

Information Retrieval in a Digital Library Using Mobile Agent

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ABSTRACT: This research presents an Information Retrieval in a Digital Library Using Mobile Agent. Mobile agent is an executing program that can migrate during execution from machine to machine in a heterogeneous network. On each machine, the agent interacts with stationary service agents and other resources to accomplish its task. In this system, mobile agents can migrate from a host node to various destinations, perform data processing there and send the relevant information back to the host. In order to facilitate such a set of events and actions, many development platform are available. The main aim of this work is to design a Mobile agent for information retrieval in a digital library environment using mobile agent that enables researchers have access to necessary files and information that are available on other systems and to enable a mobile agent that will be able to navigate from one system to another or a specified system in order to minimize the energy to be consumed for manual normal visitation to individual system for system information retrieval. In this research, C-sharp has been used as design tool for the frontend end and Microsoft access as database backend. The developed agent was tested by some researchers.

KEYWORDS: Mobile Agent, Information, Library, Retrieval.

I. INTRODUCTION

Overview of Electronic Library

An electronic library (also referred to as digital library or digital repository) is a focused collection of digital objects that can include text, visual material, audio material, video material, stored as electronic media formats (as opposed to print, micro form, or other media), along with means for organizing, storing, and retrieving the files and media contained in the library collection.

Digital libraries can vary immensely in size and scope, and can be maintained by individuals, organizations, or affiliated with established physical library buildings or institutions, or with academic institutions (Witten, Bainbridge and David, 2014). The electronic content may be stored locally, or accessed remotely via computer networks. An electronic library is a type of information retrieval system.

The term digital library was first popularized by the NSF/DARPA/NASA Digital Libraries Initiative in 1994 [1]. These draw heavily on As We May Think by Vannevar Bush in 1945, which set out a vision not in terms of technology, but user experience. The term virtual library was initially used interchangeably with digital library, but is now primarily used for libraries that are virtual in other senses such as libraries which aggregate distributed content [2].

A distinction is often made between content that was created in a digital format, known as born-digital, and information that has been converted from a physical medium, e.g. paper, by digitizing. It should also be noted that not all electronic content is in digital data format. The term hybrid library is sometimes used for libraries that have both physical collections and electronic collections. For example, American Memory is a digital library within the Library of Congress. Some important digital libraries also serve as long term archives, such as arXiv and the Internet Archive. Others, such as the Digital Public Library of America, seek to make digital information widely accessible through public libraries [3]

Mobile Agents

Mobile agents are programs that encapsulate data and code, which may be dispatched from a client computer and transported to a remote server for execution [4], [5], [6]. When

large quantities of remote-sensing data are stored at distributed remote hosts, moving the computations to data is a more realistic and feasible approach, compared with migrating data to the computations. Instead of gathering data distributed in remote sites at a centralized site, users can dispatch mobile agents to a destination site to perform information retrieval and filtering locally, and to return to a user the results of analysis. Thus, the information transmitted over the network is minimized, especially when using a low-bandwidth access network.

Mobile agents execute asynchronously and autonomously. Once a user has created an agent, it can run autonomously and asynchronously, without intervention from the user. The agent performs its task and saves any results until its connection to the user is re-established. Mobile agents provide a reliable transport between a client and server without necessitating a reliable underlying communications medium.

In computer science, a mobile agent is a composition of computer software and data which is able to migrate (move) from one computer to another autonomously and continue its execution on the destination computer [7].

Problems of Information Retrieval in Digital Library

According to [8] digital libraries face many challenges – interoperability; 24/7 operation; stress; insufficient database; multi-language, multi-culture and multi-legislation situations; multiple types of information and ever changing digital formats; information asset security; digital preservation; and IPR – Intellectual Property Rights. The last two seem to be the most crucial. Worldwide, many efforts have been devoted to the study of these two topics and to finding solutions to the problems they represent in the use of digital contents.

Digital preservation can be seen from three different points: (1) the physical preservation of the supporting Medium (HDs, CDs, DVDs, tapes); (2) the technological preservation to avoid technological obsolescence; and (3) preservation of access. Some important actions can be mentioned dating as far as the 1990s.

