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The Normative Basis of Islamic Astronomy For The Transformation of Prayer Schedules To Digital And Its Accuracy

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Abstract

The provisions for prayer times have been determined based on the instructions contained in the Qur'an and Sunnah. The Prophet gave an example of starting a prayer time based on the shadow of an object perpendicular to the sun's position relative to the earth. For example, the midday prayer is set when the sun is at its culmination. This shows that the determination of the start of the prayer time is based on the observation of the sun which must be in a certain position for each prayer time. These provisions are transformed into a set of mathematical formulas based on ongoing astronomical observations. In subsequent developments, this prayer schedule will not only be in hard copy form but also in the form of a website and Android application. Several Android applications display the starting schedule for prayers in a place that is different from the others. Every android application that displays prayer times should refer to the initial provisions of the times stipulated in the Shari'a and Fiqh, not limited to mere calculations, nor is there an API which is a common reference for program developers. There needs to be a unified standard calculation system for the android application for prayer times. It is also necessary to make a standard API and Indonesian standards in accordance with the fiqh provisions for the start of prayer times set in Indonesia.
Keywords: Prayer Times, Android Applications, API

Abstrak

Ketentuan waktu-waktu salat sudah ditetapkan berdasarkan petunjuk yang terdapat dalam alqur'an dan Sunnah. Rasulullah mencontohkan masuknya suatu awal waktu salat didasarkan kepada bayangan suatu benda tegak lurus yang menunjukkan posisi matahari terhadap bumi. Seperti salat zuhur ditetapkan pada saat matahari berada di titik kulminasi. Hal tersebut menunjukkan bahwa penetapan awal waktu salat didasarkan kepada pengamatan matahari yang harus berada pada posisi tertentu untuk setiap waktu salatnya. Ketentuan-ketentuan ini ditransformasikan kedalam satuan rumus matematik berdasarkan pengamatan yang terus berlangsung dalam bidang astronomi. Pada perkembangan selanjutnya jadwal salat ini tidak saja dalam bentuk hard-copy, namun dalam bentuk website dan aplikasi android. Terdapat beberapa aplikasi android yang menampilkan jadwal awal salat suatu tempat berbeda dengan yang lainnya. Setiap aplikasi android yang menampilkan waktu salat seharusnya merujuk pada ketentuan-ketentuan awal waktu yang ditetapkan dalam syariat dan fiqh tidak terbatas kepada perhitungan semata, juga tidak adanya API yang menjadi acuan bersama pada develover program. Perlu adanya kesatuan system perhitungan yang baku untuk aplikasi android waktu salat. Juga perlu dibuat API yang baku dan standar Indonesia sesuai dengan ketentuan fiqh awal waktu salat yang ditetapkan di Indonesia.
Kata Kunci: *Waktu Shalat, Aplikasi Android, API*

Introduction

Every Muslim is charged with praying five times a day and night. Sequentially starting from the Fajr, Zuhr, Asr, Maghrib, and Isha prayers. Everything is carried out according to the time and each prayer time has certain time limits. Every Muslim is not allowed to pray outside of the stipulated time. The midday prayer is held from the start of the time until before the start of the Asr prayer. Likewise, the Asr prayer is held from the start of time until before the time for Maghrib arrives which is marked by the setting of the sun. The position of the sun relative to a place on earth will tell the time for that place. Each place will get a different position relative to the sun, so the time that applies varies from other places.[1]

In the beginning, to determine the start of the prayer time had to be done by observing the position of the sun relative to a place on earth. The object being observed must be in an upright position, not obliquely, and also get direct sunlight, so that a precise image of the object is obtained and shows accurate time. If the object's position is not perpendicular, such as tilted to the right or left, then the resulting image is not symmetrical with the object's position and does not show precise time. So that the position of objects that are perpendicular is the main basis for getting the start of accurate prayer times. If we refer textually to the hadiths of the Prophet, it is necessary to look at natural signs as a determinant of the entry of

[1] Encep Abdul Rojak. *Ilmu Falak Hisab Pendekatan Microsoft Excel*, (Jakarta: Kencana, 2021), p. 5

prayer times. Equipment is needed to get the shadow position perpendicular. Usually use rubu' mujayyab and sundial which are also known as special sticks or miqyas. As the beginning of midday is marked by the decline of the sun. During the noon prayer on Friday, Friday prayers are held.[2]

Substance of Theoretical Studies

In the advancement of science and technology, integration between religion and science is a necessity because science and technology are developing rapidly and can be a bridge to solve problems.[3] The development of science and knowledge makes a very real contribution to Muslims.[4] In determining the beginning of the prayer time, according to the hadith instructions, the method for determining the beginning of the prayer time is based on observing the shadow of a perpendicular object that is directly illuminated by the sun. However, this can be known by calculating the position of the sun. From this solar data can show accurate time. The position of the sun greatly influences the time difference that applies to each place, including determining the start of the prayer time. In order to know when the time for prayer begins, one must first know the position of the sun. Different positions of the sun will show different times. Therefore, the initial determination of the prayer time is known in advance from the altitude of the sun.[5] If the early determination of prayer times does not use the science of reckoning, then Muslims will experience many difficulties.[6] Every time we are going to perform the five daily prayers, every time we also have to observe the position of the sun to measure the height of the shadows.[7]

Advances in technology also contribute to achieving perfection and convenience in carrying out obligations as a Muslim.[8] In the Qibla direction, before Android technology existed, the simplest way to measure the Qibla direction was to

[2] Salman Abdul Muthalib, Furqan Amri, Bukhari Ali, "Practices of the I'adah Zuhur after Friday Prayers in Aceh Besar District: An Analysis with The perspectives of Islamic Law Approaches," *Samarah: Jurnal Hukum Keluarga dan Hukum Islam*, Volume 5, Number 1 (2021), p. 338-356.

