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OPTIMAL ROUTING ALGORITHM FOR EFFICIENT OVERLAY NETWORK DESIGN AND DEVELOPMENT

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ABSTRACT

This paper delves into the concept of overlay systems, which create virtual geographies on top of existing network structures, acting as an intermediary layer between end-user applications and network services. Such systems offer significant benefits, including enhanced functionality and improved performance achieved through the implementation of application-specific protocols. The study investigates the advantages provided by overlay systems and proposes novel tools to enhance execution and functionality in networking applications. The paper also explores the Peer-to-Peer (P2P) paradigm, an alternative approach to distributed systems that relies on the resources and services offered by connected endpoint devices. P2P-based distributed systems establish dedicated virtual networks, known as overlay networks, over physical communication mediums, effectively meeting both functional and non-functional requirements. The process of organizing overlay systems presents challenges, especially in satisfying requirements while effectively managing potential conflicts. To address this, the paper adopts a simulative approach, utilizing a tool capable of capturing user behavior and network characteristics, thereby facilitating improved evaluation and performance measurements across various scenarios. Through this investigation, the paper contributes to the understanding and advancement of overlay systems and their application in modern networking environments.

Keywords: Overlay systems, Network virtualization, Application-specific protocols, Peer-to-Peer (P2P) paradigm, Simulative evaluation

INTRODUCTION

Distributed computing and interpersonal communication often rely on P2P overlay networks. P2P is particularly influential in multimedia content delivery and communication frameworks, forming groups based on relations between individuals or technical criteria like latency and performance. Groups are essential for maintaining service reliability. Over the years, P2P overlay networks have integrated groups and clusters to enhance performance and handle network flaws. Group management involves establishing, configuring, discovering, joining, and removing groups, facilitating resource sharing and communication among members.

However, the distributed nature of P2P overlay networks raises security concerns, including malicious nodes, DoS attacks, worms, and other threats, impacting peer activities and degrading network performance. To send data between peers, a distributed hash table is used to locate peers and transmission resources. This hash table contains information about all peers and their positions, enabling peer nodes to transmit data efficiently based on this information.

Problem statement: The P2P worldview offers unique strengths compared to the C/S perspective. However, a brief examination of existing overlay systems for Peer to Peer structures highlights their shortcomings and identifies unaddressed design challenges. Current solutions fail to meet essential requirements, such as scalability, evenly distributed workload, and support for heterogeneity, calling for a carefully researched approach with a high degree of flexibility to manage their inherent tradeoffs.

Objectives

The primary goal of this research is to develop a generalized algorithm capable of finding all feasible and optimal alternative paths within a selected communication network, connecting any source to any destination, while considering the metric of the least number of hops. Additionally, the study aims to integrate a Trust Model and an efficient Key Management plan to ensure secure communication in P2P overlay networks. Furthermore, an improved secure trust model will be devised to detect and eliminate malicious nodes attempting to join the network during routing or group communication. By merging the Trust Model with the efficient Key Management plan, a secure communication environment will be established, offering enhanced reliability and protection within P2P overlay networks.

Review of literature

Bisadi et al. (2016) clarified about the DSDS for P2P network. The DSDS is actualized utilizing non excess Rainbow Skip diagram. This chart can be utilized by DSDS so as to organize the transmission of data between the hubs. The conveyed model means to give the expanded dependability, adaptability and vigor to information structure. A disappointment strategy has additionally been acquainted all together with serve the inquiries in any event, when a hub in the network fizzles. The proposed technique requires just less messages to answer the inquiries contrasted with its current framework.

Jaideep et al. (2016) examined about the presentation of the P2P network. The P2P network is more agreeable for document sharing and to shape the overlay on the head of the network. The significant issue in the assault Denial of Service (DoS) is more helpless. The inspiration is to shield the networks from the aggressors.

Liu et al. (2016) proposed a programmed fixing instrument dependent on social registering. A programmed fix can be created and sent it to the center point hubs. These hubs acknowledge the fix and forward to its companions in the interpersonal organization as indicated by the level of its neighbors. At that point the collectors acknowledge the fix as per its trust connection between the client and his companions. The programmed fixing is engendered all through the informal organization to fix the weak hubs. A programmed fixing assists with expanding the network execution and furthermore to build more number of clients in the P2P overlay network.

