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MEDICAL VIDEOS AND IMAGES MANAGEMENT SYSTEM IN GRID ENVIRONMENT

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ABSTRACT
Nowadays, most of the medical videos and images are migrating from one dimensional (1D) (e.g. cardiograms and encephalograms) and two dimensional (2D) (e.g. x-rays) images into three dimensional (3D) (e.g. tomography) and eventually four dimensional (4D) (3 spatial dimension + time) images. The improvement in those medical images and videos has also increased their volume size on the computer disk. Thus, a huge data storage is required for storing and managing them. In this paper, a medical data storage named the Academic Grid together integrating with Exponential-and-Uniform-based Splitting Technique is introduced to reduce data transmission time and merge the storage.

Keywords: medical videos and images, grid computing, framework, network.

INTRODUCTION
Nowadays, images and videos have become most important to some fields, such as the news broadcasting (news, shows, series, etc.), advertising, educational learning, and also the medical applications (Toharia, Sánchez, Bosque, & Robles, 2008). In medical area, most of the images and videos are migrating from one dimensional (1D) (e.g. cardiograms and encephalograms) and two dimensional (2D) (e.g. x-rays) images into three dimensional (3D) (e.g. tomography) and eventually four dimensional (4D) (3 spatial dimension + time) images (Castiglione *et al.*, 2015; Chong & Rohaya Latip, 2011). However, the improvement in those medical videos and images has also increased their volume size on the computer disk.

To overcome the size increment on the medical data, there are a lot of investigations and researches done during these few years. One of the popular researches work is on the compression technique. Castiglione *et al.*, 2015 is one of the research paper that work on the compression technique for the medical data. In their research, they adapted a well-established 2-D predictive approach called Median Edge Detector (*MED*) predictor (Carpentieri, Weinberger, & Seroussi, 2000) and a modified version of the Linear Predictor (*LP*) (Rizzo, Carpentieri, Motta, & Storer, 2005) for the medical images compression.

Fang, Li, Kang, Izatt, & Farsiu, 2015 is another paper that work on compression technique too. In their paper, they introduced a novel general-purpose compression method for tomographic images, termed 3D adaptive sparse representation based compression (3D-ASRC). They focused on the applications of 3D-ASRC for the compression of ophthalmic 3D optical coherence tomography (*OCT*) images. Min & Sadleir, 2011, another researchers that introduced an efficient segmentation based lossless compression technique for used with the abdominal CT datasets. In the paper of Hwang, Chine, & Li, 2003, they were introduced a novel medical data compression algorithm, called layered set partitioning in hierarchical trees (*LSPIHT*) algorithm, which is used for the telemedicine applications. However, from previous studies, we found that using the compression technique on the medical data is not a good choice due to the image quality of the data will be reduced.

Since a large data require a huge data storage for storing and managing, thus, besides doing research on the data compression technique, some of the research projects also work on the storage part. Grace, Manimegalai, & Kumar, 2014, is one of the research projects that work on the storage part. They proposed a grid architecture that uses the Apache Hadoop framework and also using the texture based Content Based Image Retrieval (*CBIR*) algorithm for efficient image retrieval in the system. In the paper of Hani, Paputungan, Hassan, Asirvadam, & Daharus, 2014, they presented a private cloud storage design and prototype that implemented on OwnCloud cloud storage framework.

Wan & Sankaranarayanan, 2013, they proposed a system that employing a mobile cloud facilitating storing of Electronic Medical Records (EMR) which also enables data retrieval using mobiles. They also focused on the design of mobile data exchanging and data processing using information system approach. In the paper of Y. Jin, Deyu, & Xianrong, 2011, they were introduced the cloud storage mechanism for electronic medical records. They proposed a distributed storage model that is not limited to storage capacity for electronic medical records based on *HBase* according to *HL7*.

As a summary, there are still a lot of challenges in the medical data and its storage needs to be solved. Thus, from the previous studies, to solve on the storage problem and maintain the quality of the medical data, we decided to propose a framework of the grid based medical data storage with a splitter, which is using the Exponential-And-Uniform-based Splitter to split the medical data (e.g. Echocardiography data) into chunks and using the Academic Grid Environment to store these huge number of chunks.

