Disseminating Local Time in Egypt using Web–Based Clock

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Abstract

Disseminating the standard time in Egypt through internet is introduced in this paper for the first time. Establishing a web-based clock is the first step of the time dissemination process. The standard time that is disseminated to users in Egypt is synchronized to the Egyptian time scale (Coordinated Universal Time of the National Institute of Standards UTC(NIS)) to be traceable to it. Enhancing the performance of UTC(NIS) is firstly discussed before using it as the main source for the synchronization process. Also, the accuracy and reliability of the disseminated time is further enhanced by proposing two alternative synchronization sources to be used in the absence of the main source. This research aims to develop a traceable and reliable dissemination of the standard time in Egypt using web-based clock. It investigates the benefits, challenges, and potential solutions associated with implementing clocks on the NIS internet portal to provide accurate and accessible local time information in Egypt. The results emphasize the need for individuals and organizations operating in or dealing with Egypt to consider the time difference when scheduling time-based events or communications. They should also utilize recent technology tools as portal and others to facilitate effective planning and coordination across different time zones and maintain clear communication with counterparts in different time zones for successful global operations and collaboration.

Keywords: Coordinated Universal Time (UTC), Accessible, Potential solutions, Time zone, Global time, NTP (Network Time Protocol

1 Introduction

In today's interconnected world, accurate and reliable timekeeping plays a crucial role in various aspects of our lives. Whether it's scheduling time-based events, coordinating travel plans, or simply staying on track with daily activities, having access to the correct local time is essential. With the advent of web-based technologies, disseminating local time has become more convenient and accessible than ever before.

There are various time dissemination techniques: time dissemination via radio signals, time dissemination via telephone signals, time dissemination using Network Time Protocol (NTP) servers, and time dissemination via satellites. The accuracy of time synchronization varies according to the time dissemination techniques. During the beginning of the 20th century, synchronized time signals were transmitted via electromagnetic waves across various frequency bands, such as VLF, LF, and HF. The accuracy of this technique is limited to a few seconds. With the advent of Internet services and their reach accessible to everyone, time dissemination via NTP (web-based clock) is nowadays the most frequent technique with an accuracy of millisecond/microsecond, Satellite time dissemination technique is intended for highly precise clients with an accuracy of nanoseconds. However, this technique needs expensive infrastructure deployment [1] [2].

This paper focuses on how web-based clocks are utilized to disseminate local time in Egypt [3]. These clocks leverage the power of the internet to provide real-time updates and synchronize with official time sources, ensuring accuracy and consistency [4].
Egypt operates on Egypt Standard Time (EST), which is two hours ahead of Coordinated Universal Time (UTC+2) during standard time and three hours ahead during daylight saving time [5]. One of the key advantages of using web-based clocks to disseminate local time in Egypt is the ability to gather a wide range of users, both within the country and beyond its borders. Websites, applications, and online platforms can integrate these clocks seamlessly, allowing users to view local time in Egypt regardless of their geographical location. This is particularly beneficial for travellers, international businesses, and individuals who need to coordinate activities with counterparts in Egypt [6].

Moreover, web-based clocks can be embedded in websites, displayed on digital signage, or incorporated into mobile apps, providing users with multiple avenues to access accurate local time in Egypt. These clocks often come with additional features such as automatic adjustment for daylight saving time, customizable time formats, and synchronization with reliable time servers to ensure precision [7]. Additionally, web-based clocks serve as valuable tools for online education platforms, event management systems, and financial institutions that operate across different time zones and require accurate time references. Publicizing local time is a critical task to ensure that people have accurate and reliable timekeeping information. Choosing how to publish local time depends on several factors, such as the target audience, cost, and level of accuracy required. For example, radio broadcasting is a cost-effective way to disseminate local time to a large audience, but it may not be as accurate as other techniques.

