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Universal Laboratory Networking System (ULabNet)

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Abstract – *The Laser Light Scattering and Materials Science Group (LLSMS) at the University of South Australia (www.unisa.edu.au/laser) has developed sophisticated instrumentation which has been widely used by many researchers from outside the laboratory. To increase convenience and utilization, it is desirable remote users could gain access to the instruments. Here we outline the development and testing of a remote instrumentation solution (ULabNet) which provides a free generic tool to create a remote control capability for laboratory instrumentation systems over a variety of Microsoft Windows platforms.*

Keywords – *virtual laboratory, remote laboratory, virtual instrumentation, light scattering, web laboratory, networked laboratory, Netmeeting, DLS, Dynamic Light Scattering.*

I. INTRODUCTION

An ideal remote instrumentation tool providing generic remote laboratory access should meet these requirements:

- Require no (or minimal) modification to the existing instrumentation hardware and software: A typical instrument control application maintains a high level of complexity (for instance, performing collection and analysis of data). A software alteration may be extensive and either impractical or impossible.
- Operate over diverse platforms: A generic remote instrumentation tool should be platform independent because instrumentation systems are usually installed over a variety of software and hardware combinations.
- Prompt access to remote users: Remote users should obtain access to the shared instrumentation application through an internet enabled computer promptly after the tool is installed.
- Operate transparently: The remote user should operate the system as much as possible as he would if present at the equipment in the laboratory and the application window should look similar and be augmented by audio and video links to the laboratory.
- Provide simultaneous multi-user capability: For orderly execution, the experiment should be run by only one remote user. However, other remote users should have the opportunity to follow the experiment progress (e.g. data collection, data analysis and parameter settings). They should also be able to interact with the remote user currently in control.
- Be low cost: The proposed tool should prove economical to be implemented.
- Be useful for other applications: Although not the specific purpose of this tool, such a general purpose facility could be useful in teaching laboratories by allowing remote access to students.

An examination of currently available applications found that they either do not meet all the requirements outlined above or are expensive commercial products.

II. PROPOSED APPROACH

For the particular case of the Laser Light Scattering Laboratory, the developed system should work on any 32 bit version of Microsoft Windows and adapt to the particular platform based application.

A. The Dynamic Light Scattering System at LLSMS

Although intended as a general tool, ULabNet was developed for a well established and heavily used Dynamic Light Scattering (DLS) system maintained by the Laser Light Scattering and Materials Science group of the University of South Australia. It consists of an Ar+ laser, a digital correlator and an automated goniometer to adjust the required scattering angle (Figure 1).

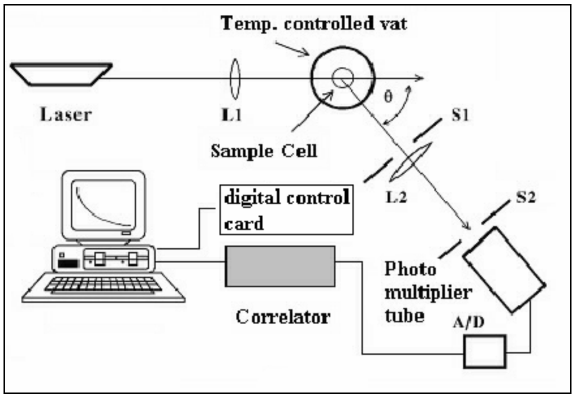

Fig. 1. DLS system block diagram

The lens L1 focuses the laser beam down into the sample which is enclosed in a temperature controlled vat surrounded by refractive index matching liquid. Light scattered at an angle θ is focused onto the photomultiplier tube – which is used as a detector - by lens L2 and pinholes S1 and S2. The uncorrelated data is obtained from the photomultiplier tube to

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a specialized digital correlator via an amplifier discriminator (A/D).

The Correlator Control application software is used to collect and analyze autocorrelation data from the correlator and to access the goniometer digital control card. This control software runs on any 32 bit version of Microsoft Windows. The software controls the correlator and goniometer via a custom digital interface card.

Figure 2 shows a front view of the DLS system. At the back of the table is the Ar^+ laser followed by the lens system which focuses the laser down into the temperature controlled vat with the sample inside. The goniometer rotates the photomultiplier tube that collects uncorrelated data which is sent to the correlator box at the bottom left corner.

