White Paper

Virtual Leased Line Services Using Cisco MPLS DiffServ-Aware Traffic Engineering

Service Description

Challenge

Service providers need to integrate their packet- and circuit-switched infrastructures to save costs, while offering guaranteed data services. One attractive service is the ability to provide point-to-point "leased line"-like services over circuit and/or packet infrastructure to carry bandwidth-guaranteed applications such as voice, video, and online transaction processing. Understandably, providing point-to-point bandwidth guaranteed services over circuit-switched data infrastructure is trivial. The challenge is to mimic that over IP networks to provide transport to Layer 2, such as PPP, HDLC, Ethernet, or Frame Relay, or to Layer 3, such as IP traffic over MPLS—providing leased-line service to end users. Trunking of voice traffic between central offices or between enterprise sites is an example of an application of virtual leased-line service.

Today's enterprise customers are responding to voice and data convergence by actively seeking solutions that are both robust and inexpensive. These customers are increasingly using data networks to trunk voice traffic between sites for intracompany communications over virtual private networks (VPNs). Another requirement of enterprise customers is to transport large volumes of data periodically between primary and disaster recovery sites.

With increasing adoption of voice over IP (VoIP), the landscape for deployment is rapidly changing. Service providers are often driven by the need to provide customers a high grade of service to carry voice traffic across a network.

Cisco MPLS DiffServ-Aware Traffic Engineering (DS-TE) Solution

Today's multiservice packet networks rely on IP-based packet switching. However, IP by itself is simply best-effort service that is not sufficient enough to provide the strict delay, jitter, and bandwidth guarantees required for VoIP and other real-time traffic. Cisco IOS® quality of service (QoS) features are ideal for this situation. Using the IETF Differentiated Services model (DiffServ) for QoS, VoIP traffic can be treated appropriately. Though today's bandwidth is fairly inexpensive, fiber resources are relatively scarce, and adding DWDM trunks can be an expensive proposition without a real need. Even in networks with ample bandwidth, an "insurance policy" is essential to ensure guaranteed quality for voice traffic, regardless of the overall network traffic load. Service providers must therefore extract the maximum profit benefit from all available bandwidth. While the DiffServ model allows for this, a service provider must have the ability to:

- Determine the path that IP routing takes for a particular customer's traffic

- Provision each router along the path for DiffServ
- Manually assure that not too many customers pass over that path, to avoid demand in excess of available bandwidth (the “over-subscription” scenario)

While this is feasible in a small network, a more scalable way to manage bandwidth is necessary to provide a point-to-point guarantee to the customer. The Cisco DS-TE solution is ideal for this situation. By automatically choosing a routing path that satisfies the bandwidth constraint for each service class defined (such as Premium, Gold, Silver, or Bronze), using DS-TE relieves the service provider from having to compute the appropriate path for each customer, and each service class per customer. Cisco IOS software enables service providers to implement the QoS capabilities they need to provide virtual leased-line services on a data network.

Service Offerings

Virtual leased line services. Virtual leased line services can be broadly classified into two types:

1. A service that is primarily focused on transporting IP, known as IP virtual leased line
2. A service that can be used to transport any Layer 2 technology, including Ethernet, Frame Relay, ATM, PPP, or Cisco HDLC

IP Virtual Leased Line

The primary purpose of this service type is to transport IP in a point-to-point manner. Connectivity between the edge device and provider router is therefore always an IP connection. This IP trunk may emulate a voice trunk or may simply transport data between a backup site and a data center. In each case, the QoS requirements are distinct. In the former, tight QoS guarantees are needed, while in the latter, loose QoS guarantees are required. (Explanation of tight and loose QoS is provided in the Service Characterization section further along in this document.)

