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Congestion Control Techniques in Named Data Networks

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Abstract

In the growing networking world, increasingly more accentuation is being set on speed, connectivity, and reliability. Systems administration has affected our regular data to day existences, as the interconnectivity of families and companions has changed the manners by which they convey and look for data. With the developing number of network users and simultaneous transmission of packets, chances of congestion have been expanded. In simple terms, Network congestion which is very normal in communication networks happens when demand for network resources surpasses the available limit. On the other side, it degrades the performance of the networks while communication. Hence, it is essential to identify and control congestion to improve the performance of the network. There are different hotspots for congestion like the collision of packets, overflow of the buffer, simultaneous transmission of data/packets, etc. A new paradigm called Named Data Network (NDN), another worldview for the future web that focuses on content (content-based) instead of host (host-based) communications. Though this worldview has new highlights, for example, recipient driven, one-interest one-data, multisource, still it poses new difficulties for congestion control. Accordingly, this paper focus on giving a brief review of congestion control mechanisms based on hop-by-hop mechanisms. Furthermore, it presented the features of NDN and the current challenges in congestion control over these networks.

Keywords: *WSN, Congestion control, Named Data Networks (NDN), packet loss*

1. Introduction

Wireless Sensor Network (WSN) is an assortment of nodes capable of detecting, handling, and correspondence in an autonomous manner. These minor sensor hubs interconnect with one another in an Adhoc design to detect and screen the phenomena of interest. Every node utilizes a short-range transmitter to route the packets using transitional hubs towards a sink hub, otherwise called a base station. These smaller than usual sensor hubs are normally sent in perilous and human-unavailable landscapes to detect and to monitor different applications [1]. These applications incorporate yet are not restricted to seismic detecting, territory observing, and medicinal services, home automation, modern mechanization, rural checking and target following [2]. Congestion arises when the quantity of transmitted packets surpasses the packet handling with the limit of a specific hub [3]. This essentially diminishes the exhibition of the system which brings about higher information misfortunes at the hub level. In a multi-hop environment, the intermediate nodes experience the ill effects of asset resource exhaustion because of unfair traffic dissemination which is steered towards the base station using them. These hubs consume a lot of resources when contrasted with the source hubs. Thus, energy-efficient congestion control protocols should be planned that successfully alleviate congestion for the reliability of the network.

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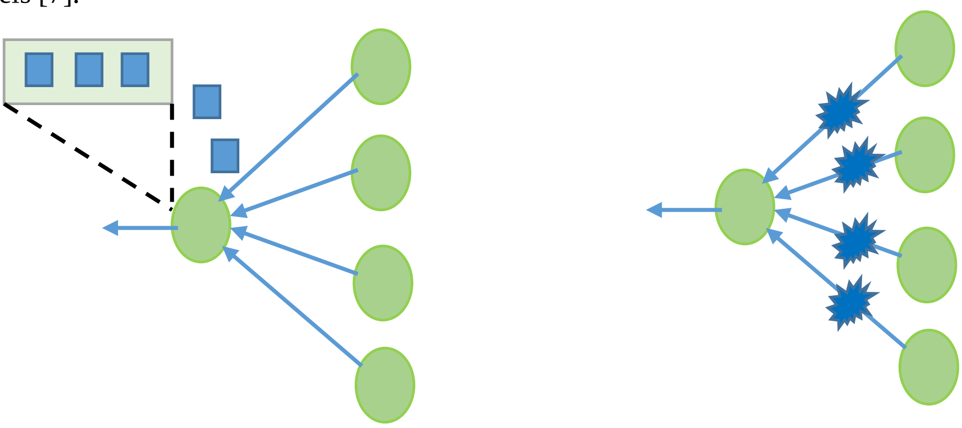
In WSNs, congestion can be controlled primarily by utilizing two distinct systems, i.e., traffic-based and resource-based. Other than these methods specialists are utilizing hybrid methodologies too by combining the distinctive features of these two systems. In a traffic-based method, the information pace of approaching streams from the downstream hubs is balanced against the sending limit of the upstream node(s). The resource-based mechanism exploits the inactive system resources to adjust the traffic load at whatever point congestion emerges. The achievability of these systems may fluctuate starting with one application then onto the next. For instance, traffic-based congestion control methodology is practical in circumstances when the transient over-burden happens [4]. Different conventions under this category decrease the impact of congestion by changing the data rate of incoming flows. Be that as it may, these conventions bring packets to drop and are not attainable for real-time applications [5]. Congestion in WSN is characterized into two categories i.e. node level or link-level (See Figure 1). The first category is common in multi-hop networks [6]. In acquires during the overflow of intermediate sensor buffer, while the last outcomes with the loss of packets and time to conveyance as packets must hold up until those are sent to different hubs or sink. Furthermore, the hubs require additional vitality given the retransmission of failed packets. Link-level congestion is commonly rising because of collisions because of the simultaneous transmissions of adjacent nodes. Congestion at the link level prompts loss of packets, devours more energy, delay in outputs and information loss, and diminishes the use of channels [7].