The on-demand mechanism for timestamp synchronization in multi-hop ad hoc and sensor networks utilizes the local clock of a sensor node for local or global synchronization. The proposed mechanism uses the local clock of a sensor node to generate timestamps for events that it senses [8]. Satellite laser ranging (SLR) is a two-way optical measurement technique that achieves precise time and stable reference frequencies for space geodesy. However, precise control is necessary to move time between two clocks apart. This paper addresses the role of time in web-based clock time disseminations and sources of error, leading to a redesign of local time distribution at the Wettzell Geodetic Observatory [9]. The research presents in [10], [11] a web-based clock mechanism for disseminating local time in distributed systems, utilizing a web-based clock server to provide a reference time for system nodes to synchronize their local clocks.

The study in [12] analyses magnetic field and plasma data from the Juno spacecraft's first 11 orbits around Jupiter to investigate local time asymmetries in the magneto disc currents, providing insights into Jupiter's magnetosphere dynamics and transport processes. The study in [13] compares web-based clock mechanisms for local time dissemination in distributed systems, evaluating accuracy, precision, and scalability. This comparative analysis aids system designers in selecting the most suitable mechanism for their specific requirements. The study by [14] proposes a secure web-based clock mechanism for disseminating local time in cloud environments, using a secure server to synchronize local clocks among nodes. The study [15] proposes a WebRTC-based web clock mechanism for real-time local time dissemination, using a server to provide reference time for system nodes to synchronize their local clocks. The study by [16] proposes a blockchain-based web clock mechanism for trusted local time dissemination, allowing other nodes to synchronize their local clocks using a reference time.

2 Problem Statement

Before this work, the current method of disseminating local time in Egypt is a non-standard and non-scientific method that is based on traditional time dissemination techniques as radio broadcasting. This method is not always reliable and not traceable to the national time scale UTC(NIS) and has performance issues which causes large time delay between the source of time and the clients. Moreover, the current traditional time dissemination techniques as radio broadcasting can be interrupted by weather conditions or other factors and suffers from lack of accuracy. To address these problems, there is a need to introduce a more reliable, accessible, accurate and traceable time dissemination method of standard time in Egypt. Internet is nearly available to everyone in Egypt. So, we think in time dissemination technique using internet. The first step for disseminating local time in Egypt using internet is establishing a web-based clock which is traceable to UTC(NIS) to provide time with high accuracy to users. In addition, the delay required to transfer the time from the server to the web-based clock must be calculated and minimized as possible, ensuring that the accuracy of the time displayed on the web page is guaranteed.

3 Proposed System Methodology and Setup

The overall system setup is divided into two parts which are: the first part that related to National Time Scale Generation System at the Time and Frequency Laboratory at NIS and second part is related to NIS web-based clock across the Data Centre Department via optical fiber cable as shown in Fig. 1.

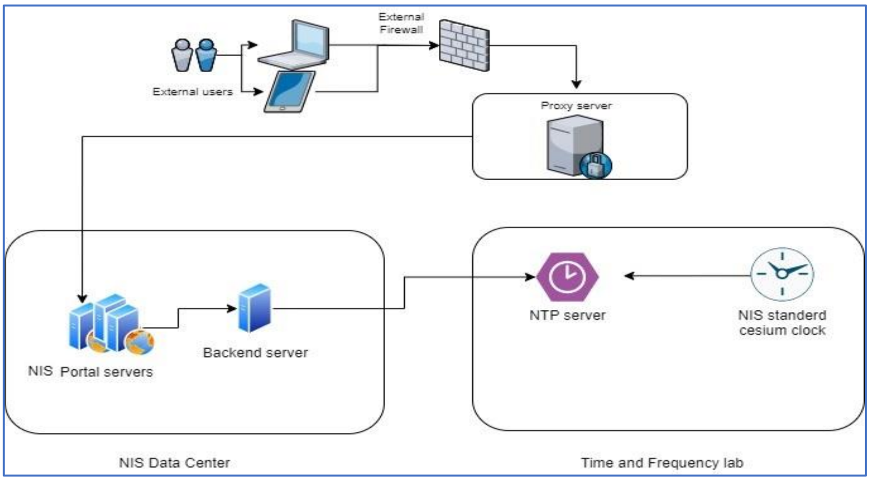

Figure 1: NIS Web-based Time Dissemination Setup.