Virtual Leased Line for Layer 2 Transport

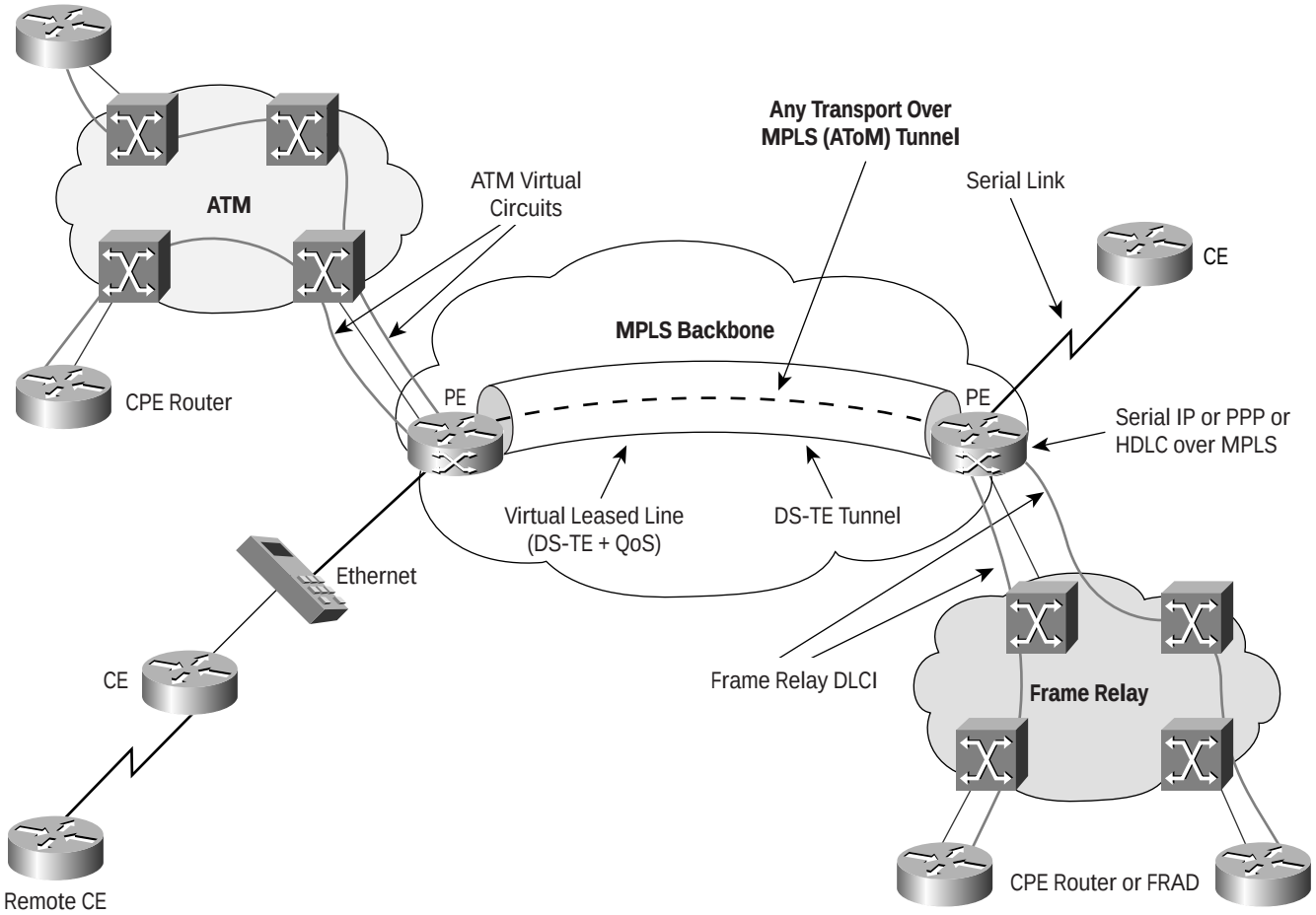
This service focuses on transporting Layer 2 protocols such as Ethernet, Frame Relay, and ATM in a point-to-point fashion across MPLS networks. Layer 2 transport across an MPLS network may be required either to extend existing services or to provide simple, easy-to-provision services that are attractive to enterprise customers. For example, one service gaining popularity with providers is Ethernet over MPLS. Customers can trunk non-IP protocols such as AppleTalk and IPX across the provider cloud, or extend VLAN domains by transporting raw Ethernet frames. Service providers can use this service to create remote peering points that appear as a single hub by extending the broadcast domains and trunking Ethernet. Another example is to provide services to multidwelling units by providing Ethernet connect and then trunking the Ethernet to the POP without adding any routing or content services at the customer location.

