could bring something new and unique to the world.

   For him, it's a lot of fun and satisfaction to bring something unique into the world, something that has never been there. Well-known ideas and calculations are reassembled in an astonishing way and one is amazed at the achievements of the human mind. All ideas are already there in the spiritual world and he was allowed to bring one or the other into the physical world.

2. Feeling free and no worries

   He has the privilege of being able to freely think and act and live without major worries. The children have grown up and he has enough time, skills, know-how, creativity and perseverance to develop a perhaps extraordinary app. With every expansion of Sunclock He is always fascinated by what can be built into an app from the actually simple process of sunrise and sunset. The fact that

[10] Henning Benecke, *interview*, Gmail, 5 February 2021 M./22 Jumadil Akhir 1442 H.

he was able to convince over 500,000 people to download his app is an honor and an additional incentive for him.

3. Satisfaction seeing the response from the user

   Since four month he cannot give Sunclock for free no more and he had to add the advertisement / donation feature. It doesn't make him rich and it doesn't even pay the rent. But it is satisfactory when people donate 5 or even 10 euros instead of the one euro it takes to turn off the advertising. Not only do they clap applause, but also toss a coin in his hat.[11]

In this phase, he doesn't feel compelled to program some applications, he just does it as a token of appreciation for the freedom he has. One of the books that shaped his thinking in the context of freedom is “The Philosophy of Freedom" from Rudolf Steiner. In fact he has new things that he is ready to do in the future. According to him, App development is now in an intense phase like other projects years ago. The app phase will pass and then he'll focus on a new topic.[12]

B. Sunclock Application

Sunclock is an application that develop by Henning Benecke by his self. He published the first version of Sunclock

[11] Ibid.,

[12] Henning Benecke, *interview*,, Gmail, 11 February 2021/ 29 Jumadil Akhir 1442 H.

on December 24th, 2015, as a Cristmast present for his daughter. And Sunclock is constantly being developed, around 75 versions have been published so far.

The application was tested after every development step, no matter how small. The methodes and princips used by Hening Benecke are:

1. Risk Driven : The "most dangerous" steps were taken first. Example: the prayer times algorithm was first put through its paces before it was incorporated. In this way, the work is reduced in the event of a "new work", since not everything has to be done again.
2. Good is never good enough: If optimization options are noticed during development, these are implemented directly. Practice shows that postponing an optimization phase rarely leads to an optimization, as more and more important things are pending.
3. Pragmatic: As an apparent contradiction to the previous point, the following principle applies: Better a suboptimal Christmas present on time for Christmas than an optimal Christmas present for Easter (based on Rolf Brugger, a former manager).
4. Tools: Java and Android are very good prerequisites so that many development errors do not even happen. When the compiler runs, there is a very high probability that the

app will be error-free compared to, for example, Javascript.[13]

The sunclock application has many parts arranged in it. Most of these features are related to the movement of the sun from rising to setting.The detail of the application will be explain below:

1. Sunclock concept

   Sunclock is a classic analogue clock with a 12-hour dial, an hour hand a minute hand. Sunclock runs on every phone and Tablet since IcecreamSandwich, Android Version 4.0 from 2011. But this application is doing it best on Marshmallow, Android 6.0 from 2015.[14]

   Sunclock becomes an astronomical clock if an astronomical dial is added. It has a scale of 0 to 24 and is devided into a day and a night section. It rotates once per day, because we want to reuse the hour hand from the 12-hour dial on the 24-hour dial. The ratio of sections change with the seasons similar to the changes of day length and night length. The day is sparated from the night by the twilight. One speaks of the civil twilight for the time when the Sun has set up to 6º below the horizon. The nautical

[13] Henning Benecke, *interview*, Gmail, 5 February 2021 M./ 22 Jumadil Akhir 1442 H.

[14] *Ibid.*,

twilight goes to 12º and the astronomical twilight goes to 18º.[15]

Picture 3. 1: 12-hour dial

Picture 3. 2: 24-hour dial with day/night sectors

Source: Sunclock Application

The small yellow dots near the 12 and 24 o'clock show true noon and midnight. They changes theiir position up to 15 minute per year according to the equation of time and jump one gour with daylight saving time.

If both dials are combined, we get a unique 24-hour clock the normal hour hand angle like on classic 12-hour dial. The hour hand is still horizontal for three o'clock and nice o'clock and vertical for six o'clock and twelve o'clock. The 12-hout hand rotates twice per day and the

[15] Sunclock Application

24-hour dialrotates one per day. As a result, the hour hand shows the time on both dials.

Picture 3. 3: Day Clock

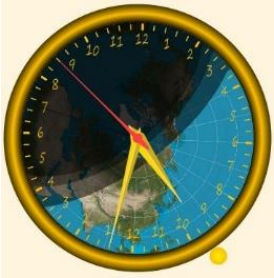
It is 3 past 9 at day

Picture 3. 4: Night Clock

It is 3 past 9 at night

Source: Sunclock Application

Picture 3. 5: The time on classic 24-hour dial. The 24-hour dial is turned 30 minutes because the real noon shall be displayed vertically on top. It is also twisted by an hour because of daylight saving time.



Picture 3. 6: The Northern and Southern Hemisphere can shown with Sun symbol, analemma (eot), users location and latitude

Source: Sunclock Application

By dragging over the app, the time and date can be simulated for any time of day and every day of the year. The upper of the screen is reserved for time simulation and the lower half for date simulation.

The round button with a curved arrow, which runs the funtion Animation, changes time (simple tap) or change date (doble tab) or stops animation (triple tap).

Sunclock be shown full screen. It the phone or tables is connected to a charger, the light will not go off. Sunclock

can be used as dekstop clock or wall clock and permanently show the time.

Sunclock needs location and time zone to calculate sunrisse, sunset and prayer times for any place on Earth. The location is used to calculate sunset and sunrise relative to Greenwich Mean Time (GMT). The time zone and the current date are used to add an hour automatically if the date is in daylight saving time.[16]

The clock display in this application can be used as a widget and wallpaper. The widget can be place on the home screen, one for home location and one for abroad location. But, the second hand canot be displayed in the widget, because the widget canot be update every second (android limitation). Then the wallpaper can be used for the home screen and lock screen. It canot be used for lock screen without using it for home screen. The second hand can be shown in the wallpaper if wanted. Even a "linear" second hand which updates every 16 miliseconds (60 times/second) can be shown. Such as the second hand is not recommended for the wallpaper, as the large number of redraws may use too much power.[17]

[16] Sunclock Application
[17] Sunclock Application

Picture 3. 7: Widget

Picture 3. 8: Wallpaper

Source: Sunclock Application

The different colour schees can be selected in the preferences screen.

Picture 3. 9: Coloured clock theme

Picture 3. 10: Dark coloured clock theme

Picture 3. 11: Pale dark clock theme

Source: Sunclock Application

2. The Features of Sunclock Application

   a. Moon concept

      For the fifth anniversary of Sunclock app on December 24th, 2020, a novel moon display was added.