[3] Arino Bemi Sado, "Waktu Shalat Dalam Perspektif Astronomi; Sebuah Integrasi Antara Sains Dan Agama", *Muamalat Jurnal Hukum Ekonomi Syariah*, Volume VII, Number 1, (Juni 2015), p. 69-83.

[4] Ahmad Junaidi, " Syahadah Rukyatulhilal Using Astro Digital Imaging: From Subjectivity to Objectivity", *De jure: Jurnal Hukum dan Syar'iah* 14, no. 1 (2022), p. 58-74.

[5] Susiknan Azhari. *Ilmu Falak Perjumpaan Khazanah Muslim dan Sains Modern*, (Yogyakarta: Suara Muhammadiyah, 2007), p. 67.

[6] Iqnaul Umam Ashidiqi, "Irsyadul Murid Hisab Of The Beginning Islamic Lunar Month On Digital Falak Web-Based", *Syariah: Jurnal Hukum dan Pemikiran* 19, no.2 (2019), p. 141-150.

[7] Dirjen Bimbingan Masyarakat Islam, *Almanak Hisab Rukyat*, (Jakarta: Kemenag RI, 2010), p. 23.

[8] Muhammad Hasan, "The Interaction of Fiqh and Science in the Dynamics of Determining the Beginning of the Hijri Month in Indonesia", *Journal of Islamic Law* 4, no. 2 (2023), p. 237-257.

use a compass that had to be purchased.[9] The better the quality of the compass will affect the price level. But for now, the compass does not have to be owned physically, but can already be owned by the Android program.[10] Then regarding the schedule for the start of the prayer times that apply to a particular area, it is usually printed and distributed. There is a weekly prayer schedule, monthly prayer schedule, annual prayer schedule, even a perpetual prayer schedule that applies to a certain area. But at this time, to measure the Qibla direction and see the prayer times that apply to an area, you just need to look at the same application. And this greatly facilitates and helps the Muslim community in achieving the perfection of worship.[11]

The way humans work with computers cannot be equated with interactions in general, because humans are intelligent and intelligent living beings, while computers are objects that can be interacted with if there is a system. The interaction between humans and computer systems will help humans when the system between the two has been formed and understood. The interaction system translates what the user or human wants from the existing system. Like making an android prayer schedule program, the user must first know what program is used to compile the prayer schedule. If the user uses the right program, the system will provide the desired results. And the relationship between the two is bridged by the user interface.[12]

Prayer times are based on the position of the Sun relative to the Earth, so the start of the prayer times will vary between several places, according to the coordinate data used as a reference in the calculations. GPS is a tool that is useful for knowing the coordinates of a place accurately. Even this GPS has been embedded in Smartphones, making it easier to find coordinate data. An application "Ma'a Almusalli - مع المصلي" that utilizes GPS on smartphones as location data. This is in line with the research entitled "Offline Prayer Times System".[13]

The prayer schedule has developed from manual to digital, such as a wall clock that is incorporated into a digital clock and displays the prayer schedule. Then it developed again into a computer program, both in the form of a website and Android-based. However, the accuracy of each prayer program is different. There are differences in the results displayed, such as prayer schedules from Google, muslimpro., and others. Everything is discussed in full in the research The accuracy

[9] Reza Akbar, Aslan Aslan, Riza Afrian Mustaqim, Qibla Direction Calculation Methods in Islamic Astronomy References in Indonesia", *AHKAM: Jurnal Ilmu Syariah* 22, no. 2 (2022), p. 385-410.

[10] Hosen, Abdul Jalil, Abd. Wahid, Ach Muzayyin, Ziyad Ravasdeh, "Tagyîr Mawdhî' Inhirâf Qiblat al-Masjid fî Bamîkasân 'alâ Asasi al-Tiknôlôjiyya al-Mutaqaddimah: al-Tahlîla al-Ijtimâ'î wa al-Tsaqafî", *Al-Ihkam: Jurnal Hukum dan Pranata Sosial* 18, no. 2 (2023), p. 591-625.

[11] Muh Arif Royyani, Maryatul Kibtyah, Adeni Adeni, Ahmad Adib Rofiuddin, Machzumy Machzumy, Nor Kholis, "Religious Dialogue and Astronomy from the Perspective of Indonesian Muslim Scholars", *Samarah: Jurnal Hukum Keluarga dan Hukum Islam* 7, no. 1 (2023), p. 261-280.

[12] Sudarmawan dan Dony Ariyus, *Interaksi manusia dan computer*, (Yogyakarta: Andi Offset, 2007), p. 9.