The systems setup in NIS time and frequency laboratory consists of two main components; NIS standard Master Clock (Cesium Clock), and NIS NTP server. These two main devices are connected tougher using high quality and bit rate fiber optics cable. Regarding to the Data Center part, this part contains the application Server and web portal server that connected for security purpose to external user using Secured Proxy server, and High-quality Firewall device.

3.1 National Time Scale Generation System at NIS

The Time Scale (TS) generated at the National Institute of Standards (NIS) is the national TS. This is denoted as Coordinated Universal Time of NIS (UTC(NIS)), and it is the real-time version of the international reference time scale Coordinated Universal Time (UTC). UTC(NIS) provides the reference for all calibration and time dissemination services in Egypt. It is generated at the Time and Frequency Laboratory of NIS, as shown in the block diagram of Fig. 2.

The national TS (UTC(NIS)) is generated by the master clock method [18]-[22] using the NIS master clock, which is a high-performance Cesium (Cs) beam frequency standard (5071A) with Bureau International des Poids et Measures (BIPM) code number (1353654), and Auxilary Output Generator (AOG). The one Pulse Per Second (1 PPS) and 5 MHz signals at the output of AOG represent UTC(NIS) with high accuracy and frequency stability characteristics. The frequency doubler converts the 5 MHz at its input to 10 MHz because the Time Transfer Systems (TTSs) use only 10 MHz. The 1 PPS distribution unit and frequency distribution unit are used to distribute the 1PPS and the 10 MHz reference signals for different calibration and time dissemination services at NIS. The time transfer systems (TTS3 and TTS5) use UTC(NIS) reference signals (1 PPS and 10 MHz) to generate daily time transfer files to be sent to BIPM for participation in international time scale difference comparison to achieve UTC(NIS) traceability to UTC. The time scale difference comparison results UTC-UTC(NIS) with its associated uncertainties, published monthly in the BIPM Circular_T, are the source of traceability for all time and frequency calibrations and time dissemination services at NIS. Also, the Network Time Protocol (NTP) server is synchronized to a 1 PPS reference signal from UTC(NIS) for disseminating local time in Egypt through the internet. The NTP is connected to the NIS data Center server using two optical fiber cables, as shown in Fig. 2.