Similarly, virtual leased-line service can be used to provide Frame Relay transport. Service providers can continue to sell Frame Relay services to end users and by using Cisco DS-TE QoS techniques and Cisco IOS MPLS Label Stacking with AToM (Any Transport over MPLS) capability. They can provide Committed Information Rate (CIR) guarantees for Frame Relay end-to-end. Likewise, combining the above methodology with ATM over MPLS can provide ATM VBR guarantees.

MPLS networks can be used to build virtual leased-line services and provide connectivity regardless of physical connections at each site. For example, a customer can connect with Frame Relay on one site and connect with Ethernet on the other. If this customer also wants to trunk, it's the Integrated Gateway Protocol (IGP) across the provider cloud, the provider can trunk the traffic and provide bandwidth guarantees by using a common encapsulation such as Point-to-point Protocol (PPP). Cisco IOS MPLS provides the ability to traffic engineer the Label Switched Paths (LSPs) and combine them with QoS to provide services beyond the offering of traditional packet networks.

A number of sites with various types of connectivity for virtual leased line services are shown in Figure 1.

Figure 1
Virtual Leased Lines Summary



Service Characterization

Service providers have two choices:

1. Over-engineer the network so that under all circumstances there is no congestion—i.e., throw bandwidth at the problem
2. Enable QoS in the network for a particular traffic and use other intelligent mechanisms such as DS-TE in MPLS to provide tighter QoS guarantees for network bandwidth, delay, and jitter.

The mechanism the service provider chooses depends on how stringent the QoS requirement is. For example, to build voice-over-IP services for toll-bypass trunking, the QoS requirement is more strict than to build point-to-point bandwidth guarantees for data transport.

Services such as voice over IP, toll-bypass trunking, ATM VBR-rt, and SONET CES require strict QoS. Service providers must control both network bandwidth and delay. But services such as Ethernet over MPLS, ATM VBR-nrt, and Frame Relay over MPLS, require more lenient QoS. These services need bandwidth guarantees, and though they do not maintain very stringent delay requirements, they do need a loose upper bound.

To implement leased line services with the desired QoS, service providers must control the following network characteristics:

Bandwidth guarantees: Virtual leased-line service requires the equivalent of an emulated circuit, point-to-point connection in the network that has bandwidth guarantees. The network devices must be capable of scheduling traffic so that the network can assure voice traffic ample link capacity under any (moderate or heavy) congestion conditions.

Delay guarantees: Bandwidth guarantees don't always ensure a proper delay or jitter. For example, satellite links may provide a bandwidth guarantee, but they may not meet the delay requirement for stringent QoS-based services. Applications such as Virtual Leased Line therefore require a delay guarantee. For lenient QoS services, low-delay requirements are not necessary, but a more lenient upper bound is required.

Jitter Bounds: Virtual Leased Line applications also require consistent predictable network behavior. Network devices introduce jitter during traffic queuing and scheduling, regardless of how smooth the initial traffic entry is. Providing low network jitter also reduces the requirement of large de-jitter buffers in the end nodes, resulting in smooth playback of voice or video at the receiving end.

For successful deployment to equal today's voice or video networks. Meeting these requirements will provide a powerful alternative to circuit switching, at a fraction of the cost.

Technology Components

Cisco IOS software delivers a powerful combination of industry-leading technology and features to build virtual leased lines for voice, video or real time traffic. The following Cisco IOS MPLS features are the essential ingredients in building a profitable and highly robust voice trunking, Virtual Leased Line or toll bypass trunking service.

Cisco MPLS Traffic Engineering (MPLS TE)

Cisco MPLS TE automatically sets up Label Switched Paths (LSPs) that can assure, through appropriate aggregate QoS (across the LSPs), to meet the bandwidth, delay, and jitter constraints imposed by voice, video or real time applications. Additionally, MPLS TE is the first step to setting up these paths for carrying high-priority traffic in a diverse manner for better network utilization, overall throughput, and resiliency.

Cisco MPLS DS-TE

Traffic engineering does not differentiate among traffic types. To carry voice and data traffic on the same network, it may be necessary to account separately for the amount of voice traffic being transferred over the network, to provide the necessarily stricter QoS guarantees. Cisco DS-TE not only allows the configuration of a global pool for bandwidth accounting, it also provides a restrictive subpool configuration for high-priority network traffic such as voice. Available bandwidth both on the global pool and in the subpool are advertised by IGP LSA or TLVs, ensuring each router keeps track of the available bandwidth when admitting new LSPs for voice or high-priority traffic. In this manner, service providers, depending on their service level agreement (SLA) requirements, can choose to overbook lower-priority classes or even underbook higher-priority traffic to meet tight QoS requirements. They can also charge a premium for that extra protection of voice, video and other high-priority traffic.