      The moon in Sunclock is not displayed with the well-known moon phase, but similar to the Sun display with a circular sector. The well-known moon phase display shows wha the moon looks like. Sunclock shows when and where the moon rises. With the combination of circular sectors for the moon and Sun, users can see at glance whether the moon has risen

and is nor outshone by the much brighter light of the Sun and whether the Moon is visible in the morning in the East or in the evening in the West . Let's look at examples of Moon phase:

Picture 3. 12: New Moon on 11 February 2021

Picture 3. 13: Half Moon on 19 February 2021

Picture 3. 14: Full Moon on 27 February 2021

Source: Sunclock Application

In addition to the circle segments, the culmination of the Sun and Moon can be displayed with a spere. The sphere are calculated from the middle between rise and set. In this way, the full Moon, crescent Moon and new are specially visualized.[18]

b. Culture and religion

1) Rahu Kalam

[18] Sunclock Application

Rahu kalam or the period of Rahu kalam is a certain period of time every daythat is considered inauspicious for any new venture according to Indian Vedic astrology. The bezel is red if it's Rahu Kalam time.

2) Time Since Sunrise

Shows the number of hours and minutes that have passed since sunrise. (When I personally set a timer every day to count the daytime, the feeling of time was completely different. It was alive, energetically capacious.)- Dmitry M.

3) Prayer Time

Picture 3. 15: Prayer Times display on 12 February 2021

Source: Sunclock Application

Sunclock can show Salah with small markers on the 24 hour dial. They mark:

- Fajr – when the sky begins to lighten (dawn).
- Zuhur – when the Sun begiin to decline after reaching its highest point in the sky.
- Asar – the time when the length of any object's shadow reaches a factor (usually 1 or 2) of the length of the object itself plus the legth of that object shadow at noon.
- Magrib – soon after sunset
- Isya – the time at which darkness falls and there is no scattered light in the sky,
- Midnight – the average time between Magrib and Fajr between Magrib and Sunrise depending on the calculation method.
- Tahajjud – Last third of the night. (voluntary night prayer),
- Sunrise – the time at which the first part of the Sun appears above the horizon,
- Sunset – the time at which the Sun dissapears brlow the horizon.

Seven calculation method are implemented:

- Itsna Ashari
- University of Islamic Sciences, Karaci
- Islamic Society of Islamic Society (ISNA)
- Muslim World league (MWL)

- Umm al-Qura, Makkah
- Egyptian General Authority of Survey
- Institute of Geographysics, Univercity of Tehran

4) Shabbat Candle-Lighting Time

Shabbat candle is lit on Friday evening before sunset to usher in Jewish Rabbath. Lighting Shabbath candles is rabbanically mandateed law.[19] Sunclock can show candle lighting time with a small yellow hand on the astronomical dial.

5) Horae Temporales/zmanim

For many religious people, daytime and night time are devided (separately) into 12 equal parts. Sunrise and sunset begin the count. In Roamn time keeping, the Natural Day (dies naturalis) ran from sunrise to sunset.[20]

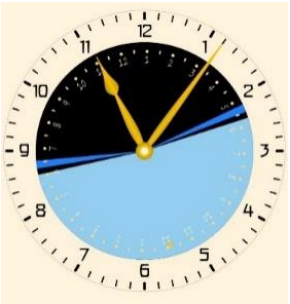
c. Photography Time

Phootographers can enable the blue hour and golden hour. The term blue hour refers to the particular colouration of the sky during the time of dusk after sunset and before the night time darkness, while the sun is about 4º to 8º below the horizon. The same

[19] Wikipedia, "Shabbath Candle-Lighting Time", accessed on 12 February 2021M./ 30 Jumadil Akhir 1442 H.

[20] Sunclock Application

colour is also seen at dawn. Then, the golden hour is the time when the sun is ±6º around sunrise and sunset. Daylight is redder and softer than when the sun is higher in the sky.[21] This is the display of photography time:



Picture 3. 16: Blue hour

Picture 3. 17: Golden hour

Source: Sunclock Application

d. Compass

[21] *Ibid.*

Picture 3. 18: Solar Compass

Picture 3. 19: Maghnetic Compass

Picture 3. 20: Direction to Mecca

Source: Sunclock Application

The solar compass shows;

- The direction to North (blue arrow),
- The azimuth (horizontal direction) to the Sun (yellow arrow)
- The direction to Mecca (white arrow) and prayer times if they are enabled in the settings for the app,
- The relation between day length by a blue and black circular sector with the azimuth to sunrise and sunset.
- And an azimuth split for sunrise and sunset for summer solstice and winter solstice with the blue ring segments.

Date and time can be change by wiping the screen, compass sensor can be turned off and the location can be changed in the settings of the main screen.

C. The Sunclock's Prayer Times Algorithm

1. Prayer times on Sunclock

Muslim perform five prayers a day, each prayer is given a certain precribed time during which it must be performed.[22] Prayer Times features is added in Sunclock with the 4th version in early 2016.[23] The prayer times program of Sunclock application is from a website namely Praytimes.org from Hamid Zarrabi – Zadeh, an Assistant professor of Department of Computer and Engineering Sharif University of Tekhnology. This program provide an open source library for calculating Muslim prayer times.[24] Hening Benecke choose this website because the website praytimes.org and the sourcecode looks relyable and professional, has a good references and passed his

[22] Hamid Zarrabi Zadeh, "Praytimes", http://praytimes.org/calculation , accessed on 12 February 2021 M./ 30 Jumadil Akhir 1442 H.

[23] Henning Benecke, *interview*, Gmail, 5 February 2021M./ 22 Jumadil Akhir 1442 H.

[24] Hamid Zarrabi Zadeh, "Praytimes", http://praytimes.org/calculation , accessed on 12 February 2021 M./ 30 Jumadil Akhier 1442 H.

extensive calculation result verifications againts other web based calculation.[25]

The website briefly describes prayer times, and explains how they can calculated mathematically. To determine the exact time period for each prayer (and also for fasting), we need to determine nine points of time per a day. These times are defined in the following table.

Time	Definition
Fajr	When the sky begins to lighten (dawn)
Sunrise	The time at which the first part of the Sun appears above the horizon
Zuhur	When the Sun begiin to decline after reaching its highest point in the sky
Asar	The time when the length of any object's shadow reaches a factor (usually 1 or 2) of the length of the object itself plus the legth of that object shadow at noon
Sunset	The time at which the Sun dissapears brlow the horizon
Magrib	soon after sunset

[25] Henning Benecke, *interview*, Gmail, 5 February 2021 M./ 22 Jumadil Akhir 1442 H.

