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Exploring DNS, HTTP, and ICMP Response Time Computations on Brain Signal/Image Databases using a Packet Sniffer Tool

V. ELAMARAN[1], N. ARUNKUMAR[1], G. VENKAT BABU[1], V. S. BALAJI[1], JORGE GÓMEZ[2], (Member, IEEE), CRISTHIAN FIGUEROA[3], AND GUSTAVO RAMIREZ-GONZÁLEZ[3]

[1]School of EEE, SASTRA Deemed University, Thanjavur 613401, India
[2]System Department, University of Córdoba, Córdoba 14071, Colombia
[3]Telematics Department, University of Cauca, Popayan 190001, Colombia

Corresponding author: Gustavo Ramirez-González (gramirez@unicauca.edu.co)

ABSTRACT Neurological signal processing is of significance not only the physiologist doing research and the clinician investigating patients but also to the biomedical engineer who is needed to collect, process, and interpret the physiological signals by prototyping systems and algorithms for their manipulations. While it is a fact that there does hold immense stuff (material) on the subject of digital neurological signal processing, however, it is dispersed in various scientific, technological, and physiological journals, databases also in various international conference proceedings. Consequently, it is a quite hard, more time-consuming, and often tiresome job, especially to the stranger to the domain. Hence, this study concentrates on how much time would require to access the databases belong to the brain signal/image collections, neurological signals, etc. The sixteen US-based Servers, ten UK-based Servers, and the five Servers from other countries are included in this study. Mainly, the domain name system, hyper text transfer protocol, and the Internet control message protocol query/response times are analyzed using a popular packet sniffer called Wireshark.

INDEX TERMS Brain signal/image, DNS, HTTP, ICMP, packet sniffer, Wireshark.

I. INTRODUCTION

The brain waves (popularly known as EEG) characterize the electrical activity of the brain. A few key points of the structure of the brain are as follows: The cerebrum, the cerebellum, the brain stem, and the thalamus are the main parts of the brain. The cerebrum is partitioned into two hemispheres, detached by a longitudinal groove over which there is a large connective band of fibers (corpus callosum). The cerebral cortex – the exterior surface of the cerebral hemispheres – is devised of neurons in complex and difficult patterns, and divided into regions by sulci (fissures). Underneath the cortex recline nerve fibers that lead to variant parts of the brain and the body [1], [2].

The need for the research of EEG signals emerges from the fact that these brain signals yield a non-invasive diagnostic tool in a wealth of disorders that include anesthesia, coma, sleep disorder, encephalopathy, and epilepsy assessment in intensive care. EEG rhythms agree with the basis of behavior, that is, like sleeping, waking, coma, seizures, level of attentiveness, etc. as shown in Fig. 1 [3], [4].

The primary issue here is that the analysis of the continuous EEG signals. The prevailing idea is to exploit digital signal processing techniques to identify and classify the EEG signals of the constructive essence. To assist the classification of these patterns, feature-extraction is prototyped closely on the mechanism used by an expert neurophysiologist, is adopted. It primarily incorporates of (appropriate) segmentation of the brain wave record into stationary/quasi-stationary chunks and yielding an illustration for each one of them. Consequently, the vital task is to split the EEG signal into stationary/quasi-stationary sections – which can be accomplished efficiently by an adaptive pre-whitening filter owing to Wiener [1].

This study mainly focuses on the different brain signal/image databases throughout the world regarding how fast/quickly access them via the network of networks (Internet). The backbone of the Internet is the Internet Protocol (IP). The IP describes the way in which a group of independent networks can communicate together to form the Internet, i.e., the network of networks. The early Internet researchers found packet switching was essential for the

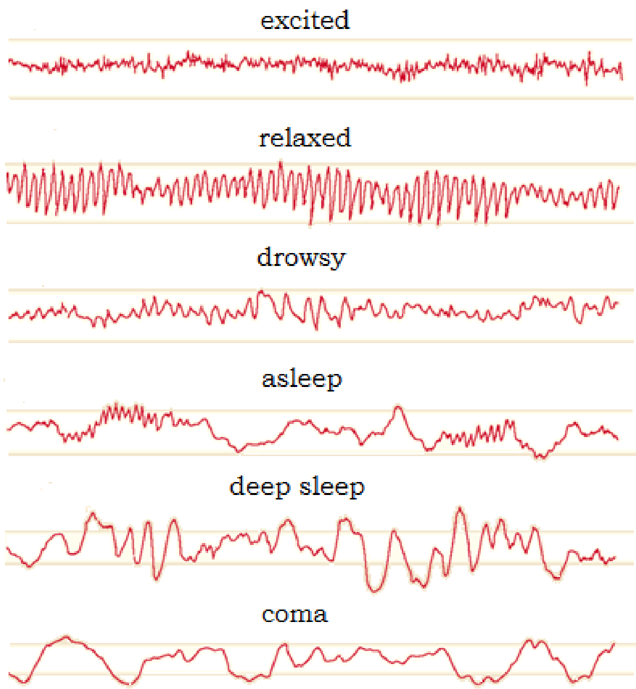


FIGURE 1. Some EEG rhythmic patterns.