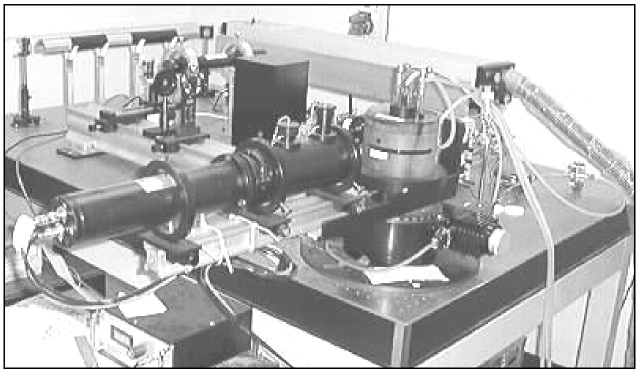


Fig. 2. Instrumentation for Photon Correlation Spectroscopy at the DLS system.

B. *ULabNet system architecture block diagram*

Ideally, the remote access connectivity should be added to the system ‘as is’ (i.e., without modifying the software or installing complementary hardware, other than the internet access). Therefore, the remote laboratory is implemented only by the installation of the software package and an internet connection.

Remote users should connect via a web browser to obtain visible access to a facsimile application window, allowing them to control and browse remote measurement results. Thus ULabNet saves potentially excessive costs and time that would have to be spent by experienced scientist-programmers on rewriting long code (e.g. modifying the control program for the DLS system at the LLSMS originally written in Visual Basic).

ULabNet functions both as a client and as a platform. The client can be invoked in a web page as its components can be embedded, providing an easy access of audio, video, and program sharing.

By using this approach, its users simply access a web page which invokes and properly enables an ActiveX component. In other words, ULabNet does not need to be installed at the client computers but only at the computer that has the control program required to be shared. Figure 3 shows a block diagram of the infrastructure of the system.

As a platform, standards are responsible for interpreting, sending, and receiving data. This architecture supports internetworking protocols that can be used to transport information over the Internet or corporate intranet using Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) connections. While TCP is used primarily for data transport and call control and application program sharing, UDP is used for sending and receiving audio and video. This architecture provides an effective data transfer between ULabNet clients.

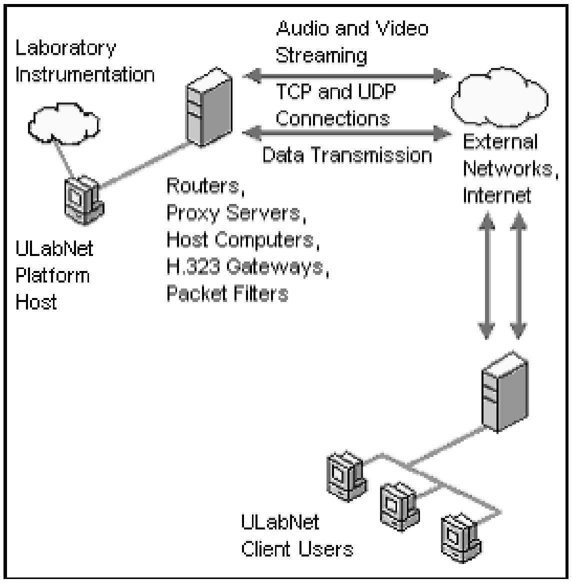

Laboratory Instrumentation
Audio and Video Streaming
TCP and UDP Connections
Data Transmission
External Networks, Internet
Routers, Proxy Servers, Host Computers, H.323 Gateways, Packet Filters
ULabNet Platform Host
ULabNet Client Users

Fig. 3. Implementation of ULabNet connection points

III. CURRENTLY AVAILABLE PLATFORMS

Generally, there are two types of systems which would normally be considered for the remote control of a laboratory setup. The first category and probably the most popular software, LabVIEW (National Instruments Corporation), incorporates a web server (versions above 5.1), allowing remote users to view the front panel of applications from a remote machine by means of an internet web browser (Bitter et al, 2000).