METHODOLOGY

The simplest method to achieve reliability in Overlay Networks is by using a reliable protocol, often TCP, between the endpoints of a connection. This approach offers ease of use and setup but comes with a significant cost in recovery from a loss.

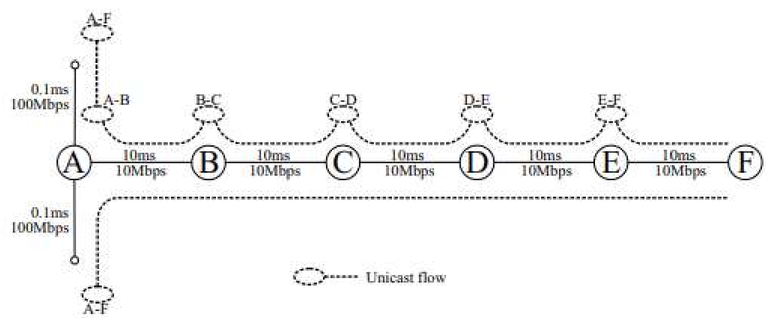

FIGURE 1: Chain Network Setup

Furthermore, congestion control on the overlay connection can recover the congestion window faster than an end-to-end connection due to a smaller round trip time. Jump-by-jump reliability involves buffering and processing at the intermediate overlay nodes, where these nodes handle reliable protocol, packet monitoring, congestion acknowledgment, and control, in addition to their regular routing functionality. While implementing this approach at the level of Internet routers may be challenging due to scalability limitations, deploying it at the overlay network level allows us to pinpoint congestion and limit the issue to the congested portion of the network. For instance, using five reliable hops of 10 milliseconds each instead of one end-to-end connection results in fewer delayed packets when the same message is lost on the same middle connection. The reduced recovery time span becomes more significant as the throughput increases.

Having reliable overlay links alone does not guarantee end-to-end reliability. Intermediate nodes may crash, and overlay connections may become disconnected, necessitating local handling of reliability issues at each hop. However, to ensure end-to-end reliability, some packets need to be recovered from the underlying sender in case of temporary node failure or route changes. Sending double acknowledgments for some packets is significantly reduced by resending the missed data packets only locally, at the hop where the loss occurred, rather than end-to-end. To minimize latency and burstiness, packets are forwarded even if flawed at intermediate hops, and the correct order is restored at the end recipient. Multiple streams using the same overlay link don't need to reorder packets relative to each other, improving overall efficiency. The end recipient signals congestion promptly, and the sender's congestion control interprets it as a loss, though the sender does not resend the corresponding packet. However, the sender still sends retransmissions when necessary (e.g., in case of node failures and rerouting). In the absence of congestion, this phenomenon doesn't affect traffic burstiness, but in congested situations, the recipient sends end-to-end acknowledgments for each packet (stepped by a congested middle overlay switch) until the congestion is resolved. If an application is slow in receiving messages (even if the overlay network is not congested), an end-to-end flow control system should block the sender application.

RESULT

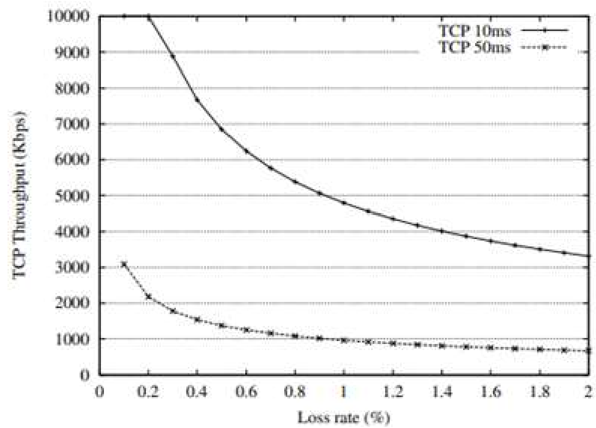

FIGURE 2: TCP throughput (analytical model)