computer data communications across the network in contrast to the telephone network where the circuit switching plays a role. By tracing the packets during the network traffic, the network administrators can troubleshoot the network problems or issues, developers can debug the protocol implementations, security engineers can investigate the internet security issues, or anybody to understand how their networks function [5]–[7].

Wireshark, Angry IP Scanner, Zenmap, Colasoft Capsa Free and the Ether Appe are the five free and easy use of IP traffic monitoring tools. Despite there are many free packet tracer tools available, Wireshark is one of the best and popular open source network traffic analysis tool which seizes, unpacks, and shows the contents of network traffic. This tool is broadly used in education and for the industry. This tool can be used as a protocol analyzer, network analyzer, packet sniffer and forensic tool – hence it is called as a multipurpose tool [8]–[11]. Due to the advancements in broadband Internet access and wireless local area networks (WLAN), a home network is quite common in day-to-day life which is designed using wired or wireless modem and one or more computers. The survey says that more than 85% of people in the world use some of form of the home router for their home network. Hence the students and researchers can prefer them (their home network) to learn the computer networking fundamentals in a more practical way using some open source packet sniffer tools [12]–[15].

This paper is organized as follows. Section 2 contains the materials and methods involved in computing the DNS, HTTP, and ICMP response times from the database Servers and Section 3 includes experimental simulation results obtained using Wireshark and Ping command line tool. The conclusions are finally described in Section 4.

II. MATERIALS AND METHODS

Firstly, the survey on brain signal/image database servers throughout the globe are discussed. Subsequently, the methodologies to obtain the DNS, HTTP, and ICMP response times from the servers are discussed in detail.

A. A SURVEY ON BRAIN SIGNAL/IMAGE DATABASE

1) US-BASED DATABASES

The ADNI (Alzheimer's Disease Neuroimaging Initiative) holds an MRI database on Alzheimer's patients records with genomic, biomarker, and clinical data too. The PhysioNet is the most popular research resource with the huge collections of complex physiological signals along with the open-source PhysioToolkit (software). The data.PyMVPA.org server distributes records PyMVPA crew in the context of multivariate pattern analysis in Python – which is maintained by the Center for Cognitive Neuroscience, Datamouth college, USA. The brain-map.org contains the fMRI coordinate database organized by the Allen Institute Publications for Brain Science. The brainmaps.org server holds the high-resolution stained sections from brains. The human neurodegenerative disease database is maintained by the GLIMPS (GLucose IMaging in Parkinsonian Syndromes) project with a huge set of images in a macroscopic level. The NeuroData.io server has the atlases and volumetric datasets with 3D/4D images of various disorders [16], [17].

A NeuroMorph.org comprises contributions of digitally reconstructed neurons from over 400 laboratories around the globe with data sharing support. The SchizConnect is an open, public virtual database about schizophrenia neuroimaging (MRI) datasets with clinical and cognitive assessments. The painrepository.org is another access point for functional, diffusion, and structural MRI datasets with macroscopic level organized by the UCLA Oppenheimer Center for Neurobiology of Stress (CNS). The NeuroImaging Tools and Resources Collaboratory (nitrc.org) holds the collection of neuroimaging resources for structural and functional MRI analyses. The unthresholded statistical maps, atlases, and parcellations of the brain can be publically stored and accessed with interactive visualization in the Neurovault public repository (neruovault.org). The Open Access Series of Imaging Studies (OASIS) – oasis-brains.org – is a project focused on creating neuroimaging datasets of the brain publically available to the research community. The functional and structural MRI datasets of the human brain can be accessed from the OpenfMRI project which has been moved to openneuro.org. The BrainCloud (braincloud.jhmi.edu) is a biologist-friendly and freely available application which supports gene expression in the human prefrontal cortex. The Major Depressive Disorder Neuroimaging Database (MaND) holds the database and meta-analysis information in an Excel spreadsheet file which can be accessed freely from the server (depressiondatabase.org) [16], [17].