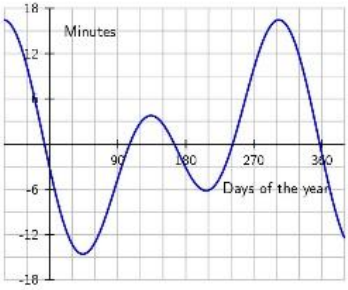
Isya	The time at which darkness falls and there is no scattered light in the sky
Midnight	The average time between Magrib and Fajr between Magrib and Sunrise

Table 3. 1: Definition of prayer times

2. Astronomical Measure

There are two astronomical measures that essential for computing prayer times. These two measures are the equation of time and declination of the Sun.

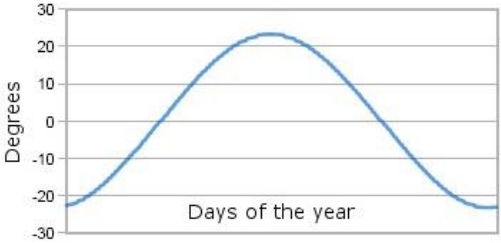
The equation of time is the difference between time as read from a sundial and a clock. It results from an apparent irregular movement of the Sun caused by a combination of the obliguity of the Earth's rotation axis and the eeccentricity of its orbit. The sundial can be ahead (fast) by as much as 16 min 33 s (around November 3) or fall behind by as much 14 min 6 s (around February 12), as shown in the following graph:



Picture 3. 21: The equation of time

Source: Praytimes.org

The declination of the Sun is the angle between the rays of the sun and the plane of the earth equator. The declination of the Sun changes continuously throughout the year. This is a consequence of the Earth's tilt, i.e. the difference in its rotational and revolutionary axes.[26]



Picture 3. 22: The declination of Sun

Source: praytimes.org

[26] Hamid Zarrabi Zadeh, "Praytimes", http://praytimes.org/calculation , accessed on 12 February 2021 M./ 30 Jumadil Akhier 1442 H.

The above two astronomical measures can be obtained accurately from The Star Almanac, or can be calculated approximately. The following algorithm from U.S. Naval Observatory[27] computes the Sun's angular coordinates to an accuracy of about 1 arcminute within two centuries of 2000.[28]

```
d = jd - 2451545.0;  // jd is the given Julian date

g = 357.529 + 0.98560028* d;

q = 280.459 + 0.98564736* d;

L = q + 1.915* sin(g) + 0.020* sin(2*g);

R = 1.00014 - 0.01671* cos(g) - 0.00014* cos(2*g);

e = 23.439 - 0.00000036* d;

RA = arctan2(cos(e)* sin(L), cos(L))/ 15;

D = arcsin(sin(e)* sin(L));  // declination of the Sun

EqT = q/15 - RA;  // equation of time
```

[27] Known as USNO, one of the oldest scientific agencies in the United States, with a primary mission to produce Positioning, Navigation and Timing (PNT) for the United States Navy and the United States Departement of Defense.

[28] Hamid Zarrabi Zadeh, "Praytimes", http://praytimes.org/calculation, accessed on 12 February 2021 M./ 30 Jumadil Akhier 1442 H.

3. Calculation of Prayer Times on Sunclock

To calculate the prayer times for a given location, we need to know the latitude (L) and the longitude (Lng) of the location, along with the local Time Zone for the location. We also obtained the equation of time (EqT) and the declination of the Sun (D) for given date using the algorithm mentioned in the previous section.[29]

a. Zuhur

Zuhur can be calculated easily using the following formula:

Zuhur = 12 + Time Zone – Lng/15 – EqT

The above formula indeed calculates the midday time, when the Sunn reaches its highest pount in the sky. A slight margin is usually considered for Zuhur as explained in this note.[30]

b. Sunrise/Sunset

[29] *Ibid.,*
[30] *Ibid.,*

The time difference between the mid-day and the time at which Sun reaches an angle a below the horizone canbe computed using the following formula:

$$T(\propto) = \frac{1}{15}\arccos\left(\frac{-\sin(\propto)-\sin(L)\sin(D)}{\cos(L)\cos(D)}\right)$$

Astronomical sunrise and sunset occur at a=0. However, due to the refraction of light by terrestial atmosphere, actual sunrise appears slightly before astronomical sunrise and actual sunset occure after astronomical sunset. Actual sunrise and sunset can be computed using the following formulas:

Sunrise = Zuhur – T(0,833)

Sunset = Zuhur + T(0,833)

If the observer's location is higher than the surrounding terrain, we can consider this elevation into consideration by increasing the above constant 0,833 by 0,0347 x sqrt (h), where h is the observer's height in meters.[31]

c. Fajr and Isya

[31] *Ibid.,*

There are differing opinions on what angle to be used for calculating Fajr and Isya. The following table shows several conventions currently in use in various countries.

Convention	Fajr Angle	Isya Angle
Muslim World League	18	17
Islamic Society of North America (ISNA)	15	15
Egyptian General Authority of Survey	19,5	17,5
Umm al-Qura University, Mekkah	18,5	90 min after Magrib 120 min during Ramadhan
University of Islamic Sciences, Karachi	18	18
Institute of Geographysics, University of Tehran	17,7	14
Shia Itsna Ashari, Leva research Institute, Qum	16	14

Table 3. 2: Criteria of Sun altitude

*Isya angle is not expliciting defined in Tehran Method

For example, according to Muslim World League convention, Fajr = Zuhur + T(17)

Higher Latitudes

In locaton at higher latitude, twilight may persist throughout the night during some months of the year. In these abnormal periods, the determination of fajr and ‘isya is not possible using the ususal formulas mentioned in previous section. To overcome this problem, several solutions have been proposed, three of which are discribed below.

1) Middle of The Night

   In this method, periods of Sunset to Sunrise is devided into two halves. The first half is concsidered to be the “night” and the other half as “day break”. Fajr and ‘Isya in this method are assumed to be at mid-night during the abnormal periods.

2) One Seventh of the Night

In this method, the period between Sunset and Sunrise is devided into seven parts. ‘isya begin after the first one-seventh part, and Fajr is at the begining of the seventh part.

3) Angle-Based Method

This is an intermediate solution, used by recent prayer time calculators. Let a be the twilight angle for ‘Isya, ant let t = a/60. The period between Senset and Sunrise is devided into t parts. ‘Isya begins after the first part. For example, if the twilight angle for ‘Isya is 15, then ‘Isya begins at the end of the first quarter (15/60) of the night. Time for Fajr is calculated similarly.

In case Magrib is not equal to Sunset, can apply the above rules to Magrib as well to make sure that Magrib always falls between Sunset and Isha during the abnormal periods.[32]

d. Asar

There are two main opinions on how to calculate Asar time. The majority of schools

[32] *Ibid.,*

(including Syafi'i, maliki, Ja'fari, and Hambali) say it is at the time when the length of any objects shadow equals the length of the object itself plus the length of that object's shadow at noon. The dominant opinion is Hanafi school says that Asar begin when the length of any object's shadow is twice the length of the object plus the length of that object's shadow at noon.