Characteristics of Mobile Agents

Mobile agents seem to have many characteristics. One may however claim that virtually any task that can be performed with mobile agents can be performed with other technologies (e.g. remote method invocation). Despite the fact that there are not many distributed

computing problems that cannot be solved without mobile agents, nevertheless mobile agents make certain applications easier to develop and may improve reliability and efficiency. According to [9] some of the characteristics of mobile agents over conventional approaches are as below;

- i. Efficiency: Mobile agents consume fewer network resources since they move the computation to the data instead of the data to the computation.
- ii. Less Bandwidth: Most communication protocols involve several interactions, which cause a lot of network traffic. Mobile agents consume bandwidth only when they move.
- iii. Robustness and Fault Tolerance: The ability of mobile agents to react dynamically to adverse situations makes it easier to build fault tolerance behavior in complex distributed systems.
- iv. Support for Heterogeneous Environments: Mobile agent systems are computer and network independent. Therefore, a Java mobile agent can target any system that has a Java Virtual Machine.
- v. Support for Electronic Commerce: Mobile agents are being used to build electronic markets since they embody the intentions, desires, and resources of the participants in the market.
- vi. Easier Development Paradigm: The construction of distributed systems can be made easier with mobile agents. Mobile agents are inherently distributed in nature. Therefore, they are a natural view of a distributed system.

Importance of Digital Library

According to IMS Global Learning Consortium, Inc., Digital libraries are suitable tools to manage courseware and additional reference items used in class. Some reasons for this use are:

- i. Management of documents in all formats in a unified way – texts, animations, interactive exercises, audio files, video streams, e-books, e-journals and online tests can be stored, described and distributed through computers and networks. The management is independent of the type of information, as long as it can be stored in digital files. It also can be shared without human intervention making the whole process faster and cheaper.
- ii. Access control – contents can be assigned different types of access according to the classes of users that are entitled to them. Authors can decide if their works are to be used by their students only, by any student of a given institution or the public in general.
- iii. Content sharing – authors can make their

contents available for other faculty to aggregate into their courseware. This can be done without duplication, simply by 'pointing' to the contents with the suitable set of metadata elements.

- iv. Interactivity – contents that are managed by digital libraries can be interactive and based on multimedia. Students can listen to soundtracks, view animated images, solve exercises and have them checked online, write and send comments to authors and/or tutors.
- v. Customization – some users may require special characteristics of the contents and the system. This is true when people with special needs are involved, for example, persons who are blind or visually impaired. System interfaces and contents in digital formats can be customized to fulfill these necessities.
- vi. Re-use – courseware can be developed with a granularity that makes it flexible to combine and support multiple syllabus. Re-use is important because developing courseware is expensive and takes time, so increasing re-use improves efficiency.
- vii. Cross-institution cooperation – digital libraries in general are connected to the Internet, this allows that contents be used from different cooperating institutions, as long as the LOs are described (metadata) and managed in a suitable way. An example of the importance of cooperation is MERLOT – Multimedia Educational Resource for Learning and Online Teaching, an organization whose mission, as stated on the website, is "MERLOT is a leading edge, user-centered, searchable collection of peer-reviewed, higher education, online learning materials created by registered members, and a set of faculty development support services.
- viii. Any place and at any time – students study in different hours of the day any day of the week, this is more significant when distance learning is considered. Students can be in any country and accessing courseware anytime. Since digital libraries are available 24/7 (24 hours per day, 7 days per the week) and the Internet connects the whole world, courseware is always available from any geography.

Motivation for the Study

Nigeria is a developing country which is progressing towards developing an IT society. In such a society, the software development consists of the development of algorithms, which are the targets of my study. In many real life problems, a

need to develop algorithms to search for mobile agents in information retrieval system solutions is needed. Area of algorithms is vast and in this research, we are mainly interested in developing software for solving the problems formulated for mobile agent in gathering file information from the clients or local systems back to the host system.

The advantages of digital libraries as a means of easily and rapidly accessing books, archives and images of various types are now widely recognized by commercial interests and public bodies alike [10].