2) UK BASED DATABASES

The researchers can learn a lot about brain-computer interfaces (BCIs) from the BNCI (Brain/Natural Computer Interaction) Horizon 2020 project (bnci-horizon-2020.edu) with many EEG datasets. A Dataset for Emotion Analysis using Physiological signals (DEAP dataset) – mainly with EEG signals – distributes a multimodal dataset for the analysis of human brain states which is maintained by Queen Mary and Westfield College, University of London. The complete solutions for clinical Neurodiagnostics and Neuroscience research can be obtained from the commercial organization – the ANT company website (ant-neuro.com) – which focus mainly on the EEG and MEG data. The enormous collection of high-quality, long-term EEG signal recordings are available in the European Epilepsy Database (epilepsy-database.eu). The improvement in detection and decoding of brain waves obtained by EEG signals is the main objective of the Berlin Brain-Computer Interface (bbci.de) which is maintained by the Berlin Institute of Technology, Germany [16], [17].

The design, test and the usage of Brain-Computer Interfaces (BCIs) can effectively be done using the OpenViBE software (openvibe.inria.fr). The MEG data can be obtained from the "Mind Reading Challenge" conducted in the International Conference on Artificial Neural Networks (ICANN – 2011, cis.hut.fi). The different kinds of neuroscience results which are essential for modelling can be obtained from the Collaborative Research in Computational Neuroscience (crcns.org) about humans and other species. The Brede database contains fMRI and Positron Emission Tomography (PET) coordinate records obtained from PET scanners in hendrix.imm.dtu.uk. There are around 600 MR images available for the computational analysis of brain development in the brain-development.org server which is maintained by the Imperial College London [16], [17].

3) DATABASES FROM OTHER COUNTRIES

The 3D reconstruction of a complete brain from cell-body stained histology section images obtained with the highest resolution at 20 μm is available only for research in the bigbrain.loris.ca. The aim of the NeuroElectro project (neuroelectro.org) is to reproduce information about the electrophysiological properties of different neuron types from the available literature and keep them into a centralized database. The structural MRI volumes, the multimodal data (EEG, cell and field recordings), and the demographics can be obtained for education and research purposes from the Open MEG Archive (OMEGA) from mcgill.ca server which is maintained by McConnell Brain Imaging Centre from Canada. The ECoG public domain datasets are available from neurotycho.org without registration only for academic and research purposes. The Brain Machine Interface Platform (BMI-PF) contains BCI-related data which are handy for academic, research and experimental purposes [16], [17].

B. DNS RESPONSE TIME COMPUTATION

The main role of the Domain Name System (DNS) protocol (Layer 5 in TCP/IP) is to obtain the IP address of the given host name. The DNS lies on the top of the User Datagram Protocol (UDP, Layer 4 in TCP/IP) rather than Transmission Control Protocol (TCP) due to many DNS query interactions among the DNS servers to get the response as shown in Figure 2. For example, to obtain the IP address of the "physionet.org" server, the DNS query can be propagated as follows: Laptop – to – local DNS server; then local DNS server – to – root DNS server to get the information about org DNS server; then the local DNS server – to – org DNS server to obtain the information about the authoritative DNS server; then the local DNS server – to – authoritative DNS server in which the IP address of "physionet.org" (128.30.30.88) is available. Then, this DNS response is propagated back to the local DNS server, and this IP address is propagated back to the client finally from the local DNS server [7].

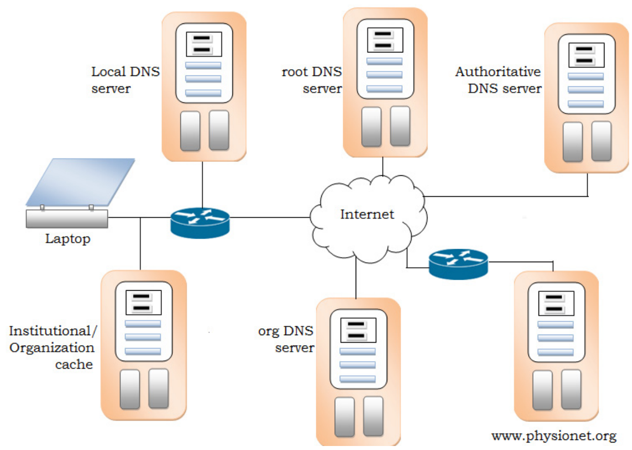
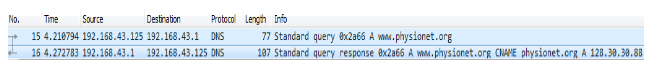


FIGURE 2. DNS query/response activities.