The following formula computes the time difference between the mid-day and the time at which the object's shadow equals t times the length of the object it self plus the length of that object's shadow at noon.

$$\mathrm{A}(t) = \frac{1}{15}\arccos\left(\frac{\sin(arcoot(t+\tan(L-\mathrm{D})))-\sin(L)\sin(D)}{\cos(L)\cos(D)}\right)$$

Thus in the first schools of through, Ashr = Zuhur + A (1), and in Hanafi school Asar = Zuhur + A(2)[33]

e. Magrib

In the Sunni's point of view, the time for Magrib prayer begins once the Sun has completely set beneath the horizon, that is, Magrib Sunset (some calculators suggest 1 to 3 minutes after Sunset for

[33] *Ibid.,*

percaution). In the Syiah's view, however, the dominant opinion is that as long as the redness in eastern sky appearing after Sunset has not passed overhead, Magrib prayer should not be performed. It is usually taken into consideration by assuming a twilight angle like Magrib = Zhuhur + T(4).

f. Midnight

Midnight is generally calculated as the mean time from Sunset to Sunrise,. i.e., Midnight = ½ (Sunrise-Sunset). In Syiah point of view, the juridical Midnight (the ending time for performing 'Isya prayer) is the mean time from Sunset to Fajr, i.e., Midnight = ½ (fajar - Sunset).[34]

[34] *Ibid.,*

CHAPTER IV
AGORITHMIC ANALYSIS OF PRAYER TIMES ON SUNCLOCK APPLICATION

A. Calculation Analysis of Prayer Times on Sunclock Applications

If you back at the background I raised about the difference in prayer time schedules generated by the Sunclock application from the schedule used massively in Indonesia, namely the schedule from the Ministry of Religion, the first thing to analyze is how the algorithm is used. I have explained the concept of prayer time calculation in the Sunclock application in the previous chapter. From this explanation, I will discuss several things that need to be raised in an analysis, they are:

1. Algorithm of Sun Declination and Equation of Time

   This data uses an algorithm from the US Naval Observatory. However, this data could not be accessed because the US Naval Observatory website itself was damaged. The physics community I follow has tried to create computation programs that use this algorithm. However, the shared links are also mostly broken. Therefore, I compile a program using Ms. Excel with existing algorithms. manually, the method I use is:

a. Calculates the elapsed time from noon at Greenwich on January 1st, 2000, abbreviated by the variable "d"

   d = JD - 2451545.0

b. Calculate the Mean Longitude of the Sun (q) with the light deviation correction, which is determined by the following equation:

   q = 280.459 + 0.098564736 * d

c. Calculating the Mean Anomaly (g) because the Sun's orbit is elliptical and its velocity varies throughout the year,

   g = 357,529 + 0.98564736 * d

   q and g data are converted to a range of 0º to 360º.

d. Determine the Ecliptic Longitude (L) equation,

   L = q + 1,915 * sin g + 0.020 * sin (2g)

e. The axial tilt of the Earth (ε) compared to the ecliptic is obtained from:

   ε = 23.429 - 0.00000036 * d.

f. Right Ascension (RA), it is the angular distance of a point measured eastward along the celestial equator from the Sun at the March equinox to the (hour circle of the) point in question above the Earth.

   RA = arctan2(cos(e)* sin(L), cos(L))/ 15

   Or use this following formula:

RA

"=ATAN(COS(L18*PI()/180)*TAN(L16*PI()/180))*180/PI()

RA = If L < 90, then RA= RA""

If L <180, then RA = 180 + RA""

If L <270, then RA = 180 + L

If L >270, then RA = 360 + RA""

g. Sun's Declination:

D = arcsin (sin (e) * sin (L))

h. Equation of Time

EoT = q / 15 - RA

The calculation above produces data on the Sun's Declination and Equation of Time. The following is the declination and equation of time data on the 1st date for one year:

Date	Declination	Equation of Time
1/01/2021	-22 ° 59 '28.34' '	-03 '25.37 "
1/02/2021	-17 ° 05 '55.73' '	-13 '30.81 "
1/03/2021	-07 ° 30 '04,31' '	-12'19,80 "
1/04/2021	04 ° 37 '19.78' '	-03 '53,60

1/05/2021	15 ° 08 '10,26' '	02 '52.40 "
1/06/2021	22 ° 04 '19.60' '	02 '09 "
1/07/2021	23 ° 04 '44,40' '	-03 '52.61 "
1/08/2021	17 ° 56 '54.28' '	-06 '20.80 "
1/09/2021	08 ° 11 '39,10' '	-0 '00.98 "
1/10/2021	-03 ° 16 '05,18' '	10 '19.49 "
11/1/2021	-14 ° 29 '12.62' '	16 '24.63 "
12/1/2021	-21 ° 49 '12.90' '	10 '59.99 "

Table 4. 1: Sunclock's declination and equation of time

To measure the algorithm and to see the effect of different calculation, I use the data of Indonesian Ministry of Religious Affairs:

Date	Equation of Time	Declination
1/01/2021	-3'32 "	-22°58'55 "
1/02/2021	-13'35 "	-17°2'20 "
1/03/2021	-12'20 "	-7°30'22 "
1/04/2021	-3'52 "	4°37'19 "
1/05/2021	2'53 "	15°8'28 "

1/06/2021	2'9 "	22°4'53 "
1/07/2021	-3'53 "	23°5'25 "
1/08/2021	-6'21 "	17°57'32 "
1/09/2021	0'2 "	8°12'01 "
1/10/2021	10'18 "	03°12'01 "
11/1/2021	16'28 "	-14°29'30 "
12/1/2021	11'0 "	-21°49'27 "

Table 4. 2: Ephemeris Hisab Rukyat declination and equation of time

The difference of declination and equation of time from Sunclcok and Ephemeris Hisab Rukyat is in this following table:

Date	Difference	
	EoT	Declination
1/01/2021	0'6.63 "	0°0'33,34"
1/02/2021	0'4,19"	0°3'35,73"
1/03/2021	0'0,2"	0°0'17.69"
1/04/2021	0'1,6"	0°0'0.78"
1/05/2021	0'0,6"	0°0'17,74"

1/06/2021	0 '	0°0'8,6"
1/07/2021	0'0.39"	0°0'40,6"
1/08/2021	0'0,2"	0°0'37.72"
1/09/2021	0'1,02"	0°0'21,9"
1/10/2021	0'1.49"	0°4'4,58"
11/1/2021	0'3,37"	0°0'17,38"
12/1/2021	0'0.01"	0°0'14,1"

Table 4. 3: the difference of Sunclock to Ephemeris Hisab Rukyat

The value of the lowest difference in the equation of time from the Sunclock algorithm to the Ephemeris of the Republic Indonesia's Ministry of Religious Affair's system is 0 second, which means the value is the same. This happened on June 1, 2021. While the largest difference was 0'6.63", which occurred on January 1, 2021. The Sun declination value from the algorithm used by Sunclock when compared to the Ephemeris of the Republic Indonesia's Ministry of Religious Affairs reached the lowest difference in numbers.0°0'0.78 "on April 1, 2021. Meanwhile, the highest difference was 0°4'4.58" on October 1, 2021.

