Management of Network Congestion using an Explicit Congestion Network (ECN)

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ملخص: يحدث ازدحام الشبكة عادةً في حالات التحميل الزائد لحركة المرور عندما يتعامل ارتباط أو عقدة شبكة مع بيانات تتجاوز سعتها. يمكننا توضيح الموقف الذي زاد فيه نقل البيانات بسبب الإنتاجية المنخفضة أو الأصغر نسبيًا، والتي تتعلق بسعة الاتصال، والتي يتم قياسها من حيث عرض النطاق الترددي كميغابت في الثانية. عندما تكون الشبكة مزدحمة، فإنها تحاول إرسال المزيد من البيانات، ولكن سيتم إرسال بيانات أقل نجاحًا. في حالة حدوث ازدحام في الشبكة، لا يوجد نطاق ترددي كافٍ للتعامل مع حجم حركة المرور على الشبكة. بمعنى آخر، يحدث الازدحام عندما تتجاوز طلبات الموارد السعة. يعد النطاق الترددي من بين الأسباب الأكثر شيوعًا لازدحام الشبكة. يشير النطاق الترددي إلى المعدل الأقصى الذي يمكن أن تتحرك به تلك البيانات على طول المسار أو السعة الإجمالية لذلك المسار. يحدث ازدحام الشبكة عندما لا يكون هناك عرض نطاق ترددي كافٍ للتعامل مع الازدحام الحالي . يهدف هذا البحث إلى تقليل مخاطر الازدحام باستخدام طريقة من بروتوكول MPLS تسمى شبكة الازدحام الصريح (ECN)، بعد حساب قيم زمن الوصول للشبكة (التأخير) بجميع أنواعه، وتعريف الازدحام وأنواعه وأسبابه.

Abstract: Network congestion typically occurs in traffic overload situations when a network link or node handles data beyond its capacity. We can illustrate the situation where data transmission has increased due to relatively lower or smaller throughput, which is related to the connection capacity, which is measured in terms of bandwidth as megabits per second. When the network is congested, it tries to send more data, but less successful data

will be sent. If Network congestion occurs, there is not enough bandwidth to handle the traffic volume on the network. In other words, congestion occurs when resource requests exceed capacity. Bandwidth is among the most common causes of network congestion. Bandwidth refers to the maximum rate at which that data can move along a path or the total capacity of that path. Network congestion occurs when there is insufficient bandwidth to handle the current traffic. This research aims to reduce the risk of congestion by using a method from MPLS protocol, called **E**xplicit **C**ongestion **N**etwork (**ECN**), after computing the latency (Delay) values of all kinds, and the definition of ***congestion*** and its types and causes.

Keywords: Network congestion, Bandwidth, Networks, Traffic monitoring, Traffic Measures, TCP, MPLS, ECN, BGP, QoS.

1- Introduction:

Network congestion occurs when a network overruns more data packet traffic than it can handle.

When congestion occurs, the number of packets transmitted over the network approaches the packet handling capacity of the network [Andrew, et al.].

When a network is tasked with more data than it can comfortably handle, congestion can occur, whereby congestion is an overload of data that causes slowdowns throughout the company [Aftabuzzaman, Institute of Transport Studies]. Everyone on the network feels the effects of network congestion. Like that "The connection is too slow "or" Web pages can't be opened "or" The network is really bad".

The crowding effect can be explained as follows:-

- Incoming packets are stored in input buffers: which act almost like a FIFO ("First In, First Out)" queue and drop packets only if the queue is full.
- Delay: Delay is the time it takes for a destination to receive a packet sent by the sender, for example, the time it takes for a webpage to load is a result of how long it takes for the packets from the web server to get to the client.
- Packet loss: While packets may take a while to get to their destination (delay), packet loss is an even more negative effect of network congestion. The packet moves to the output buffer. Routing decision made.
- Connection Timeouts: Network congestion can also result in timeouts in various applications. Since most connections will not stay up indefinitely waiting for packets to arrive, this can result in lost connections; many services will timeout instead of waiting for the arrival of packets. Packets queued for output transmitted as fast as possible. When queues grow, the network is said to be congested; this effect will manifest itself in increased delay and, at worst, packet loss.

A complete congestion management solution has two functional components:

- A mechanism to manage the impact of congestion.
- A mechanism to trigger management policies.

Fig.(1) illustrates Mechanisms for Congestion Control.

