

White Paper

# Transitioning from IP-over-LANE/ATM to IP/MPLS Networks

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Part Number : 200013-001 07/01

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## Executive Summary

Juniper Networks, Inc. leads the industry in IP routing technology with the world's largest service providers deploying Juniper Networks routers in the core and at the edge. Ultimately, a Juniper Networks IP network reduces costs by having the same ASIC technology, software, and services across all platforms, thus lowering capital expenditures and operational expenses.

This paper addresses the limitations of IP-over-LANE/ATM networks and offers a viable IP/MPLS network alternative that supports voice, video, and data services. It also describes an example transition plan for migrating away from an IP-over-LANE/ATM infrastructure to a carrier-class infrastructure capable of delivering differentiated IP services with the performance, density, functionality, reliability, and scalability to accommodate increasing bandwidth needs.

## Perspective

ATM technology previously was touted as the mechanism by which real-time service guarantees would be provided end to end in a single, homogeneous network. While ATM proliferated in the WAN due to higher data rates and traffic engineering capabilities, ATM to the desktop never gained wide-scale acceptance due to cost, performance, and complexity. While some high-end users demanded native ATM to the desktop, the viability of ubiquitous ATM applications and guaranteed quality of service became doubtful, as did the scalability of SVCs. LANE added even more complexity and greater diagnostic hurdles when problems occurred in the network. At the edge of the ATM network, most workstations remained attached to the network via Ethernet switches.

Today, switched Ethernet and VLAN technology improves the network performance to hosts, while Juniper Networks routers with predictable performance remove the bottleneck that routing once posed. With the availability of Juniper Networks routers supporting fractional T1 to OC-192c/STM-64 interfaces, including Fast Ethernet and Gigabit Ethernet, many have turned away from ATM technology that is limited to OC-12/STM-4 router interfaces because to date, there are no commercial interfaces that can perform segmentation and re-assembly (SAR) at OC-48/STM-16 rates. Additionally, there are no near-term prospects for OC-192c/STM-64 SAR chips. Based on these ATM limitations and the advances in router technology, ATM will likely not be the sole end-to-end link layer technology since networks of the future will also employ SONET/SDH and Gigabit Ethernet technologies.

Fueling the transition to an IP-based multiservice network is the availability of high-performance routers capable of simultaneously supporting wire-rate forwarding on a wide range of interfaces while deploying smart IP services, which are enabled by such features as firewall filtering, filter-based forwarding (policy routing), class of service, class-based forwarding, and MPLS.

## Limitations of IP-over-LANE/ATM Networks

The fundamental assumptions that fueled support for the original deployment of ATM to the desktop and ATM-based cores are no longer valid. High-speed interfaces, deterministic performance, and traffic engineering no longer distinguish ATM switches from Internet backbone routers. Additionally, VLAN technology is available today that provides virtual LAN technology without all the complications introduced by LANE emulated LANs.

To accomplish the emulation of a broadcast environment like Ethernet over an ATM network, which is inherently a non-broadcast multiple access (NBMA) technology, LANE requires many server functions to perform address discovery of broadcast servers and address resolution servers. LAN emulation client (LEC) software must be written for all client devices on the emulated LAN (ELAN), including routers, ATM switches, ATM-attached workstations, and Ethernet LAN switches. This client and server software is complicated and when a failure occurs, the addition of LANE adds an extra layer of complexity to the normal troubleshooting process. For example, the problem could be a client software configuration error or it could involve the LES, BUS, or LECS configuration. Additionally, LANE operation involves several ATM control channels between client and LANE servers, which adds to the complications involved in debugging problems and identifying the source of failures. Some LANE issues are as follows.

- Connection setup latency
- Service restoration interval
- Limited LAN support
- CPU intensity
- Need for another router to route between ELANs

ATM network architectures present a disparity between the high-speed Gigabit Ethernet and SONET/SDH router interfaces (OC-48c/STM-16 and OC-192c/STM-64 SONET/SDH) and the fastest ATM router interfaces available, which operate only at OC-12/STM-4 rates. This disparity is due to the current inability to produce commercial router interfaces with SAR functionality for OC-48c/STM-16 and OC-192c/STM-64. The limits in SAR scaling impacts network design in that to increase network capacity, large ATM switches with OC-48c/STM-16 links between them must be deployed. Additionally, routers with many OC-12/STM-4 ATM interfaces will be required. Alternatively, a single backbone router interface at OC-192c/STM-64 is 16 times faster than the ATM interfaces, which dramatically reduces the cost and complexity of growing the network.