BACKGROUND

In this section, we briefly explain what is the grid computing and the challenges in grid computing. Besides, due to the medical management system is integrated with the Academic Grid Malaysia, the background of Academic Grid Malaysia will be described in this section too.

What is grid computing?

Grid computing is an architecture that combines all the heterogeneous and shared network connection resource to solve the large-scale of scientific, execute technical or business data or tasks. These heterogeneous shared resources are including the devices of disk drives, mass storage, and other utilities. Due to the reason of public collaborations across many companies and networks, generally the size of the grid computing is large and growing.

Nowadays, this technology has been applied in many research fields, such as the scientific field (Dabas & Arya, 2013), mathematical field or even the academic field. In the commercial enterprises, grid computing has been used for drug diagnostics applications (Lee & Park, 2014), protein folding applications (Desell *et al.*, 2010), financial modeling applications (DAWSON, Rick, Joseph, & Seaman, 2014), earthquake simulation applications (Cinquini *et al.*, 2014; Cossu *et al.*, 2010; Dabas & Arya, 2013; Fernández-Quiruelas, Fernández, Cofiño, Fita, & Gutiérrez, 2011; Renard, Badoux, Petitdidier, & Cossu, 2009), climate or weather modeling applications (De & Nationale, 2014; Sper de Almeida, 2012), medical videos and images applications (Amendolia *et al.*, 2004; Benkner *et al.*, 2004; Camarasu-Pop, Cervenansky, Cardenas, Nief, & Benoit-Cattin, 2010; Chong & Rohaya Latip, 2011; Grace, Manimegalai, & Kumar, 2014; Krefting *et al.*, 2009; Warren *et al.*, 2007) and other applications.

However, there are some challenges faced by the grid computing now. As what presented in the papers of Hussin & Latip, 2013 and Sadashiv & Kumar, 2011, resource in the grid are owned and managed by more than one organization. Thus, when there is a resource enter or leave the grid, it will become burden for the grid. Besides the challenge on the resources, administration also face a big challenges in grid. To form a unified resource pool, a heavy system administration burden is raised along with other maintenance work to coordinate local administration policies with global ones (Sadashiv & Kumar, 2011). For others challenges include the development issues, the financial issues, and the heterogeneity issues.

What is academic grid?

Academic Grid also called as A-Grid, is a learning and discovery grid. It aims to let the academic staffs, research officers or assistants, and postgraduate students work on the grid facilities. More than 3 Terabytes of storage spaces are available to the grid users for storing their data inside the Academic Grid Storage. The members of the Academic Grid Malaysia are including the Biruni Grid of Universiti Putra Malaysia, the Crystal Grid of University Malaysia, and the Grid of Universiti Teknologi Malaysia.

There are 4 layers inside the Academic Grid, which are the Network Layer, Resources Layer, Middleware Layer, and Application and Serviceware Layer. In the Network layer, it is the layer that contains the switches or routers. For the Resources Layer, is related to the storage, sensor, supercomputer and other resource. A Middleware Layer commonly involving the Grid Information Service and also the security services. Lastly, for the Application and Serviceware Layer, it is normally a layer that provides the services to the end users.

MEDICAL VIDEOS AND IMAGES MANAGEMENT FRAMEWORK

There are some important components in the medical videos and images management framework, such as the video splitter for use to split the video data before transmitting through the network, Virtual Organization Management System for authenticating the users' identity and Grid Information Service System for checking the status of each Grid Storage Node. Figure-1 shows the details of this framework.

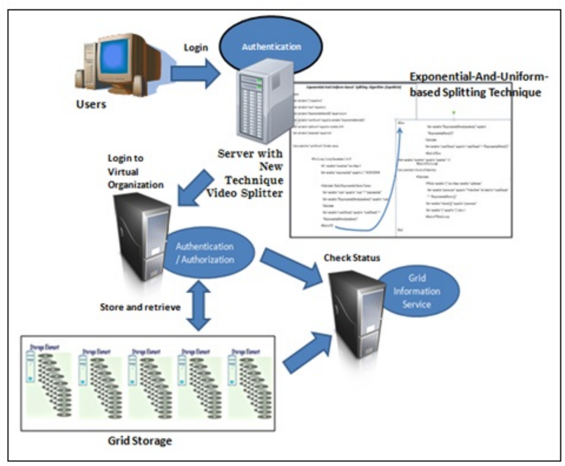

Figure-1. Components in this framework.