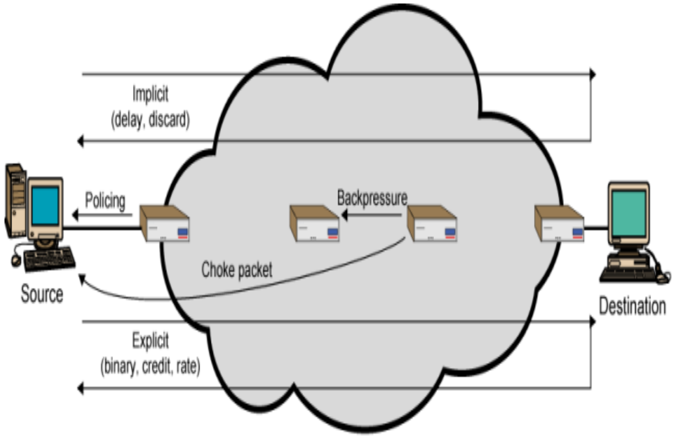

Fig.1 Mechanisms for Congestion Control

2- Causes of network congestion:

2.1 Over-Used Devices: - Not all devices are created equal. Some devices are designed to handle more traffic than others, such as routers, switches, and firewalls are constructed with expectations for network throughput.

2.2 Too many devices:-It is also important to clarify when a network might be using too many devices. Given that, every network has a precise level of support it can provide, issues may arise if this capacity being too strained with an excessive volume of devices.

2.3 Deficient design or poor configuration: Each network needs to be designed or structured in ways tailored to the operation's needs a small-scale company with only a dozen or so employees requires different architecture than a network servicing hundreds. A network needs to be optimized to provide connection to all segments while maximizing performance across each of those segments.

3- ECN as an Indicator the congestion

Explicit Congestion Notification (ECN) from Multiprotocol Label Switching (MPLS) [Briscoe, 2006]. The dominant form of congestion control in today's IP networks is the congestion avoidance mechanisms of TCP, invented primarily. These mechanisms depend on the generally correct assumption that packet losses in the network are an Indication of congestion. Using loss as a congestion indication, TCP senders reduce sending rates when they experience packet loss and slowly increase their rates during periods when no packets have been lost[Briscoe, 2006]. Use the packet loss as an indicator to see if congestion is occurring, and forward the packet instead of dropping it. For some applications, the lost packet will need to be retransmitted and thus will arrive much later at its destination than it would have done had it not been lost. This can cause degradation of the response time of interactive applications such as telnet. For other applications, such as conferencing it is out of the question to retransmit a lost packet; because the retransmitted data will be useless by the time it arrives, so packet loss causes a degradation in application quality. Another issue is that a lost package consumes some resources as it traverses where it is lost. It would be preferable not to send the packet at all if it is just going to be thrown away so that other packets that will be delivered successfully can more profitably use those resources. Given the problems of using loss as an implicit indication of congestion, ECN introduces a way to explicit signal congestion without dropping a packet. [Ramakrishnan, 1999], [Briscoe, 2006].

4- Fixes for Network Congestion and Parameters Used to Measure Network Performance

Network congestion can be fixed by the following:-

a. **Traffic monitoring: - Monitoring network traffic will provide insight sufficient for identifying problem areas. It will help determine where congestion may exist.**
b. **Bandwidth**: The number of messages successfully delivered per unit of time is referred to as throughput. Throughput is influenced by the available bandwidth, as well as the available signal-to-noise ratio and device limitations The simple solution to increasing the amount of transferable information is to increase network bandwidth.
c- **Latency:** Latency is simply the time it takes for data to travel from one designated location to another regarding network performance evaluation. The term "delay" is sometimes used to describe this attribute.

The latency of a network should be as low as possible. Speed of light is the fundamental factor for latency, but packet queuing and refractive index of fibre optic cable are also two factors that can be used to reduce latency

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Pinging www.google.com [142.250.203.228] with 32 bytes of data:

Reply from 142.250.203.228: bytes=32 time=46ms TTL=113

Reply from 142.250.203.228: bytes=32 time=47ms TTL=113

Reply from 142.250.203.228: bytes=32 time=40ms TTL=113

Reply from 142.250.203.228: bytes=32 time=38ms TTL=113

Ping statistics for 142.250.203.228:

   Packets: Sent = 4, Received = 4, Lost = 0 (0% loss)،

Approximate round trip times in milli-seconds:

   Minimum = 38ms, Maximum = 47ms,

 Average = 42ms
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Fig.2 Measuring time of Routers