When viewed from the comparison above, the value of the equation of time and declination of the Sunclock algorithm using the system from the US Naval Observatory is close to the data from the Ephemeris of the Republic Indonesia's Ministry of Religious Affairs.

2. Sun altitude data during prayer time

The provisions for prayer times described in the Quran and Hadits relate to the position of the Sun on the celestial sphere. I have explained the explanation of the position of the Sun during this prayer time in the previous chapter. The criteria mentioned in the Al-Quran and Hadis can be explained in astronomical language, however, due to limitations and differences in observer perspectives, there are differences in the calculation process and the results of the criteria used.

In the Sunclock application, there are various criteria to determine the height of the Sun at prayer times, namely:

a. Asar

The calculation in the Sunclock application uses the following formula:

h_{Asar} = arccot (t + tan (L - D))

This calculation algorithm will produce the Sun altitude at Asar time. Thus, in the first schools of through, t+ 1, and in Hanafi school t = 2. t in this case is the opinion of the length of shadow during Asar. This algorithm is similar to that used by Ministry of Religious Affair of Indonesia with a different logical formula. The formula used by Indonesian Ministry of Religious Affair is:

$$\text{Cotan } h_{asar} = \text{Tan } zm + 1$$

$$= \text{Cotan}^{-1} (\tan |\delta^m - \phi^x| + 1)$$

$$= \text{arccot} (\tan |\delta^m - \phi^x| + 1)$$

b. Fajr and Isya

Sunclock Application has t criteria of prayer times calculation that can be chosen by user. The criteria are focus on the Sun altitude on prayer times. The criteria are:

Convention	Fajr Angle	Isya Angle
Muslim World League	18	17

Islamic Society of North America (ISNA)	15	15
Egyptian General Authority of Survey	19.5	17.5
Umm al-Qura University, Mecca	18.5	90 min after Magrib 120 min during Ramadhan
University of Islamic Sciences, Karachi.	18	18
Institute of Geographic's, University of Tehran	17.7	14
Shia Itsna Ashari, Leva research Institute, Qum	16	14

Table 4. 4: Criteria of Sun altitude

Criteria used by Indonesian Ministry of Religious Affairs is 18º for Isya and 20º for Fajr. The criterion closest to the opinion used by Indonesia is the opinion of the University of Islamic Sciences, Karachi, and

even Muhammadiyah at the end of 2020 announced its new opinion about the Sun altitude of Fajr to be -18º, Ministry of Religious Affair still use his own criteria because the opinion is based on research.

The seven criteria provided in the Sunclock application can be chosen by the user himself. This option does not exist in other applications. This feature can certainly bridge the differences that often occur among religious organizations. However, the criteria used by the Republic Indonesia's Ministry of Religious Affairs have not become an option for the calculation system, so that in its use, users who use criteria from the Indonesian Ministry of Religion must use criteria from the University of Islamic Sciences, Karachi, and make corrections at dawn their self.

3. Hour Angle

Hour angle calculation algorithm of Sunclock:

t = arccos (-tan L x tan D + Sin (arccot | tan (L - D) + 1 |): cos L: cos D): 15

While the formula from the ephemeris:

t = cos-1 (-tan ϕ. tan δo + sin h: cos ϕ. cos δo)

From this, I can conclude that if the calculation of the angle of time uses the same method, the difference is only

in the logic of the formula used. Because basically the formula Sin (arccot | tan (L - D) + 1 |) is a formula for calculating the altitude of the Sun. The Ephemeris uses a shorter definition using only Sin h. The ephemeris division by 15 is entered when calculating the longitude correction (interpolation), so that the final value remains the same.

4. *Ihtiyāṭ*

In Sunclock, there is no clear explanation of the amount of *ihtiyāṭ*, for example at the time of midday prayer which is defined when the declination of the Sun exits the Zenith line, which is the line between the observer and the center of the Sun when its position is highest. The time used to find the time it will take for the Sun to slip is based on the following data:

Sun's Radius (r) = ~ 695,500 km

The distance from the Sun to Earth (d) = 147,098,074 km ~ 152,097,701 km

Given r and d, the time t it takes for the Sun to cross the Zenith line can be calculated using the following formula:

T = arctan (r / d) / 2π x 24 x 60 x 60

The maximum value obtained from the above formula is 65 seconds. So, it is estimated that about 1 minute until the disk of the Sun comes out of Zenith out of Zenith and can be considered as the calculation of the Zuhur time.[1]

The calculation of the Ephemeris system of the Ministry of Religious Affairs of the Republic of Indonesia uses an *ihtiyāṭ* of 3 minutes from the *istiwā'* time in determining the Zuhur time. The amount of the 3-minute *ihtiyāṭ* is only used for Zuhur. Other prayer times, namely, Asar, Magrib, Isya, and Fajr use 2 minutes of *ihtiyāṭ*.

If refer to the author's explanation in Chapter II regarding the use of *ihtiyāṭ*, then the Sunclock Application does not need to use the *ihtiyāṭ* system. Because the Sunclock application is personal on someone's cell phone device, the time is focused on being used by the person at the coordinate point. In my opinion, this system is more accurate because everyone has their own schedule to pray at the right time.

[1] Dini Rahmadani, "Telaah Rumus Perhitungan Waktu Salat: Tinjauan Parameter dan Algoritma", *Al-Marshad: Journal of Islamic Astronomy in Relevant Sciences*, vol. 4, No. 2, 2018.

B. The Accuracy of Prayer Times

This part of analysis is about the accuracy of Sunclock Application, so, it needs measurement data. The data that used is from Ministry of Religious Affairs of Indonesia. Because this data is the standard data used by the Indonesian government officially. In testing the accuracy data, I use parameters with several basic criteria. So that the similarities or differences in the results can be seen immediately. These parameters include are:

1. The coordinates of the place used use the same point, namely 7º0’ S and 110º24’ E (Semarang) and 6º10’ S and 106º49’ E (Jakarta)
2. The date of calculating using the 1st of each month within a period of one year (January to December).
3. The Sun altitude criteria use the criteria for each system
4. The calculations displayed are the time of Fajr, Zuhur, Asar, Magrib, Isya.
5. The calculation uses the algorithm of each application and ignores the *ihtiyāth*.
6. The measurement of the accuracy is using the difference to the prayer times of Indonesian Ministry of Religious Affairs

Sunclock Application use the criteria of University of Islamic Sciences, Karachi, because this is the closest criteria

to the Ministry of Religious Affairs. So, I am assuming that this criterion is used by Indonesian users.

