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Introducing to Large Scale Network Using Adaptive Simulation for an Optimum Solution on Dynamic Systems

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Abstract—**As computers become more and more networked, and more bandwidth will be consumed by network flow because customers will be connected through networks which will transfer files and data, such as video files (MPEGn, AVI, WMV, etc.) to be watched at a customer?s computer. The main purpose of this paper is to optimize large scale network handling capabilities for large system inventories and to implement strategies for the purpose of reducing capital expenses. Furthermore, these networks terminals will be used as mini warehouses to save files and data. Although adaptive simulation will be used to simulate the selective files that are transferred to the host computer on network. The research will present techniques that optimize transfer storage media for the purpose of minimizing waiting time and hardware cost while maximizing efficiency and customer satisfaction.**

Keywords: Large Scale, Network, Optimization, Adaptive, Simulation, Model, Dynamically, Complex, Systems

1 Introduction

During the Scientific Revolution of the 19th and 20th centuries there was a growing need to understand complex mechanisms that were central to human concerns. These complex mechanisms are known today as systems and complex systems. Systems are defined as a set of elements or entities that can be real or conceptual, encompassing a whole where each element interrelates or is correlated to at least one other element. A complex system is a system that has several degrees of freedom that often strongly interact with its components [1].

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Today, new revolutions have been used as powerful tools to explain the complexity of a system, such as using mathematical analysis, experimental tools and software for computers [2]. Dynamic systems.

contain huge numbers of elements that vary simultaneously in space and time as well as surrounding environments which may also change with time.

Sterman [3] shows that defenders of system thinking define the world around us as a complex system. Every thing in a system is interconnected, nothing can be accomplished singularly, therefore system thinking is vital for survival of the system. Dynamic complexity stresses the system in any multi-process, such as multi-loop, multi- state or even nonlinear characteristics. Increasingly, understanding dynamic change in a complex system demands mutually supportive research to analyze the allocation between all nodes that can interact within time but also within space. Figure 1 illustrates the differences between static systems and dynamic systems.

Complex systems can be described by a general logistical and temporal analogy that indicates how both apply for the corresponding underlying data in ?space? and how these data are performed on each element or node. Fox et al [4] suggest problems mapped with space and time were evolving optimization processes, that problems must be broken down into separate parst. Fox [5] also stresses how important it is to take time to structure problems along with the importance of the data flow between nodes that exist on a time scale and the need to apply different strategies to express microscopic dynamic dataflow [6, 7].

The nodes in figure 1 represent data, these data can contain a large size like video files, between customers who requested the service to watch certain movies. The selected video file is downloaded to the customer?s computer site according to the system requested. It is also added to an inventory which can be allocated to several other sites in the future. System redundancy has been taken into account with regard to system needs for any overly excessive demands.

Computer models are used for interesting research practices and testing theories within certain discipline struc-

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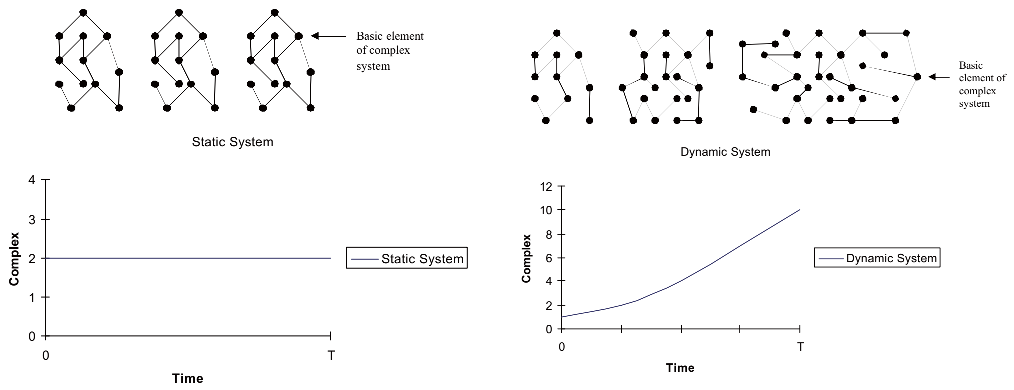

Figure 1: Static and dynamic complex systems.

tures. The fundamentals progress of a real-world structure are difficult to be observe and collecting data as well as manipulating it under certain conditions is impossible. Assumptions based on theories for these structures can be implemented in a computer model that can perform and compared to this to practical data.

In this situation where real-world data exists, quality of performance is relatively easy to determine, but entities related to dynamically complexity are much harder to identify. Many approaches have been used to explain the exchange between goodness of fit and Agent-based models (ABM). These Both of them merge a maximum possibility term that determines fit and a consequence term to measure complexity. Conventionally, the majority of ordinary factors integrated in a complexity scenario are: number of free parameters, functionally forms, ranges of values for free parameters and number of self-governing data models [8, 9, 10, 11].