We can see here there are no lost packets when we ping the biggest website Google.

d-Packet Loss: Packet loss refers to the number of packets that fail to transfer from one destination to another regarding network performance measurement. This statistic can be measured by recording traffic data on both ends and then identifying lost packets and packet retransmission. as shown in Fig 2.

e-Jitter The variance in time delay for data packets carried over a network is known as jitter. This variable denotes an interruption in data packet sequencing that has been identified. Jitter and latency are linked because jitter generates increased or uneven latency between data packets, which can damage network performance and cause packet loss and congestion. While some jitter is to be expected and can typically be tolerated, quantifying network jitter is an integral part of measuring overall network performance. [Pranav Bhardwaj].

However, we are not sure if bandwidth processing is always available. This is why we need to do a check-up periodically; hence, we use ECN to do that from the MPLS protocol.

2.3 Congestion Controls:

Congestion control refers to the mechanism and techniques that can prevent congestion either before it happens or remove congestion after it happened. [Srikant, 2003], [Welz, 2005]. The goal of congestion control mechanisms is simply to use the network as efficiently as possible, that is, attain the highest possible throughput while maintaining a low loss ratio and small delay. Congestion must avoid because it leads to queue growth and queue growth leads to delay and loss.

That is, attain the highest possible throughput while maintaining a low loss ratio and small delay.

2.4Congestion control techniques:

We can divide the congestion mechanism into two broad categories:-

2.4.1 Closed-loop congestion control. (removal) techniques are used to treat or alleviate congestion after it happens, several techniques are used by different protocols; some of them are backpressure in which a congested node stops receiving packets from an upstream node as shown below:

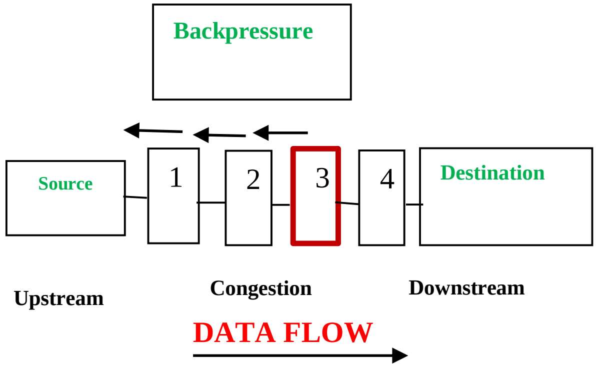
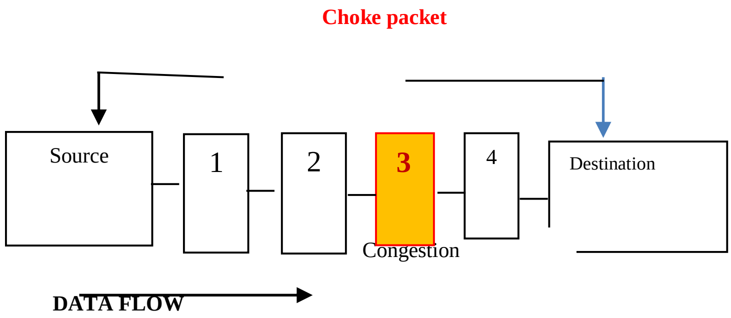


Fig. (5) Backpressure Mechanism

In this type, the warning is from one node to its upstream, although the warning may eventually reach the source station.

Another mechanism has choked a packet**,** used in network maintenance and quality management to inform a specific node or transmitter that its transmitted traffic is creating congestion over the network. [Srikant, 2003]. This forces the node or transmitter to reduce its output rate, choke packets are used for congestion and flow control over a network. As shown below:



Fig, (4) Choke packet Mechanism

In the choke packet method, the warning is from the router, which has encountered congestion to the source station directly.

2.4.2Open-loop congestion control (prevention): in this category, policies are applied to prevent congestion before it happens. Some of the techniques used to manage the congestion are:

- Retransmission policy.
- Window policy.
- ACK policy.
- Discarding policy.

2.5The measurement of network congestion:-

The level of services (LoS) is a grade from **A** to **F. A** being free flow and **F** being very congested indicates how well the roadway or intersection serves its intended traffic. LoS is based on a Volume-to-Capacity (V/C) ratio and has long been used as the primary measure of congestion for planning purposes.

2.5.1 Measures of traffic congestion:-

Measures of traffic congestion can be categorized into four broad groups:

The use of level of service (LoS) has been one of the most popular measures of traffic congestion.