[13] Ahmad Hafez, Akram M. Zeki, Offline Prayer Times System, Journal of Advanced Science and Engineering Research Vol. 6, Number 2 (2016), p. 1-6

of online-based prayer times applications which was completed by the research team Encep Abdul Rojak, Ilham Mujahid, and Muhammad Yunus.

This research is different from previous research, namely exploring the standard concept of the Android program and looking for a solution to the problem of differences in prayer schedules in the Android program. After collecting the data, it was found that there were differences in the results of prayer schedules from the android program because they differed in basic criteria, such as altitude correction to determine the start of sunset time, as well as the absence of a system referred to by the android program developer sourced from authorized institutions such as the API (Application Programming Interface). As a result, each Android prayer program runs individually and is prone to differences in final results.

The normative foundation of prayer times

Prayer is one of the most important acts of worship in Islam. Even this practice will be the first reckoning question on the Day of Resurrection. As long as a human being is in a healthy state of mind, still conscious and intelligent, even though his body is sick, he is still required to pray. Because the implementation of prayer can adjust to the human condition. If he is in good health, then it must be done standing. However, for those who are sick, Islam provides an alternative according to their circumstances, which can be done by sitting or lying down, or even with a gesture. So this is part of the importance of prayer for humans. Included in this section are the provisions for starting and ending prayers which are discussed in detail the times. There are no prayer times that overlap one another, but all are determined and run according to their time. The basis of the Qur'an and Sunnah follows: an-Nisa verse 103: …Indeed, prayer has been decreed upon the believers a decree of specified times.[14] al-Isra verse 78: Establish prayer at the decline of the sun [from its meridian] until the darkness of the night and [also] the Qur'an of dawn. Indeed, the recitation of dawn is ever witnessed.[15] Taha verse 130: So be patient over what they say and exalt [Allah] with praise of your Lord before the rising of the sun and before its setting; and during periods of the night [exalt Him] and at the ends of the day, that you may be satisfied.[16]

Hadith of Imam Muslim (Hadith No. 612); From Abdullah bin 'Amr that Rasulullah SAW said: "The time of Dzuhur prayer when the sun is inclined and someone's shadow is the same length as long as the Asr prayer time has not yet arrived, and the Asr prayer time as long as the sun has not turned yellow, the maghrib prayer time during the red mega (Syafaq) has not disappeared. , the time for the evening prayer is up to midnight, and the time for the Fajr prayer is from dawn until the sun has not risen. If the sun rises, then do not pray, because it rises between two devil horns."[17]

[14] https://quran.ksu.edu.sa/index.php?l=en#aya=4_103, accessed on March 4, 2023.

[15] https://quran.ksu.edu.sa/index.php?l=en#aya=17_78, accessed on March 4, 2023.

[16] https://quran.ksu.edu.sa/index.php?l=en#aya=20_130, accessed on March 4, 2023.

[17] Abi al-Husain Muslim bin al-Hujjaj al-Qushairi an-Naisaburi, *Shahih Muslim,* t.tp: Maktabah Fayyad, 2010, 210

Fiqh of Prayer Times

As a normative basis, that the obligatory prayers for every Muslim amount to 5 times consisting of midday, asr, sunset, evening, and dawn. The provisions for starting each prayer time are different. Some are held at the beginning of the day, some are held in the middle of the day, at the end of the day, early in the evening and at night. Each prayer must occupy its own portion without any imbalance from one to the other.

The beginning of the noon time begins shortly after the sun reaches its culmination point or slips in its daily cycle, and ends at the start of the asar time, that is, when the length of the shadow of an object perpendicular to the object itself. When the sun slips, the eastern sun circle will be tangent to the vertical line of the place in question. At that time it will form an hour angel of 0.25°.[18]

The beginning of the Asr time begins when the length of the shadow of an object is perpendicular to the exact length of the object, which indicates the end of the noon prayer time and increases slightly, until the sun sets. The shadow of a straight object that is the same length as the original shows the sun's elevation data for the beginning of this prayer time. Because the position of the sun is not always the same every day, to find out the height of the sun on a certain day it must be done by calculating it using a predetermined formula. Therefore, the height of the sun at Asr time is always different every day.[19]

The time for the Maghrib prayer begins when the sun sets below the horizon and ends when the red megaphone disappears which marks the time of evening prayer. The limit of setting the sun when the upper disk is in contact with the horizon, which indicates that the sun has completely set. In Indonesia, the sun's altitude data for the beginning of maghrib time is set at -1°.[20] However, there are also some other opinions that add a mean sea level correction for altitude, as a correction for the lowering of the horizon which affects the data for the height of the sun at the beginning of the evening prayer time.[21]

The start of the evening prayer time is marked by the disappearance of the red megaphone in the western sky. Earth is equipped with an atmosphere layer. This part is a protective layer of the earth from various threats from space objects, it is also one of the media for reflected sunlight. The end of the evening prayer is in the middle of the night. But there are also those who say until the time of dawn prayer

[18] Ismail, "Urgensi dan Legitimasi Fatwa Majelis Permusyawaratan Ulama Aceh Nomor 3 Tahun 2018 tentang Penetapan Arah Kiblat", *Al-Manahij: Jurnal Kajian Hukum Islam* 14, no. 1 (2020), p. 87-98.