Several application domains of ABM are complex adaptive systems (CAS) [12] where large scale performance emerges from small scale performance and local exchanges. The word ?model? had been referred to as an entity by scientists, but with statisticians a model is used as a point of hypothesis for probability distributions [10], Rissanen [13] describes a model where any hidden act was explained by model-ruled data for any theories. Definition of models differed, until recently when [14] differentiated models into two categories: ?models as a realization of theory? and ?models as depiction of reality?.

Further, Rissanen [14] argued that model theory did not only explain model functionality but went beyond that by describing how the real world works and how models? data infer procedures and configurations primarily through experimental behavior. The models used in this paper can not predict the future because of unpredictable characters, such as initial conditions, path dependency and agent edition, as namely in CAS [12].

Generally, models used in this paper either use computational algorithms or procedure implementations developed by Matlab to simulate agent based models in a principal programming language and mathematical theory using clusters, these clusters work as a high performance computational to run the program in parallel computational. In both cases, a model is defined as compilation of a set of structures

2 System Description

The network evaluated in this paper has a total of 250 nodes which represent the total number of customers carried by this network. These nodes are virtually connected by a network, such as internet, and each node can connect to every other node. Each node in the network follows these assumptions:

- Each node is connected to the network and works online all year long with no loss of connection. All nodes share the same bandwidth speed (uploading or downloading).
- The bandwidth speeds that will be used are limited to 1000kb per second. Uploading bandwidth and downloading bandwidth are two different streams and separated at each. All nodes can download simultaneously from the server with no affect on delay or connectivity.
- All nodes are spread all over the internet and connect to a separate network that can be located physically anywhere with no adverse affects on location or distance.
- Each node can be used as a virtual storage and uploading any necessary file needed by another node upon requested and can only be done to one node at a time. Each node can be downloaded from the server or from another node according to these guidelines:

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- Each node can download, at the maximum, from two locations and can be the server, the server and a single node or two nodes simultaneously.
- Only one file can be downloaded at a time.
- If the file exists in two virtual locations in network, the server will be exempt.

- Each node has an internal storage device and is selected randomly from a set of sizes: 50, 100, 150, 200, 250, 300, 350, 400, 450 or 500GB.

Each node will be studied throughout the year and is equivalent to 8760 hours download time and is evaluated for how many files has been selected and downloaded as these files are selected according to each node's preferences.

Selected files will be chosen randomly and according to each node's preferences. These files have the following characteristics and assumptions:

- The network will handle files of different sizes having different time durations, and is limited to 10,000 files and all files can be downloaded from the server.
- The 10,000 files will be divided to five categories. Each category includes 2,000 files ranked from the highest priority to the lowest according to the power law degree distribution $P(k) \sim k^y$ with an exponent y range between 2 and 3 [15]. These categories are Actions, Crime, Comedy, Drama and Romance.
- The files can be downloaded from server, two nodes or a node and server at the same time by splitting the file's size to two batches - each batch contains half of the file.
- The file's batches will be downloaded either simultaneously by dividing the downstream bandwidth in half or downloading individually as the second batch will not start till the first one is completely downloaded.
- These files do not have expiration time but rather are replaceable inside the network's virtual storage which located at the nodes. If the node's storage device reaches 75%, the files will be deleted according to the file's priority from low to high with the exception of the server. In this case, it will be remain stored as a reference for future requests.

All nodes will be able to download any files from a server at any time with no delay. All files are ranked according to its priority and stored in the server in the five different categories. Any node can search for any file across the entire network and download it in another node in order to overcome network load and reach an optimum soliton for network.

2.1 Network and Their Dynamic Complexity Purpose

The networks acts as a huge virtual storage warehouse that will dynamically change over a period of time. The address of the nodes will be constantly but a file's location will change from node to node with time and determined priority.

The duration of this study is equivalent to 8760 hours and over an entire year. This study will follow several procedures to highlight and identify the purposes of this research. In addition, it will also simulate the generated data not only to show the output results but to also understand how the network works with layers of dynamic changes as the files flow across the network.

A network's complexity is represented by nodes and a server that are interactively and laterally ordering files from the server, other neighbor nodes or both at the same time. These nodes are connected virtually by an intranet at all times, shares their contents at the same time and evaluate best practices to be closed to an optimal scenario as an ideal network which can change periodically over space and time.

Optimizing a network has a set of fundamentals that are required to help to simulate this kind of network and evaluate the results. In order to do this, the following sections describe sets of identifying parameters and metrics that have to be fully gathered and understood in order to direct these types of networks to the second stage, which is ready to be integrated as an optimal large scale dynamic complexity network.