This technology, called “graphic panels”, requires specific implementation for the particular measurement system and could require the use of rather expensive data acquisition and control cards. The only ‘inexpensive’ connection could be arranged through the generic serial and parallel ports. This is quite limiting although the latest version is capable of running via the fast 400Mbps USB2.0 port. The second category of products is uncommitted conferencing platforms offering audio and video streams together with application sharing over the internet. These tools provide an attractive solution for instrumentation running under Windows but which is not designed to run under LabVIEW at the moment.

C. *Application sharing platforms*

Videoconferencing denotes sharing of information in terms of live video images and audio. Collaborative tools use these features and include some others like sharing a message board between two or more participants. An important feature in some collaborative tool products is that they enable the conference participants to share the same application which is being executed at one of the inter-connected machines.

Sharing expensive resources like unique laboratory facilities will help students and researchers to increase their productivity and knowledge, as Brey and Furht (2000) state "Most large corporations have determined that it is in their critical business interest for their workers to have access to educational tools that will help them increase their knowledge level and skill sets".

In accordance with the above, many collaborative tools focus on business purposes (e.g. a presenter sharing ideas with others). However, no specific tool has been developed focusing on the application sharing part of the meeting. ULabNet proposes a new approach to collaborative tools by focusing on application sharing which could be used in instrumentation laboratories.

D. *Relevant standards for collaborative tools*

The International Telecommunication Union (ITU) recommendation T.120 is a conferencing standard which is used for data transfer (Brey and Furht, 2000). As a part of this process, Microsoft submitted Netmeeting (a trademark of Microsoft Corporation) to ITU to form the core of the standard (Microsoft, 2005). Netmeeting could establish a connection to other platforms, as long as they adhere to both standards T.120 and H.323 (Team Solution, 2005).

The T.120 standard. The T.120 specifications describe the data conferencing part of the conference (Black, 2002). The International Teleconferencing Consortium, Inc. (IMTC) is, in particular, concerned with four sets of communications protocols agreed upon by the ITU. These families of protocols are H.320, H.323, H.324 and T.120 which is the core standard for Real Time Data Conferencing (IMTC, 2005).

The T.120 standard was used for the data and remote application sharing; this standard includes the T.127 on file transfer, and T.128 on program sharing standards. Also, the protocols for establishing and managing data flow, connections, and conferences; extra security capabilities for call negotiation and data encryption are handled by T.123 Annex B.

The H.323 standard. The H.323 standard is mainly used to define the signalling needed to set up calls and conferences and codec establishment, while the previous protocol standard RTP/RTCP is used to determine the network quality. The H.323 standard is specified by the ITU, enabling users to participate in the same conference even if using diverse video conferencing applications (Hersent, Gurle & Petit, 2000).

The H.323 standard provides a basis for audio, video communications. Its strong point is that it describes terminals, equipment, and services for multimedia communication over a Local Area Network (LAN) or IP networks independently of software or hardware combinations. By using this standard, many different modes of telephony can be supported by sending and receiving audio and video information to H.323-compatible nodes.

IV. REVIEW OF APPLICATION SHARING TOOLS

Currently there are several applications that, by using the protocols mentioned above, provide conferencing and application sharing capabilities:

A. *IP Nexus*

IP Nexus is a suite of IP network based collaborative tools, it offers: Instant messaging, application sharing, file transfer and video conferencing (Nexus, 2005). IPAppShare is an application sharing tool not based on the T.120 protocol. IP Nexus Complete ranges from 25-1000 logins, with pricing from $12,000-$68,500. Priced per concurrent login (Network World, 2005)

B. *Centra*

Centra software provides basically the same features as IP Nexus; the software provides centralized control and provides Web conferences, sharing applications, audio, video and other enhancements (Centra, 2005). Pricing starts at $92 (U.S.) per month per concurrent seat. For on-premises installations, customers pay starting at $58,000. (Network world, 2005)

C. *VNC*

VNC stands for Virtual Network Computing. VNC (2005) states that it "is a remote control software which allows you to view and interact with one computer using a simple program on another computer anywhere on the Internet". VNC however, does not integrate audio and video connection and advanced security features are available only at the enterprise and personal editions which are not free (VNC, 2005).

D. *Live Communications server 2005*

Microsoft's Live Communications Server 2005 was developed to provide notable improvements in the user experience, particularly in collaboration, it includes an instant messaging and integrated presence solution. Presence awareness is the ability to detect another user's availability on one or more devices.