[19] Slamet Hambali, Ilmu Falak 1 Penentuan Awal Waktu Shalat & Arah Kiblat Seluruh Dunia, (Semarang: Program Pascasarjana IAIN Walisongo Semarang, 2011), p. 127.

[20] Nailur Rahmi, "Penyatuan Zona Waktu dan Pengaruhnya Terhadap Penetapan Awal Waktu Shalat", *Juris: Jurnal Ilmiah Syariah* 13, no.1 (2014), p. 75-83.

[21] Encep Abdul Rojak, Amrullah Hayatudin, M. Yunus, Koreksi Ketinggian Tempat Terhadap Fikih Waktu Salat: Analisis Jadwal Waktu Salat kota Bandung, Jurnal Al-Ahkam, Vol. 27 number 2 (Oktober 2017), p. 254

comes. The altitude of the sun at the beginning of evening is set at -18°. In the Islamic world, the altitude of the sun for the first Isha starts from -14° to -18°.[22]

The beginning of fajr prayer time is marked by the rising of the sadiq dawn in the eastern sky in a spreading manner and will end at the time the sun rises. This dawn light is the sun's light reflected through the earth's atmosphere, so you will see the light spread in the eastern sky.[23] Apart from sadiq dawn, there is also a kadzib dawn which appears before sadiq dawn. Fajar kadzib is positioned before dawn sadiq which has a slightly different shape, which is elongated and soars from the horizon towards the sky.[24] This dawn will disappear with time. In Indonesia, the height of the sun at dawn is -20°. Earth is equipped with a protective system in the form of layers in the atmosphere.[25] As a result, sunlight that is emitted to Earth will pass through the layers of the atmosphere, so that sunlight does not propagate straight but is refracted and curved.[26]

In addition to the start of the prayer time, the provisions for the time of imsak are also set for each day. This stipulation is based on the habit of the Prophet Muhammad who always stopped eating the meal when it was before dawn with the size of reading the Koran as much as 50 verses. At present, the measure of 50 verses is translated in units of time to be 10 minutes before dawn. Duha time begins when the position of the sun is as high as the *tumbak*. This is then converted into units of arc degrees to 4°30'.[27]

Calculation of prayer times

The field of study of early prayer times is the part that gets the largest portion of ijtihad. Prayer times are based on the natural phenomenon of the sun's position relative to a place, even textually the Messenger of Allah gave instructions with the shadows of objects illuminated by the sun, but this has not been done for the present. Hisab is a substitute for observing the sun to determine the start of prayer times. Observations of the sun are carried out continuously by astronomers,[28] producing

[22] Siti Asma' Mohd Nor, Mohd Zambri Zainuddin, Sky Brightness for Determination of Fajr and Isha Prayer by Using Sky Quality Meter, International Journal of Scientific & Engineering Research Volume 3, Number 8, (August-2012), p. 1-3

[23] Imam Qusthalaani, Kajian Fajar Dan Syafaq Perspektif Fikih Dan Astronomi. Mahkamah: Jurnal Kajian Hukum Islam, Vol. 3, Number 1, (Juni 2018), p. 1-16

[24] Siti Asma' Mohd Nor, Mohd Zambri Zainuddin, Sky Brightness for Determination of Fajr and Isha Prayer by Using Sky Quality Meter, International Journal of Scientific & Engineering Research Volume 3, Number 8, (August-2012), p. 1-3

[25] W. M. Smart, *Textbook on Spherical Astronomy*, (Newyork: Cambridge University Press, 1977), p. 58

[26] Noor, Laksmiyanti Annake Harijadi. Fahmi Fatwa Rosyadi Satria Hamdani. February 2018. The Dawn Sky Brightness Observations In The Preliminary Shubuh Prayer Time Determination, QIJIS: Qudus International Journal of Islamic Studies, Volume 6, Number 1, (February 2018), p. 25-38

[27] Direktorat Urusan Agama Islam dan Pembinaan Syariah Dirjen Bimas Islam, Ephemeris Hisab Rukyat 2023, (Jakarta, Kementrian Agama RI, 2022), p. 443

[28] Ibnu Elmi AS Pelu, "Kedudukan Fatwa dalam Konstruksi Hukum Islam", *El-Mashlahah* 9.no. 2 (2019), p. 44-61.

accurate data on the position of the sun at any time. Through the science of calculation, the spherical triangle formula system, can calculate the sun's position for a certain place and a certain time as well. Therefore, at this time the determination of the start of the prayer time is no longer based on direct observation of the sun, but has been directed to the use of data from observations of the sun in a systematic way so as to produce accurate initial prayer time data.[29]

In calculating the start of the prayer time, there are some data that must be prepared. The data includes location coordinate data and solar data as objects of calculation. After the data is collected, the next step is to prepare a calculating tool in the form of a scientific calculator. However, if calculations are carried out in the form of a calculator program, the program language must be selected first to facilitate the creation of the calculation system. However, these basic data are still the main thing and must be available even in the form of a computer or Android program, such as location coordinate data and sun data.[30]

