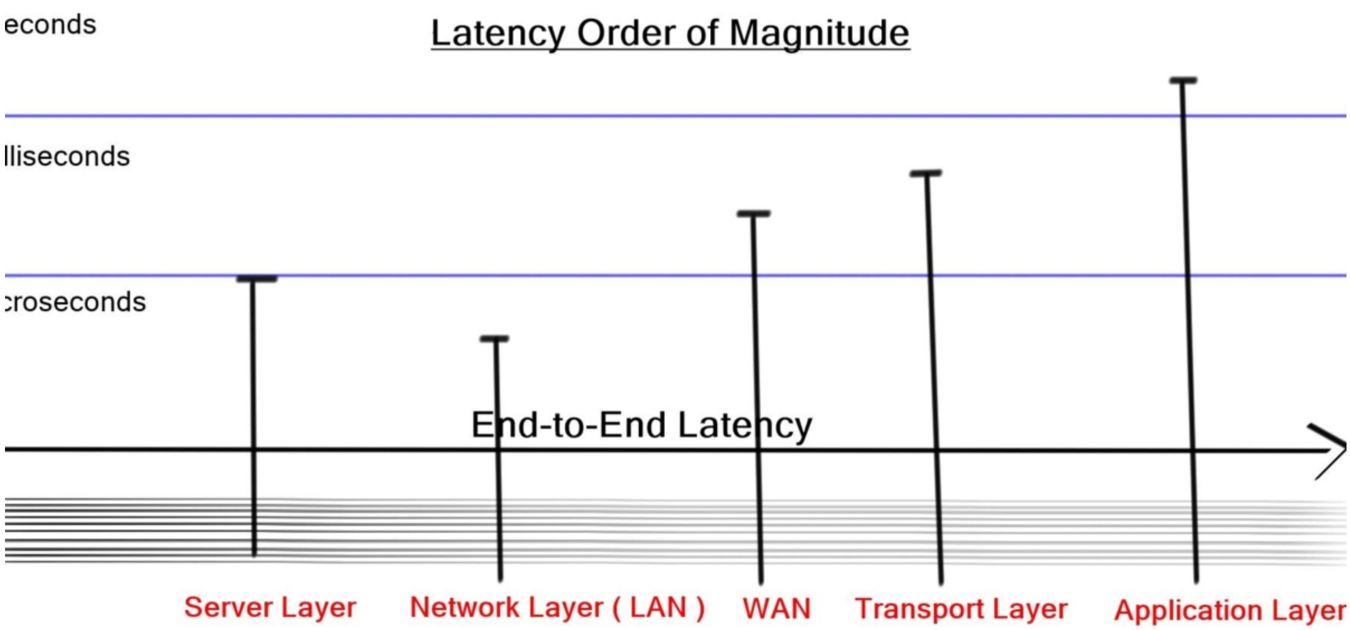
THE VISUAL AGE



March 22, 2015 by Matt Conran with one comment Blog

Low Latency Network Design

In today's fast paced digital world, where every millisecond counts, the demand for

In this blog post, we will delve into the fascinating realm of low latency network design and explore the key strategies and considerations that make it possible.

> Latency, often referred to as "network delay," is the time it takes for data to travel from its source to its destination. It includes various factors such as transmission delay, processing delay, and queuing delay. Before we dive into the design aspects, it's important to have a solid understanding of latency and its impact on network performance.

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Highlights: Low Latency Network Design

A New Operational Model

We are; now all moving in the cloud direction. The requirement is for large data centers that are elastic and scalable. The result of these changes that are influenced by innovations and methodology in the server/application world is that the network industry is experiencing a new operational model. Provisioning must be quick, and designers look to automate network configuration more systematically and in a less error-prone programmatic way. It is challenging to meet these new requirements with traditional data center designs.

Changing Traffic Flow

Traffic flow has changed, and we have a lot of east-to-west traffic. Existing data center

Key Low Latency Network Design Discussion Points:

Latency In Networking.

