AN EFFECTIVE BANDWIDTH MANAGEMENT BY COMPRESSION TECHNIQUE FOR PERFORMANCE ENHANCEMENT IN A SYSTEM

1Ashok Kumar Tripathi, 2Ramesh Bharti
1M.Tech Research Scholar, Dept of Electronics & Communication Engineering, Jagannath University, Jaipur, India
2Associate Professor, Dept of Electronics & Communication Engineering, Jagannath University, Jaipur, India

ABSTRACT
Bandwidth management is a generic term that describes the various techniques, technologies, tools and policies employed by an organization to enable the most efficient use of its bandwidth resources. ‘Efficient use’ means both the minimization of unnecessary bandwidth consumption and the delivery of the best possible levels of service to users. ‘Bandwidth resources’ refers to the bandwidth of a network, which might be a local network, a Regional Area Network or fields units. HTTP compression is a tool for a web-server to compress content before sending it to the client, thereby reducing the amount of data sent over the network. In addition to typical savings of 60%-85% in bandwidth cost, HTTP compression also improves the end-user experience by reducing the page-load latency. For these reasons, HTTP compression is considered an essential tool in today’s web supported by all web-servers and browsers, and used by over 95% of the leading websites. Further to add more bandwidth there is need of putting extra hardware which will cost more. Data compression plays an important role in improving the performance of low bandwidth network. Among other performance enhancement techniques, data compression is the most suitable and economical way to further improve network. This is because data compression technique is much simpler and can be implemented easily and freely available and no complicated hardware configuration is required. Thus, data compression is adopted in the proposed case study.

Keywords: Bandwidth Management, Organisational Networking System (ONS), Compression Techniques, Intranet Usage Policy, Compression Ratio.

I. INTRODUCTION
The organisational networking system is one of the most essential assets for any organisation to support and deliver numerous key services. This is also an integral part of computing environment that supports organizational business activity and official works [3]. It is not viable for any big organization to operate if it is not connected to the entire offices spread across the country side. This means, the survival is dependent on good working access of Intranet. Effective Intranet Access requires an information delivery chain consisting of four essential links: (i) content, (ii) connection, (iii) local resources, and (iv) bandwidth management. The content must be in a form accessible by the user. The connectivity is essential to access the content. Furthermore, the resources are required to deliver the content to the end users. These include the local network, computers, necessary tools and skills of network administration team. But bandwidth management is the core issue that attracts attention to provide seamless flow of information. In the current paper, one of the core issues of network management system, i.e. to make available adequate bandwidth is discussed in detail by considering case study of Chanakya Organisation.

II. NECESSITY OF BANDWIDTH AND ITS MANAGEMENT
The bandwidth simply represents the capacity of the communication media to transfer data from source to destination. Wider the route/path for data transmission, more packets of information will be transmitted to the user's Intranet enabled devices. Bandwidth is a gross measurement, taking the total amount of data transferred in a given period of time at a particular rate, without taking into consideration the quality of the signal itself [4]. Furthermore, the bandwidth is responsible for data transfer speed and commonly used in Intranet connections. Bigger the bandwidth quota is, the higher the connection speed and hence quicker it will be to upload and download information. The basic measurement unit of bandwidth is bits per second (bps) and it can be kilobits per second (kbps), megabits per second (mbps) and gigabits per second (gbps). Various Intranet connections are offering different bandwidth standards. For instance, the traditional dial-up Intranet Connection provides a very narrow bandwidth limit of about 56 kbps, while the current broadband connections allow data transfer at much higher speed ranging from 128 kbps to 2mbps. Bandwidth is both absolutely and relatively much more expensive for any organisation. Chanakya organization is found that it does not have reliable, usable Intranet Access for their offices and staff despite considerable investment. Improving the performance of the information delivery chain is urgent if organisation and staffs are to be benefited from the Intranet and take part in the organisational activity [5]. The performance of the existing Intranet Connection can be enhanced by monitoring and controlling mechanism and this is known as bandwidth management.
III. BACKGROUND OF THE PROBLEM
Chanakya is a virtual org having large network infrastructure which is spread across the country. The initial networks was functioning on 2 Mbps for voice and file transfer purpose. Automation of organisation started on 2000. By 2012 the various networks users increased manifold. The users were using networks for voice, data transfer, video, photo, emails, file transfer, website and online database accesses activity. The BW has been increase up to 8 mbps by different via media like line, wireless, microwave and VSAT. Now the network is facing congestion during day time from morning 9 am to 6 pm and mission critical web applications are not accessible across the users of Chanakya. Chanakya is under pressure to provide their staff and offices with reliable Intranet access. As Intranet connectivity is increasingly becoming a strategic resource for firm management, a robust Branch office network with good connectivity to the Intranet is no longer a luxury to a Chanakya, in actual fact, it is now a basic necessity. The use of the Intranet can enhance the efficiency and capacity of Chanakya .Intranet connectivity provides a gateway to vast amounts of information from the headquarters to area offices and thus provides support and enhances recourses and activity management by both staff and officials. Chanakya have set aside a significant fraction of their budgets towards increasing their bandwidth and upgrading their networks. Despite considerable investment in bandwidth, many of these Area offices are still finding themselves not having reliable, usable Intranet access for their staffs and offices. The demand for bandwidth within Area office is constantly rising and the overall bandwidth usage continues its upward trend. A definite trend is continuing towards p2p, multimedia websites, which contain bandwidth-hungry images, video, animations, and interactive content. Staffs in offices use the Intranet in many different ways, some of which are inappropriate or do not make the best use of the available bandwidth. [14]