1. Latitude of a place is data that shows the position of a place measured from the earth's equator according to the location of that place. This data zero point starts from the earth's equator circle, all the way to the north pole and south pole with a maximum amount of data of 90°. From the equator towards the North Pole is called north latitude and is positive. Whereas from the earth's equator towards the south pole is called south latitude with a maximum data of 90° and a negative value (-).
2. Longitude data for a place is calculated starting from the Greenwich meridian in London to the meridian of places along the circle that crosses the place. Longitude data is divided into two parts, namely East Longitude for places that are east of the city of Greenwich London and has a positive (+) value and West Longitude for places that are in the West area of Greenwich City and has a negative value (-).
3. Elevation data for each surface of the earth has a height above sea level that varies depending on the topography. Places that are in the coastal area and its surroundings, with flat conditions and not mountains, have low elevations and do not have a significant effect. As for areas that are in the mountains and highlands, especially places that are on the shoreline facing the sunset and sunrise, the altitude must be taken into account. This data will affect the start of the evening prayer time. However, for some astronomers, this elevation data has no effect on determining the start of prayer times.
4. Times zone for each places, thats Indonesia is divided into 3 parts of time, namely the time of western Indonesia (105°) which includes the

[29] Muhajir, *Awal Waktu Shalat Telaah Fiqh Dan Sains,* Madinah: Jurnal Studi Islam, Volume 6 Number 1, (Juni 2019), p. 39-50

[30] Encep Abdul Rojak. *Ilmu Falak Hisab Pendekatan Microsoft Excel*, Jakarta: Kencana, 2021, p. 159-168

first level regions of Sumatra, Java and Madura, West Kalimantan and Central Kalimantan. The next part of time is the time of Central Indonesia (120°) covering the regions of East Kalimantan, South Kalimantan, Bali, West Nusa Tenggara, East Nusa Tenggara and Sulawesi. The last part of Eastern Indonesia Time (135°) includes the Maluku and Irian Jaya regions. This is in accordance with the Decree of the President of the Republic of Indonesia Number 41 of 1987 concerning the division of the territory of the Republic of Indonesia into 3 (three) time zones.

5. Declination of the Sun, that's the sun's declination is data that shows the sun's position relative to the celestial equator. As a result of the earth's rotational movement, the sun in its annual movement does not always rise and set at the same point. The sunrise point will shift from time to time due to the tilt of the earth's orbit, so that the sun is sometimes in the northern sky or in the southern sky. In mid-March, the position of the sun will be above the earth's equator, so that the sun's rays will spread all over the world. The day after that, the sun gradually heads north until mid-June around the 22nd. In the middle of this month the sun will be at its northernmost point. As a result, the southern part of the earth or the south pole does not get sunlight or even it is always night. Then after mid-June, the sun will gradually return to the equator and will arrive at the midline of this earth in mid-September around the 21st. After that date, the sun will gradually move southward until mid-December around the 22nd. After that date , the sun will return to the equator, and so on it will repeat like that. As a result, there will be an earth's surface that is always day or even night. This must be anticipated in determining the prayer schedule due to the position of the sun in the abnormal area. Transforming from observations of celestial bodies to mathematical units is an ijtihad. Ijtihad will help implement a law as it should.[31] 19 To obtain solar declination data, this can be done by taking the declination tables issued by the Ministry of Religion in the Ephemeris Hisab Rukyat book, the Indonesian Ministry of Religion's Win Hisab Software, Nautical Almanac data, declination online, calculated manually with astronomical data, and so on. etc.
6. Equation of time of the sun, that's the equation of time data is also interpreted as the time average for the sun's movement and it varies every year. This data is symbolized by a lowercase "e". As with the declination data, this time average data can be taken from the ephemeris data of the Indonesian Ministry of Religion. In this

[31] Pauzi M., Darul Hipni, Anwar M. Radiamoda, "The Importance of the Ijtihad Jama'i Method in Contemporary Fiqh Formulations", *Al-Risalah: Forum Kajian Hukum dan Sosial Kemasyarakatan* 23, no.1 (2023), p. 13-20.

ephemeris data recap it includes sun and moon data, which is needed as a basis for knowing the position of the sun and moon.

7. Altitude of the sun for for each beginning of the prayer times, that's the altitude of the sun at the beginning of each prayer time must be determined. The altitude of the sun is the arc distance along the vertical circle, calculated from the horizon to the sun. If the initial determination of the prayer time is carried out by observation, then the height of the sun becomes the basis and guide in making observations. However, if the determination of the prayer times is based on calculations/ reckoning, then the sun height data is included as the main data to be prepared. There is data on the height of the sun that has been standardized for the beginning of each prayer time, except for the start of the Asr time. There are two possibilities for the height of the sun, namely negative (-) and positive (+). The sun has a negative altitude value when the sun's position is below the horizon. This altitude is usually the height of the sun at the start of the Maghrib, Isha and Fajr prayers. Then the sun has a positive high value, that is, when the sun is above the horizon, that is, at the beginning of the time for Duha prayer, midday prayer, and Asr prayer.
8. In addition to these data, additional data is also needed to correct the calculation results to obtain the most accurate data. This provision is stipulated in the reckoning guidelines from the Indonesian Ministry of Religion with an additional amount of 2 minutes to 4 minutes. However, there are also those who do not add ikhtiyat to the beginning of each prayer time, such as the reckoning system developed by BHRD prov. West Java. This institution adds this data only at two times, namely the beginning of midday and the beginning of sunset. Apart from those two times, data on the ikhtiyat correction were not provided. The following is the sun elevation data for the start of the prayer times:

Table 1. Altitude of the sun

No	Prayer Times	Altitude	Data
1	Zuhr	No	-
2	Ashr	By formula	Cotan h = tan [φ – δ] + 1
3	Magrib	Y	-1°
4	Isya	Y	-18°
5	Fajr	Y	-20°
6	Duha	Y	4°30’

Source: Ephemeris Hisab Rukyat 2023.