Cisco IOS QoS

Cisco IOS software also provides a rich set of QoS features that are necessary to provide the minimum guarantees to TE tunnels. These mechanisms work with DS-TE to provide a point-to-point guarantee for each service class. At the network edge, traffic traveling into a tunnel is appropriately policed and colored. Coloring refers to marking the packets with the appropriate MPLS EXP bits. This color is then used in the core to identify the class to which the packet belongs. In the core, the Cisco Low-Latency Queuing (LLQ) scheme is deployed to ensure the minimum bandwidth for tunnels of a particular class. This allows a service provider to ensure strict priority, and an assured amount of bandwidth for voice, while dividing the remaining bandwidth into sections called Class-Based Weighted Fair Queuing (CBWFQ) for the other tunnels and data traffic.

Cisco MPLS Fast Reroute (MPLS FRR)

Fast reroute is the ability to locally patch traffic onto a backup tunnel in case of a link or node failure with failover time of 50 ms or less, which is competitive with SONET APS (Automatic Protection Switching). Cisco FRR utilizes MPLS label stacking with RSVP signaling to create a backup tunnel around the link or node that needs to be protected. On detection of signal loss of signal from the link, the MPLS FRR application in Cisco IOS software starts forwarding the traffic onto the backup tunnel transparent to end users or applications in 50 ms or less. Actual failover time may be greater or less than 50ms, depending on the hardware platform, the number of TE Tunnels and/or Network prefixes.

Cisco MPLS AutoBandwidth Allocator

Cisco IOS software supports another first: An MPLS TE feature, called Cisco AutoBandwidth allocator, to ease constant network monitoring and provisioning. The AutoBandwidth feature constantly tracks average use of MPLS TE Tunnel and can resize TE tunnel bandwidth to suit the traffic flow. Service providers can efficiently utilize available network bandwidth and maximize profits. The average monitoring duration is configurable, thereby providing better control of network resources.

Advantages

By using Cisco's technology, MPLS guaranteed bandwidth services can be used to construct virtual leased lines for IP traffic, an alternative first available with Cisco IOS software.

Service providers and enterprises can gain advantages in several ways:

Offering new premium services for high-priority traffic, such as voice traffic or online transaction processing with tight guarantees for throughput, delay, and more.

Increasing utilization of bandwidth by load balancing traffic on alternate traffic engineered paths.

Achieving higher network availability by using Cisco MPLS FRR to quickly use alternate traffic engineered paths—in 50 ms or less (actual failover time may be greater or less than 50ms, depending on the hardware platform, the number of TE Tunnels and/or Network prefixes).

Simplifying network manageability and reducing costs with the Cisco AutoBandwidth allocator to take advantage of available tunnel bandwidth while still providing guarantees for high priority traffic.

Preventing theft of service with policing. An important requirement for maintaining bandwidth guarantees is the ability to police traffic to check if the traffic is in profile. This can be completed using the policing feature in Cisco IOS software. Policing allows each user of a guaranteed bandwidth tunnel to get a fair share of allocated capacity. No overall degradation occurs due to heavy usage of one application/user, and theft of resources is avoided.

With Cisco IOS QoS, the following can help reduce and prevent service theft:

- Policing and traffic shaping (smoothing) at the network edge (customer edge or provider edge)
- Reexamining the markings and possible remarking
- Increasing the probability of packet drop when the network becomes congested, when customer is transmitting over a purchased "guaranteed"/assured bandwidth link, (Specifically, use RED and WRED features)