The ATM cell tax adds significant overhead for IP packets forwarded over an ATM core. When accounting for framing and a realistic distribution of packet sizes, a 20-percent overhead occurs, resulting in 1.99 Gbps of user data and 498 Mbps of ATM overhead (practically an OC-12c/STM-4 link) of an OC-48c/STM-16 link. At OC-192/STM-64 rates, the overhead consumes 1.99 Gbps of the 10-Gbps bandwidth that could otherwise be used for customer traffic.

Traffic engineering enables you to map traffic flows onto an existing physical topology. It provides a means of controlling the distribution of traffic across all network links so that they are more evenly utilized. Traffic engineering historically required the presence of a Layer 2 technology that supports switching and virtual circuits. On a mixed-media network, the dependency on a specific Layer 2 technology (ATM) to support traffic engineering can severely constrain possible solutions.

## Transitioning Away from IP-over-LANE/ATM Networks

Increasingly, corporate networks are moving towards a ubiquitous IP/MPLS infrastructure, removing the last vestiges of protocols such as Appletalk and IPX. Many campuses migrated to ATM backbones in the mid 1990s with the promise of higher speed connectivity on the backbone and to the desktop. Common ATM architectures include campus networks that have dark fiber and use ATM or LANE/ATM as a means of connecting backbone routers together, as well as for Layer 2 connectivity between desktops. This architecture can benefit from the migration to an IP/MPLS infrastructure.

A primary goal of the enterprise customer is to create a scalable network that is easy to manage, relegates ATM to a transport protocol in the short term, and provides an incremental migration path to higher speed technologies including, Gigabit Ethernet, OC-48c/STM-16 SONET/SDH, and 10-Gbps technologies, such as OC-192c/STM-64 SONET/SDH today and 10 Gigabit Ethernet when standardized.

To achieve the architectural goals of closed user groups and fast switching provided by ELANs, Ethernet technologies (for example, 802.1Q VLANs) and IP router capabilities (such as Layer 2 and RFC 2547bis Layer 3 VPNs, wire-rate packet forwarding, and packet filtering) have evolved. High-speed, low-cost switches and interfaces make 100-Mbps and Gbps access to the desktop and servers preferable to LANE. Best-in-class Juniper Networks routers deliver predictable performance with IP services enabled, offering both speed and intelligence not available in the past.

The major challenges for customers transitioning away from ATM networks are as follows.

- Leveraging legacy equipment
- Smooth integration
- Standardization and simplified management
- Scalability

## IP/MPLS Network

An IP core merges the separate control planes of Layer 2 and Layer 3 networks into a single network. This integration eliminates the management burden of coordinating the operation of two distinct networks, permits routing and automated traffic engineering to occur on the same platform, and reduces the operational cost of the network. As well, you can migrate to OC-48c/STM-16 and OC-192c/STM-64 interfaces using a single, integrated IP-based core. This new IP infrastructure is made possible by technological advances in routers, such as Juniper Networks ASIC-based route lookups and forwarding that provide the high-speed links, deterministic performance, and CoS capabilities formerly found only in ATM switches. Moreover, an IP infrastructure increases reliability and enables you to provide value-added customer services.

An IP architecture has numerous other advantages.

- Supports high-speed optical interfaces without the limitations imposed by SAR chips on ATM router interfaces. For instance, Juniper Networks routers support packet interfaces up to OC-48c/STM-16 and OC-192c/STM-64 speeds.
- Eliminates the cell tax because ATM is no longer required as the Layer 2 technology. The bandwidth that was previously consumed with ATM cell overhead, usually 15 to 25 per cent of the provisioned bandwidth, is now available to carry additional customer traffic.