There are several applicable formulas:

a. Meridian Pass: MP = 12 – e
   12 = raw value
   e = equation of time
b. Time interpolation = λ –TZ
   λ = Longitude
   TZ = Time Zone (TZ)
c. Hour angel, namely the unit formula used to find the value of time indicated by the position of the sun to a certain place. The formula is as follows:
   Cos t = sin ho ÷ cos φ ÷ cos δ – tan φ x tan δ
   t = hour angel
   ho = altitude of the susn
   φ = latitude
   δ = declination of the sun
d. Time converter, which converts the true time into the applicable regional standard time, with the formula: Regional Time (WD) = MP – interpolation + Ikhtiyath)

Perform Calculations

For example, calculating prayer times for the city of Bandung on February 19, 2023 with the following data:

1) Data dan Formula

Latitude (φ) = 6°55’54” S
Longitude (λ) = 107°43’3” E
Time Zone (TZ) = 105°
Elevation = 700 MSL
Deklination (δ)= -11°15’51,57”
Equation of time (e) = -0h 13m 49,3s
Ikhtiyat = 0h 3m or 0h 2m
Meridian Pass (MP) = 12 – e
Interpolasi (Int.) = Longitude (λ) - TZ
Sun Altitude of ‘ashar (ha)
formula Cotan h = tan [φ – δ] + 1
Cotan h = tan [-6°55’54”– -11°15’51,57] + 1
h = 42°54’34,85”
Sun Altitude of Magrib (hm) = -1°
Sun Altitude of Isya (hi) = -18°
Sun Altitude of Subuh (hs) = -20°
Sun Altitude of Terbit (ht) = -20°
Sun Altitude of Duha (hd) = 4°30’
MP = 12 – 0h 13m 49,3s
= 12h 13m 49,3s LMT
Interpolation = (107°43’3” E – 105°)/15°

= 0h 10m 52,2s

Zuhr

MP = 12h 13m 49,3s
Interp. = 0h 10m 52,2s –
12h 02m 57,1s
Ikhtiyat = 0h 03m +
12h 05m 57,1s rounded to 12:06

Ashar

Hour angel (t);
Cos t = sin 42°54'34,85" ÷ cos -6°55'54" ÷ cos -11°15'51,57" – tan -6°55'54" x tan -11°15'51,57"
t = 47°32'12,89"
convert to time system = t / 15,
= 47°32'12,89"/15
= 3h 10m 08,86s

MP = 12h 13m 49,3s
t/15 = 03h 10m 08,86s+
15h 23m 58,16s LMT
Interp. = 0h 10m 52,2s –
15h 13m 5,96s
Ikhtiyat = 0h 02m +
15h 15m 5,96s rounded to 15:15

Magrib

Hour angel (t); Cos t = sin -1° ÷ cos -6°55'54" ÷ cos -11°15'51,57" – tan -6°55'54" x tan -11°15'51,57"
t = 92°24'54,66"
convert to time system = t / 15,
= 92°24'54,66"/15
= 6h 09m 39,64s
MP = 12h 13m 49,3s
t/15 = 6h 09m 39,64s +
18h 23m 28,94s LMT
Interp. = 0h 10m 52,2s –
18h 12m 36,74s
Ikhtiyat= 0h 02m +
18h 14m 36,74s rounded to 18:15

Isya

Hour angel (t); Cos t = sin -18° ÷ cos -6°55'54" ÷ cos -11°15'51,57" – tan -6°55'54" x tan -11°15'51,57"
t = 109°58'32,36"
convert to time system = t / 15

= 109°58’32,36” /15
= 7h 19m 54,16s

MP = 12h 13m 49,3s
t/15 = 7h 19m 54,16s +
19h 33m 43,46s LMT
Interp. = 0h 10m 52,2s –
19h 22m 51,26s
Ikhtiyat= 0h 02m +
19h 24m 51,26s rounded to 19:25

Fajr

Hour angel (t); Cos t = sin -20° ÷ cos -6°55’54” ÷ cos -11°15’51,57” – tan -6°55’54” x tan -11°15’51,57”
t = 112°03’23,25”
convert to time system = t / 15
= 112°03’23,25” / 15
= 7h 28m 13,55s

MP = 12h 13m 49,3s
t/15 = 7h 28m 13,55s –
4h 45m 35,75s LMT
Interp. = 0h 10m 52,2s –
4h 34m 43,55s
Ikhtiyat= 0h 02m +
4h 36m 43,55s rounded to 04:37 WIB