As the popularity and usage of heavy bandwidth consuming applications grows and the number of network users multiplies, the need for a concerted and co-ordinate effort to monitor bandwidth utilization and implementation of effective bandwidth management strategies becomes increasingly important to ensure excellent service provision. Policy based bandwidth management was adopted and BW was optimized up to some extent. However in spite of all, the data base web services are still not able to get access in far flung of field unit/offices. Since bandwidth is a strategic resource, the efficient usage and management of such a resource should always be a priority. Without bandwidth management, mission critical applications would be starved of bandwidth, disrupting services that impact the operational activities of a Chanakya.

As such, this study sought to illuminate the bandwidth management strategies that were being employed by Chanakya in his large network. The case study concentrated on technology based i.e. compression techniques to optimize the bandwidth at server end and browser end. [13].

IV. THE PROBLEM
The demand for bandwidth within Chanakya is on a constant rise. The available bandwidth is generally not enough to meet demands and to support optimal usage. Area office is faced with a major challenge in their use of the Intranet. The major challenges experienced by Chanakya are:

(a) Database web application not accessible at field/mobile units/offices.
(b) Violations of network due to peer–to-peer (P2P) file sharing.
(c) Poor application performance and Quality of Experience (QoE) during congestion.
(d) Mission critical application not able to access in last end office.
(e) Experience of sluggish network speed during peak office hours.
(f) Sudden very less bandwidth availability at user end and non response of web enabled hosted applications. [14].

V. OBJECTIVES OF STUDY
1. To apply data compression techniques to compress the data and optimise the web browser to save the bandwidth.

2. To ensure that mission critical application are available at last field units/office of the Chankaya and hence enhance and optimise overall bandwidth for performance enhancement on a organisation network.

VI. APPROACH OF STUDY
As the popularity and usage of heavily bandwidth consuming applications grows and the number of network users multiplies over the coming years, the need for a concerted and coordinated effort to monitor bandwidth utilization and implement bandwidth management will become increasingly important to ensure excellent service provision. As already stated, it is believed that this effort will be greatly facilitated by the formulation and implementation of an organizational bandwidth management strategy. To set the scene, a broad review of technology-based and policy-based bandwidth management can be undertaken, followed by an overview of network monitoring. Bandwidth management components fall into three broad categories: technology-based, policy-based and monitoring. The policy based bandwidth management was adopted to filter the unwanted traffic and utilised the best available bandwidth. However, still the mission critical web
application was not accessible fully. As compression techniques are simple and freely available, hence it is
taken as case study to optimise the bandwidth in chanakya.[12][24][25]

VII. COMPRESSION TECHNIQUE-BASED BANDWIDTH MANAGEMENT

Compression of data reduces the total amount of traffic that traverses the network, thereby reducing congestion. Network compression affects all (previously uncompressed) data prior to transmission, similar to the way WinZip reduces the size of individual files or folders. HTTP compression is an essential tool for web speed up and network cost reduction. Not surprisingly, it is used by over 95% of top websites, saving about 75% of webpage traffic. HTTP compression. HTTP compression[19][20] is a tool for a web-server to compress content before sending it to the client, thereby reducing the amount of data sent over the network. In addition to typical savings of 60%-85% in bandwidth cost, HTTP compression also improves the end-user experience by reducing the page-load latency [1].