Traditional libraries are limited by storage space; digital libraries have the potential to store more information, simply because digital information requires very little physical space to contain it. As such, the cost of maintaining a digital library can be much lower than that of a traditional library. A physical library must spend large sums of money paying for staff, book maintenance, rent, and additional books. Digital libraries may reduce or, in some instances, do away with these fees. Both types of library require cataloging input to allow users to locate and retrieve material. They also increase availability to individuals who may not be traditional patrons of a library, due to geographic location or organizational affiliation. Some of these advantages motivate the researcher to embark on mobile agents in digital library system

- i. No physical boundary. The user of a digital library need not go to the library physically; people from all over the world can gain access to the same information, as long as an Internet connection is available.
- ii. Round the clock availability A major advantage of digital libraries is that people can gain access 24/7 to the information.
- iii. Multiple access. The same resources can be used simultaneously by a number of institutions and patrons. This may not be the case for copyrighted material: a library may have a license for "lending out" only one copy at a time; this is achieved with a system of digital rights management where a resource can become inaccessible after expiration of the lending period or after the lender chooses to make it inaccessible (equivalent to returning the resource).
- iv. Information retrieval. The user is able to use any search term (word, phrase, title, name, and subject) to search the entire collection. Digital libraries can provide very user-friendly interfaces, giving click able access to its resources.

- v. Preservation and conservation. Digitization is not a long-term preservation solution for physical collections, but does succeed in providing access copies for materials that would otherwise fall to degradation from repeated use. Digitized collections and born-digital objects pose many preservation and conservation concerns that analog materials do not. Please see the following "Problems" section of this page for examples.
- vi. Space. Whereas traditional libraries are limited by storage space, digital libraries have the potential to store much more information; simply because digital information requires very little physical space to contain them and media storage technologies are more affordable than ever before.
- vii. Added value. Certain characteristics of objects, primarily the quality of images, may be improved. Digitization can enhance legibility and remove visible flaws such as stains and discoloration [11].

It is obvious that for every new system to be designed or newly designed system must have a purpose as being the aim of the new system to the designed. However, the major aim of project is to develop (Mobile Agents) that can migrate from one library host to another in distributed network for information retrieval.

II. LITERATURE REVIEW

Overview of Mobile Agent.

Mobile agents have been introduced initially in 1994 with the Telescript environment [12] that permitted to processes to choose themselves to move on the sites of a network in order to work locally onto resources. A mobile agent [13], [14], [15] is a process that can move from a site to another site in order to achieve a task. In general, the mobility is provided using some primitives like: move (site) that permits the agent to move toward the site designated by the parameter.

The term "agent" is heard frequently today. While it means a variety of things to a variety of people, commonly it is defined as an independent software program which runs on behalf of a network user. An agent may run when the user is disconnected from the network, even involuntarily. Some agents run on specialized servers, others run on standard platforms. Many examples of agent systems exist, and they are receiving much attention on the World Wide Web ("WWW"). Over the years, autonomous agents and multi-agent technology are part of a rationale control roles in network management and systems

management communities for several years [16].

Mobile Agents are the programs that move between computers or nodes of network, autonomously trying to fulfill some specific goals given by users. Agents are different from other applications in that they are goal-oriented: they represent users and act on their behalf to achieve some set goals in an autonomous manner – i.e. they control themselves, as in the decision where and when they will move to the next computer or node. Mobile Agents do provide a viable means of performing network security assessment and analysis efficiently and effectively. Mobile agent neither brings new method to detect for IDS nor increases detection speed for some kind of attracting. Nevertheless, it improves the design, construct, and execute of IDS obviously [17].

In wireless sensor networks based on Mobile Agent, the Agent accesses the network nodes according to a certain path for data acquisition and processing and brings integrated results to access the next node. The integrated results are gradually refined. Once the results meet application needs, the Agent will terminate accessing and return to observation node. Mobile Agent access path planning [18] is a process to determine the access node set and the sequence of Agent in networks, which requires meeting application performance with the minimum system cost. For example, the data that meets the requirements of accuracy with the minimum consumption and minimum delay [19] demands using less system costs to meet better application performance, which is one of the core problems to effectively implement the mechanism of Mobile Agent in sensor networks.

Mobile agents generally have the advantages of being able to reduce network load by; avoiding network protocol overhead e.g. avoiding many communication steps in a network protocol, the ability to filter and compress data at the server site. Mobile agent can interact with the resource without transmitting any intermediate data across the network, significantly reducing bandwidth consumption in many applications. By migrating to the location of a user, an agent can respond to user actions rapidly. It can continue its interaction with the user even if the network connection goes down [20].