1) DNS RESPONSE TIME COMPUTATION USING WIRESHARK

In practice, in this study, the DNS response time is computed using the Wireshark tool. For example, the query to obtain the IP address of the server "www.physionet.org" and the response from the server snapshots are shown in Figure 3. It reveals that there are two answer resource records (RRs) namely the CNAME (canonical name) and the IP address returned as the response to the DNS query. The CNAME is physionet.org; the IP address is 128.30.30.88. The response time (61.989 ms) is displayed by selecting the packet number 16 as shown in Figure 4.



No.	Time	Source	Destination	Protocol	Length	Info
15	4.210794	192.168.43.125	192.168.43.1	DNS	77	Standard query 0x2a66 A www.physionet.org
16	4.272783	192.168.43.1	192.168.43.125	DNS	107	Standard query response 0x2a66 A www.physionet.org CNAME physionet.org A 128.30.30.88

FIGURE 3. DNS query and its response.

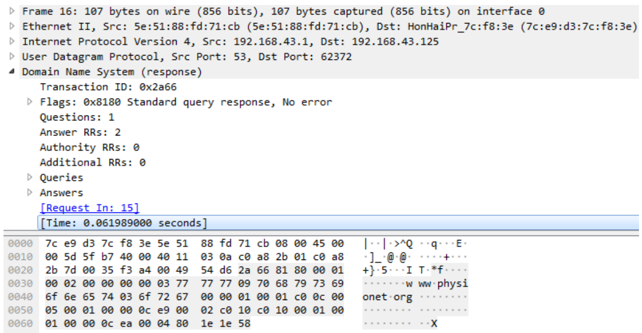


FIGURE 4. DNS response with answer RRs and the response time.

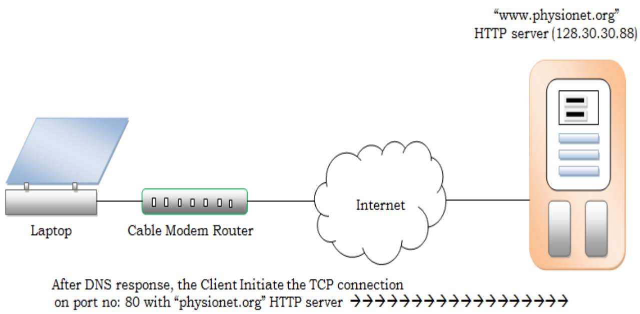


FIGURE 5. Client initiates the TCP connection the Server "www.physionet.org".

C. HTTP RESPONSE TIME COMPUTATION

Once the IP address of the remote server is identified using DNS protocol, the Client can initiate the TCP connection on the port number "80" of the server as shown in Figure 5. Then the Server may acknowledge this request to the Client; hence the one round-trip time (RTT) is involved in this action. Then again the Client may send again the acknowledgment plus the web page request to the Server. The server may respond to the query raised by the Client with one more RTT. Finally, the transmission time involved which depends on the file size or the number of objects involved in the requested web page. Figure 6 portrays the above-said sequence of activities [6], [7].

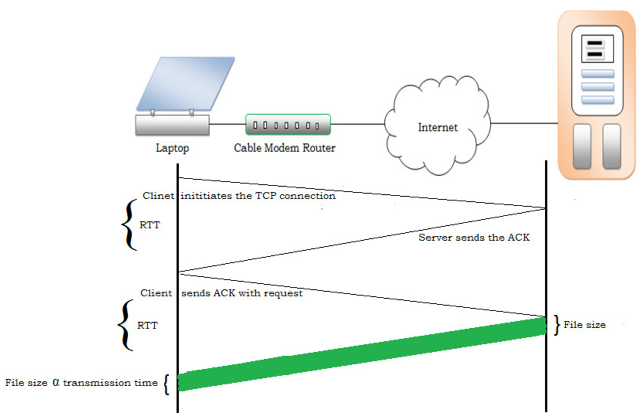


FIGURE 6. Client initiates the TCP connection the Server "www.physionet.org".