The current most popular web-servers [16] (Apache, nginx, IIS) have an easily-deployable support for compression. Due to the significant CPU consumption of compression, these servers provide a configurable compression effort parameter, which is set as a global and static value. The problem with this configurable parameter, besides its inflexibility, is that it says little about the actual amount of CPU cycles required to compress the outstanding content requests. Furthermore, the parameter does not take into account important factors like the current load on the server, response size, and content compressibility.

HTTP Compression is a technique supported by most web browsers and web servers. When enabled on both sides, it can automatically reduce the size of text downloads (including HTML, CSS and JavaScript) by 50-90%. It is enabled by default on all modern browsers, however all web servers disable it by default, and it has to be explicitly enabled. A surprising number of sites still do not have compression enabled, despite the benefits to users and the potential saving in bandwidth costs at the server-side.[1][20,21,22,23]

A. Static vs. Dynamic Compression

Static content relates to files that can be served directly from disk (images/videos/CSS/scripts etc.). Static compression pre-compresses such static files and saves the compressed forms on disk. When the static content is requested by a decompression-enabled client (almost every browser), the web server delivers the pre-compressed content without needing to compress the content upon the client’s request [17]. This mechanism enables fast and cheap serving of content that changes infrequently. Dynamic content, in the context of this paper, relates to web pages that are a product of application frameworks, such as ASP.NET, PHP, JSP, etc. Dynamic web pages are the heart of the modern web [18]. Since dynamic pages can be different for each request, servers compress them in real time. As each response must be compressed on the fly, the dynamic compression is far more CPU intensive than static compression. Therefore, when a server is CPU bound it may be better not to compress dynamically and/or to lower the compression effort. On the other hand, at times when the application is bound by network or database capabilities, it may be a good idea to compress as much as possible.[25][27]

B. CPU vs. Bandwidth Trade-off

The focus in this paper is on compression of dynamic content, namely unique HTML objects generated upon client request. The uniqueness of these objects may be the result of one or more of several causes, such as personalization, localization, randomization and others. On the one hand, HTML compression is very rewarding in terms of bandwidth saving, typically reducing traffic by 60-85%. On the other hand, each response needs to be compressed on-the-fly before it is sent, consuming significant CPU time and memory resources on the server side. Most server-side solutions allow choosing between several compression algorithms and/or effort levels. Generally speaking, algorithms and levels that compress better also run slower and consume more resources. For example, the popular Apache web-server offers 9 compression setups with generally increasing effort levels and decreasing output sizes. Figure 1a presents a typical bandwidth reduction achieved with all the 9 compression levels in an Apache site. We just mention at this point that the average page size in this example is 120 KB. [1]

C. Compression Location

Optimizing data compression in the web server [26] is very promising, but simultaneously challenging due to the great richness and flexibility of web architectures. Even the basic question of where in the system compression should be performed does not have a universal answer fitting all scenarios. Compression can be performed in one of several different layers in the web server side. Figure 2 illustrates a typical architecture of a web application server, where each layer may be a candidate to perform compression: 1) the application-server itself, 2) offloaded to a reverse-proxy, or 3) offloaded to a central load-balancer. On first glance all these options seem equivalent in performance and cost implications. However, additional considerations must be taken into account, such as a potential difficulty to replicate application-servers due to software licensing costs, and the risk of running CPU-intensive tasks on central entities like the load-balancer.[22][23]
VIII. IMPLEMENTATION

Our main contribution to compression automation is software/infrastructure implementations that endow existing web servers with the capability to monitor and control the compression effort and utility. The main idea of the implemented compression-optimization framework is to adapt the compression effort to quality-parameters and the instantaneous load at the server. [26] This adaptation is carried out fast enough to accommodate rapid changes in demand, occurring in short time scales of seconds. In this section we provide the details of two alternative implementations and discuss their properties: Both alternatives are found in the project’s site [14] and are offered for free use and modification. The compression techniques were implemented as follow:

a. Web server compression at server end
b. Web browser optimization at user end

IX. RESULT AND PERFORMANCE ANALYSIS

When compression is in use by the server, the TTFB tends to get higher. This is because today’s dynamic servers usually perform the following steps in a pure sequential manner: 1) page generation, 2) compression, and 3) transfer. Therefore, the larger the page and the higher the compression level, the larger the TTFB. On the other hand, compression obviously reduces dramatically the complete download time of a page. Altogether, although the compression increases the TTFB, there is no doubt that this extra delay pays itself when considering the complete download time [12]. The open question is how high the compression level should be to reap download-time benefits without sacrificing latency performance. For example, Figure 1c shows the compression time of a 120 KB page, where the slowest level takes x3 more time than the fastest level, which is a typical scenario as we show in the sequel.