Microsoft (2005) also states that Live Communications Server supports peer-to-peer audio, video, application-sharing, and data collaboration. However, Live Communications Server 2005 runs only on Windows Server 2003 and requires Active Directory; the new Messenger client runs only on Windows 2000 and Windows XP and costs US$3,154 for the Enterprise Edition

E. Netmeeting

Microsoft Netmeeting is described as a collaboration tool that combines, among other things, voice and data communications, video, real-time application sharing (Microsoft, 2005). It relies on the H.323 and T.120 protocol standards, and offers its Software Development Kit (SDK) license free so it can be expanded / integrated with other applications by using its SDK (Hsu, Sharda & Marques, 2000).

The tools previously mentioned provide efficient application sharing, but their licensing costs makes them uneconomical to implement, with the exception of Netmeeting which is, at the present time, a license free program. However, it has some shortcomings: the program setup is time consuming and it has also shown some security risks, which can threaten users' privacy (Hsu and Sharda, 2000).

V. ADVANTAGES OF ULABNET

A. Conferencing tools scope

There are many remote conferencing programs, but it seems that they all fall into the following two broad categories:

1. Free license (Netmeeting) with limited capabilities, extended at extra cost (VNC, VCS200).
2. Complete video, audio and application sharing solution but costly (Akiba webmeeting, Cata web conferencing, Centra 7, Horizon live, Linktivity).

Although free, Netmeeting provides a reasonably good support and, more importantly, it offers the capability to create a custom application based on its SDK (Software Development Kit). The solution proposed is to create a collaborative application tool which, while based on Netmeeting should offer focused service on application sharing while providing an easy configuration setup.

ULabNet is a generic remote laboratory tool based on Netmeeting. While incorporating a solid video, audio and program application sharing, it maintains portability allowing a number of users after a simple installation. ULabNet is specifically designed for laboratory and research groups who would like to share their control application economically and effortlessly over the internet.

B. Advantages of using the SDK

ULabNet is based on the Netmeeting SDK, which provides a set of standard application programming interfaces (APIs). The computer with the correlator program becomes an internet conferencing server sharing the control application to allowed users.

In addition, the ActiveX control for conferencing is used to embed the Netmeeting user interface directly into their web pages (Microsoft, 2005); the remote users need only to open an internet web page browser to get access. ULabNet is better than Netmeeting in the sense that it does not require the remote user to manually open or configure any other program; the server side configuration is user transparent.

VI. RESULTS

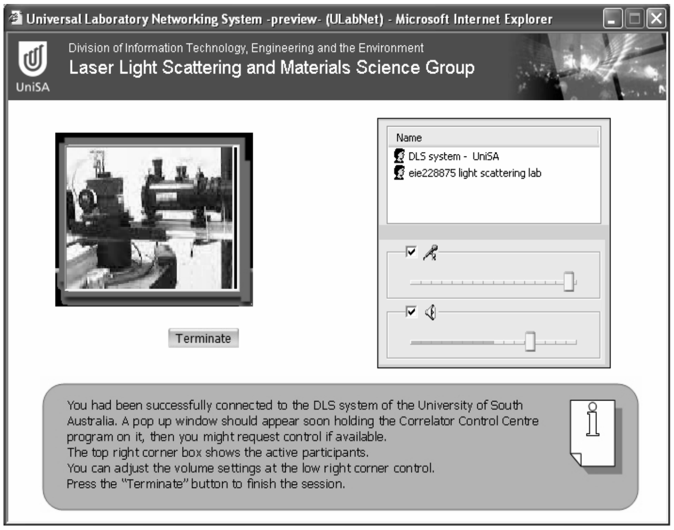
A. The Control Correlator Centre program sharing

This program is the basis of the DLS system used to measure particle size of colloidal dispersions. The DLS executes measurement and analysis of light scattering data and also controls a digital correlator and a goniometer. This software contains complex instrument control routines which cannot be easily re-configured to implement remote access capabilities, and as well as other similar software available at the laboratory, it is required to be available to remote users.

After ULabNet was installed and set up to share the Correlator Control Centre program, remote Users login at the University web page and have access to the DLS system, this implementation is done seamlessly without the time-consuming setup typically needed to install Netmeeting.