(a) Node level congestion (b) link-level congestion

Figure 1: Node and Link-level congestion

Independent of the underlying application, the type of flow assumes a significant job in observing the network congestion. There are different kinds of data flows, for example, one packet, a block of packets, and a stream of packets. Depending upon the information streams, we require a light, medium or tight degree of congestion control techniques. At whatever point the hubs transmit the data packets at a time, these packets go through different nodes. The flooding of these packets brings about congestion, which decreases reliability, network performance, and throughput, etc. In WSNs, it is moderately hard to locate the specific areas of congestion occurrence. This is because of the topological changes variations like radio channel as for time [8]. The previously mentioned factors may change over uncongested locales within a network to congested regions [9]. The regions around these areas may turn into a hotspot and there is a chance of either buffer overflow or link interference. The decision of applying a congestion control technique is application-explicit. Every application has its prerequisites for information transfer. In this way, applying a similar congestion control strategy to different applications isn't proper and will have extreme results on the throughput and system lifetime of the fundamental application. The arrangement of different congestion control conventions appears in Figure 2.

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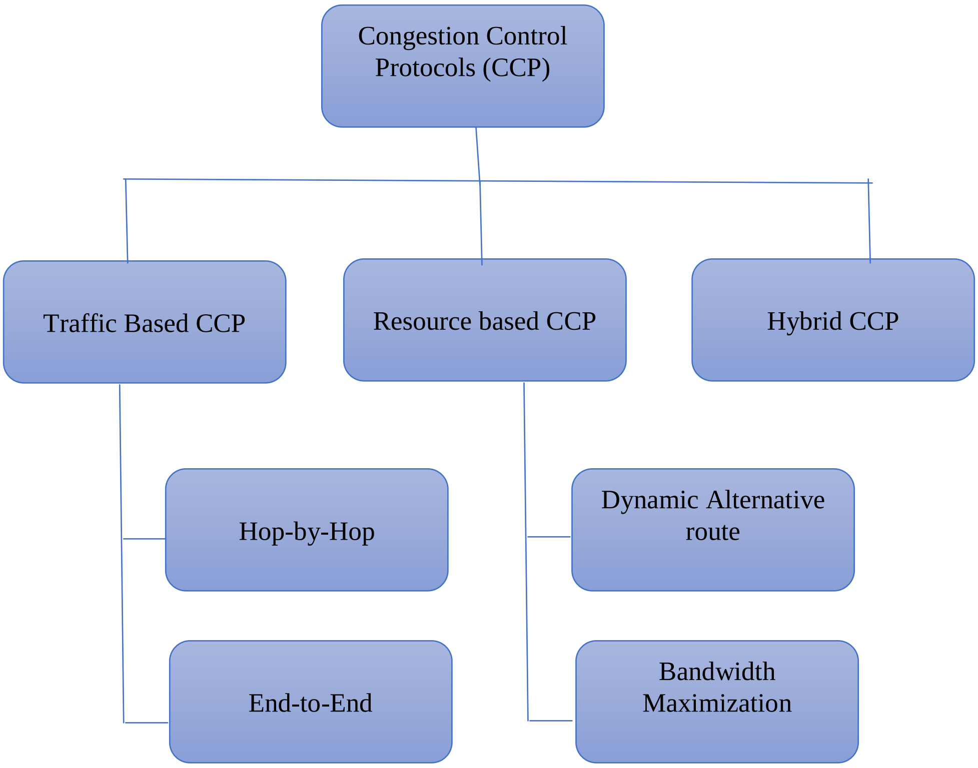