- Does not require a specific Layer 2 technology (ATM or Frame Relay) that supports switching and virtual circuits. You can implement traffic engineering at Layer 3, providing support over mixed-media networks and reducing the number of layers between IP and fiber.

Furthermore, an IP core supporting MPLS offers numerous advantages using traffic engineering to maximize the efficient use of bandwidth and reduce congestion.

- An IP/MPLS core does not exhibit ATM's n-squared PVC problem, which stresses the IGP and results in complex configuration issues.
- An MPLS architecture based on the combination of IGP extensions, CSPF path selection, RSVP signaling, and MPLS forwarding leverages work performed by the IETF without introducing radically new technologies.
- An IP/MPLS architecture provides tremendous flexibility in determining how to implement traffic engineering. You can calculate label switched paths (LSPs) online or offline. LSPs can be installed manually or by using RSVP signaling.
- Constraint-based routing provides enhanced capabilities that enable you to meet specific performance requirements. Explicit paths enable you to specify the exact physical path that an MPLS LSP takes across the network.
- You can gather per-LSP statistics at any label switching router (LSR) as input to network planning and analysis tools to identify bottlenecks and trunk utilization and plan for future expansion.
- The flexible architecture supports scalable VPN technology, including Layer 3 RFC 2547bis VPNs and Juniper Networks Layer 2 Circuit Cross-connect.
- MPLS can carry ATM cells, if necessary, by mapping virtual channels onto LSPs using Layer 2 VPN technology.

## Example Transition from IP-over-LANE/ATM to IP/MPLS Networks

This section describes an example scenario and the steps required to transition ATM/LANE networks to IP/MPLS networks. This example migration plan consists of three phases.

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NOTE This example demonstrates steps you could take to migrate to an IP/MPLS network. These steps are not, however, a set of instructions to follow. For detailed information about network designs, contact a Juniper Networks representative.

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### Example IP-over-LANE/ATM Network

One type of typical transition involves a campus network with fiber owned by the enterprise. The infrastructure consists of both real-time and non-real-time flows. A legacy video application runs over the ATM network that continue to be supported during the migration to the IP/MPLS network.

The network hardware consists of routers running the OSPF routing protocol and the Area 0 backbone routers participating in a backbone ELAN. ELANs also connect communities-of-interest networks (COINs). Generally, most ELANs are confined to an office or

building and only in exceptional cases does an ELAN span multiple buildings. ELANs are often the choice for connecting these COINs because the performance of the existing routed network was not sufficient when accessing high-speed servers.

The routers in this scenario are not capable of high-speed routing between ELANs, especially when IP services are enabled through such features as sampling, rate limiting, or packet filtering with hundreds or thousands of terms at OC-12c/STM-4, OC-48c/STM-16, or OC-192c/STM-64 data rates.

This example ATM network (Figure 1) is divided into three major entities: office nodes on each floor within a building, building nodes that attach offices within a building and attach the building to the core, and core nodes that connect buildings together. Legacy routers in the core and building nodes may also support legacy technologies such as FDDI. The office, building, and core nodes consist of multiple ATM switches, Ethernet switches with LANE clients (LEC), LEC-enabled routers, and routers and/or switches providing LANE services (LES/BUS/LECS).