1. Introduction to low latency network design and what is involved.
2. Highlighting the details of the different data center latency requirements.
3. Critical points on latency in networking.
4. Technical details on oversubscription.
5. Technical details on deep packet buffers.

Related: Before you proceed, you may find the following post helpful:

1. Baseline Engineering
2. Dropped Packet Test
3. SDN Data Center
4. Azure ExpressRoute
5. Zero Trust SASE
6. Service Level Objectives (slos)

Forwarding Features	Control Features
Network and Storage integration	Bridging without STP
Multi pathing for Layer 2 and Layer 3	Integration with server virtualization

Back to Basics: Network testing.

Network Testing

A stable network results from careful design and testing. Although many vendors often perform exhaustive systems testing and provide this via 3rd party testing reports, they cannot reproduce every customer's environment. So to determine your primary data center design, you must conduct your tests.

Effective testing is the best indicator of production readiness. On the other hand, ineffective testing may lead to a false sense of confidence, causing downtime. Therefore, you should adopt a structured approach to testing as the best way to discover and fix the defects in the least amount of time at the lowest possible cost.

Lab Guide: RSVP.

In this example, we will have a look at RSVP. Resource reservation signals the network and requests a specific bandwidth and delay required for a flow. When the reservation is successful, each network component (primarily routers) will reserve the necessary bandwidth and delay.

1. First, we need to enable RSVP on all interfaces: ip rsvp bandwidth 128 64
2. Then, configure R1 to act like an RSVP host so it will send an RSVP send path message:
3. Finally. Configure R4 to respond to this reservation:

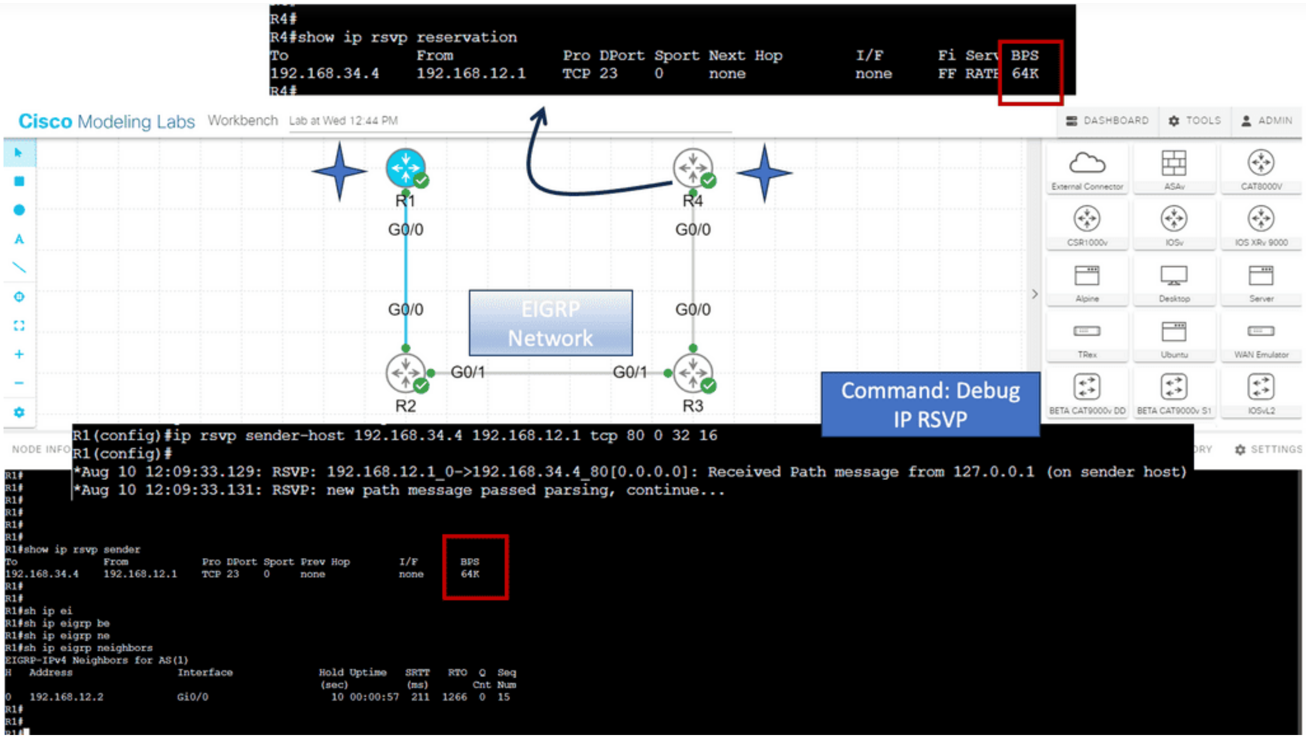


Diagram: Resource Reservation

What is low latency?

Low latency is the ability of a computing system or network to respond with minimal delay. Actual low latency metrics vary according to the use case. So, what is a low-latency network? A low-latency network has been designed and optimized to reduce latency as much as possible. However, a low-latency network can only improve latency caused by factors outside the network.

We first have to consider latency jitters when they deviate unpredictably from an average; in other words, they are low at one moment and high at the next. For some applications, this unpredictability is more problematic than high latency. We also have ultra-low latency measured in nanoseconds, while low latency is measured in milliseconds. Therefore, ultra-low latency delivers a response much faster, with fewer delays than low latency.

1. Improved User Experience: Low latency networks ensure seamless and uninterrupted communication, enabling users to access and transmit data more efficiently. This is particularly crucial in latency-sensitive applications where any delay can be detrimental.

2. Competitive Advantage: In today's competitive business landscape, organizations that deliver faster and more responsive services gain a significant edge. Low latency networks enable companies to provide real-time services, enhancing customer satisfaction and loyalty.

3. Support for Emerging Technologies: Low latency networks form the backbone for emerging technologies such as the Internet of Things (IoT), autonomous vehicles, augmented reality (AR), and virtual reality (VR). These technologies require rapid data exchange and response times, which can only be achieved through low-latency network design.

Data Center Latency Requirements

- **Latency requirements**

Intra-data center traffic flows concern us more with latency than outbound traffic flow. High latency between servers degrades performance and results in the ability to send less traffic between two endpoints. Low latency allows you to use as much bandwidth as possible.

A low-lay network design known as **Ultra-low latency** (ULL) data center design is the race to zero. The goal is to design as fast as possible with the lowest end-to-end latency. Latency on an IP/Ethernet switched network can be as low as 50 ns.