Mobile agent enabled approach for load balancing distributed web servers was proposed by [16]. They show that load balancing approaches involve frequent message exchanges between the dispatcher and the servers to detect and exchange load information. The message exchange increases the bandwidth utilization and reduces the

availability of network bandwidth for other useful purpose. They have pointed out that for effective load balancing, comprehensive and up to date load information should be available.

An approach for load balancing using mobile agents was proposed in [21], [22]. This method has certain drawbacks. First, consider that the mobile agent is lost then the scheme waits for twice the Round trip time before processing the request. It can be inferred that loss of a mobile agent cannot be left as it is, as this results in low throughput and steps must be taken to correct this situation.

In [23], mobile agents are autonomous and intelligent programs or software that are capable of moving through a network searching for and interacting with the resources on behalf of its user or network administrator [24], [25], [26], [27], [28], [29]. A mobile agent is an executable program that can migrate from one computer to another, at times, of its own choosing in a network. This means that a mobile agent is free to travel to any place in the network. It can execute without requiring a link with or being controlled from the originating location. Also, mobile agent is an execution unit that is able to migrate autonomously to another host and resume execution there, continuing from where it left off [30].

Overview of Library System

The first libraries consisted of archives of the earliest form of writing—the clay tablets in cuneiform script discovered in temple rooms in Sumer, [31] some dating back to 2600 BC.[32]. These archives, which mainly consisted of the records of commercial transactions or inventories, mark the end of prehistory and the start of history [33].

Things were much the same in the government and temple records on papyrus of Ancient Egypt. [34]. The earliest discovered private archives were kept at Ugarit; besides correspondence and inventories, texts of myths may have been standardized practice-texts for teaching new scribes. There is also evidence of libraries at Nippur about 1900 BC and those at Nineveh about 700 BC showing a library classification system [35].

Over 30,000 clay tablets from the Library of Ashurbanipal have been discovered at Nineveh, (Little and Ives, 1954) providing modern scholars with an amazing wealth of Mesopotamian literary, religious and administrative work. Among the findings were the Enuma Elish, also known as the Epic of Creation [36] which depicts a traditional Babylonian view of creation, a large selection of

"omen texts" including Enuma Anu Enlil which "contained omens dealing with the moon, its visibility, eclipses, and conjunction with planets and fixed stars, the sun, its corona, spots, and eclipses, the weather, namely lightning, thunder, and clouds, and the planets and their visibility, appearance, and stations", [37] and astronomic/astrological texts, as well as standard lists used by scribes and scholars such as word lists, bilingual vocabularies, lists of signs and synonyms, and lists of medical diagnoses.

Overview of Digital Library

The digital library concept can be traced back to the famous papers of foreseer scientists like Vannevar Bush and J.C.R. Licklider identifying and pursuing the goal of innovative technologies and approaches toward knowledge sharing as fundamental instruments for progress. Bush devised "a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility." Moreover, on top of it there is "a transparent platen. On this are placed longhand notes, photographs, memoranda, all sorts of things". Because of the lack of digital support, he identified in "improved microfilm" the means for content storage and exchange: "contents are purchased on microfilm ready for insertion. Books of all sorts, pictures, current periodicals, newspapers, are thus obtained and dropped into place". Of course, he envisaged also support for knowledge discovery ("provision for consultation of the record by the usual scheme of indexing"), access ("to consult a certain book, he taps its code on the keyboard, and the title page of the book promptly appears before him") and management ("new forms of encyclopedias will appear, ready made with a mesh of associative trails running through them, ready to be dropped into the memex and there amplified"). Licklider realized that computers were getting to be powerful enough to support the type of automated library systems that Bush had described and in 1965, wrote his book [38] about how a computer could provide an automated library with simultaneous remote use by many different people through access to a common database. Because of this, Licklider is also considered a pioneer of Internet and in its book he established the connection between Internet and digital library.