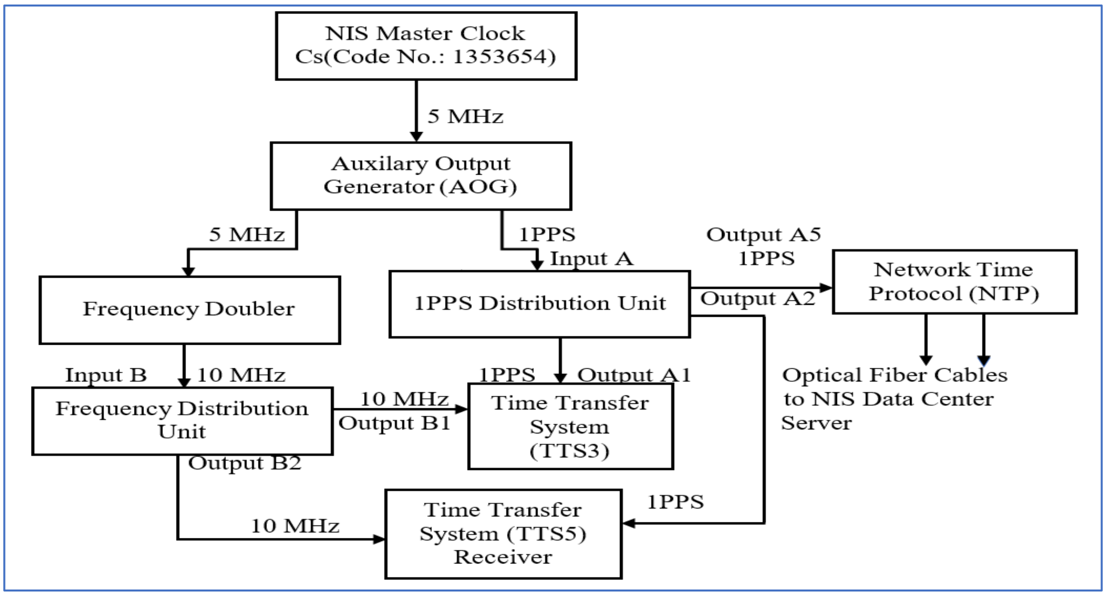

Figure 2 : UTC(NIS) Generation System.

3.2 Enhancing the Performance of UTC(NIS) and its Uncertainty

The product is disseminated to users in Egypt on the national time scale UTC(NIS). So, it was very important first to enhance its reliability, stability, and accuracy, as recommended by the Consultative Committee of Time and Frequency (CCTF). Several works have been done at NIS in the last 5 years to achieve this goal before time dissemination starts, as mentioned in [18]-[22].

Also, as recommended by CCTF, a calibrated time transfer system (TTS5) was installed at NIS on 1/9/2021 to replace the uncalibrated system (TTS3). A great effort has been made at NIS to complete the calibration and installation processes of TTS5 successfully. After that, a calibration report was sent to the BIPM time department to tell them about the improvements and modifications carried out to UTC(NIS) on 22/2/2022. This procedure enhances the combined uncertainty of UTC(NIS) from 20.0 ns to 7.1 ns starting from the date 1/3/2022, as published in the BIPM Circular_T no 411 on 11/4/2022. Due to the great effort excreted at time and frequency Lab of NIS in the last 5 years, our product UTC(NIS) accuracy and corresponding uncertainty were improved as compared to the time scale of DFNT, Tunis (UTC(DFNT)), as shown in Table 1.

Table 1: *A Comparison between UTC(NIS), UTC(DFNT) Accuracy and Uncertainty.*

Date 2024	**28/7**	**2/8**	**7/8**	**12/8**	**17/8**	**22/8**	**27/8**	**Uncertainty (ns)**
MJD	**60519**	**60524**	**60529**	**60534**	**60539**	**60544**	**60549**	
Laboratory (K)	**[UTC-UTC(K)]/ns**							
DFNT (Tunis)	-4148.6	-4226.3	-4310.7	-4395.2	-4497.6	-4602.9	-4691.4	2.7
NIS (Cairo)	77.3	72.9	66.3	72.1	55.5	39.3	18.3	7.2

The results shown in Table 1 are taken from Circular_T no 440 published by BIPM on 11/9/2024 and you can access it through the following link:https://webtai.bipm.org/ftp/pub/tai/Circular-T/cirt/cirt.440.

The results mentioned in Table 1 show the difference between UTC and its local realizations (UTC(NIS) and UTC(DFNT)) and its corresponding uncertainties at 5-day intervals in the period from 28/7 (MJD 60519) to 27/8 (MJD 60549), MJD is the Modified Julian Date. These results show that the accuracy of UTC(NIS) relative to UTC outperforms that of UTC(DFNT). At the same time, the uncertainty of UTC(NIS) is comparable to that of UTC(DFNT) because the time transfer system of DFNT was recently calibrated in the last three months.

3.3 Enhancing the Accuracy and Reliability of the Disseminated Time

The NTP server that is used to provide the traceable Egypt standard time which is selected carefully to achieve the requirements of accuracy and reliability, as shown in Fig.3. It is SyncServer S650 from Microsemi Co. with a Global Navigation Satellite Systems (GNSS) option and Rubidium oscillator upgrade.

Figure 3: NIS Sync Server S650 NTP Server at Time and Frequency Laboratory.