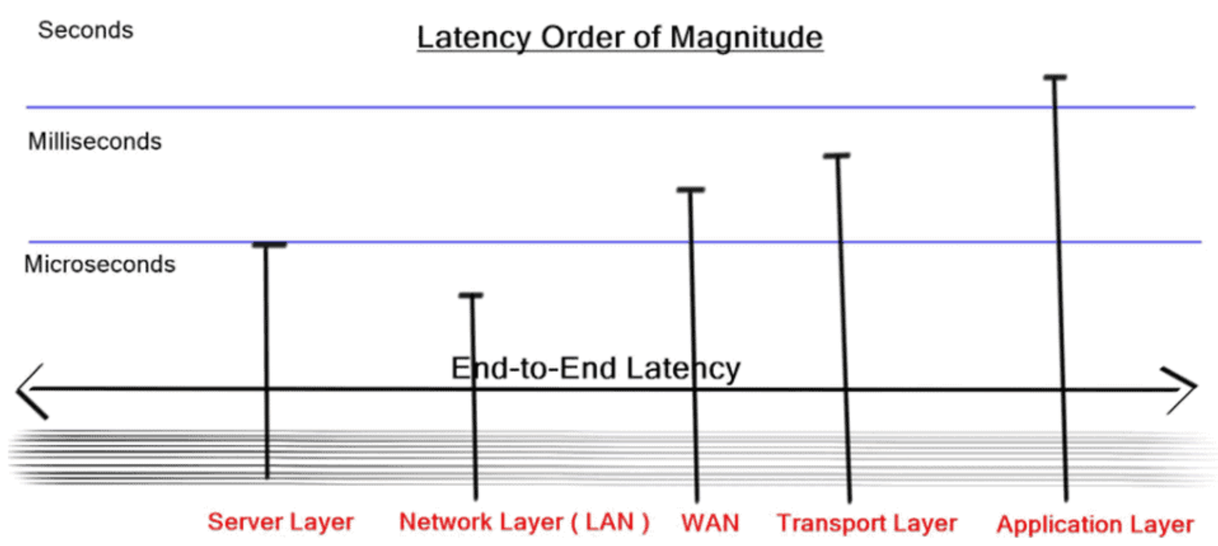


Diagram: Low Latency Network Design

High-frequency trading (HFT) environments push for this trend, where providing information from stock markets with minimal delay is imperative. HFT environments are different than most DC designs and don't support virtualization. The Port count is low, and servers are designed in small domains.

It is conceptually similar to how Layer 2 domains should be designed as small Layer 2 network pockets. Applications are grouped to match optimum traffic patterns where many-to-one conversations are reduced. This will reduce the need for buffering, increasing network performance. ***CX-1 cables are preferred over the more popular optical fiber.***

Oversubscription

The optimum low-latency network design should consider and predict the possibility of congestion at critical network points. An example of an unacceptable oversubscription

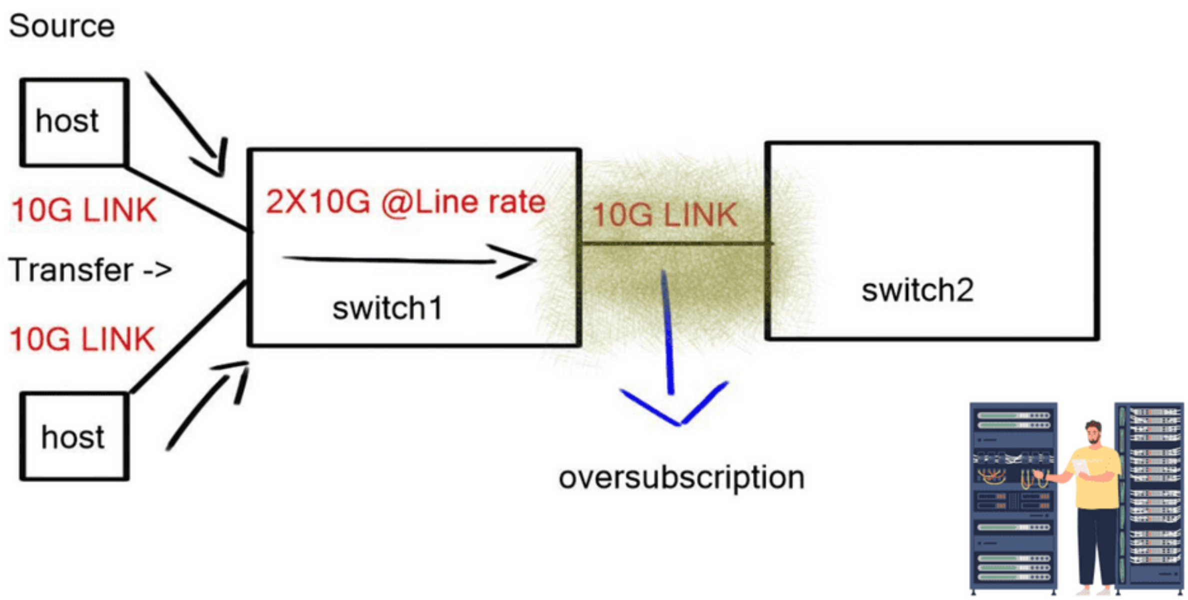


Diagram: Data center network design and oversubscription

Previous data center designs were 3-tier aggregation model-based (developed by Cisco). Now, we are going for 2-tier models. The main design point for this model is the number of ports on the core; more ports on the core result in more extensive networks. Similar design questions would be a) how much routing and b) how much bridging will I implement c) where do I insert my network services modules?