III. DESIGN OF MOBILE AGENT

Features of Mobile Agent Environment

A mobile agent environment was described in [39] as a model which comprises of a

server and a number of workstations. The server connects directly to a number of workstations. The server is a typical computer which is composed of some hardware devices such as CPU, main and secondary memory, printer, scanner, switches, modems, network ports and so on, and in which a network operating system is running. Other categories of software can be running on the server. This include: frontend software, backend software and utility software. The workstation environment on the other hand comprised of basic hardware devices, an operating system and other software systems. Though the configuration of the workstation can be lower than the server, this is not a mandatory requirement.

A mobile agent is a multi-dimensional system that can be launched from a server to monitor the basic software tools on any other workstation or a server in a computer network environment. Thus, there is a source host and one or more target hosts or destinations of a mobile agent. [40]

Architecture of mobile agent for information retrieval system

The architecture of a mobile system adopted in this research consists of two types of agents namely: the static agents, otherwise referred to as Server agents, and the mobile agent referred to as Agent Monitor, together with their underlying software and hardware infrastructure.

On the other hand, the architecture of the mobile agent system can also be categorized as comprising of backend and frontend engines. The backend engine is made up of the server machine and workstations which are considered to be static. The frontend is the software-based interface, which creates the environment for creating and launching the mobile agent and is dynamic in nature.

The architecture of the proposed mobile agents indicates that when the sender search for file string from digital library 1 and that particular file cannot be found on the digital library 1, it will autonomously move to digital library 2 and if not found, it will move to the next digital library until the agent reach the digital library n.

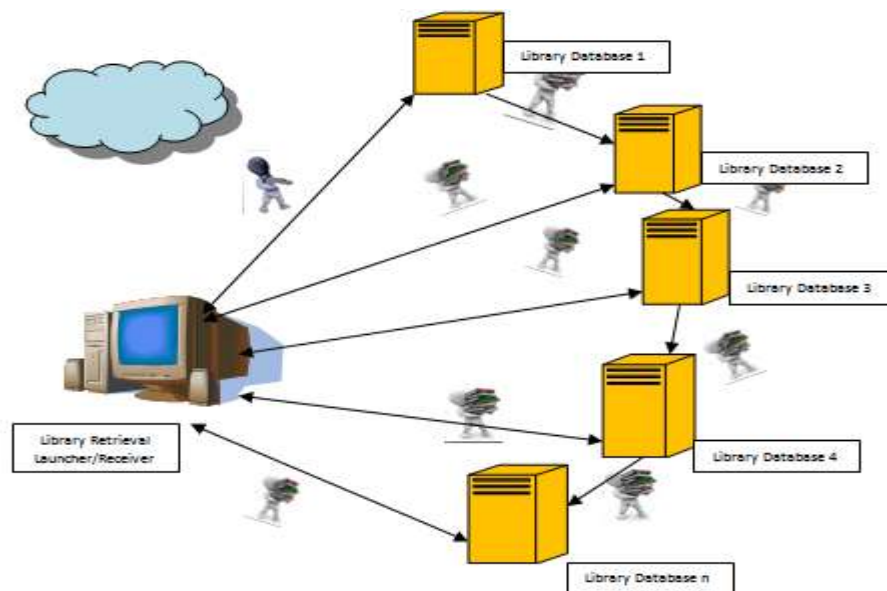


Fig. 1: Architecture of the Proposed Mobile Agent.

When the file has been found, it will now report back to the server indicating the name of the system, location, file size and file directories else the agent will return file not found.

The architecture of the proposed mobile agent is conceptualized in Figure.1. The platform for the take-off of the Agent at the server host and the platform for its landing at the target workstations are their respective operating systems. At the server host, the Agent is created and

equipped with the code, data and other necessary parameters and dispatched to the target workstations in the network. The Agent Monitor then navigate autonomously through the network from the server end and interact with the host operating system of the target workstations and its utility programs as it processes the desired information. The Agent Monitor moves from one workstation to another while carrying along intermediate results. The results obtained by the

mobile agent after successful visits to a set of target workstations are transferred to the server, which are displayed on its screen or printed out for the purpose of external analysis, interpretation, policy formulation and decision making by the Network System Administrator.

Agent Monitor

The Agent is a mobile agent dispatched from the host computer (source) with its code, data and other parameters to other workstations in the network [41]. The major function of the Agent is to go into the network to identify the information to be retrieved on the workstations or servers whose identities are known. At each workstation or server, the Agent interacts with Server at each node for the collection of the required information. The information collected at each target node with its identities is placed in the database container of the Agent Monitor for onward movement to the next workstation.