This S650 NTP server with excellent hardware characteristics was chosen and installed at NIS in Nov. 2021 to provide Egypt standard time with high reliability and accuracy characteristics as follows:

- The extremely high reliability of the traceable disseminated time is guaranteed by using one main and two backup synchronization signals from three different sources. The main source is the 1PPS signal from UTC(NIS) and the two backup signals are provided from the various satellite constellations (GNSS option) and the high-performance rubidium oscillator upgrade.
- The excellent accuracy of the disseminated time (better than 15 ns) RMS relative to the time scale of the United States Naval Observatory (UTC(USNO)) is achieved using the GNSS option in the absence of the main synchronization source (1PPS from UTC(NIS)).
- The Rubidium oscillator upgrade provides the disseminated time with accuracy better than 1 µs in the absence of the UTC(NIS) and GNSS synchronization signals.
- The S650 server can dandle at least 10,000 NTP requests per second with no degradation in the provided time accuracy. Also, the S650 server is ready to process

360,000 NTP requests per second while maintaining the required time accuracy by activating the required software licence.

3.4 NIS Web-based Clock

Displaying a traceable web-based clock on the NIS web page is the first step for disseminating local time in Egypt (UTC(NIS)) through the internet. This clock is synchronized to UTC(NIS) using the S650 NTP server installed at Time and Frequency Laboratory of NIS as shown in Fig.2. As mentioned above, the 1PPS reference signal from the pulse distribution unit (output A5) is connected to the 1PPS input of NTP server (S650) to synchronize it to UTC(NIS). Then, the S60 NTP server is connected to the NIS data center server using two optical fiber cables to achieve high reliability. The data center server acquires the time code from the S650 NTP server and displays it on the NIS electronic portal with its associated delay time as shown in Fig. 2.

Egypt's local time faces a few challenges compared to UTC such as:

- Time difference**:** Egypt is in the Eastern European Time (EET) zone, which is 2 hours ahead of Coordinated Universal Time (UTC). This means that when it is noon in Egypt, it is 10:00 AM UTC. This can be a challenge for businesses and organizations that operate internationally, as they need to coordinate their schedules with people in other time zones.
- Daylight saving time: Egypt observes Daylight Saving Time (DST) from the last Sunday in March to the last Sunday in October. During DST, the local time is 3 hours ahead of UTC. This can be a challenge for people who travel to or from Egypt during these months, as they need to adjust their watches and schedules.
- Seasonal changes: The seasons in Egypt are opposite to the seasons in the Northern Hemisphere. This means that when it is summer in Egypt, it is winter in the Northern Hemisphere. This can be a challenge for businesses and organizations that operate internationally, as they need to adjust their schedules to accommodate the different seasons.
- Communication: The time difference between Egypt and other countries can make it difficult to communicate effectively. For example, if someone in Egypt wants to call someone in the United States, they will need to call during the late afternoon or evening in the United States, which may be inconvenient for the person in the United States.

Despite these challenges, Egypt's local time is generally workable for most people and businesses. However, it is important to be aware of the time difference and the seasonal changes when planning activities or communicating with people in other time zones [23]. The delay time required to transfer the time from the server to the web-based clock can be calculated by considering several factors. Firstly, the distance between the server and the web-based clock plays a role in determining the delay. The greater the distance, the longer it takes for the data to travel between them. The speed of light, which is approximately 300 thousand kilometers per second, is used as a reference for calculating the delay caused by the distance.In addition, other factors can contribute to the delay. Internet connection speed is an important determinant, as a faster connection allows data to be transferred more quickly. Network load, which refers to the amount of traffic or data being transferred at one time, can also affect delay. A crowded network may result in additional latency. Moreover, the processing time of both the server and the web-based clock themselves should be considered. The server processing time accounts for the time required for the server to receive the time information and prepare it for transmission. Similarly, the web-based clock processing time refers to the time taken by the clock to receive and process the incoming time data [24]. The delay time can be calculated using equation (1):

$$D_{Time} = \frac{Ds}{Sl} + S_{Time} + C_{Time} \quad (1)$$

Where:

D_{Time}: Delay time between client machine clock and Time dissemination clock

Ds : Distance between Client and Time dissemination system at NIS

Sl : the speed light of used fiber optical calbes

S_{Time} : Server Processing Time

C_{Time} : web-based clock processing time

Networked devices utilize the Network Time Protocol (NTP) to align their clocks within internet-based and NIS web-based systems. This synchronization is achieved through the transmission of synchronization requests between a client and a server. Upon receiving a request packet from the client, the server responds with a packet that contains its own time. The accuracy of this process relies on a highly precise standard time source. The synchronization procedure is illustrated in Fig. 4 and employs the following formula to determine the time delay.

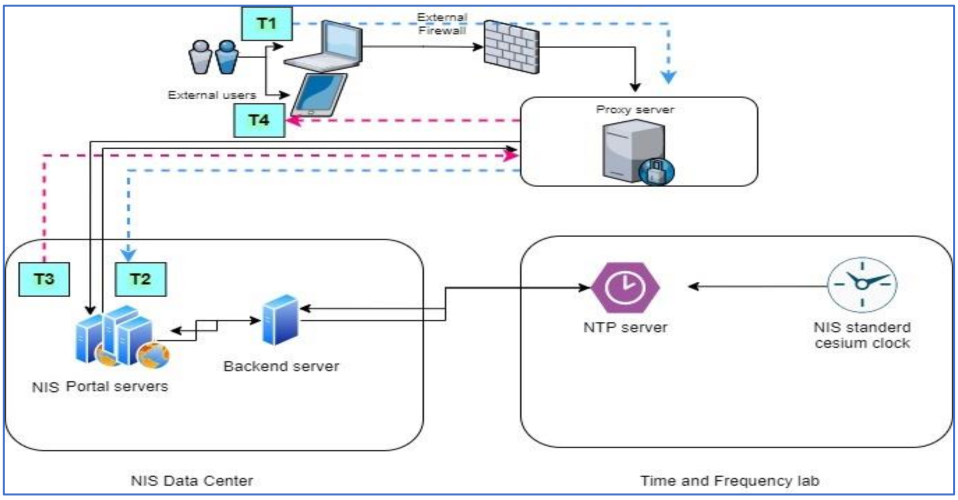

Figure 4: Request exchange between client and NIS data Center (NTP).

The client sought to receive a timing packet from the server at intervals of 10 seconds. This request was transmitted through the Internet Protocol (IP) to the NTP server on port 123. The request contained the timestamp, T_1, which represents the client's local time at the moment the request was initiated. In response to the timing inquiry, the server provided a data response that included the current time from the NTP server.

One of the time stamps provided by the server reflected T_1, which indicates the moment the client initiated the request, as measured by the client itself. Additionally, two other time stamps recorded T_2, the time at which the server received the request, and T_3,the time when the server finished preparing the response. Upon receiving the packet, the client once more checked its clock and noted T_4, the time at which the response arrived. The time difference, time delay (Td), between the clocks of the server and client was calculated using the conventional NTP formula for clock offset [25].

$$\text{Td} = \frac{(T_2 - T_1) + (T_3 - T_4)}{2} \quad (2)$$

The round-trip delay between the client and server was determined using the same four timestamps [25] [26] [27].