We are now designing networks with lots of tiers – Clos Network. The concept comes from voice networks from around 1953, previously built voice switches with crossbar design. Clos designs give optimum any-to-any connectivity. Requires low latency and non-blocking components. Every element should be non-blocking. Multipath technologies deliver a linear increase in oversubscription with each device failure and are better than architectures that degrade during failures.

Lossless transport

The remaining small percentage are elephant flows, which consume 80% of all traffic inside the data center. Due to their size and how TCP operates, when an elephant flows experience packet drops, they will slow down, affecting network performance.

Distributed resource scheduling

VMmobiliy is a VMware tool used for distributed resource scheduling. Load from hypervisors is automatically spread to other underutilized VMs. Other use cases in cloud environments where DC requires dynamic workload placement, and you don't know where the VM will be in advance.

If you want to retain sessions, keep them in the same subnet. Layer 3 VMotion is too slow as routing protocol convergence will always take a few seconds. In theory, you could optimize timers for routing protocol fast convergence, but in practice, Interior Gateway Protocols (IGP) give you eventual consistency.

VMmobiliy

Data Centers require bridging at layer 2 to retain the IP addresses for VMobility. TCP stack currently has no separation between "who" and "where" you are, i.e., IP address represents both functions. Future implementation with Locator/ID Separation Protocol (LISP) divides these two roles, but bridging for VMobility is required until fully implemented.

Spanning Tree Protocol (STP)

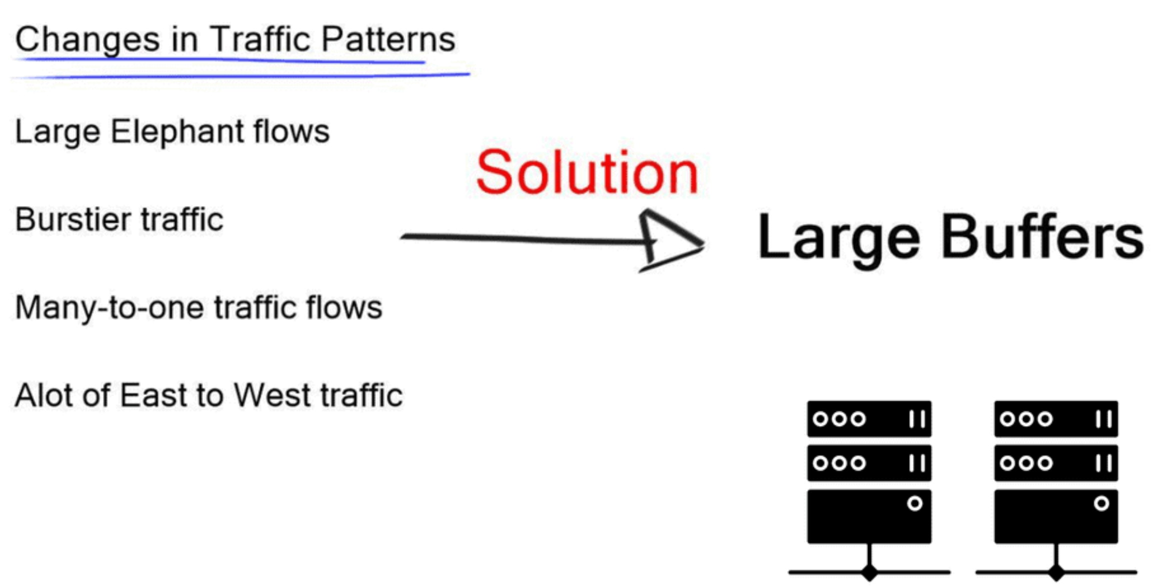
Spanning Tree reduces bandwidth by 50%, and massive multipathing technologies allow you to scale without losing 50% of the link bandwidth. Data centers want to move VMs without distributing traffic flow. VMware has VMotion. Microsoft Hyper-V has Live migration.