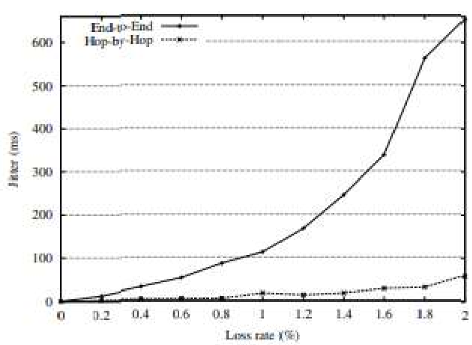

FIGURE 3: Average jitter for a 500 Kbps stream (simulation)

The distribution of packet delays for a specific loss rate is intriguing. About 18% of packets experience delays exceeding 100 milliseconds in an end-to-end connection, while only 1% of packets face such delays in a jump-by-jump connection. It's essential to note that the actual number of delayed packets is much higher than the number of lost packets.

We studied how performance is affected by the number of slow and reliable hops in an overlay network. For a network with a 50-millisecond delay, we measured the proportion of delayed packets as we increased the number of intermediate hops from 1 to 10 while keeping the total path latency constant. Surprisingly, two to four hops seem sufficient to achieve most of the benefits associated with jump-by-jump reliability. This is encouraging, as deploying small overlay networks is relatively straightforward.

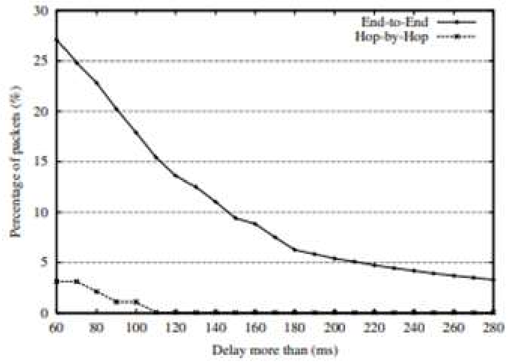

FIGURE 4: Packet delay distribution for a 500 Kbps stream (simulation)

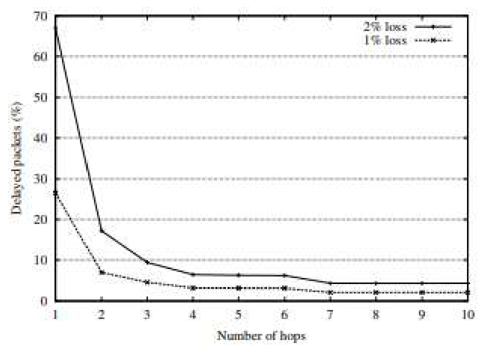

FIGURE 5: Increasing the number of hops (simulation)

The key to achieving improved performance with jump-by-jump reliability lies in minimizing the latency of the lossy connection, rather than the number of hops in the end-to-end connection. In practice, this can be achieved by strategically placing a few overlay nodes to create nearly equivalent latency overlay links since it is challenging to predict in advance which Internet connections will experience congestion.

CONCLUSION

This paper discusses various aspects related to overlay networks, including their benefits, cost-effectiveness, and applicability to real-world scenarios. The authors proposed a jump-by-jump reliability approach to reduce latency and jitter in overlay networks, and results showed that the overhead associated with overlay network handling was negligible compared to the significant performance improvement. A Trust Model and efficient Key Management (TMKM) scheme were introduced for secure communication in P2P overlay networks, incorporating features like node registration, key issuance, and node reputation-based security. The design of Peer-to-Peer overlay systems is examined, focusing on scalability, flexibility, reliability, and load balancing. The use of de Bruijn digraphs provides inherent flexibility, and a simple left-shift operation allows for efficient routing. Network proximity is achieved through latency-based neighbor selection, and peer heterogeneity is accommodated through role-based clustering. Efficient load balancing and continuous scalability are achieved using the de Bruijn digraph enhancement algorithm. The following sections delve deeper into these topics of interest.

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