1) HTTP RESPONSE TIME COMPUTATION USING WIRESHARK

In practice, in this study, the HTTP response time is computed using the Wireshark tool. For example, the query to obtain the web page from the server "www.crcn.ulb.ac.be" – Center for Research in Cognition and Neurosciences and the response from the server snapshots are shown in Figure 7. In Figure, the packet number 82 is the HTTP GET request; the packet number 134 is the HTTP OK message with the response time as 894.861 ms.

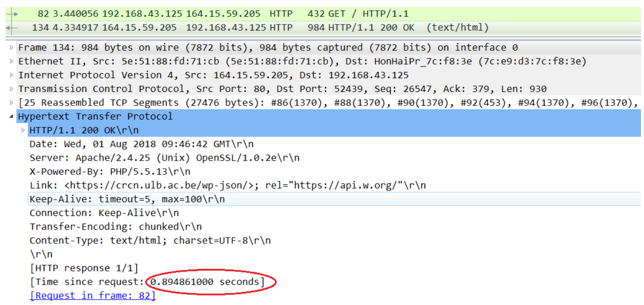


FIGURE 7. HTTP request and its response from the Server "www.crcn.ulb.ac.be".

D. ICMP ECHO/REPLY ROUND-TRIP AVERAGE TIME COMPUTATION

To know the remote Server whether it is reachable or not, the Internet Control Message Protocol (ICMP) echo packets can be sent from the Client; if it is reachable, the ICMP reply/response packets will be sent back to the Clint from the remote Server as shown in Figure 8.

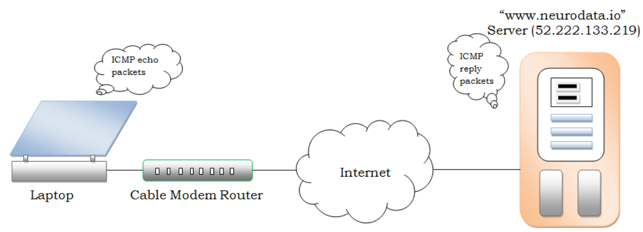


FIGURE 8. ICMP echo/reply configuration.

1) ICMP ECHO/REPLY ACTIVITY USING PING

The average ICMP echo/reply round-trip time is computed using the Ping command line tool. By default, this application will send the four ICMP echo packets to the remote Server from the Client and will receive the four ICMP echo reply/response packets back to the Client from the Server. This is illustrated in Figure 9 with the Server "www.neurodata.io". Also, these packets are captured using Wireshark tool in [6, 7, Fig. 10].

2) ICMP ECHO/REPLY ROUND-TRIP AVERAGE TIME COMPUTATION USING PING

To calculate the average round-trip time involved in the ICMP echo/reply activity, rather than the default four ICMP request

```
C:\>ping www.neurodata.io

Pinging neurodata.io [52.222.133.158] with 32 bytes of data:
Reply from 52.222.133.158: bytes=32 time=90ms TTL=242
Reply from 52.222.133.158: bytes=32 time=88ms TTL=242
Reply from 52.222.133.158: bytes=32 time=85ms TTL=242
Reply from 52.222.133.158: bytes=32 time=79ms TTL=242

Ping statistics for 52.222.133.158:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 79ms, Maximum = 90ms, Average = 85ms
```

FIGURE 9. ICMP echo/reply packets with the Server "www.neurodata.io" using Ping command.

No.	Time	Source	Destination	Protocol	Length	Info
2	0.228…	192.168.4…	52.222.13…	ICMP	74	Echo (ping) request id=0x0001, seq=21/5376, ttl=128 (reply in 3)
3	0.318…	52.222.13…	192.168.4…	ICMP	74	Echo (ping) reply id=0x0001, seq=21/5376, ttl=242 (request in 2)
4	1.286…	192.168.4…	52.222.13…	ICMP	74	Echo (ping) request id=0x0001, seq=22/5632, ttl=128 (reply in 5)
5	1.375…	52.222.13…	192.168.4…	ICMP	74	Echo (ping) reply id=0x0001, seq=22/5632, ttl=242 (request in 4)
6	2.354…	192.168.4…	52.222.13…	ICMP	74	Echo (ping) request id=0x0001, seq=23/5888, ttl=128 (reply in 7)
7	2.439…	52.222.13…	192.168.4…	ICMP	74	Echo (ping) reply id=0x0001, seq=23/5888, ttl=242 (request in 6)
9	3.426…	192.168.4…	52.222.13…	ICMP	74	Echo (ping) request id=0x0001, seq=24/6144, ttl=128 (reply in 10)
10	3.505…	52.222.13…	192.168.4…	ICMP	74	Echo (ping) reply id=0x0001, seq=24/6144, ttl=242 (request in 9)