Date	Prayer Times	Sunclock	Ministry of Religion	Difference
January 1, 2021	Zuhur	11.42	11.42	0’
	Asar	15.09	15.09	0’
	Magrib	17.57	17.59	1’
	Isya	19.14	19.14	0’
	Fajr	04.10	04.02	8’
February 1, 2021	Zuhur	11.52	11.52	0’
	Asar	15.11	15.12	1’
	Magrib	18.04	18.05	1’
	Isya	19.17	19.17	0’
	Fajr	04.26	04.18	8’
March 1, 2021	Zuhur	11.51	11.51	0’
	Asar	14.53	14.54	1’
	Magrib	17.58	17.59	1’
	Isya	19.08	19.08	0’
	Fajr	04.33	04.26	7’
April 1, 2021	Zuhur	11.42	11.43	1’
	Asar	14.58	14.59	1’
	Magrib	17.43	17.44	1’
	Isya	18.52	18.53	1’

	Fajr	04.32	04.24	8’
May 1, 2021	Zuhur	11.35	11.36	1’
	Asar	14.57	14.57	0’
	Magrib	17.31	17.32	1’
	Isya	18.43	18.43	0’
	Fajr	04.28	04.20	8’
June 1, 2021	Zuhur	11.36	11.37	1’
	Asar	14.58	14.58	0’
	Magrib	17.28	17.29	1’
	Isya	18.43	18.43	0’
	Fajr	04.30	04.22	8’
July 1, 2021	Zuhur	11.42	11.43	1’
	Asar	15.03	15.04	1’
	Magrib	17.34	17.35	1’
	Isya	18.49	18.49	0’
	Fajr	04.36	04.28	8’
August 1, 2021	Zuhur	11.45	11.45	0’
	Asar	15.06	15.07	1’
	Magrib	17.39	17.40	1’
	Isya	18.51	18.52	1’
	Fajr	04.38	04.30	8’
September 1, 2021	Zuhur	11.38	11.39	1’
	Asar	14.57	14.58	1’

	Magrib	17.38	17.39	1’
	Isya	18.47	18.48	1’
	Fajr	04.29	04.22	7’
October 1, 2021	Zuhur	11.28	11.28	0’
	Asar	14.35	14.36	1’
	Magrib	17.33	17.34	1’
	Isya	18.43	18.43	0’
	Fajr	04.14	04.06	8’
November 1, 2021	Zuhur	11.22	11.22	0’
	Asar	14.37	11.38	1’
	Magrib	17.33	17.34	1’
	Isya	18.45	18.45	0’
	Fajr	03.59	03.51	8’
December 1, 2021	Zuhur	11.27	11.28	1’
	Asar	14.53	14.53	0’
	Magrib	17.42	17.43	1’
	Isya	18.58	18.58	2’
	Fajr	03.57	03.48	8’

Table 4. 5 Prayer Times different of Sunclock to Ministry of Religion (Semarang)

Date	Prayer Times	Sunclock	Ministry of Religion	Difference
	Zuhur	11.56	11.57	1’

January 1, 2021	Asar	15.23	15.24	1’
	Magrib	18.10	18.12	2’
	Isya	19.27	19.29	2’
	Fajr	04.26	04.17	8’
February 1, 2021	Zuhur	12.06	12.07	1’
	Asar	15.26	15.27	1’
	Magrib	18.17	18.19	2’
	Isya	19.30	19.31	1’
	Fajr	04.42	04.34	8’
March 1, 2021	Zuhur	12.05	12.06	1’
	Asar	15.09	15.10	1’
	Magrib	18.12	18.13	1’
	Isya	19.21	19.22	1’
	Fajr	04.48	04.41	7’
April 1, 2021	Zuhur	11.57	11.57	0’
	Asar	15.12	15.12	0’
	Magrib	17.58	17.59	1’
	Isya	19.07	19.07	0’
	Fajr	04.46	04.38	8’
May 1, 2021	Zuhur	11.50	11.50	0’
	Asar	15.11	15.12	1’
	Magrib	17.46	17.48	2’
	Isya	18.58	18.58	0’
	Fajr	04.42	04.34	8’
	Zuhur	11.50	11.51	1’

June 1, 2021	Asar	15.13	15.13	0’
	Magrib	17.44	17.45	1’
	Isya	18.58	18.59	1’
	Fajr	04.43	04.35	8’
July 1, 2021	Zuhur	11.56	11.57	1’
	Asar	15.18	15.19	1’
	Magrib	17.50	17.51	1’
	Isya	19.04	19.05	1’
	Fajr	04.49	04.41	8’
August 1, 2021	Zuhur	11.59	12.00	1’
	Asar	15.21	15.22	1’
	Magrib	17.54	17.56	2’
	Isya	19.07	19.09	2’
	Fajr	04.51	04.43	8’
September 1, 2021	Zuhur	11.53	11.53	0’
	Asar	15.11	15.12	1’
	Magrib	17.52	17.54	2’
	Isya	19.02	19.03	1’
	Fajr	04.43	04.36	7’
October 1, 2021	Zuhur	11.42	11.43	1’
	Asar	14.48	14.49	1’
	Magrib	17.47	17.48	1’
	Isya	18.56	18.57	1’
	Fajr	04.28	04.21	7’
	Zuhur	11.36	11.38	2’

November 1, 2021	Asar	14.53	14.53	0’
	Magrib	17.46	17.47	1’
	Isya	18.58	18.59	1’
	Fajr	04.15	04.07	8’
December 1, 2021	Zuhur	11.42	11.42	0’
	Asar	15.07	15.08	1’
	Magrib	17.55	17.57	2’
	Isya	19.11	19.11	0’
	Fajr	04.13	04.05	8’

Table 4. 6: Prayer Times different of Sunclock to Ministry of Religion (Jakarta)

The resulting difference falls into the consistent category. Ranges from 0 minutes to 8 minutes. There are some reasons about the differences:

1. The Sunclock application does not use an *ihtiyāṭ* system in calculating prayer times. The *ihtiyāṭ* system that I mean is on the part of rounding data. The Sunclock prayer times presented in hour and minutes format because of the limitation of the Android. It can be concluded that there is still data in second that truncated.
2. The criteria of Sun altitude during Fajr time are different, Sunclcok Application does not provide data that match to Indonesian Ministry of Religious Affairs, the closest

criteria are -18º, which is mean it will be different about 8 minutes.

3. The Sun data that used by Sunclock Application is different. The bigger the different of Sun data, the bigger the resulting difference.