Figure 2
Virtual Leased Lines—Serial Links

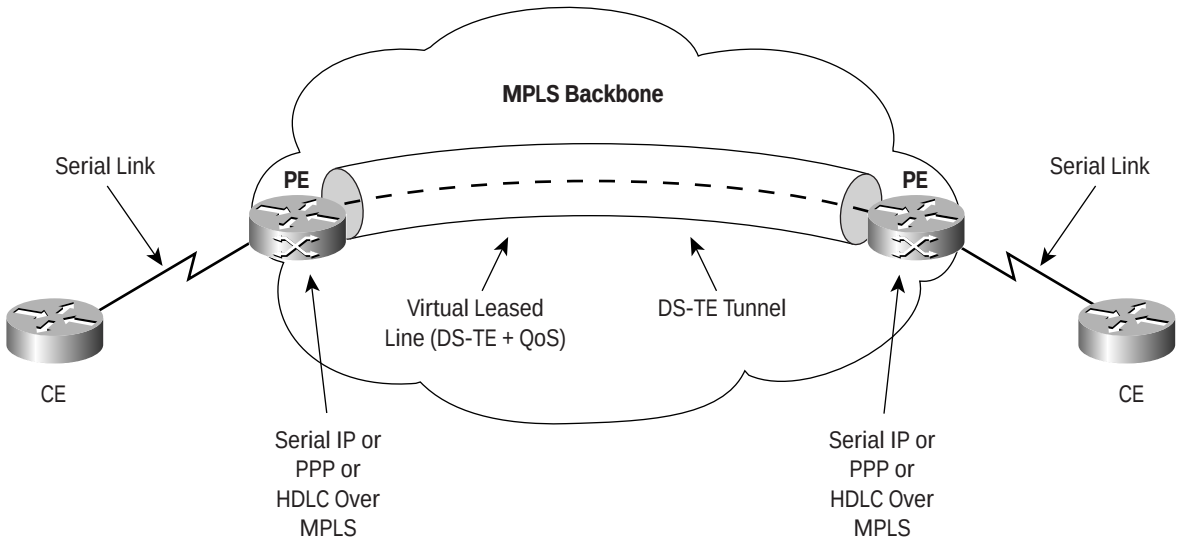


Figure 3
Virtual Leased Lines—Frame Relay Networks

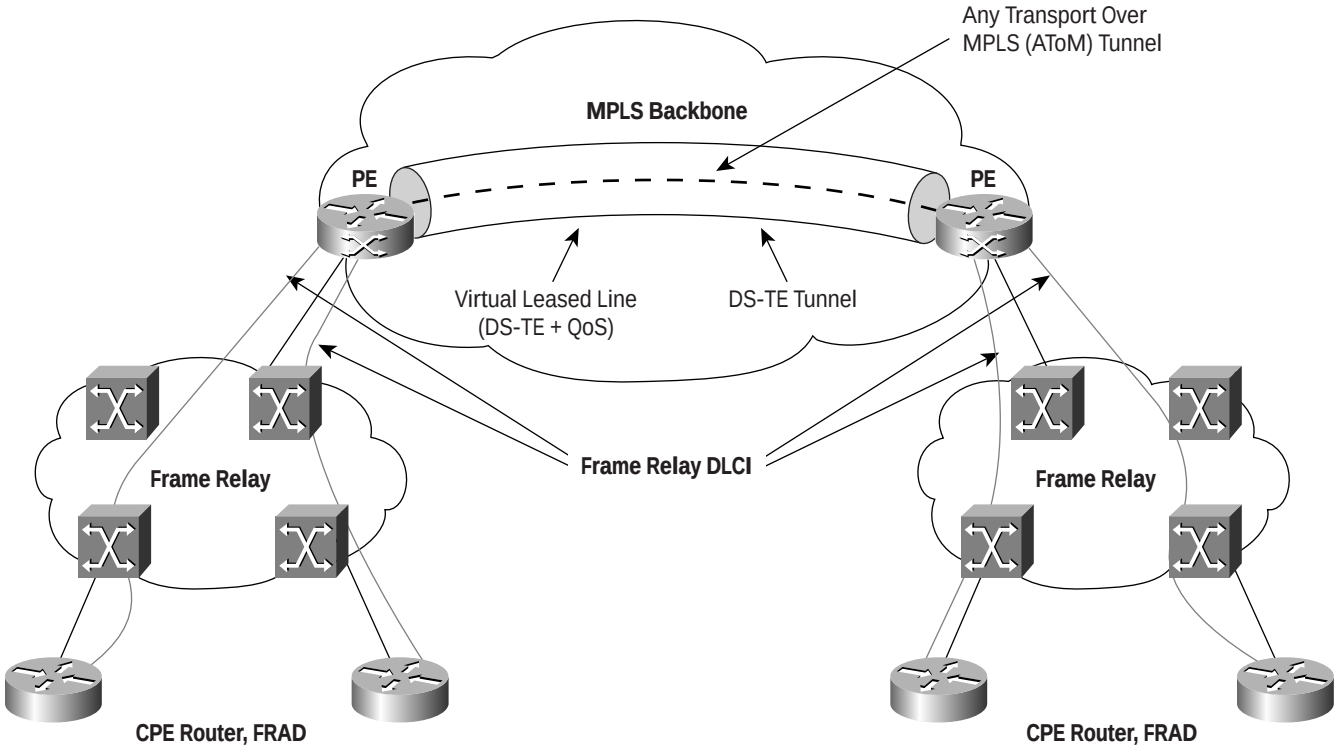