Layer 3 network requires many events to complete before it reaches a fully converged state. In layer 2, when the first broadcast is sent, every switch knows precisely where that switch has moved. There are no mechanisms with Layer 3 to do something similar. Layer 2 networks result in a large broadcast domain.

You may also experience large sub-optimal flows as the Layer 3 next hop will stay the same when you move the VM. Optimum Layer 3 forwarding – what Juniper is doing with Q fabric. Every Layer 3 switch has the same IP address; they can all serve as the next hop—resulting in optimum traffic flow.

Deep packet buffers

We have more DC traffic and elephant flows from distributed databases. *Traffic is now becoming very bursty*. We also have a lot of **microburst traffic**. The bursts are so short that they don't register as high link utilization but are big enough to overflow packet buffers and cause drops. This type of behavior with TCP causes **TCP slow start**. A slow start with elephant flows is problematic for networks.



Key Considerations for Low Latency Network Design:

1. Network Infrastructure: To achieve low latency, network designers must optimize the infrastructure by reducing bottlenecks, eliminating single points of failure, and ensuring sufficient bandwidth capacity.

2. Proximity: Locating servers and data centers closer to end-users can significantly reduce latency. Data can travel faster by minimizing the physical distance, resulting in lower latency.

3. Traffic Prioritization: Prioritizing latency-sensitive traffic within the network can help ensure that critical data packets are given higher priority, reducing the overall latency.

4. Quality of Service (QoS): Implementing QoS mechanisms allows network administrators to allocate resources based on application requirements. By prioritizing latency-sensitive applications, low latency can be maintained.

5. Optimization Techniques: Various optimization techniques, such as caching, compression, and load balancing, can further reduce latency by minimizing the volume of data transmitted and distributing the workload efficiently.

Summary: Low Latency Network Design

In today's fast-paced digital world, where every millisecond counts, the importance of low-latency network design cannot be overstated. Whether it's online gaming, high-frequency trading, or real-time video streaming, minimizing latency has become crucial in delivering seamless user experiences. This blog post explored the fundamentals of low-latency network design and its impact on various industries.

latency, businesses can improve the responsiveness of their applications, enhance user satisfaction, and gain a competitive edge.

Section 2: The Benefits of Low Latency

Low latency networks offer numerous advantages across different sectors. In the financial industry, where split-second decisions can make or break fortunes, low latency enables high-frequency trading firms to execute trades with minimal delays, maximizing their profitability. Similarly, in online gaming, low latency ensures smooth gameplay and minimizes the dreaded lag that can frustrate gamers. Additionally, industries like telecommunication and live video streaming heavily rely on low-latency networks to deliver real-time communication and immersive experiences.

Section 3: Strategies for Low Latency Network Design

Designing a low-latency network requires careful planning and implementation. Here are some key strategies that can help achieve optimal latency:

Subsection: Network Optimization

By optimizing network infrastructure, including routers, switches, and cables, organizations can minimize data transmission delays. This involves utilizing high-speed, low-latency equipment and implementing efficient routing protocols to ensure data takes the most direct and fastest path.

Subsection: Data Compression and Caching

Reducing the size of data packets through compression techniques can significantly reduce latency. Additionally, implementing caching mechanisms allows frequently accessed data to be stored closer to the end-users, reducing the round-trip time and improving overall latency.

Subsection: Content Delivery Networks (CDNs)

Leveraging CDNs can greatly enhance latency, especially for global businesses. By distributing content across geographically dispersed servers, CDNs bring data closer to end-users, reducing the distance and time it takes to retrieve information.

businesses can unlock opportunities and deliver exceptional user experiences. Embracing low latency is not just a trend but a necessity for staying ahead in the digital age.

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Matt Conran has more than 24 years of networking and security industry with entrepreneurial start-ups, government organizations, and others. He now focuses on public speaking, authoring content, consulting, and creating Elearning courses.

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