2.2 Identifying Network's Parameters

These parameters can be identified by using part of the data generated, which is as close to a realistic scenario as possible. Data have been randomly generated by using a log normal distribution curve for two independent and continuous parameters μ and $\sigma > 0$.

$$f(x) = \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{z^2}{2}}$$

$$where\ z = \frac{ln(x) - \mu}{\sigma}$$

The values had been chosen with as the maximum range possible to get more verifiable random generated data to meet this research study. μ is a range between 2.42 and 7 and σ is a range between 0.1 and 1.

$$p(x) = \frac{1}{b-a}\ for\ x\ value\ (a \leq x \leq b)$$

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Where a and b are continuous boundary parameters and $b > a$.

- Inter-Arrival Time: Inter-arrival time represents the time the movie starts being watched. This starts by setting the log normal distribution to generate no more than 800 output values per node These data sets have to meet the total required estimated hours to be watched by each node and can't exceed 8760 hours per equivalent year.

- Inter-Arrival Download: Inter-arrival download time represents the length of time it takes for each file to download to a storage device within a single node. This is calculated from the data collected from the inter-arrival time (the number of files that have been downloaded to each storage device in the network), the size of each file and download bandwidth used.

- File Prioritizing Using Power Law Distribution: Power law distribution relates two or more variables and shows areas that are more dominant in a distribution. The more dominant area has excessive priority. In this study, this shows the most common movies recommended by customers and most requested.

2.3 Identify Network's Metrics

The network need to be integrated to the second stage. This is essential to our goal which includes studying the Base Line and H1 heuristic of the system and the different possibilities that will lead to the main goal of this research paper.

The metrics can be identified by using part of the data generated, which is as close to a realistic scenario as possible. The generated data is used to describe different metrics for system boundaries and express the simulation technique used to evaluate our network. These metrics will, next, be highlighted in detail to measure our network by using parameters output data.

- Server Load: will be determine by the amount of the excessive bandwidth used from the server to upload movies' files to each node from the first hour of the service start till last hour at the end of the entire year.

- Customer's Request Penalty: will be determine by the desired time to watch the requested movie and the actually watched time, a larger time span between the desired viewing time and the actual verifying time will affect the entire future requests for more files to be downloaded and watched.

2.4 System's Boundaries

The main aspect of this paper is to study the system's boundaries and identify what the rules to be followed are and how from there we can define system's metrics. The idle scenario will be presented by Base Line followed by H1 heuristic study case, the Idle and heuristics scenarios will be defined more in depth.

2.4.1 Base Line Scenario

The Base Line represents an ideal scenario of running the network simulation; network will be unlimited accessing and downloading, the following assumption will be based on Base Line simulation:

- All nodes have limited bandwidth between themselves and the server in the same network.
- All nodes have internal infinite storage device for unlimited number saved movies' files can be downloaded.
- Nodes only can download files from server, there are no individual uploading to the network.
- Penalty is measured by the difference between the desired time of watching the movie by individual customer and the actual watched time of the files.

2.4.2 H1 Heuristic Scenario

The first heuristic represents the same scenario for Base Line with few exceptions added for more study of how the network can act and work toward optimization and using customer's preferences. Few nodes will be forced to upload certain files on there internal storage media depends on their customer's preference and personalize in addition to the files' preferences during there normal operations with the network. The following assumptions will be based on H1 heuristic simulation:

- All nodes have limited bandwidth between themselves and the server in the same network.
- All nodes have the same limitations bandwidth with themselves as they do with the server.
- All nodes have internal limited storage device with different sizes that limited number of saved movies' files can be downloaded either from the server or others nodes on the same network.
- Few nodes will be forced to keep certain files on there internal storage media by preemptive these files during there normal operations with the network.

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- Nodes are able to download files either from the server or from others nodes on the same network but following these guidelines:
  - If the file exists on the server only, all nodes are able to download with no exception or limitation but depends on the bandwidth speed, file size and ordered time.
  - If the file exists on the server and other node, any node can download the same file from the server and from the node hosting that file, but the node hosting the file will not upload it to more than one requested node at the same time.
  - If the file existing on two nodes, any node can download the same from file from these two nodes hosting that file, but the nodes hosting the file will not upload it to more than one requested node at the same time.
- Penalty is measured by the difference between the desired time of watching the movie by individual customer and the actual watched time of the files.

3 Results

The graphs are presented and summarized from the data generated that serve the purpose of the research. In resulting bandwidth values will be limited to 1Mb/s and internal storage media will be limited to 50GB and 200GB.

In addition, it was noticed for individual bandwidths that increasing the hard drive size above 200GB had no impact on the performance. All results remain the same as if the hard drive size installed is 200GB because the network assumes it is an infinite size.