The medical videos and images management framework was run on Academic Grid in Universiti Putra Malaysia (UPM). This framework will use the terabyte storage under the Academic Grid to store the medical data. A Secure Shell 2 (SSH2) channel is used to connect to the Academic Grid. However, when connecting to the Academic Grid Storage, a valid user certificate is required by the Virtual Organization Management System (*VOMS*) to verify the user's identity. Figure-2 is the statement that is used for invoking the verification query inside the Academic Grid *VOMS*.

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```
"$stream = ssh2_exec($con, "voms-proxy-init --voms academicgrid -pwstdin < pass.txt");"
```

Figure-2. Invoke the verification query inside the academic grid *VOMS*.

After confirming the identity of the user, the medical data will be sent to the Workload Management System (*WMS*) for further replication and storing process. The reason to have replication process is to enhance the availability of the data in the grid storage. Thus, when a grid storage is failure, the data still can be retrieved from other grid storage. The availability status of each Grid Storage Element (*SE*) will publish in the Grid Information Service System (*IS*). During the retrieval process, the Workload Management System (*WMS*) will find the medical data from the nearest and available grid storage and sent back to the user's personal computer for viewing or storing.

Integration of the exponential-and-uniform-based (*ExpoNUni*) splitting technique in framework

To reduce the data transmission time, in the video splitter of this framework, a "Exponential-And-Uniform-based (*ExpoNUni*) Splitting Technique" is introduced. By using this splitting technique, the framework are able to reduce the delay time. Below is the algorithm for this splitting technique:-

Algorithm of Exponential-and-Uniform-based (ExpoNUni) Splitting Technique

Step 1 : Start

Step 2 : Initialized all the related variables

Step 3 : *Calculate Each Exponential Series Terms*

Set *Exponential[0]* equal to e^0,
where is $e^0 = 2.71828182846$

For Loop: Loop 1 to *N-1*,
where *N* is the number of chunks

If *x* less than or equal to 3
Exponential[x] = Exponential[x-1] e^0
Else
Exponential[x] = Exponential[3]
EndIf

EndForLoop

Sum = Sum + (*N* - 4) Exponential[3]

Step 4 : *Calculate the total value of divider,*
$\sum_{x=0}^{3} F(x) + (n-4)(F(3))$

For Loop: Loop 0 to *3*

Sum = Sum + Exponential[x],
where *x* start from 0

EndForLoop

Step 5 : *Calculate Each Chunk of Data Size,*
$V^x = G(x) * \frac{V}{\sum_{x=0}^{3} F(x) + (n-4)(F(3))}$

While *x* less than *N*, *x=0*

V^x = Exponential[x] * VideoSize (*V*) *divide by* Sum

EndWhileLoop

Step 6 : *Split into Chunks by following the Data Size of* V^x