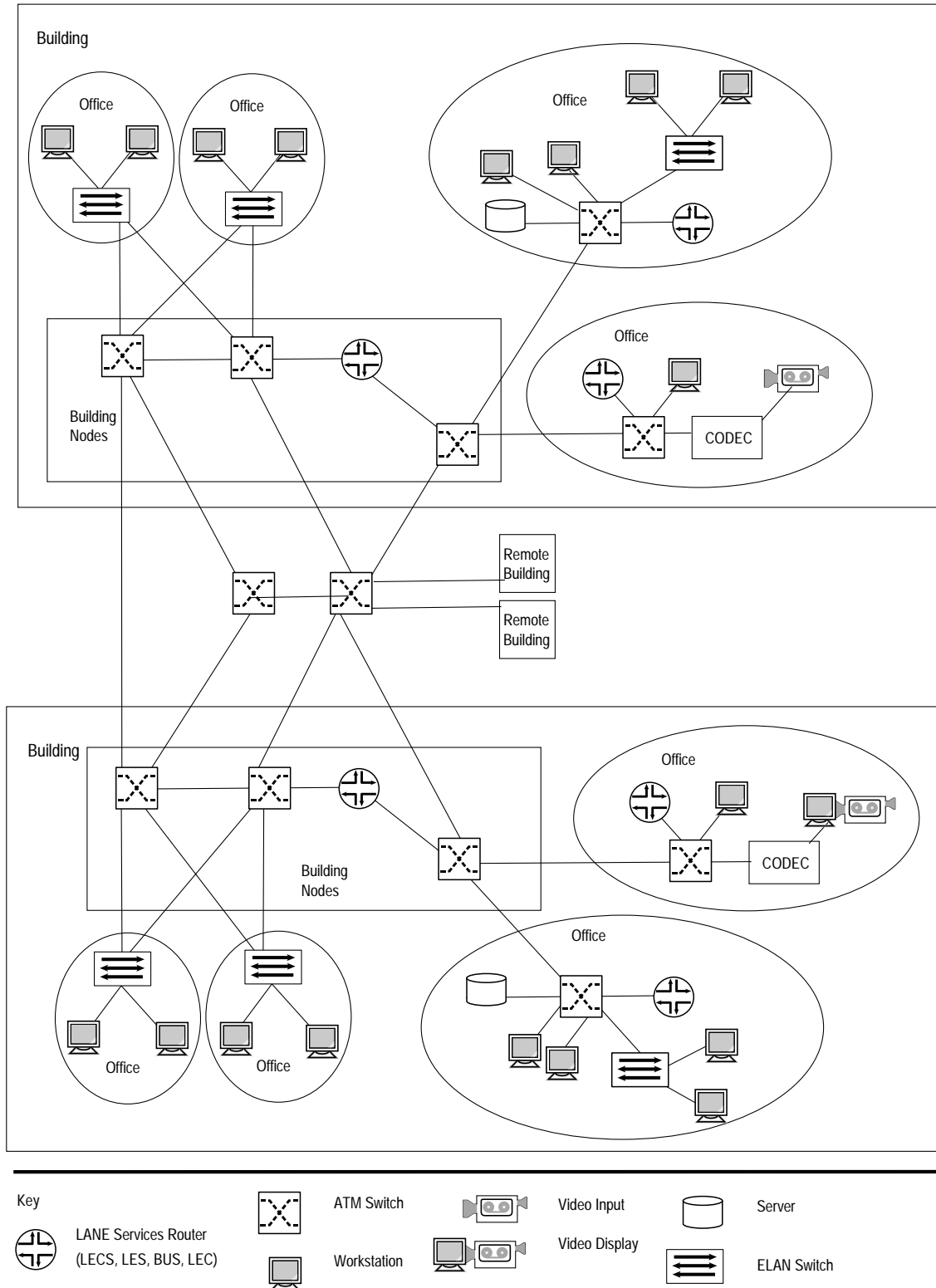
- The office nodes consist of an ATM switch, LEC-enabled Ethernet switches, and a LEC-enabled router. This design enables hosts and servers to communicate within a community of interest without the bottleneck of low-performance routers.
- Building nodes contain ATM switches and LANE services routers to support LANE services for all office nodes in the building.
- Core nodes consist of several high-capacity ATM switches and LEC-enabled routers to route between ELANs. These routers also attach legacy networks (such as FDDI) to the backbone.
- OSPF is the IGP used throughout this network. The core and building nodes participate in Area 0. Each building has a separate area and the LEC-enabled routers in the offices participate in the building OSPF area with the building node routers.

Any communication between ELANs requires going through a router. There are no routers in this network that are capable of high-speed forwarding without compromising performance, particularly when service-enabling features, such as sampling or filtering, are configured. Low-end edge routers tend to be a bottleneck with LANE and need to be replaced.

Figure 1 shows two buildings in the example ATM network connected through the ATM core. Each building consists of a building node and four offices. The offices vary in composition, consisting of offices with workstations connected to the ATM network through ELAN switches, offices with only ATM attached workstations, and offices with video CODECs for non-IP video applications.