Figure 2: Major categories of congestion control protocols

2. Recent Works

In [10], a hop-by-hop cross-layer congestion control (HCCC) scheme has been introduced. HCCC identifies neighborhood congestion at legitimate moments and conveys the congestion data to upstream hubs by abusing the transmission of RTS and CTS outlines. In the meantime, it adjusts the channel to get to needs and information transmission rates of sensor hubs. In this way, it can adaptively modify the allotment of channel resources among sensor nodes.

In [11], a congestion control procedure in which packet service time is utilized to induce the accessible assistance rate and along these lines recognizes congestion in each intermediate sensor node. The congestion is constrained by hop-by-hop strategy and it utilizes rate modification dependent on the accessible assistance rate and several child nodes. In any case, it can't use the accessible connection limit productively when a few nodes are in an inactive state.

The philosophy in [12] has given a productive strategy for both congestion identification and avoidance, the authors get the notification by Intelligent Congestion Detection (ICD), the packet administration time and inter-arrival time is considered for the discovery. At the point when the above strategy ends in the congestion stage a warning to all the close by hubs is been given by the technique called Implicit Congestion Notification. The shirking of congestion is been made out by assigning (PRA) priority by taking the packet conveyance rate as key.

In [13] Present a congestion avoidance protocol, which incorporates source check based hierarchical medium access control (HMAC) and weighted round-robin forwarding (WRRF) as the two fundamental techniques to conquer congestion. The Simulation

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consequence of this procedure keeps away from packet drop because of buffer overflow and accomplishes a lot higher conveyance proportion significantly under high traffic condition, which asserts an adequate technique for reliable event detection.

According to [14], congestion is identified by estimating the queue length. The congestion is constrained by utilizing three systems i) hop-by-hop flow control, ii) source rate-limiting and iii) prioritized MAC. Indeed, even in high offered load, it professes to accomplish great throughput and decency. The congestion is constrained by the hop-by-hop procedure and it utilizes rate modification dependent on the accessible help rate and several child nodes [15].

In [16] the author proposed measurements called Depth of Congestion (DC) to recognize congestion. The Depth of Congestion (DC) is given as input to the congestion discovery unit. When the measured DC is not exactly the threshold value, at that point, there is no congestion while when DC is equivalent to or more than pre-characterized threshold value, at that point it intimates the congestion. When congestion is detected, the warning sign is sent to all the hubs to control the congestion. On accepting the notice signal every hub modifies the transmission rate by executing Hop-by-Hop Rate Control Technique.

3. Conventional Mechanisms

The principle inspiration behind this strategy is to introduce a viable and productive system to detect and control congestion. As per the authors [17], every web switch maintains a queue. Each time a new packet arrives at the router, it keeps tracking the number of packets in the queue. The switch will attempt to send the packets to their ideal destination until the number of packets in the queue is between the parameters "min" and "max". If the quantity of packets is beyond a parameter "min", at that point switch or the middle hub requests that the source slows down the transmission. If the quantity of packets is beyond a parameter "max", at that point the hub won't queue any packet onwards and it essentially requests that the source quit sending packets and try for the new route. The sender at that point communicates the RREQ packet to its neighbors in the search for the new route. As the sender gets RREP to packet the sender at that point begins transmitting the packets through the new route found.