Meanwhile, the prayer time with the largest difference is at Fajr. This is due to different criteria for the altitude of the Sun during Fajr prayers. The sample that the authors use is a calculation system based on the University of Islamic Sciences, Karachi. Where the criteria for the altitude of the Sun at Fajr is -18 º. So that the dawn prayer time generated by the Sunclock application is later. For dawn, the author argues that the time generated by the Sunclock application is inaccurate, because the dawn prayer time is needed to determine when a person starts fasting, so the accuracy is very necessary. There needs to be special criteria that are in accordance with those used by Indonesia so that the Fajr prayer time can be used optimally.

Apart from the Fajr prayer times above, the prayer times generated by Sunclock tend to be the same as the Ministry of Religious Affairs if included in the *ihtiyāṭ* algorithm in rounding the data. However, as I explained above, the Sunclock application does not have the urgency to

provide additional *ihtiyāṭ* to make the coverage wider, because the media used is a personal cellular phone.

Furthermore, talking about a system, of course there are advantages and disadvantages. The Sunclock application program is no exception. Here are some of the advantages of Sunclock Application in my analysis after operating the application:

a. In accordance with the needs of the times, because of its practical use and only requires an Android-based cellphone that has been massively used in the community as well as the internet network to update locations. It is very easy to use to find out the start of prayer time in any area.
b. There is a feature to select the criteria for calculating prayer times. This feature makes the application more likely to be used widely because it is not only covered by one organization, so that the application can be used in many communities.
c. The Indonesian language used has been translated by Indonesian native speaker, so that it is more understandable for users who come from Indonesia.

d. Can be displayed in the form of wallpapers and widgets on android, so there is no need to open the application to see the prayer time schedule
e. The Sunclock application uses a modern prayer time calculation system, where astronomical data uses the US Naval Observatory algorithm that is one of the oldest scientific agencies in the United States, with a primary mission to produce Positioning, Navigation and Timing (PNT) for United State Navy and the United States Department of Defense.
f. Location can be set manually or automatically. Automatic location using Latitude and Longitude data that are received from the phones built in GPS or from the network. Then, the manual location can be entered directly in the latitude and longitude fields. Alternatively, one of over 1000 cities can be selected from the city list. The city list is filtered when the text is entered. Selecting a country in the country list filters the cities for that country.
g. Displayed in hours and minutes so it is more practical and more convenient to use.

And the disadvantages are:

a. None of the criteria for the altitude of the Sun for Fajr match those used in Indonesia. So that users need to make their own corrections when using this Fajr time, as is known, 1-degree difference means a difference of 4 minutes.
b. Sun data from the US Naval Observatory which is the basis for calculations in this system cannot be accessed so it is difficult to track the accuracy of the data.
c. The Widget feature often experiences errors, the analog clock and prayer times that are displayed suddenly shrink so that they are not readable by the user.
d. The prayer time schedule display is uninteresting, because it seems that it is only attached to the side of the analog clock.

From the explanation above, I simply conclude the result of calculating the accuracy. The difference in data generated by Sunclock Application is close to the Ephemeris Hisab Rukyat. Although in the presentation of the prayer times the difference from the Sunclock Application is in minutes, apart from Fajr, the difference in other prayer times is still within the range of *iḥtiyaṭ* used by the Ministry of Religious Affairs. So, the prayer times is accurate for the four prayer times.

My preference is excepting the Fajr time, because it is really dangerous for people who don't know about prayer times calculation when they use that time to start fasting. Therefore, in this thesis I clearly say that the criteria of Fajr from University of Islamic Sciences, Karachi, Pakistan, that is the closest criteria for Indonesia, only used for people who use Fajr criteria of Muhammadiyah. For people who use the criteria from Indonesian Ministry of Religious Affairs, it is better to decrease at least 8-minutes from the time that presented on Sunclock Application.

CHAPTER V
CLOSING

A. Conclusion

Based on the discussion and analysis that I explained above, I makes several conclusions in deep summarizing the response to the previous subject matter, here are some conclusions:

1. The prayer times program of Sunclock application is from a website namely Praytimes.org from Hamid Zarrabi – Zadeh, an Assistant professor of Department of Computer and Engineering Sharif University of Technology. This program provides an open-source library for calculating Muslim prayer times. The Sun's data is based on U.S. Naval Observatory algorithm. Two main data that be produced by this algorithm are Equation of Time dan Sun's declination. Sunclock Application doesn't use *iḥtiyaṭ*, on my point of view, Sunclock Application does not need to use the *iḥtiyaṭ* system. Because the Sunclock application is personal on someone's cell phone device, the time is focused on being used by the person at the coordinate point. According to the author, this system is more

accurate because everyone has their own schedule to pray at the right time.

2. The difference in data generated by Sunclock Application is close to the Ephemeris Hisab Rukyat. Although in the presentation of the prayer times the difference from the Sunclock Application is in minutes, apart from Fajr, the difference in other prayer times is still within the range of *iḥtiyaṭ* used by the Ministry of Religious Affairs. So, the prayer times is accurate for the four prayer times. My preference is excepting the Fajr time, because it is really dangerous for people who don't know about prayer times calculation when they use that time to start fasting. Therefore, in this thesis I clearly say that the criteria of Fajr from University of Islamic Sciences, Karachi, Pakistan, that is the closest criteria for Indonesia, only used for people who use Fajr criteria of Muhammadiyah. For people who use the criteria from Indonesian Ministry of Religious Affairs, it is better to decrease at least 8-minutes from the time that presented on Sunclock Application.

B. Recommendation

Based on the conclusions mentioned above, there are several suggestions, namely:

1. There are so many applications of prayer times that scattered on the Playstore, but the system and accuracy

need to be studied by the practitioners of Ilmu Falak, because the user needs to know the accurasion before use.

2. The research recommendation is the important of a deeper analysis of the Solar data calculation algorithm used by the US. Naval Observatory. This algorithm is often used, but there are very few academic papers that discuss this matter.
3. To the programmer of Sunclock application, it is important to enclose the algorithm of prayer times that match to Indonesian, because there are so many users from Indonesia. Or, the programmer can add the custom feature for the users that have different criteria of calculation.

C. Closing

All praises to Allah that gives me the strength and patient until I finished this thesis and pass the obstacles. Finish this thesis is such a miracle without *riḍa* from Allah. But of course, This thesis still has many shortcomings that I do not realize, because perfection is only belonging to Allah. Therefore, I open the wide door to constructive criticism and suggestion. Hopefully the research that I have done will be of benefits to everyone directly or indirectly.

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ATTACHMENT

Attachment 1: Sunclock Application

Interview Question 1

Informant : Henning Benecke

Media : Gmail/ hngbke@gmail.com

Date : 5 February 2021

1. Before I start to interview you about Sunclock, let me ask about your biography first.
    a. When and where were you born?
    b. You learned about mathematics and electrical engineering when you were in college, may I know a little story from your education and your interest in programming?
    c. Do you interest with astronomy? And did you learned about it?
    d. From the CV that you send to me, you have soo many job experiences, is that all about Android Developer?
2. Are you develop Sunclock by your self?
3. When did you start to make Sunclock and how many times that you need to finish it?
4. How many versions of this Application are there?
5. What methods did you use to test this Application before release?