A Compression at Low Bandwidth Scenario

Figure 4 & 5 below shows the distribution of best compression rate over the congestion rate for Case 1(5%),2(10%) and 3(15%) in Scenario 1(Low Bandwidth) & 2(High Bandwidth). Best compression rate is the compression rate that yields the highest throughput, with the condition that its corresponding packet drop rate does not exceed the limit in each case. Notice that in both scenarios, the best compression rate increases with the congestion rate. This means that a larger compression buffer, which can accommodate more packets, is favoured to obtain a higher performance when the link is getting more and more congested. In Scenario 1, due to the packet drop rate constraints that limits the highest throughput that can be achieved, the best compression rate line of Case 1 is slightly lower than the line of Case 2 & 3, while Case 2 & 3 both achieve similar results (overlapped lines). In Scenario 2, all three cases favour the same compression rates.

Figure 1. Compression location alternatives in the web server side [7]

Figure 2. Compression Latency grow in upper level

Figure 3. Bandwidth saving in upper level
As shown in the figures, low bandwidth scenario requires higher compression rates (1 - 232) while high bandwidth scenario requires lower compression rates (1 - 16). This shows that the proposed scheme performs better in low bandwidth scenario compared to high bandwidth scenario. This is because high bandwidth scenario has sufficient bandwidth to accommodate heavy flows of traffic, thus compression might not be needed, while in the case of low bandwidth, compression is mandatory as bandwidth limitation problem will cause the communication link to be severely congested.

**B. Compression at high Bandwidth Scenario**

**C. Packet Drop Rate at Low Bandwidth Scenario**

Figure 6 & 7 shows the distribution of packet drop rate over the congestion rate. Notice that in both scenarios, the packet drop rate without compression increases with the congestion rate. This means that communication link with higher congestion value has higher packet drops. With the adoption of the proposed scheme, block compression reduces the heavy network load and hence avoiding network congestion. Thus, the packet drop rate can be reduced significantly as no packet being dropped due to buffer overhead at the router. The proposed scheme succeeds in reducing the packet drop rate by 1 – 92 percent in Scenario 1 and 1 – 83 percent in Scenario 2. In Scenario 1, due to the packet drop rate constraint of 5%, the packet drop rate line of Case 1 is slightly lower than the line of Case 2 & 3, which with the limits of 10% & 15%. Since the best compression rates for Case 1, 2 & 3 are similar as illustrated in Figure 7, thus the corresponding packet drop rate values of these three cases are the same too.

**D. Packet Drop Rate at High Bandwidth Scenario**

**E. Throughput at High Bandwidth Scenario**

Figure 8 & 9 below shows the distribution of packet throughput over the congestion rate for the simulation running without the proposed scheme and simulation running with the proposed scheme (Case 1, 2 and 3) in Scenario 1 & 2. The throughput for simulation without compression decrease with the congestion rate in both scenarios. The more congested the link, the more packets being dropped due to buffer overhead at the router, hence the lower the throughput. As shown in Figure 7 & 8, the proposed scheme succeeds in improving the throughput by 7 – 165 percent in Scenario 1 and 5 – 65 percent in Scenario 2. This is because by applying block compression, more packets can be transmitted over the communication link at one time; hence the throughput can be greatly improved. Notice that the improvement of packet throughput in Scenario 1 is better than in Scenario 2. This also suggests that the proposed scheme is performing much better in a low bandwidth scenario compared to a high bandwidth scenario. This is because compression might not be necessary in high bandwidth scenario, as there is no bandwidth limitation problem and sufficient bandwidth is provided to accommodate heavy traffic.
flows. In contrast, applications are competing for the low and limited bandwidth when there are heavy flows in a low bandwidth scenario, thus, compression is required to further improve the network performance.