An important consideration when transitioning is the need to carry non-IP traffic across the IP/MPLS network. Two types of traffic for consideration are 1) non-IP video traffic carried on the ATM network and 2) ATM-encrypted cells that cannot be re-assembled for transport over the IP/MPLS core. In both cases, application traffic must be transported over the IP/MPLS network without modification. During the transition, it is possible to perform this transport using MPLS Circuit Cross-connect Layer 2 VPN technology.

Figure 1: Example Legacy LANE/ATM Network



## Example Migration Plan

To overcome the problems imposed by the example IP-over-LANE/ATM network, you can transition the design to an IP/MPLS infrastructure using high-performance routers and VLAN switches. During the transition, use LEC-enabled routers for routing between ELANs and for providing LANE services.

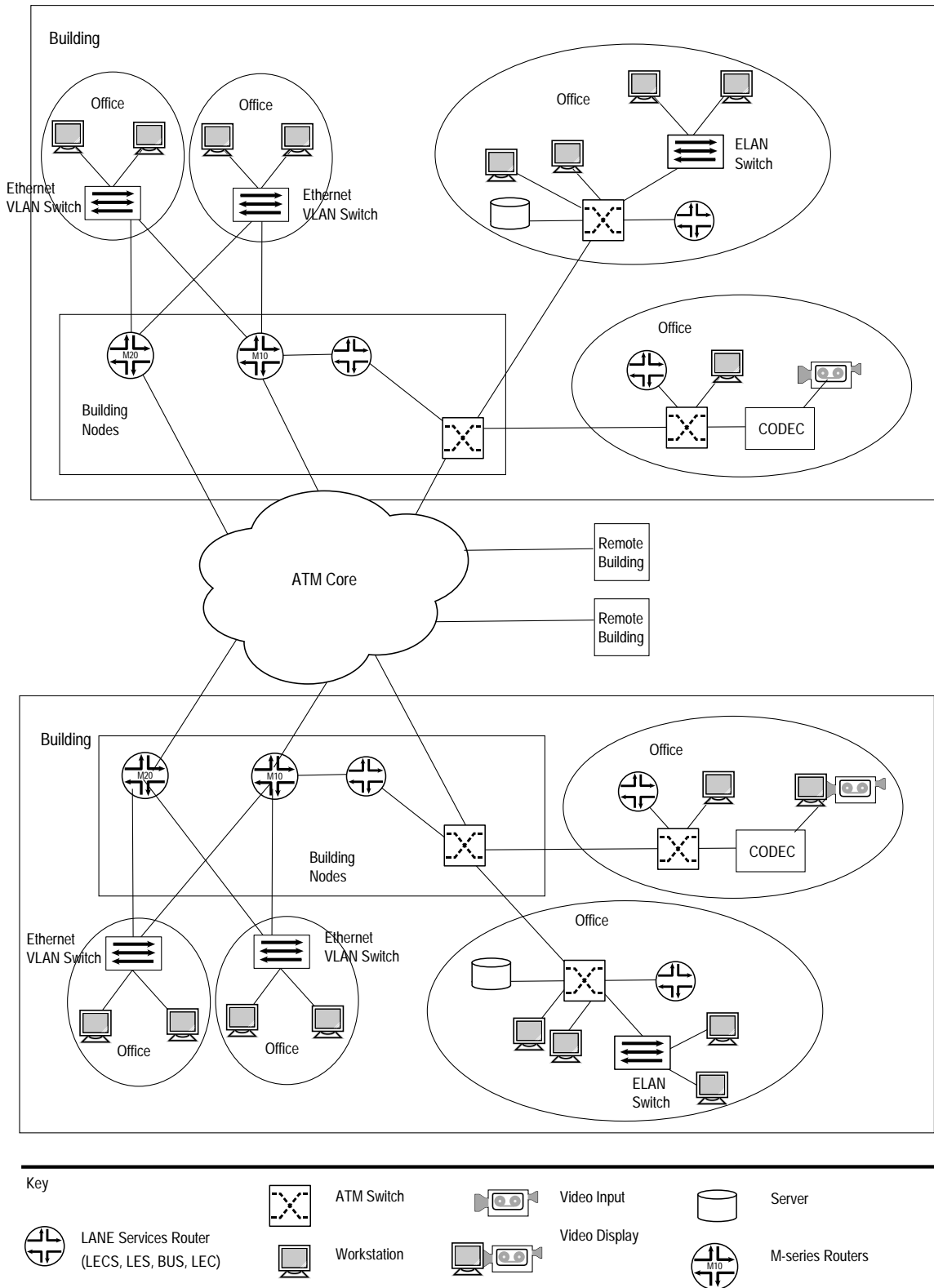
<b>High-performance Router</b>	Best-in-class, ASIC-based, high-speed router capable of predictable forwarding performance with IP services enabled on links ranging from T1 to OC-192c/STM-64. Service-enabling features include MPLS, as well as packet filtering, rate limiting, sampling, logging, and counting.
<b>LEC-enabled Device</b>	An Ethernet switch, ATM switch, or router that has LEC software running on it.
<b>VLAN Switch</b>	Best-in-class switch with Gigabit Ethernet uplinks, 802.1Q trunking to high-performance routers, and 10/100-Mbps Ethernet ports for workstations.