6. Why you make Sunclock?
7. What kind of Android that can operate this application optimally?
8. Before discuss about prayer time, I want to know about where the data of time that you use in this application from?
9. You once explained to me that you use praytimes.org. Why you choose that program?
10. Is the prayer time feature on your app can be used globally? Even in South and North Pole?
11. In this application, you need time and location access from the user's android, this access is used to synchronize the user's astronomical and geographic data collection with the system in the application. Which astronomical data do you use in this application?
12. Actually, I have a little problem. When I use the Sunclock as a widget, sometimes the analog clock shrinks. How could that happen?
13. Why you put the Prayer Times in Sunclock?
14. What is the importance of the prayer time feature in the form of an application in your perspective?
15. Do you create another application beside Sunclock?
16. Are you write a book or journal about your expertise?

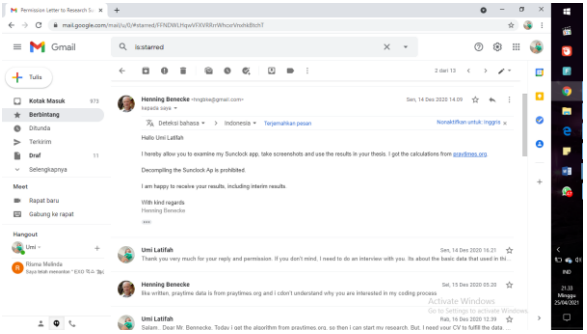
Interview Question 2:

Informant : Henning Benecke

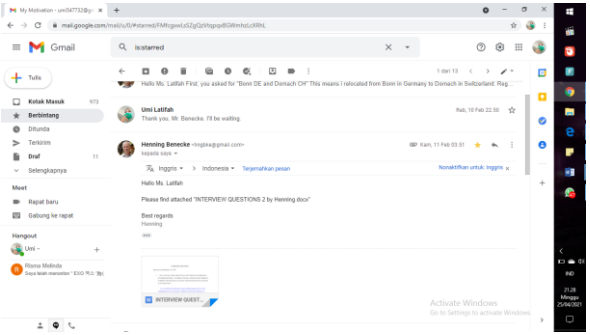
Media : Gmail/ hngbke@gmail.com

Date : 11 February 2021

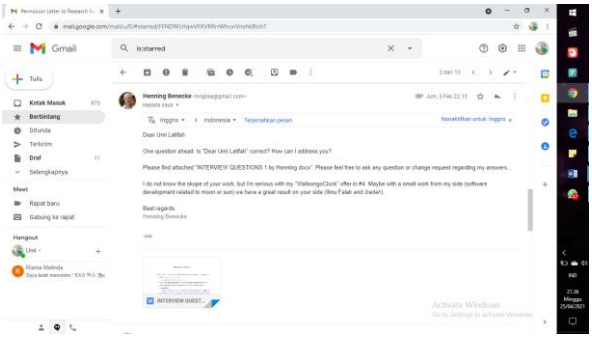
1. At your age, which is almost 60 years old, I still feel your enthusiasm in developing many things, even though, at that age, usually government employees in Indonesia take their pension. Can I know what kind of motivation you built up to have that passion?
2. I don't understand, what are Bonn DE and Dornach CH?



Permission to make a research



Interview on 5 Februari 2021 M./ 22 Jumadil Akhir 1442 H



Interview on 11 Februari 2021 M./ 29 Jumadil Akhir 1442 H

Letter of Statement

Letter of Statement

Undersigned below,

Name	: Henning Benecke
Place and date of birth	: Writtingen Germany, April 4th 1961
Email Address	: hngbke@gmail.com
Profession	: Android Developer

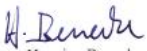
Truly declare that,

Name	: Umi Latifah
NIM	: 1702046104
Faculty/Major	: Syari'ah and Law/Ilmu falak
Alamat	: PP Life Skill Daarun Najaah, Bukit Beringin Lestari street, kav. C131, Wonosari, Ngaliyan, Semarang.

Actually has conducted an interview with me on February 5th 2021 and February 11th 2021 in order to complete the data needed to compile the undergraduate thesis with the title:

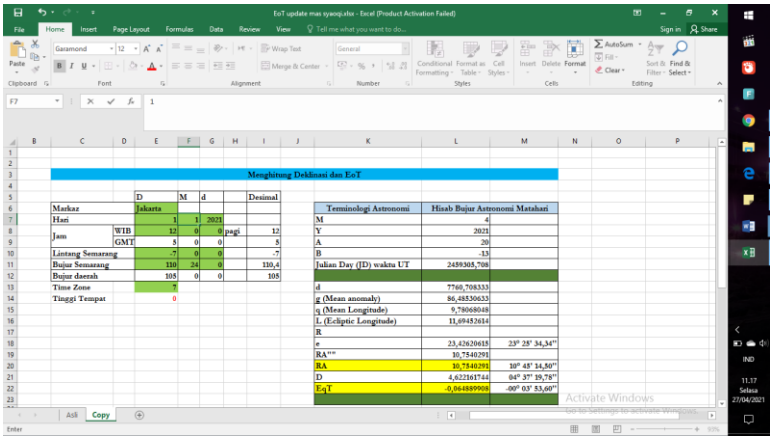
"Algoritmic Analysis of Prayer Times on Sunclock Application"

Best Regards,



Henning Benecke

Attachment 2: The calculation of prayer times



Menghitung Deklinasi dan EoT

		D	M	d	Desimal
Markaz		Jakarta			
Hari		1	1	2021	
Jam	WIB	12	0	0 pagi	12
	GMT	5	0	0	5
Lintang Semarang		-7	0	0	-7
Bujur Semarang		110	24	0	110,4
Bujur daerah		105	0	0	105
Time Zone		7			
Tinggi Tempat		0			

Terminologi Astronomi	Hisab Bujur Astronomi Matahari	
M	4	
Y	2021	
A	20	
B	-13	
Julian Day (JD) waktu UT	2459305,708	
d	7760,708333	
g (Mean anomaly)	86,48530633	
q (Mean Longitude)	9,78068048	
L (Ecliptic Longitude)	11,69452614	
R		
e	23,42620615	23° 25' 34,34"
RA""	30,7540291	
RA	30,7540291	30° 45' 14,50"
D	4,622501741	04° 37' 19,78"
EqT	-0,064889908	-00° 03' 53,60"

The Sun data of Sunclock

1 April 2021 1 May 2021 1 June 2021

Prayer Times of Sunclock Application

CURICULUM VITAE

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   MTs. Darul Falah Sirahan (2011-2014)
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   TPQ Al-Amin Payak (2007-2011)
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1. Coordinator of KOMINFO CSSMoRA UIN Walisongo Semarang (2019-2020)
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