$$RT_{Delay} = (T_4 - T_1) - (T_3 - T_2) \quad (3)$$

The time interval necessary for the server to handle the NTP request, denoted as $T_3 - T_2$, is deducted from the round-trip delay recorded by the client clock. Consequently, fluctuations in server processing time do not affect the RT delay In the server employed for our study, $T_3 - T_2$ generally averaged around 100 µs, although it can occasionally be significantly larger, surpassing 1 ms in some instances. The outcomes of both the time difference and round-trip measurements are refreshed every 10 seconds on the client system's display and documented in a file. (NIS Website). It is important to highlight that in our development setup, both the server and client were synchronized to the same clock, which implies that the Td in Equation (2) should ideally be 0. Any observed deviation from 0 can be attributed to uncertainties associated with NTP time transfer. Furthermore, the "divide by 2" in Equation (2) is predicated on the assumption that the delay from the server to the client is half of the total round-trip delay. If this assumption holds true, the delays in both directions to and from the server would be equal, and thus dividing by two would adequately account for all delays. However, in practice, the delays experienced in the incoming and outgoing paths are not equal, and this asymmetry in delay contributes to the uncertainty surrounding NTP time transfer.

However, it is important to note that the specific hardware and software configurations of the server and web-based clock will influence the processing times. By accurately calculating and accounting for the delay time, it becomes possible to synchronize the time displayed on the web page with the server time effectively. This ensures that the users accessing the web-based clock receive the most accurate and up-to-date local time information, without compromising the overall accuracy due to delays in data transmission and processing.

4 Results and Discussion

The results focus on a comprehensive understanding of the importance of Coordinated Universal Time (UTC), as Coordinated Universal Time (UTC) is a reasonable global time that effectively influences and influences various global events. UTC helps achieve time synchronization between various locations around the world and organizes the organization effectively. Knowing the local time challenges in Egypt, facing the challenges necessary to work in Egypt, and the challenges related to the local time. This includes the time difference with other time zones, daylight saving time adjustments, and seasonal changes that can be made by intergovernmental operations. It can have significance related to the local time in Egypt through several actions, Fig. 5 shows NIS developed portal with time dissemination part, time dissemination part includes Current Date, Current Time in additional to transmission delay at a moment.

Figure 5: Disseminate Egypt Local Time on the NIS Electronic Portal.

According to the experimental setup, the results obtained for the specified period were calculated using equation (2) over three consecutive days. This involved conducting 300 readings each day, with an interval of ten seconds between each reading. The outcomes of this experiment are illustrated in Fig. 6.

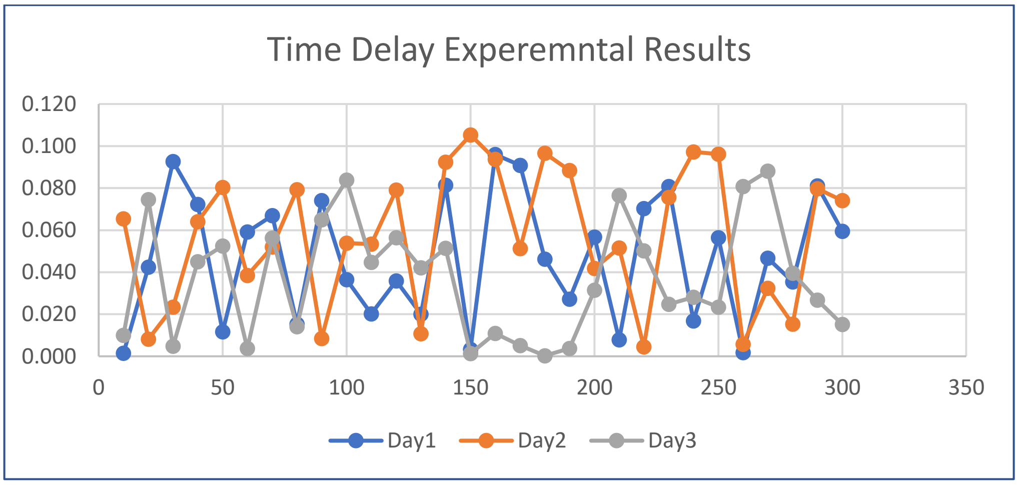

Figure 6: Time delay for client-NTP for three consecutive days.

Table 2 presents the average time delay values for each individual day, as well as the overall average time delay value calculated for the three-day experiment.