### Phase 1: Move ELANs to VLANs

In phase one, prepare the network for migration from an ATM focus to a scalable high-speed routed network (Figure 2). LANE, through emulated LAN (ELAN) technology, attempts to support VLANs through several server functions that complicate the provisioning and maintenance of the network. To resolve these issues, remove the LANE emulated LANs and use VLAN technology.

Remove ATM switches and LANE services from office nodes without ATM- attached hosts. If feasible, you can redeploy this office node ATM equipment in other parts of the network for robustness.

**Figure 2: VLAN Switches Attached to High-performance Building Node Routers**



## Equipment Requirements

Only new high-performance routers are required in this phase. The goal is to remove the user ELANs and office node ATM switches from the network. The high-performance routers must be capable of simultaneously performing classification, policing, and filtering on many interfaces operating at rates up to 10 Gbps. These high-performance routers allow for predictable routing between Ethernet VLAN switches. For reliability, redundant high-performance routers should be part of the network design.

In a higher cost phase 1 plan, high-performance VLAN switches replace the current low-end Ethernet hubs and switches. This solution provides reliable workgroup VLAN switches to the office for high-speed switching within the office and provides high-speed uplinks and bundling of interfaces to the newly installed high-performance routers.

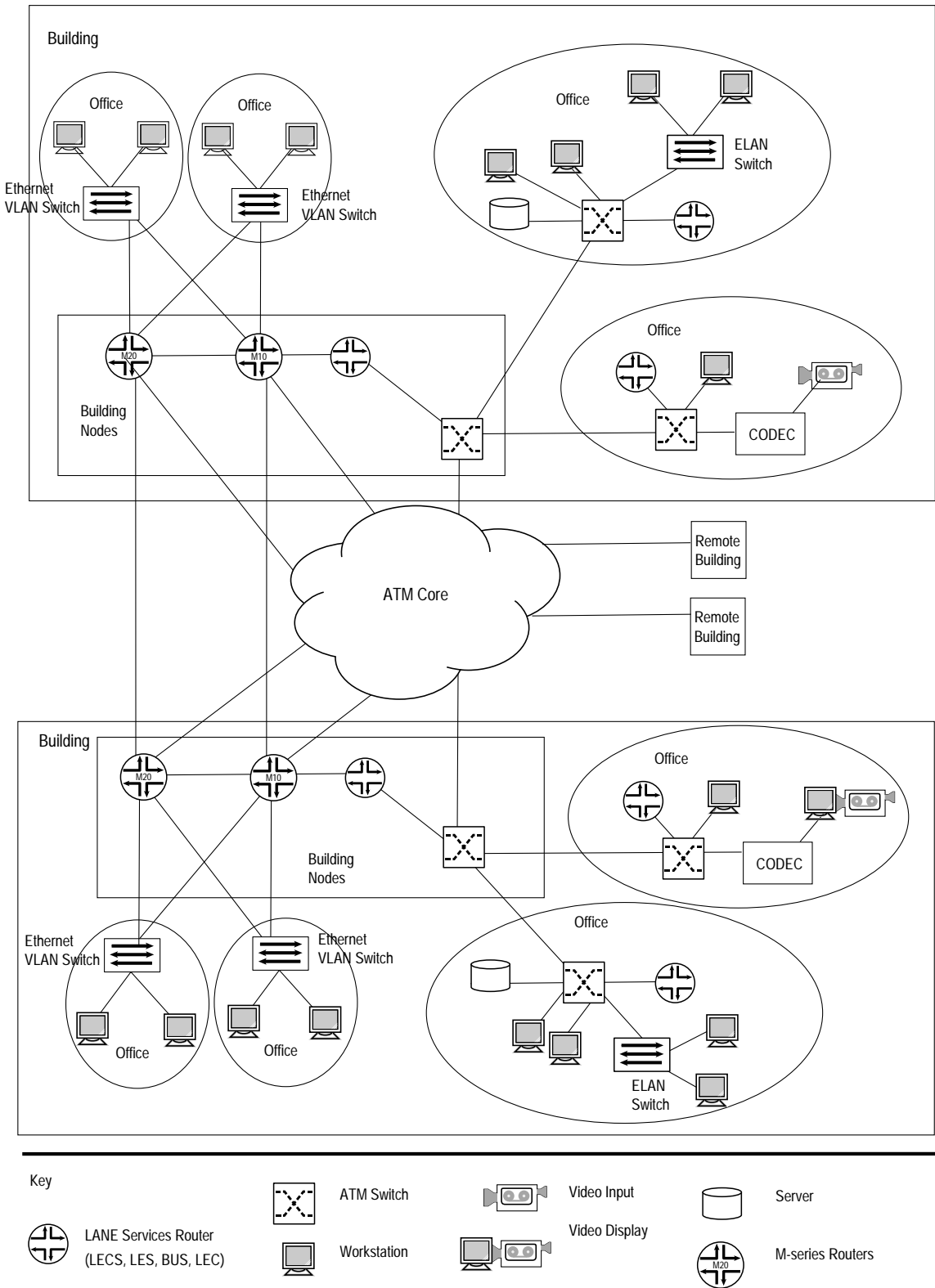
## Migration Steps

1. Remove the office ELANs from the network, but maintain the ATM core. LEC-enabled Ethernet switches may be reused in the offices or replaced with VLAN switches.