FIGURE 10. ICMP echo/reply packets with the Server "www.neurodata.io" using Wireshark.

packets, here the hundred ICMP request packets are sent to the Server from the Client. Also, the hundred ICMP response packets arrive at the Client from the Server. The portion of this scenario is illustrated in Figure 11.

```
C:\>ping www.neurodata.io -n 100

Pinging neurodata.io [52.222.133.219] with 32 bytes of data:
Reply from 52.222.133.219: bytes=32 time=93ms TTL=242
Reply from 52.222.133.219: bytes=32 time=101ms TTL=242
Reply from 52.222.133.219: bytes=32 time=304ms TTL=242
Reply from 52.222.133.219: bytes=32 time=112ms TTL=242
Reply from 52.222.133.219: bytes=32 time=183ms TTL=242
                              •
                              •
                              •
Reply from 52.222.133.219: bytes=32 time=451ms TTL=242
Reply from 52.222.133.219: bytes=32 time=388ms TTL=242
Reply from 52.222.133.219: bytes=32 time=336ms TTL=242

Ping statistics for 52.222.133.219:
    Packets: Sent = 100, Received = 100, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 69ms, Maximum = 1304ms, Average = 221ms
```

FIGURE 11. The hundred ICMP echo/reply packets with the Server "www.neurodata.io" using Ping.

III. EXPERIMENTAL RESULTS AND DISCUSSION

For the preliminary discussions, the queries are sent to various Servers throughout the globe from the Client which is located in Southern India. The sixteen US-based Servers, the ten UK-based Servers, and the five Servers from other countries are investigated in this work to compute the DNS, HTTP, and ICMP response times.

A. RESULTS OF DNS AND HTTP RESPONSE TIMES

1) ON US BASED WEB SERVERS

Figure 12 shows the DNS and HTTP response times for the 16 US based servers about brain signal/image and neurological signals. It reveals that the servers such as

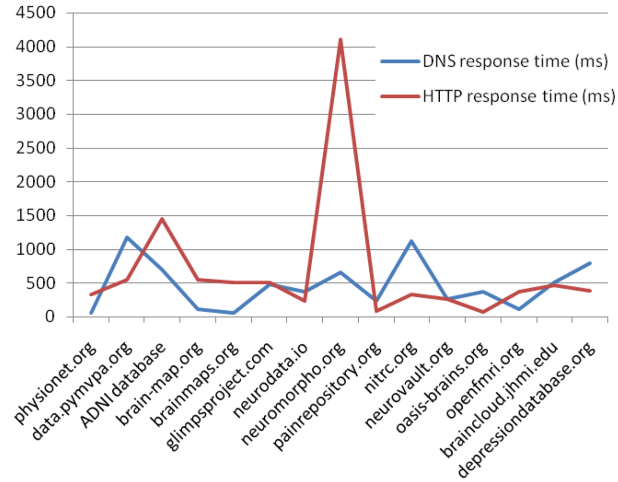


FIGURE 12. The DNS and HTTP response times on US-based Web Servers.

"neuromorphor.org" and the ADNI database require more HTTP response time due to many objects (images, GIFs, etc.) available on the home page. Also, for some servers (oasis-brains.org, painrepository.org, etc.), the DNS response time is higher than the HTTP response time due to the many query/response interactions among DNS servers. And for some servers (neuromorpho.org, ADNI database, etc.), the HTTP response time is greater than the DNS response time due to the nearby located authoritative DNS servers (maybe).

2) ON UK BASED WEB SERVERS

Figure 13 shows the DNS and HTTP response times on UK based Web Servers.

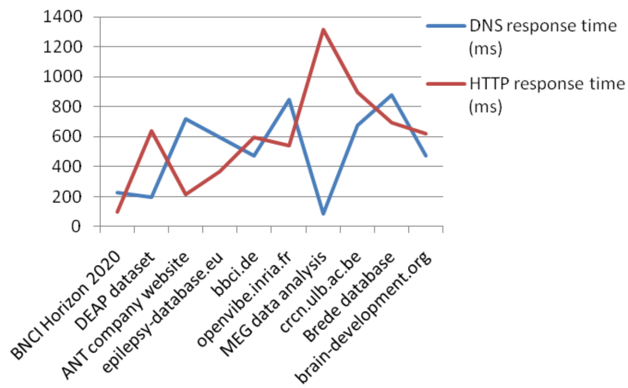


FIGURE 13. The DNS and HTTP response times on UK-based Web Servers.