While VideoSize (*V*) not equal to 0 and *x* less than or equal to *N*

Chunk[x] equal to V^x of video data
VideoSize (*V*) = VideoSize (*V*) - V^x

EndWhileLoop

Step 7 : Stop

Figure-3. Algorithm of exponential-and-uniform-based splitting technique.

Figure-3 shows the algorithm for the Exponential-and-Uniform-based (*ExpoNUni*) Splitting Technique. Initially, all the related variables will be set. Then, each term of the Exponential-and-Uniform-based Series will be calculated, such as *Exponential [0]* = e^0, *Exponential[1]* = e^1, *Exponential[2]* = e^2, *Exponential[3]* = e^3 and etc. However, starting from *Exponential[4]*, all the remaining terms will follow the value of *Exponential[3]*. This is because all the remaining video chunks will be split in uniform.

After that, as illustrated in Step 4, the total sum of the e^0, e^1, e^2 until e^n will be calculated. To simplify the equation of the total sum, we derived an equation, which is $\sum_{x=0}^{3} F(x) + (n-4)(F(3))$. $\sum_{x=0}^{3} F(x)$ is the sum for the e^0, e^1, e^2, and e^3 (first four chunks), while the $(n-4)(F(3))$ is the sum for the remaining Exponential-and-Uniform-based Series.

In Step 5, each chunk of data size will be calculated by using the equation of $V^x = G(x) * \frac{V}{\sum_{x=0}^{3} F(x) + (n-4)(F(3))}$. From the equation of $V^x = G(x) * \frac{V}{\sum_{x=0}^{3} F(x) + (n-4)(F(3))}$, it shows that in order to get the size for every video chunk (V^x), the whole size

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of the video (*V*) will be divided by the equation of $\sum_{k=0}^{n} F(x) + (x_n - 4)(F'(x))$ and then just multiply with each term of the Exponential-and-Uniform-based Series, *G(x)*. Finally, based on the value of V^x, the system will start the video splitting process as illustrated in Step 6.

CASE STUDY: ECHOCARDIOGRAPHY IN GRID-BAESD MEDICAL VIDEOS AND IMAGES MANAGEMENT SYSTEM

To test the medical videos and images framework, the framework is implemented in the real grid environment, which is the Academic Grid Malaysia. Echocardiography is one of the dataset sample that used for testing the framework. This sample of echocardiography data is retrieved from the Hospital UiTM Sungai Buloh and National University of Malaysia Medical Centre (HUKM). Figure-4 and Figure-5 show the sample of echocardiographys from Hospital UKM and UiTM.

Figure-4. Sample from national university of Malaysia medical centre (HUKM).

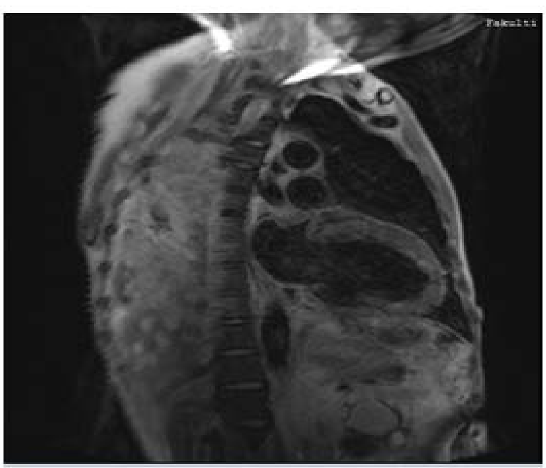

Figure-5. Sample from hospital UiTM Sungai Buloh.

For future integration in the hospital such as Hospital UiTM, a web-based "Medical Data Management System Portal" is developed for the doctors and technicians to access the echocardiography data in the Academic Grid Storage. This portal is providing the upload, download and streaming services for the doctors or technician. Through the web portal, doctors or technicians do not need to go to the reviewing station (which is in the lab) to view the data.