This process is repeated until the last node is visited, at which point, the Agent migrate back with all information in its database container to the source computer that launched the Agent. At the target workstation, the operating system provides the platform for interaction between the Server Agent and the Agent Monitor. The Server Agent gets into the files of the operating system to collect

the information about the software tools on that workstation and place it in the database container of the Agent Monitor. The database container of the mobile agent monitor is used to update the source mobile agent server from where the collected information is displayed on the screen or printed out for the system administrator.

Accessing the Mobile Agent System

The Agent Monitor of software tools is basically a network administrator's utility application system. The sensitive nature of the mobile agent system necessitates the need to incorporate in the design, facilities for deterring unauthorized usage of the system. Consequently, it is essential to encode the network administrator's name and password as part of the design process. Encoding simply involve representing the characters of the data items in a way that appears different from the original. That way, an unauthorized user having no access to the original data item may not gain access to the system. The usage of the mobile agent system will require the entering of the name and password by the administrator, which must be verified. The verification process involves authentication of the administrator's name and password. Entering the correct name and password activates the mobile agent system [42]. The agent mobility for the system is presented in figure.2.

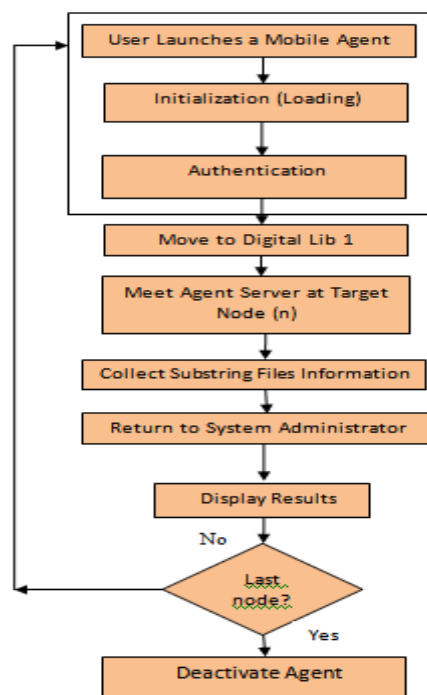


Fig. 2: Mobility of the Mobile Agent

IV. IMPLEMENTATION TECHNIQUES OF AGENT MONITOR

The mobile agent has been coded with C# providing the mobility in an environment characterized by Windows NT operating system as the platform software, Microsoft Access as backend engine, and C# application language as the frontend engine.

All agents' activities start from the server interface where the server is configured to include all other workstations. The following are the steps involved in running Agent Monitor:

- Bring up all the computers involved in the network.
- Configure the computers by assigning IP addresses.
- Start the server agents in all the workstations.
- Start the login page on the server. If login fails at first attempt, try to reenter the correct password. If login succeeds, the welcome screen is presented.

- When "Launch Server Agent" button is clicked, the server agent is loaded.
- Launch the Agent Monitor through the server to visit the configure target computers.
- The Agent Monitor visits a target node or all the target nodes depending on the instruction of the administrator.
- Agent Monitor reports back with the information about file string on target nodes to the system administrator in Microsoft excel format.

Library System Login

Access is granted to the mobile agent monitor by typing ADMIN as username and admin as password. The login screen shot is presented in Figure 3. This is where the authorized user will enter the username and password for authentication. It helps to protect the program from unauthorized users.



Fig. 3. Library login System

Configuration of Systems on the Network

For the Agent Monitor to identify and connect the computers on the network, all the computers must be configured by IP (Internet Protocol) Address to each computer. The IP address can be assigned manually (static) or dynamically by use of Dynamic Host Configuration Protocol (DHCP). For the purpose of this research work, dynamic configuration of computers on the network is used.