Fig 8. Throughput at low Bandwidth Scenario

Fig 9. Throughput at high Bandwidth Scenario

F. Improvement at Low & High Bandwidth Scenario

To evaluate the performance and effectiveness of the proposed scheme, extensive simulations have been conducted using captured TCP traffic. The proposed scheme is evaluated under two main scenarios: low bandwidth and high bandwidth. Simulation results show that the proposed scheme succeeds in reducing the packet drop rate and improving the packet throughput significantly in both low and high bandwidth scenarios, as shown in Table 3.

Table 1: Improvement in low and high bandwidth.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Improvement Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low bandwidth</td>
<td>Packet drop rate: Up to 90</td>
</tr>
<tr>
<td>High bandwidth</td>
<td>Packet drop rate: Up to 82</td>
</tr>
</tbody>
</table>

H. The Effects of Compression

After employing compression at server end and optimization at user end, the comparative bandwidth saving achieved using compression is tabulated in table 9.2 here is an analysis of a range of popular web sites in chanakya. The download times assume an average bandwidth of 20kbps.

Table 2. Comparison of compression of various web pages

<table>
<thead>
<tr>
<th>Web pages</th>
<th>Size without compression (kB)</th>
<th>Size with compression (kB)</th>
<th>Down load time without compression (s)</th>
<th>Down load time with compression (s)</th>
<th>Relative saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web server page</td>
<td>170</td>
<td>156</td>
<td>68</td>
<td>62</td>
<td>8%</td>
</tr>
<tr>
<td>Databade web page</td>
<td>78</td>
<td>70</td>
<td>31</td>
<td>28</td>
<td>10%</td>
</tr>
<tr>
<td>Online news page</td>
<td>796</td>
<td>695</td>
<td>318</td>
<td>278</td>
<td>13%</td>
</tr>
<tr>
<td>Training centre</td>
<td>450</td>
<td>173</td>
<td>180</td>
<td>69</td>
<td>62%</td>
</tr>
<tr>
<td>search results page</td>
<td>27</td>
<td>12</td>
<td>11</td>
<td>5</td>
<td>66%</td>
</tr>
</tbody>
</table>

X. CONCLUSIONS AND FUTURE WORK

Bandwidth management is a serious and emerging challenge for almost all organisations in the present world of Information Technology. Lack of appropriate bandwidth management is preventing useful Intranet Access which in turn yielding low quality of organisational and offices works. Better management of bandwidth makes Intranet Access wider especially for those who need it in actual.

In this we need to go for procurement of hardware and software which involve additional financial burden. It is a very complex and time consuming solution due to its expensive nature because it needs to get approvals from various authorities in a hierarchical manner within the organisation and also at the government level, and as a result bureaucratic delay for immediate solution. So it was decided to go on parallel for second option, i.e. “compression based bandwidth Management” for immediate relief to the genuine users and mission critical applications. Since compression techniques are simple and freely available then it was decided that compression technique will be utilised for bandwidth saving. It was employed at server end at main server farm and also at user end for web browser optimisation. By applying compression we could achieved bandwidth saving of around 21% which could enable us to access dynamic web page of database server at field unit and area offices. We have used gzip open software for compression, other
various freeware can be utilised. Other techniques which can be utilised as future works are like QOS techniques, load balancing and caching techniques for better and effective bandwidth optimisation.

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Author Profile

Ashok Tripathi received his B.E. degrees in Electronics Engineering from SGGS College of Engg &Technology, Nanded in 1996, MMS from Berhampur University, Odisha in Military Science and Technology in 2005 and PG Diploma in VLSI & Embedded System from C-DAC, Pune in 2012, respectively. Presently he is pursuing MTech from Jaganth University, Jaipur, India in Embedded System Technology. His areas of interest are embedded system, robotics, radar technology, web technology, computer Network and Security, Microprocessor and Microcontroller Based System Wireless and Mobile Computing and Database and Management Information System.

Asso. Prof. Ramesh Bharti has received his M-Tech. Degree in Electronics & communication Engineering from Malviya Institute of Technology, Jaipur. India in 2010 and B-Tech from SKIT&G, Jaipur in 2004. He is pursuing his Ph.D from Jaganth University. He has got teaching experience of 11 years in same field. Presently he is working as Associate Professor in department of Electronics and Communication Engineering, Jaganth University, jaipur.