B. The ULabNet client

The ULabNet client is the Netmeeting ActiveX control component embedded in a web page. ULabNet relies on this technology so its users simply access a web page invoking the Netmeeting ActiveX component, which at the moment is included on any windows operative system version from 95 and on (Microsoft, 2006). Figure 4 shows a screenshot of the web access of the DLS system implemented on www.unisa.edu.au/laser. This particular web page was fully constructed by using the Netmeeting ActiveX control components.


Universal Laboratory Networking System -preview- (ULabNet) - Microsoft Internet Explorer

Division of Information Technology, Engineering and the Environment
Laser Light Scattering and Materials Science Group

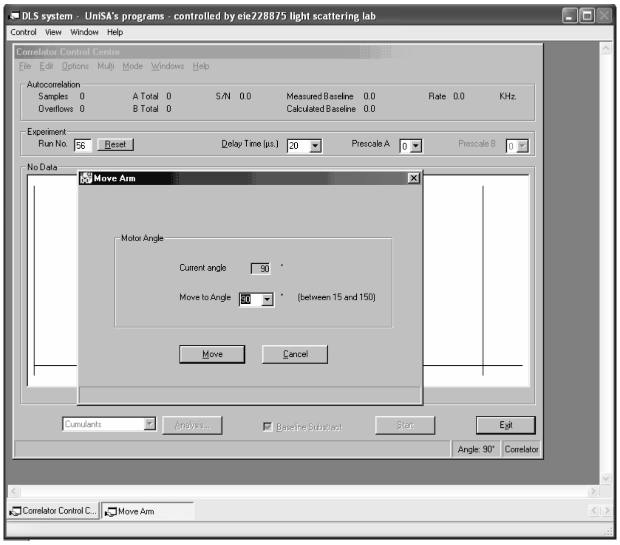
Name
DLS system - UniSA
eie228875 light scattering lab

You had been successfully connected to the DLS system of the University of South Australia. A pop up window should appear soon holding the Correlator Control Centre program on it, then you might request control if available.
The top right corner box shows the active participants.
You can adjust the volume settings at the low right corner control.
Press the "Terminate" button to finish the session.

Fig. 4. ULabNet client implementation of the DLS

The video at the left is live and shows the moving of the photomultiplier tube of the DLS system on real time. The "Name" box shows the users connected to the DLS system. The audio controls on the box allow the user to easily adjust the volume of the incoming audio from the laboratory, as well to adjust the recording level (i.e. the audio sent to the control computer). The box at the bottom shows relevant information about the conference status.

The control application program is then shared remotely and users login and have access to it. ULabNet is then installed to share a different program at the laboratory and then another instrument control application is shared in the same fashion as shown on Figure 5. Data is read and parameters set up while having audio and video feedback from the experiment.


DLS system - UniSA's programs - controlled by eie228875 light scattering lab

Correlator Control Centre

Autocorrelation
Samples 0 A Total 0 S/N 0.0 Measured Baseline 0.0 Rate 0.0 KHz.
Overflows 0 B Total 0 Calculated Baseline 0.0

Experiment
Run No. 56 Delay Time (µs.) 20 Prescale A 0 Prescale B 0

No Data

Move Arm
Motor Angle
Current angle 90 °
Move to Angle 90 ° (between 15 and 150)

Cumulants ☑ Baseline Substract
Angle: 90° Correlator

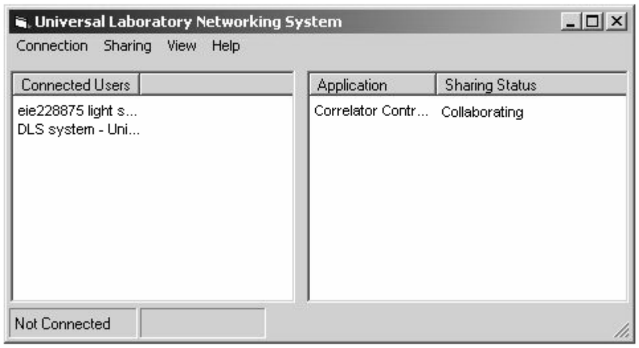
Fig. 5. The shared application window container of ULabNet, implementing the DLS control program

The shared application window container holds the shared applications previously configured on ULabNet; the user obtains access by providing authentication. The set up process was minimal and the same process could be used to offer connectivity to other equipment present.