To prevent the usage from unauthorized users, a login page is developed for securing the portal. Users need to register themselves under the administrator first before login. If the registration is successful, the administrator will give them a login id and a password to access the portal. After login to the web portal, user can choose to use anyone of the services that provided. Figure-6 shows the process of how the medical users can access the Academic Grid Storage through this web portal. Figure-7, and Figure-8 are illustrating the latest download interface that was developed for the medical users.

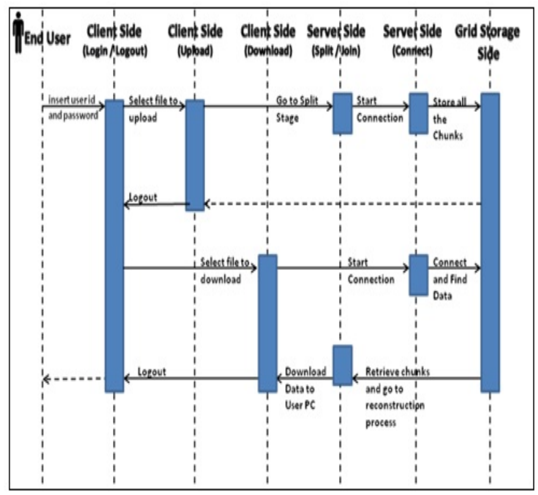

Figure-6. Diagram of web portal's processes.

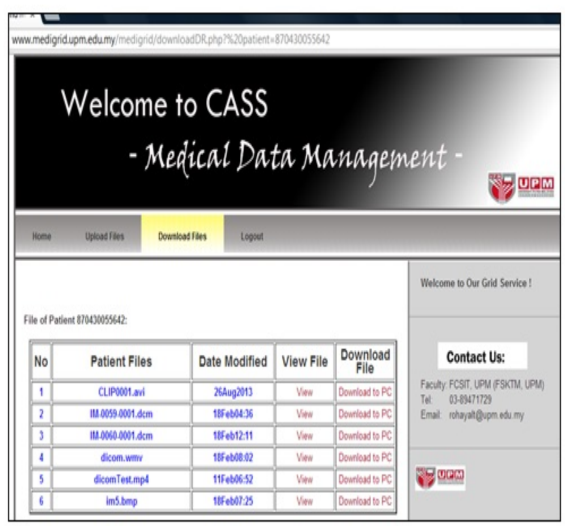

Figure-7. Selected patient’s data list example.

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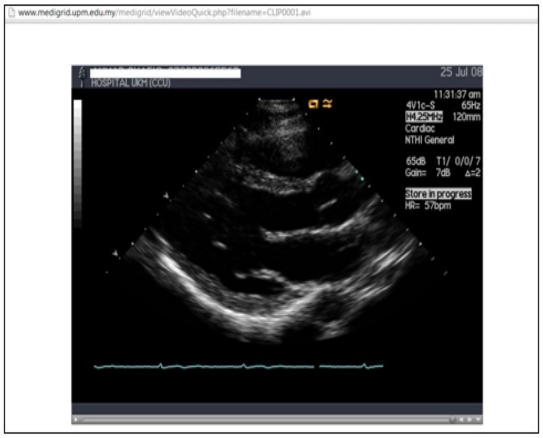

Figure-8. Example of "*streaming process*" in portal.

RESULTS AND DISCUSSION

Quality of the videos and images is one of the important key for medical field. Sometimes, when a data went through some processes such as splitting or reconstructing process, its quality may not be remain the same. For example, the clarity of the data would sometimes be lost (noise) or the pixels in the video would be missing. Since in the framework is integrated with the "Exponential-And-Uniform-based (*ExpoNUni*) Splitting Technique", thus, to ensure that the “*ExpoNUni*” Splitting Technique will not affect the medical data quality, the MATLAB tool is used to analyze the comparison between the original echocardiography data and the split echocardiography data.

Quality of the echocardiography data

For this quality experiment, the evaluation metric is the correlation differences between the original data and the split data. By analyzing the results from the correlation differences, we can determine whether the splitting technique has affected the quality of the split video. Hence, to find out the difference between the two videos, the meanGrayLevel, meanBlueLevel, meanRedLevel and the meanGreenLevel were checked for both the video data.

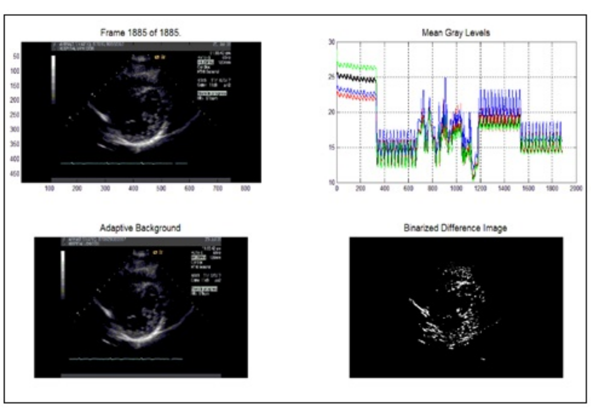

Figure9. Original echocardiography (did not go through the split and reconstruct process).

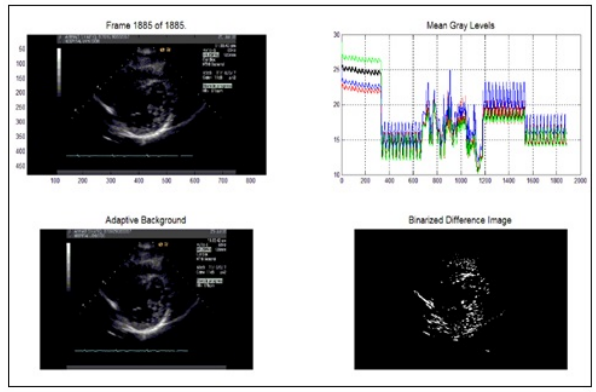

Figure-10. Echocardiography that went through the split and reconstruct process.