Dynamic configuration of computers

An alternative to the use of manual assignment of IP address is by the use of Dynamic Host Configuration Protocol (DHCP). This is used in a wireless Ad hoc network. The nodes on the network request configuration settings using the

DHCP such as IP address, a default route and DNS server addresses. Once the client implements these setting, the host is able to communicate on that network [43]. DHCP provides IP addresses automatically so there is no need for manual configuration of IP addresses in the nodes. In this research work, DHCP for dynamic assignment of IP addresses to computers on the network was used because:

- Dynamic configuration reduces the stress of configuring each and every connected computer on the network.
- It eliminates the problem of IP conflict that sometimes arises while using static/manual IP address configuration.
- It reduces the expenses incurred in terms of cables and other accessories needed in wired

- d. It is portable and can be easily used on mobile equipments.
- e. Most of today's computers have built-in DHCP and ad-hoc settings that facilitates for dynamic configuration of IP addresses.

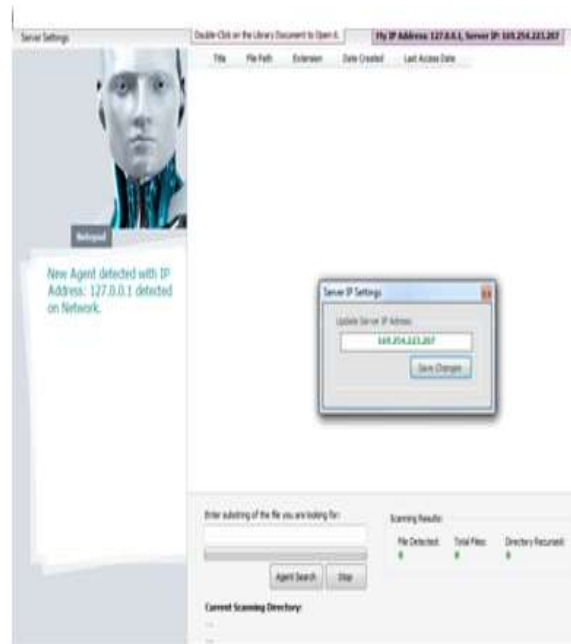


Fig. 4 Dynamic configuration of IP address using DHCP.

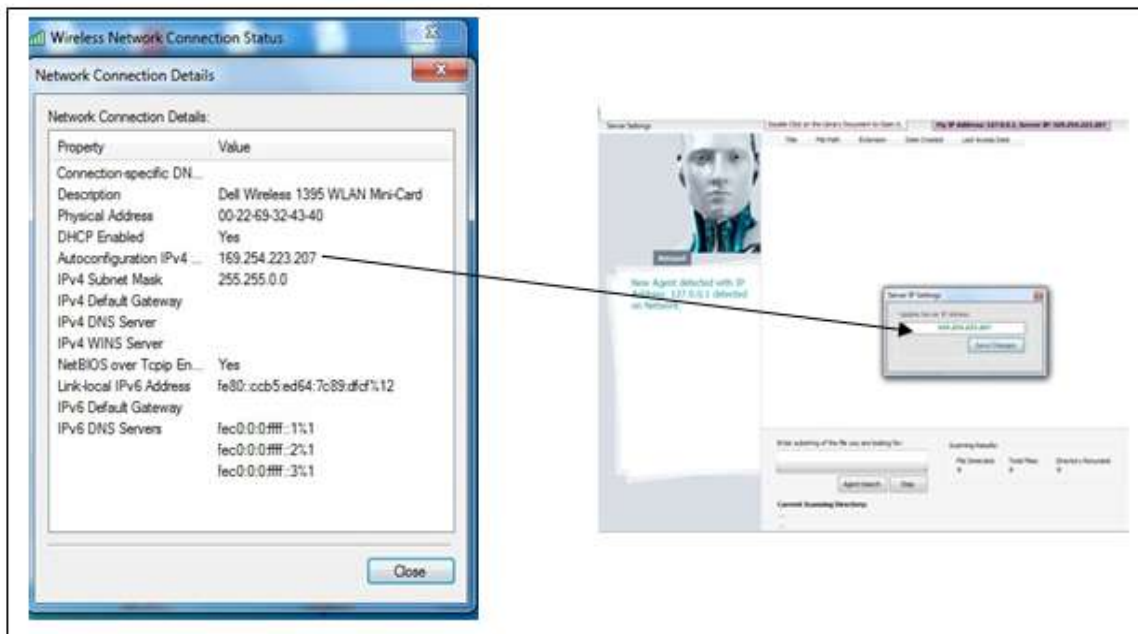


Fig. 5; Agent Server Configuration

Agent Server Configuration

The Figure 5 shows the screen of Agent server interface and how it acquires the IP address of the target computer to start listening for an

incoming connection from client agents on nodes. DHCP configuration approach was used, and that makes it possible for the server connection to get client agent IP address immediately they attempt to

establish a connection to it. Unlike Manual IP configuration, its counterpart, DHCP configuration is a protocol on network that assigns IP address to all nodes on the network automatically, including the server system. So it is mandatory for all monitor agents on the network to know the server IP address.