Imsak

Imsak schedule is determined for 10 minutes before the start of dawn. Because dawn starts at 04.37 WIB, so the start of the imsak at 4:30 a.m. 04.27

Syuruq

Hour angel (t); Cos t = sin -1° ÷ cos -6°55’54” ÷ cos -11°15’51,57” – tan -6°55’54” x tan -11°15’51,57”
t = 92°24’54,66”
convert to time system = t / 15,
= 92°24’54,66”/15
= 6h 09m 39,64s

MP = 12h 13m 49,3s
t/15 = 6h 09m 39,64s –
6h 4m 1,66s LMT
Interp. = 0h 10m 52,2s –
5h 53m 9,46s
Ikhtiyat= 0h 02m -
5h 51m 9,46s rounded to 05:51

Duha

Hour angel (t); Cos t = sin 4°30' ÷ cos -6°55'54" ÷ cos -11°15'51,57" – tan -6°55'54" x tan -11°15'51,57"

t = 86°46'5,65"

convert to time system = t / 15,

= 86°46'5,65"/15

= 5h 47m 4,38s

MP = 12h 13m 49,3s

t/15 = 05h 47m 4,38s –

6h 26m 44,92s LMT

Interp. = 0h 10m 52,2s –

6h 15m 52,72s

Ikhtiyat= 0h 02m +

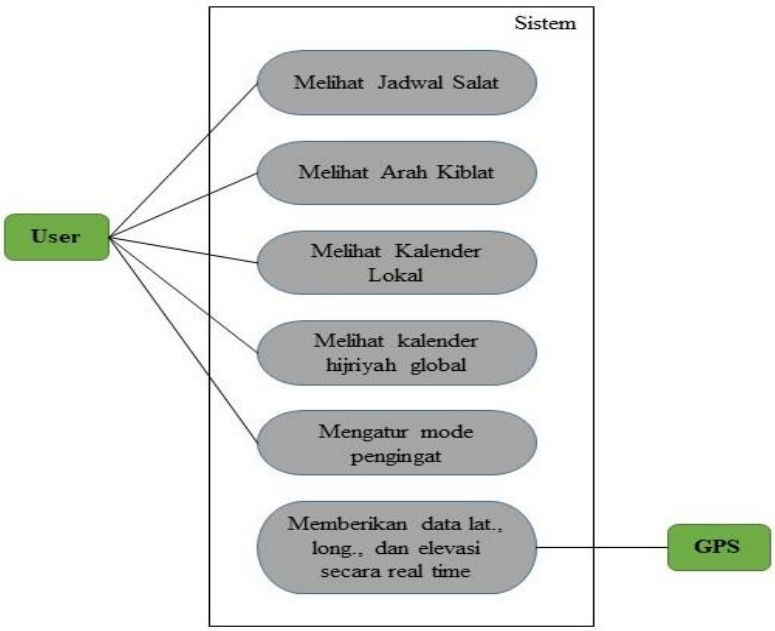
6h 17m 52,72s rounded to 06:18.

Android prayer schedule framework

Every mobile phone gadget that is classified as a smartphone usually has a global positioning system (GPS). This application can provide coordinate data for a place including longitude, latitude and elevation. These three data become the basic data to be able to calculate prayer times in a place. To access the coordinate data from the GPS, an additional android application is needed as a GPS accessor to read the coordinate data of a place. To make an application, we need a tool that functions to design a desired application.[32] The use of diagrams is one of the important things in the process of making android programs. One type of diagram that can be used is JSD (Jackson Structured Design). These diagrams can be used for various aspects of task analysis and dialogs.[33] The following is an example of a prayer schedule program use case diagram that can be developed:

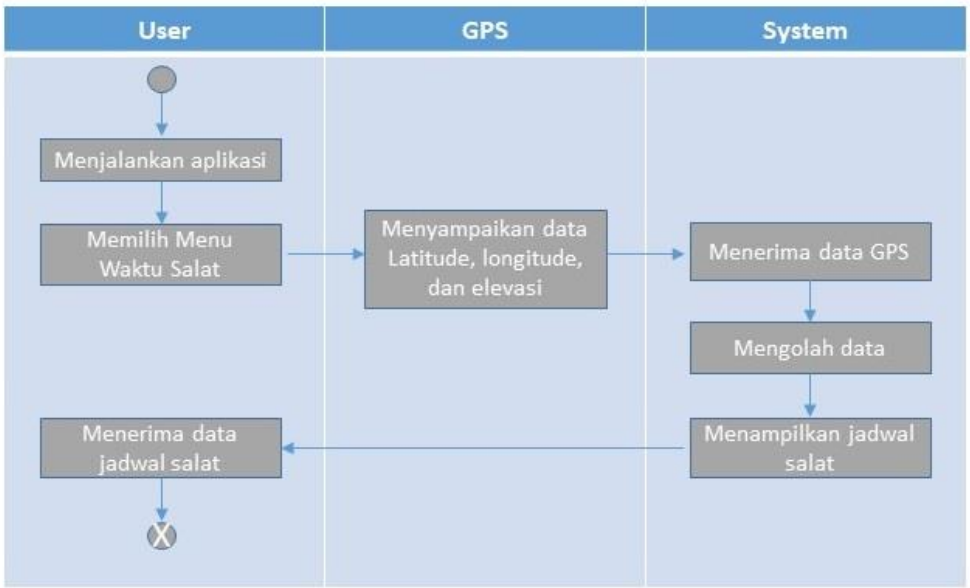
[32] Anton Yudhana, Abdul Fadlil, Safiq Rosad. Jadwal Sholat Digital Menggunakan Metode Ephemeris Berdasarkan Titik Koordinat Smartphone, IT Journal Research and Development (ITJRD), Vol.3, Issued 2, Maret 2019, p. 30-43