The LoS of a facility is determined by traffic flow characteristics such as vehicle density, volume-to-capacity ratio, average speed, and intersection delay, depending on facility type. The scale of the LOS measure has six discrete classes ranging from A to F. It would be preferable not to send the packet at all if it is just going to be thrown away so that other packets that will be delivered successfully can more profitably use those resources. Given the problems of using loss as an implicit indication of **congestion**, ECN introduces a way to explicit signal congestion without dropping a packet. The basic idea is for a router to set a bit in a packet header when it detects congestion, and then forward the packet rather than drop it.

2.5.2 Indices

The measurement of traffic congestion has been developed by including several congestion-related elements in an equation to produce a single measure called an index. A congestion index was developed as a measure of congestion. This congestion index is the ratio of link delay (the difference between actual and acceptable travel time) to acceptable travel time.

5- Delays in Computer Networks (Latency =Delay)

It defines how long it takes the entire message to completely arrive at the destination from when the first bit is sent out from the source.[Farrell, Cahill]. The formula to measure the value of delay can be illustrated as follows:-

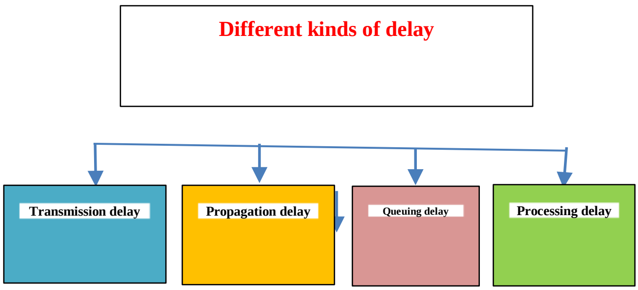
Latency = propagation time + transmission time + queuing time + propagation delay

Consider

- Two hosts A and B are connected over a transmission link/transmission media.
- Host A sends a data packet to Host B.

Following different types of delay occur during transmission-

Different kinds of delay:



Fig, (6) Different kinds of delay

i. Transmission delay
ii. Propagation delay
iii. Queuing delay
iv. Processing delay

We should calculate all kinds of these delays:-

i. Transmission Delay: The time taken to put the data packet on the transmission link is called a transmission delay

Mathematically

Transmission delay ∝ Length / Size of the data packet

Transmission delay ∝ 1 / Bandwith,

$$\textit{transmission delay} = \frac{\textit{Length / Size of data packet}}{\textit{Bandwith of network}}$$

ii. Propagation Delay

The Time taken for one bit to travel from the sender to the receiver end of the link is called propagation delay.

Mathematically,

Propagation delay ∝ Distance between sender and receiver

Propagation delay ∝ 1 / transmission speed

Thus,

$$\text{Propagation delay} = \frac{\text{Distance between sender and receiver}}{\text{Trasmission speed}}$$

iii. Queuing Delay-

Time spent by the data packet waiting in the queue before it is taken for execution is called a queuing delay. It depends on the congestion in the network.

iv. Process The Delay-

The time taken by the processor to process the data packet is called a processing delay. It depends on the speed of the processor. Moreover, Processing the data packet helps detect bit-level errors that occur during transmission.

- **6-Conclusion:-**

Acceptable latency numbers disagree by application and network connection uses for instance; video calls need to require low delay (video conference).

This paper shows that network traffic often occurs in most cases because of how the internet is designed (bandwidth problems). Internet traffic is controlled by the Border Gateway Protocol (BGP) is an algorithm designed to determine the path of Internet traffic. BGP directs traffic along the shortest possible distance, not the most bandwidth. Each problem would require a different solution. Some common practices it could follow to avoid network congestion are to implement a QoS policy, replace faulty or old devices or attend to security attacks as soon as discovered.

Multiple routers at the same time maybe provide the solution. However, this solution needs to modify network infrastructure, to accept the function of multipath. To reduce the risk of congestion, we used the ECN from the MPLS protocol as a solution; to reduce packet loss to fewer packets, which only affects video conferencing. Missing packets will be a word or two words, not a speech sentence. Acceptable latency numbers disagree by application and network connection uses for instance; video calls need to require low delay (video conference). Quality of Service (QoS) parameters are a method for prioritizing network traffic and can solve network issues to keep bandwidth under control. QoS can be quantitatively measured using parameters such as packet loss, bit rate, transmission delay, jitter, throughput, and availability.

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