3) ON OTHER COUNTRIES BASED WEB SERVERS

Figure 14 shows the DNS and HTTP response times on other countries based Web Servers.

B. RESULTS OF ICMP ECHO/REPLY AVERAGE TIMES

1) ON US-BASED WEB SERVERS

The 100 ICMP echo packets are sent to the Web Servers, and the ICMP reply packets are propagated back to the Client

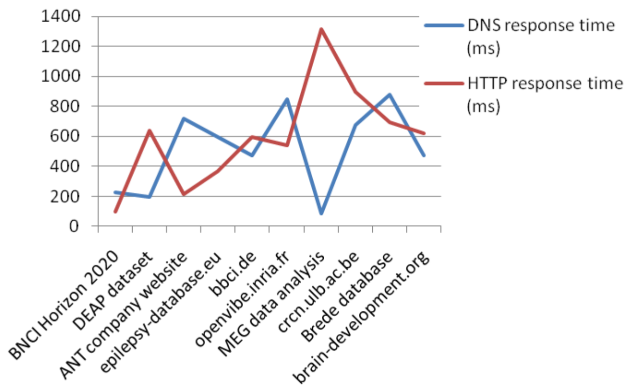


FIGURE 14. **The DNS and HTTP response times on other countries based Web Servers.**

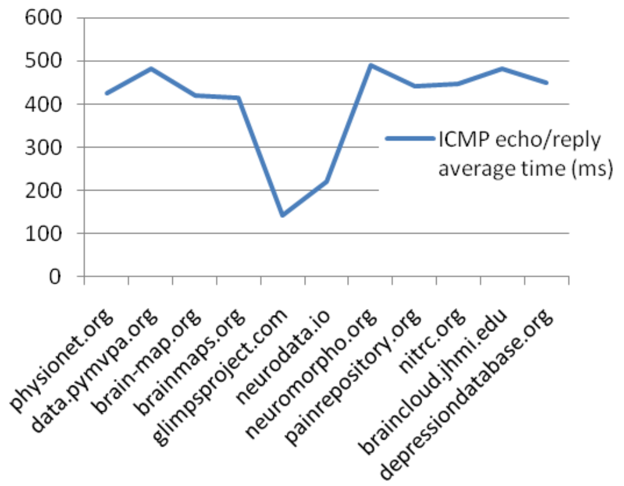


FIGURE 15. **The ICMP echo/reply average round-trip time on US-based Web Servers.**

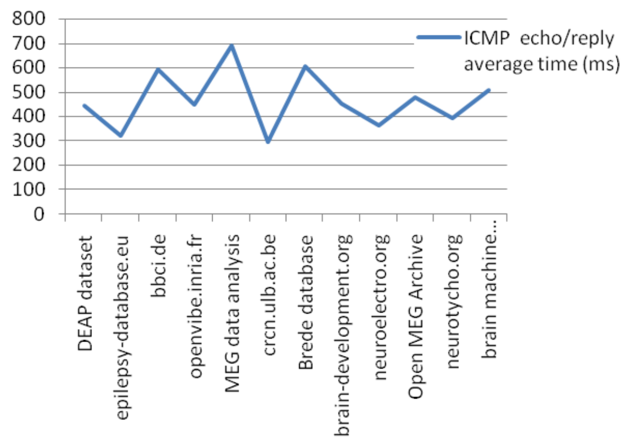


FIGURE 16. **The ICMP echo/reply average RTT on the UK and other countries based Web Servers.**

from Server to obtain the average time. Figure 15 shows the ICMP echo/reply average times for the eleven US-based servers. The lowest and the highest average time are obtained from the limpsproject.com and the neuromorpho.org Servers respectively. Also, results reveal that the other five US-based Servers namely ADNI, neurovault.org, oasis-brains.org, and openfmri.org do not support (accept) ICMP packets even though the Servers are active due to the security reasons.

2) ON UK AND OTHER COUNTRIES BASED WEB SERVERS

Figure 16 shows the ICMP echo/reply average times for the twelve servers (eight UK-based and four other countries based). The other Servers namely BNCI Horizon 2020, ANT company website, and bigbrain.loris.ca Servers do not support (accept) ICMP packets even though the Servers are active due to the security reasons.

IV. CONCLUSION

This study would help the research community to collect physiological signals, brain signals/images from the various Servers located throughout the globe which are the most important part for them. Also, the nuances involved in obtaining the IP addresses of the Servers through DNS protocol, the procedure behind sending an HTTP request and receiving the HTTP response, and the ICMP echo/reply packet scenarios are discussed in detail with relevant diagrams which may be handy for the buddy networking engineers too to understand the concept.