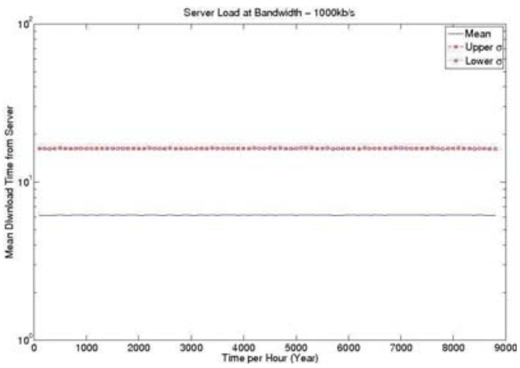

Figure 2: Server load for Base Line case scenario.

Figure 2 demonstrate the mean download time of the baseline scenario in the time series analysis is completely dependent on the server for all files downloaded to each node.

The H1 heuristics as shown on figure 3 indicates that the mean download time from server values decreased exponentially through the entire year for each individual hard drive size. All results remain the same as if the hard drive size installed was 200GB because the network assumes it is an infinite size.

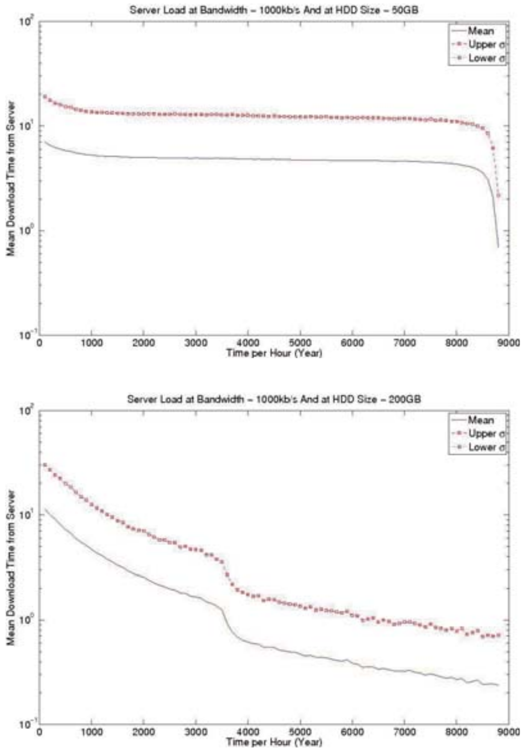

Figure 3: Server load for H1 case scenario

On figure 4 shows that the mean Penalty per hour were exponential decay, also the total mean values were decreased per each had drive size. However, the graphs show an exponentially decay because there is enough bandwidth to accommodate the file size. In addition, the existing files that have already been downloaded before on other nodes are used as a sharing point along with the server; as the time goes on, the customer's are more likely downloading the files from other nodes than from the server.

4 Conclusions and Future Work

The Base Line scenario for server load in which the hard drive is assumed to be an irrelevant factor because files will not be download between nodes. The other following heuristic is H1 for server load was simulated on different hard drive sizes, each size was run separately with single bandwidth value.

The goal of this research was to twofold; the first goal was to develop a non-homogeneous network and develop an understanding of how the constructed network interacts with its internal elements.

The second goal was to evaluate and analyze the network

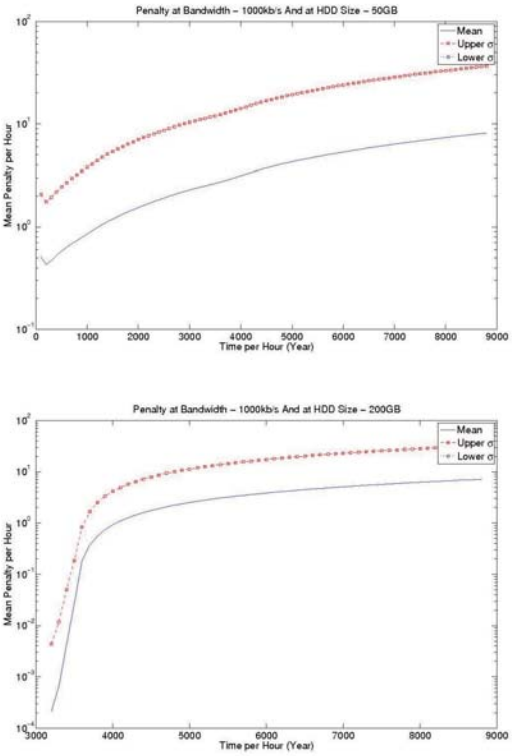

Figure 4: Penalty for H1 case scenario.

that was optimized in two dimensions by changing 'space' and 'time'. As part of the research, a Matlab simulation of a network was developed to evaluate and analyze the network's elements interaction with each other and with server. The server load and penalty along with different hard drive sizes were also evaluated for its usability and effectiveness as measuring tools.

Based on the results of this study, it is evident that the addition of real simulation of a network has the potential of improving the performance measured and thereby improving network operations and network optimization in 'space' and 'time'. The delivery method of a real simulation needs to be determined.

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