[33] Sudarmawan dan Dony Ariyus, Interaksi manusia dan computer, Yogyakarta: Andi Offset, 2007, p. 254



Source: processed from various sources

The built Android system will describe the interaction between the user and the system. When the user has interacted and given orders to the system, the system must describe the interactions between parts. The Android prayer schedule makes it possible to take advantage of the GPS embedded in the smartphone so that GPS becomes an integral part of this system. The following is an Activity diagram that can be developed to compile an Android-based prayer schedule



Source: processed from various sources

The navigation structure drawn from an android program can be developed as shown below:[34]

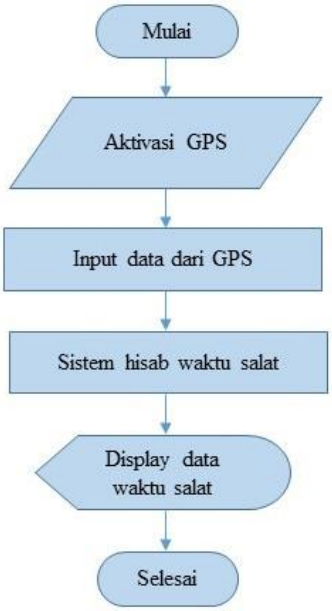
Source: processed from various sources

To help understand the system and the use of the structure, it is necessary to make a flowchart that explains the system being made. Especially the REPEAT structure is very helpful in solving problems that arise.[35] Interactive applications are generally user-driven. The application action is determined by the input provided by the user.[36]

[34] Encep Abdul Rojak, Ramdan Fawzi, *Digitalisasi Hisab Awal Waktu Salat dan Problematika Jadwal Digital*, (Bandung: CV Sadari, 2023), p. 62

[35] Rinaldi Munir dan Leony Lidya, Algoritma dan Pemrograman dalam Bahasa Pascal, C, dan C++, Bandung: Informatika Bandung, 2016, p. 206

[36] Sudarmawan dan Dony Ariyus, Interaksi manusia dan computer, Yogyakarta: Andi Offset, 2007, p. 294



Source: processed from various sources

Android prayer schedule problems

Prayer schedules in the form of computer and mobile applications are increasing. In the form of website applications, for example bimasislam.kemenag.go.gi, google browsing and prayer times.org. in the form of android applications there are also many, such as bhrd jabar applications, fond of Qibla, Muslim pro, athan, and so on. This makes it very easy for Muslims to refer to the desired prayer schedule. Even in sharia-based services or financial applications, a prayer schedule menu will appear. Such as the BSI Mobile application, Bank Mega Syariah, and other applications. Of the many existing application options, Android applications are more in demand by the Muslim community. This is due to the convenience and efficiency according to the gadgets carried on Android-based devices.

The large number of prayer schedule applications has also created new problems, because among the schedules that are spread out and easily accessed directly by the public, there is no uniform system. At least the difference starts to differ by 1 minute for each prayer time, some even up to 5 minutes.[37] This is due to the following reasons:

1. Program developers do not refer to the same concept and formulation. There is a calculation system between different experts including the things

[37] Encep Abdul Rojak, Ilham Mujahid, and Muhammad Yunus, The accuracy of online-based prayer times applications, Ijtihad: Jurnal Wacana Hukum Islam dan Kemanusiaan, Vol. 21, Issued 1 (2021), p. 21-37

behind the differences. Such as the use of ikhtiyat and altitude correction for determining the start time for the evening prayer

2. There is no similar Application Programming Interface (API) system for prayer schedule programs in Indonesia. The Republic of Indonesia's Ministry of Religion has not yet developed an API system that can be used by program developers, so that each developer uses their own system according to their abilities so that the results may differ.

API (Application Programming Interface) is a set of definitions and protocols for building and integrating application software. In short, API is an application programming interface. API allows products or services to communicate with other products and services without having to know how it is implemented. This method can simplify application development. When designing new tools and products or managing existing ones, APIs provide flexibility to simplify design, administration, use, and provide opportunities for innovation.[38].

Conclusion

The development of science and technology can be used as a medium that helps Muslims determine their prayer schedule. This convenience can be in the form of an android application created through a computer program. The interaction that is built between humans and computers is determined by humans as users. The computer can provide results according to the input data from the user. In the android application that displays the prayer schedule, it turns out that it has not provided a uniform schedule for Muslims. There are still differences in the results of prayer schedules from various existing applications. This can happen because one of them has not yet formed an API (Application Programming Interface) system that is referred to by every developer. A suggestion to the Indonesian Ministry of Religion or related institutions such as the Regional Hisab and Rukyat Board to make an Android reckoning system API that can be used by every android developer or computer-based prayer schedule.

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