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V. ELAMARAN was born in Srivilliputhur, India, in 1977. He received the B.Eng. degree in electronics and communication engineering from Madurai Kamaraj University, Madurai, India, in 1998, the M.Eng. degree in systems engineering and operations research from Anna University, Chennai, India, in 2007. He submitted his master's thesis at SASTRA Deemed University, Thanjavur, India, in 2018. He has held lecturing positions at the Anand Institute of Higher Technology, Chennai, and Easwari Engineering College, Chennai, for several years. He was an Assistant Professor at Aurora's Scientific, Technological and Research Academy, Hyderabad, India, from 2007 to 2010. He is currently an Assistant Professor with SASTRA Deemed University, Thanjavur, India. He is a Life Member of the Indian Society for Technical Education (ISTE) and the Indian Society of Systems for Science and Engineering (ISSE).

N. ARUNKUMAR is currently with SASTRA University and is active in research. He has published several papers in engineering streams in various top journals. He has been guiding several students from various countries in their research works.

G. VENKAT BABU received the B.E. degree in electronics and communication from Bharathidasan University, Trichy, the M.E. degree in microwave communication and RADAR from Dr. Bhimrao Ambedkar University, Agra, India, and the Ph.D. degree in electronics and communication from Bhagwant University, Ajmer, India. He is currently an Assistant Professor with the Department of Electronics and communication, SEEE, SASTRA Deemed University, India. He has an academic experience of about 16 years. His research is related to reconfigurable antenna and RF-MEMS. His publications include seven journals, five international conferences, and five national conferences. He has co-authored a book in the field of electromagnetic fields. He is a Life Member of IETE and ISTE.

V. S. BALAJI was born in Mayiladuthurai, India, in 1976. He received the B.E. degree in electrical and electronics engineering from the University of Madurai Kamaraj, Madurai, through Mepco Schlenk Engineering College, Sivakasi, India, in 1999, and the M.Tech. degree in biomedical signal processing & instrumentation from SASTRA Deemed University, Thanjavur, India, in 2002, and the Dr. Phil. degree from SASTRA Deemed University in 2017. In 2003, he joined the Department of Electronics & Instrumentation Engineering, SASTRA Deemed University, as an Assistant Professor. His current research interests include biomedical signal processing, control systems and system identification. He is a Life Member at the Indian Society for Technical Education, Biomedical Engineering Society of India, and a Life Member at the Indian Society of Systems for Science & Engineering. He has published 16 articles in Scopus Indexed Journals and five articles in Science Citation Indexed-E journals in the area of biomedical signal processing, image processing, control systems and sensors, and signal conditioning.

JORGE GÓMEZ (M'15) received the B.S. degree in system engineering from San Martín University Foundation, Colombia, in 2006, and the M.S. degree in telematics engineering from the University of Cauca. He is currently pursuing the Ph.D. degree in ICT with the University of Granada, Spain. He is a Professor and also a Researcher with the Department of System, University of Córdoba. He has participated in national and international projects in Colombia. His subjects of interest are the Internet of Things, systems of context awareness, and SDN. He has published several research papers in reputed journals.

CRISTHIAN FIGUEROA received the B.S. degree in electronics and telecommunications engineering, the M.Sc. and Ph.D. degrees in telematics from the Universidad del Cauca, Colombia, in 2008, 2012, and 2017, respectively, and the Ph.D. degree in informatics and systems engineering from Politecnico di Torino, Italy, in 2017. He is an experienced researcher, who has participated in national and international projects in Colombia and Italy. He is currently a Teacher and a Researcher with the Department of Telematics, Universidad del Cauca. His research interests include semantic web, recommender systems, machine learning, mobile information systems, IoT, and business process discovery.

GUSTAVO RAMIREZ-GONZÁLEZ received the B.S. degree in electronic and telecommunications engineering from the University of Cauca, Colombia, in 2001, and the M.S. degree in telematics engineering from the University of Cauca, and the Ph.D. degree in telematics engineering from the Carlos III University in Spain, in 2010. He is currently a Professor and also a Researcher with the Department of Telematics, University of Cauca. He has participated in national and international projects in Colombia and Spain. His research interests include image processing, secure communication, machine learning, and IoT. He has published several research papers in reputed journals and served as a Guest Editor for several special issues at many journals.