C. *The ULabNet platform*

ULabNet was developed using software application programming interface (API) from Netmeeting, so that it integrates these conferencing features without the need to load the Netmeeting User interface. One advantage of this architecture is that being based on industry standards, it ensures that services will interoperate even if Netmeeting is not supported in the future. Figure 6 shows a screenshot of the operation of ULabNet. The messages box shows that the remote client (eie228875) successfully connected to the DLS control computer (DLS system).

To access the interfaces and call the methods that the Netmeeting 2.1 COM objects expose, the SDK interface method declarations were included at the ULabNet project, i.e. the application becomes extensible with dynamic component discovery; since those objects are free of charge with no run-time royalties, then ULabNet can access the ActiveX control component embedded at the clients.


Universal Laboratory Networking System

Connected Users
eie228875 light s...
DLS system - Uni...

Application	Sharing Status
Correlator Contr...	Collaborating

Not Connected

Fig. 6. The ULabNet platform

A great deal of effort was made to manage the intricate relationships between Netmeeting COM objects. ULabNet allows to automatically share an application program, and to optionally require a password to establish a connection.

In addition, a successful virtual classroom presentation of the DLS laboratory to research students was performed. It was found that if the host is windows 95 or 98 then the maximum number of clients is limited to 8 and if windows xp or windows server 2003 then is limited to 16. Only one client user at a time can take control of the application if its request is accepted at the platform user, users requesting control first have priority over users requesting control later.

D. *The platform structure*

The Netmeeting SDK COM object model consists of several API object definitions (for a detailed list, please consult the Netmeeting SDK). The Conference Manager object is the most important one, as it allows any other object to be accessed or even created through it. As the uppermost object in the hierarchy, this object provides methods to create and manage individual conferences between conference participants. The conference manager object supports the INmManager interface.

In ULabNet, a C++ wrapper class holds the INmManager interface pointer. Figure 7 shows the implementation of the structure; this wrapper class is called CConferenceManager and acts as a "client" to the Netmeeting Conference Manager object. This architecture allows ULabNet to easily access all the functions supported by the Netmeeting COM object model since the Conference Manager can obtain access to them.

ULabNet responds to Netmeeting requests through a wrapper class that holds a connection point sink called INmManagerNotify. This wrapper class is called CConferenceManagerNotify and is a nested internal C++ class owned by CConferenceManager. This class is responsible to notify ULabNet if a conference or call is initiated at the Conference Manager of Netmeeting.

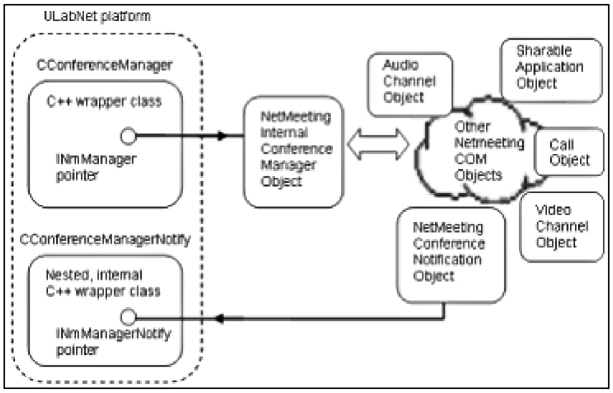

ULabNet platform
CConferenceManager
C++ wrapper class
INmManager pointer
NetMeeting Internal Conference Manager Object
Audio Channel Object
Sharable Application Object
Other Netmeeting COM Objects
Call Object
Video Channel Object
NetMeeting Conference Notification Object
CConferenceManagerNotify
Nested, internal C++ wrapper class
INmManagerNotify pointer

Fig. 7. Structure of the ULabNet platform

E. Prospects for the future

As technology evolves, new platforms are developed; an important point of consideration is the compatibility of ULabNet with new versions of Windows including Vista (also referred to as WinVI) which is Microsoft's next version of its Windows operating system. This generic tool could be improved as well by providing an embedded text communication (chat) among participants thus permitting a better interaction between users. Other interesting improvements would be a better installation and setup configuration, an easier web server configuration and the capability to be free and easily accessible to any research institution.

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