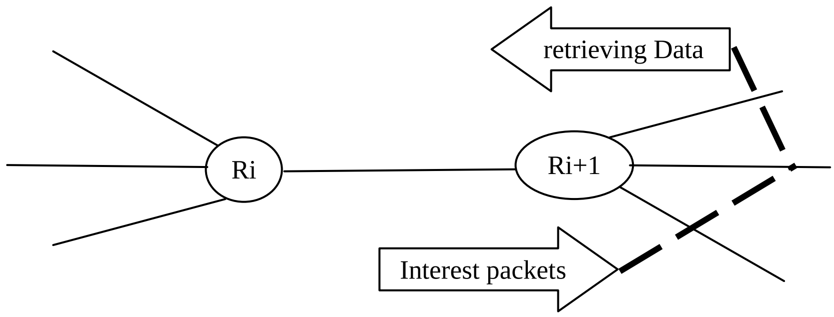

Figure 3: Hop-by-Hop NDN congestion control

Figure 3 presents the essential thought of hop-by-hop control in the rate-based category. The intermediate hub ‘Ri’ decides its state of congestion by observing the length of the incoming data queue. As indicated by the state of congestion, the switch chooses whether the forming rate will be expanded or decreased. The first hop-by-hop technique proposed was HoBHIS, which predicts congestion discovery and diminishes the shaping rate before the recipient could identify congestion utilizing clock lapse. HoBHIS utilizes the data queuing occupancy to ascertain the shaping rate. In [20], NACK feedback has been incorporated into the HoBHIS algorithm to advise a downlink hub when congestion

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happens that the interest packet can't be transferred upstream. The rate-based component permits the consumers and switches to control the rate of sending interest parcels as indicated by the neighborhood data, for example, the transmission capacity of the connection.

The window-based mechanism permits the consumers to send interest packets constantly inside the impediment of the window size. While the size of the window must be resolved by transmission capacity and round-trip time (RTT). A case of this methodology is represented in [20], which presents a window-size control for per-bounce interest transmission utilizing H-ACK and a line to store the packets of interest when the window is shutoff. This strategy permits you to decide the size of the interest window of a particular stream dependent on the sending rate related to each stream and RTT interface, in this manner permitting the data packets to use their maximum link bandwidth. The technique utilized in [20] appears to be new and diverse because it controls the transmission of interest packets utilizing a window size and an H-ACK packet.

Consider a network that utilizes Modified AODV for instance. S is source and D is a destination and the rest of the nodes are transitional nodes (Figure 4). Source S is sending packets to destination D through the middle of the intermediate node B. The transitional node continues to monitoring its queue. As the queue length at hub B goes beyond the max parameter is 4/fifth of the queue length, it requests that the sender quit sending packets and try for the new route. The sender at that point communicates RREQ message to every one of its neighbors i.e., hubs A, B, C. The hub that is prepared to send the packet to destination answers with RREP message (See Figure 5). Assume in this model let us say its hub A. In the wake of getting RREP message the sender S begins sending the packets to the destination through that new route (See Figure 6). Existing hop-by-hop techniques are categorized in to window-based and rate-based techniques [18. 19].

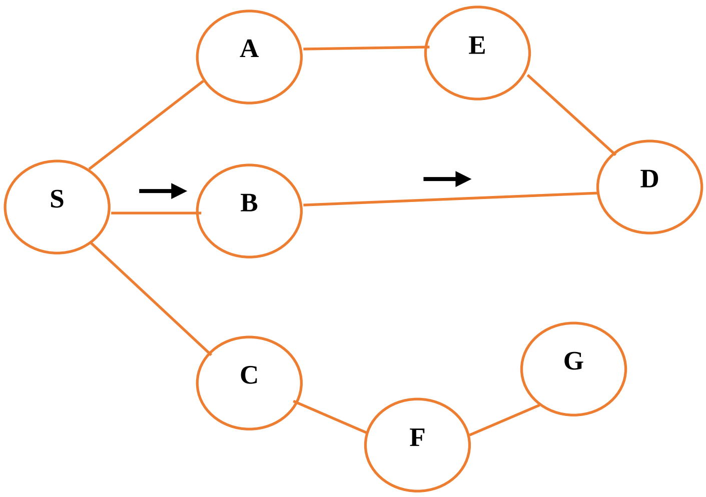

Figure 4: Data flow from Sender S to Destination D

It reaches high throughput execution. Subsequently, the greatest least decency, while keeping away from congestion efficiently proficiently. [21, 22] appear to work splendidly when we have a diverse number of simultaneous consumers, yet they wipe out the response delay parameter and don't consider multi producers that necessities more examination right now. Overall, the throughput of the window-based systems is smaller than the throughput of the rate-based mechanisms. In this way, the rate-based methodology is viewed as proper for the NDN.