Table 2: *Average time delay values.*

Day	Average Time Delay in Seconds
Day 1	0.047
Day 2	0.057
Day 3	0.037
General Average	0.047

We have used NIS network configurations to measure the performance of proposed NTP time transfer system. The results show a measurement uncertainty (37 µs). also, the result indicates that other sources of uncertainty, such as client instability, asymmetry in network interface cards, and server instability, become visible when network latency is removed. The primary cause of uncertainty seems to be the delays that network components introduce during request reception. Though these uncertainties may be regarded as the practical limit of NTP time transfer for most purposes, they might be further enhanced with hardware and software that is better tuned for time transfer, Table 3 shows uncertainty measurement result of the proposed system practical experimental.

Table 3: *Uncertainty measurement result of the proposed system.*

Average Measured Time Delay (ms)	Standard Deviation (STDEV)	Uexp.
47 ms	23.7 µs	37 µs

The discussion focuses on two main aspects: the use of Coordinated Universal Time (UTC) and the challenges faced by local time in Egypt. Coordinated Universal Time (UTC) is the primary time standard around the world and is used by many organizations and countries. It provides a consistent reference point for timekeeping, ensuring synchronization across different areas. The discussion indicates that Coordinated Universal Time (UTC) is not adjusted to coincide with daylight saving time and is about 1 second ahead of mean solar time at 0 degrees longitude. It also highlights the importance of Coordinated Universal Time (UTC) in areas such as aviation, maritime operations, meteorology, communications, and Internet standards.

AS Egypt's local time is two hours ahead of UTC , One challenge of disseminating Egypt standard time is the accurate time delay between users and NIS time disseminating system that improved in this work this remove difficulties for companies and organizations operating based in Egypt Time local time.

5 Conclusion

The proposed web-based clock, as the first step of the official time dissemination in Egypt using internet, solves many of the performance related issues related to the conventional time dissemination technique (based on radio broadcasting) used in Egypt till now, as traceability, lack of reliability and accuracy. The complete system setup of the traceable, accurate and reliable web-based clock has been explained in this paper. Also, the work that has been done for enhancing the performance of the national time scale UTC(NIS) is also discussed. Enhancing the reliability, accuracy of the disseminated time using the web-based clock has been considered in details.

Moreover, the proposed NTP time dissemination system has several benefits. By modifying the time delay dynamically in accordance with proposed methodology, the synchronization mechanism remains flexible and adaptable to evolving network circumstances. As a result, it keeps an accurate record of network timing. This adaptive behaviour enables time synchronization and the best possible use of system resources in both typical and highly unpredictable network situations. However, NTP has significant drawbacks. Specifically, when a large number of network devices are connected, the monitoring and adjustment of the delay calculation may result in additional processing overhead, which could affect resource utilization and power budget. For applications where time synchronization is necessary, the benefit of enhanced precision and adaptive behaviour produces exact time reference, notwithstanding certain constraints. This is especially true for distributed systems and communication networks, which gain a great deal from the proposed dynamic time dissemination-based on NTP method's increased reliability. Our method offers a solid means of accomplishing precise time synchronization in a range of practical applications by carefully balancing the trade-offs between computational complexity and synchronization performance. Finally, the proposed NIS web-based clock for time dissemination is traceable to UTC(NIS), accurate and reliable in additional to its enhanced performance that minimizes the delay between the UTC(NIS) source and the customers. The combined uncertainty of UTC(NIS), as published by BIPM time department, is now 7.2 ns as compared to that of UTC(DFNT). But, the accuracy of UTC(NIS) does not exceed 100 ns, as recommended by the CCTF, and outperforms that of UTC(DFNT). The estimated uncertainty of the measured time delay values is 37 µs and this value is less than that of the Australian disseminated time (disseminated by National Measurement Institute (NMI) of Australia) which is close to 100 µs.

In the future, this work can be extended by disseminating Egypt standard time through a range of fixed or real Internet Protocols (IPs) in order to applying automatic adjustment for all operating system-based devices clocks and making it traceable to national time scale of Egypt.

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