As shown in Figure-9 and Figure-10, the result from the MATLAB reveals that there is no correlation difference between the two echocardiography data. Therefore, it can be concluded that the quality of data remains the same. Thus, from this experiment, it can conclude that the “*ExpoNUni*” Splitting Technique does not affect the quality of the medical data. In other words, this particular technique is capable of maintaining the quality of the split medical data.

Upload time and download time

Besides the quality of video images, the data transmission time is also one of the important key that need to be investigated. In this experiments, the upload and download time is calculated. The upload and download time is compared between the system with the splitting technique (our system) and the system that do not have the splitting technique. 100MB to 600MB data were used in the experiments. All the 100MB to 600MB data are split into 4 chunks during the experiments. Figure-10 shows the upload time result (in seconds); while the Figure 11 shows the download time result (in seconds).

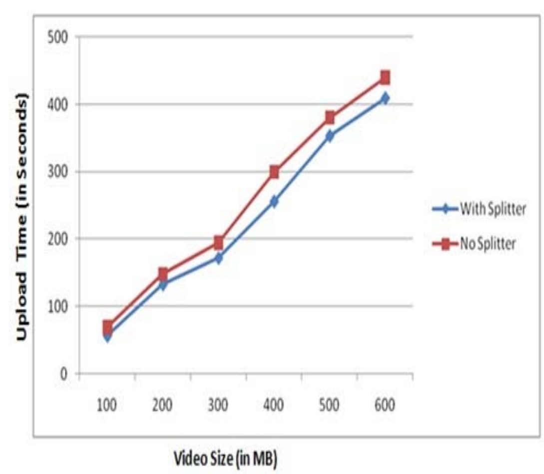

Figure-11. Upload time.

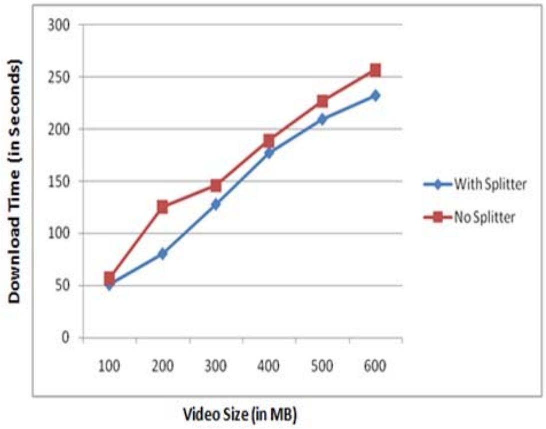

Figure-12. Download time.

As illustrated in Figure-11 and Figure-12, our system is giving the lesser upload and download time, where overall with an average of 9.86% lesser time for the upload time, and an average of 12.24% lesser time for the download time. As a summary, our system is able to reduce the data transmission time.

CONCLUSIONS

As a conclusion, most of the medical images and videos are also migrated from one dimensional (1D) (e.g. cardiograms and encephalograms) and two dimensional (2D) (e.g. x-rays) images into three dimensional (3D) (e.g. tomography) and eventually four dimensional (4D) (3 spatial dimension + time) images. Due to this reason, the size of those medical data also increased. Increasing on the data size also affects the storage. Thus, a small single storage is not capable to store and manage them.

To overcome the storage problem, the medical data in the single-based storage is needed to migrate and store inside the storages of grid computing. Thus, in this paper, a new "Medical Videos and Images Management System" framework is built. Besides, to reduce the data transmission time, a splitting technique named as "Exponential-And-Uniform-based (*ExpoNUni*) Splitting Technique" is used in this framework too.

Since in the framework is integrated with the "Exponential-And-Uniform-based (*ExpoNUni*) Splitting Technique", to ensure this splitting technique will not affect the medical data quality, a quality experiment has been done in this research. Based on the result from the MATLAB tool, it can conclude that the "*ExpoNUni*" Splitting Technique does not affect the quality of the medical data. Besides, from the upload and download time experiments, it also conclude that our system is able to reduce the data transmission time.

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