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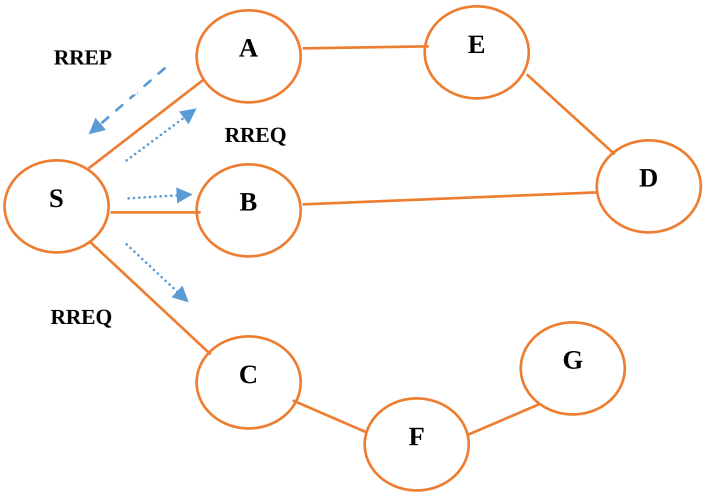

Figure 5: Search New route as queue length exceeds 4/5th of the queue.

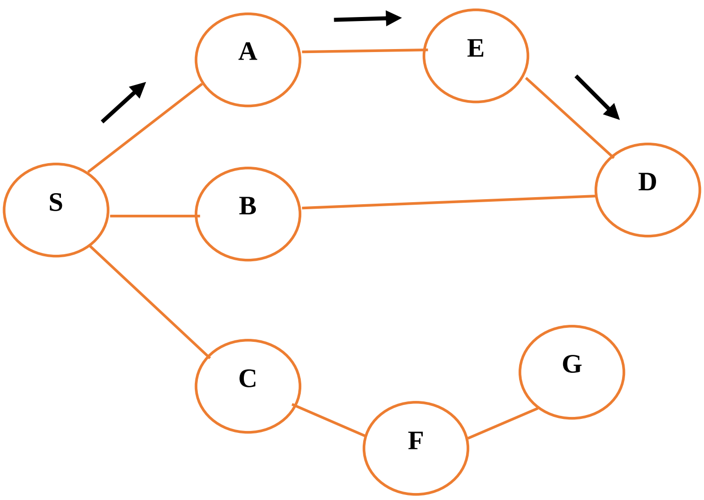

Figure 6: New path for transferring data

Consider a router having a queue with length 30. So by the mentioned formula parameters 'min' and 'max' will be calculated as 20 and 24 respectively.

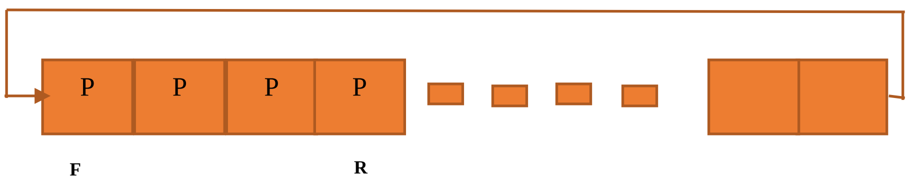

Figure 7: No congestion

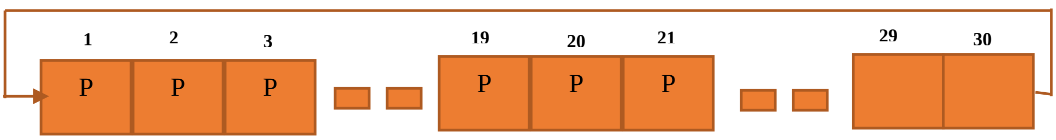

Figure 8: packets in a queue greater than min

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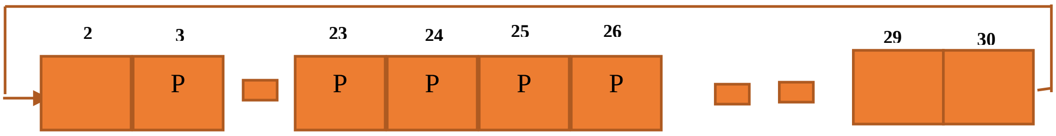