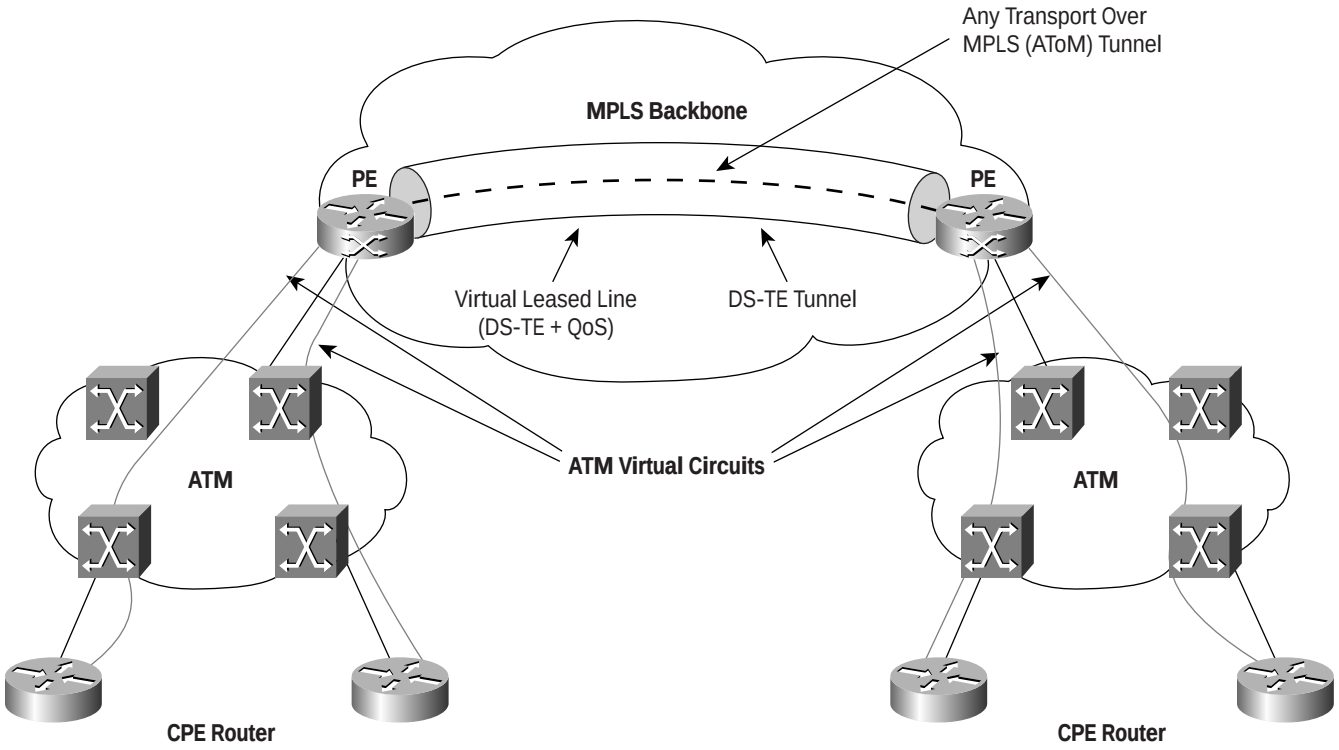


Figure 4
Virtual Leased Lines—ATM Networks



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