The server does not need to know the monitor agent IP before it connects, but the monitor agent needs to, since it is possible for the server agent to easily retrieve monitor agent IP address and the port from its connection information.

The figure shows how the IP address assigned to the server can be located in the Network and Sharing Center→Network Connection Details. Both server agent and monitor agents allow entry of IP address for their communication because, the IP address can change as the computer devices use change. So to prevent hard-coding IP addresses in the program, the agent program adopts the IP address entry approach to make the program flexible, dynamic, and easy to implement.

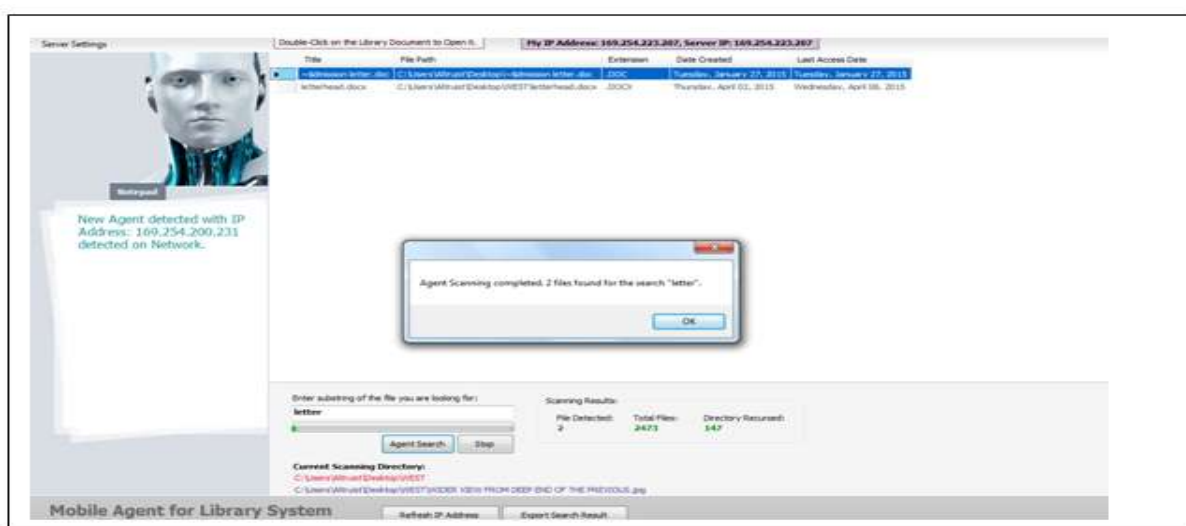


Figure 6. Dispatch Screen

Dispatch Screen

Figure 6 displays a notification message dialog box on the server to notify user on the server-side of new file found reports from the node agents. After clicking “Ok” button, the server collates and processes the incoming data, and it generates a report for each node agent in Microsoft excel format. The Microsoft excel format is chosen to preserve the processed system information and to make it portable and organized. This screen orders an agent to migrate or nomad to another system. You enter the substring of the file you are looking for and then select Search Agent. A dialog window will pop up after the agent has discovered the file indicating the title, file path, extension, date created and last access date. After the completion of the search agent, another dialog window will display indicating the systems the agent has discovered.

V. CONCLUSION

The mobile agent system for monitoring software tools in a network environment is utility software that would enable the network administrator monitor the software tools on all machines in the network [44]. Architecture comprising of backend engine (server and workstations) considered to be static and frontend engine (mobile agent) which serves as the software-based interface considered to be dynamics was proposed. The platforms for the take off of the mobile agent at the source and for its landing at target destinations are the respective operating system.

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