Figure 9: packets in a queue greater than max

Here the number of packets, N is found to be 4, which is less than 'min', therefore there is no congestion (Figure 7). In Figure 8, the number of packets, N is calculated to be 21, which is between the values of min and max, so the router will set Flag=1. In Figure 9, the number of packets, N is calculated to be 28, which is greater than max, so the router will drop 1 packet after every specific interval of time.

The producer returns a Data packet to the consumer. One Interest packet requests one Data packet, which traverses the reverse path of the corresponding Interest packet. While transferring a Data packet, intermediate NDN routers (routers for short) cache the Data packet for distribution in the future. To address the gap between the substances situated user demand and the location-oriented Internet architecture, Information-Centric Network (ICN) has stood out as another networking architecture that is appropriate for recovering and conveying content. Named Data Networking (NDN) is one of the broadly considered ICN models. In NDN, a content requester (consumer) utilizes the name of the content instead of the location of the node distributing the content (producer). NDN utilizes two sorts of packets: Interest and Data. A consumer that demands a specific content sets the name of the content in an Interest packet and sends it toward the producer of this content. The producer restores a Data packet to the consumer. One Interest bundle demands one Data parcel, which crosses the switch way of the relating Interest packet.

4. Congestion Control in NDN

Since NDN has new features, for example, recipient driven, one-interest one-data, transport is connectionless, multi-sources and multi-way. The customary TCP congestion control systems can't be applied to the new type of NDN design.

A. NDN Transport Mechanism

NDN's transport is not quite the same as what is in TCP/IP because of the new functionalities of the NDN worldview as portrayed beneath Receiver-driven: For NDN, a receiver requests content by conveying an interest packet and an information source answers with a correspondent data packet. On the off chance that no recipient requests the data, no data will be transmitted over the system. One-interest one-data: In NDN, an interest packet can recover at most one data packet, which ensures the stability of the stream in the network. In-network caching: The substance storing at intermediate nodes diminishes the load on the content producer, utilizing the link bandwidth, transmission time, etc. Multi-source: In NDN, the transport is connectionless, the content can be put away in an intermediate node, permitting the consumer to recover information packets from different sources.

With the expanding number of Internet surfers, an enormous amount of traffic is created each day. This stances numerous issues, specifically those identified with congestion. In NDN community congestion control is a significant area of research to avoid packet delays, packet loss, etc. In NDN architecture, data packets are the essential cause of congestion, as they are more voluminous than the interest packets. To keep away from this issue, it is better to regulate the rate of sending interest packet to control the rate of

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returning packets. The present methodologies can be sorted into three classes. One is receiver-based, second hop-by-hop methods, and the third one is hybrid methods. The hybrid strategies recognize and control congestion at the receiver and intermediate routers.

5. Conclusion

Congestion control is a hotly debated issue in NDN. The strategies for NDN are classified into two methodologies: the rate-based and window-based. In the window-based methodology, the ideal window size can't be resolved due to the great extent evolving round-trip time. In this way, the rate-based methodology is viewed as appropriate for NDN and has been concentrated effectively. There is a significant differentiation between NDN's method of transport and TCP/IP's method of transport, and their designs are additionally totally different. Hence, the customary congestion control mechanisms that are proposed for TCP/IP can't be legitimately applied to the type of NDN systems. In NDN, congestion control has different points of interest because of its new highlights, which are talked about before right now. A few congestion control systems have been proposed to keep away from the congestion in NDN. Right now, we mean to stretch out our study to progressively complex situations with multiple bottlenecks along with various kinds of links and traffic.

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