2. Attach these Ethernet/VLAN switches to the high-performance routers in the office nodes. This step allows for high-performance routing between offices on the floor of a building. Alternatively, you can directly connect the Ethernet/VLAN switches to the high-performance routers in the building nodes. For redundancy, use multiple Gigabit Ethernet interfaces and link bonding for increased resiliency.
3. Logically connect building node high-performance routers via ATM PVCs. For example, given a network with 5 buildings and 1 high-performance router per building node, 20 simplex PVCs are required. If you add a second router to each building for redundancy, 40 simplex PVCs are required. VRRP should also be used when high-performance routers are paired in the building nodes for resiliency of the default routers. These building node high-performance routers participate in the OSPF routing protocol and are integrated into Area 0 and the building OSPF areas.
4. Convert user ELANs that go outside the office node into 802.1Q VLANs and trunk them across the core using Circuit Cross-connect label switched paths. Doing so enables you to retain current addressing.
  - A. Create a VLAN to connect the remote sites to the main office. Tag the traffic from the main office to that site with the appropriate VLAN tag designated for the remote site.
  - B. Traffic arriving at the router with the VLAN tag destined for the remote site is label switched between the sites using an MPLS Layer 2 Circuit Cross-connect LSP. This feature enables you to retain current addressing and extends the VLAN with no routing in between sites. The two segments of the VLAN must be joined using Circuit Cross-connect LSPs.

## Phase 2: Connect Building Node Routers Directly

In phase two, directly connect the building node high-performance routers (Figure 3). By connecting the buildings with high-speed packet links, you can avoid the ATM core completely by creating larger bandwidth pipes between buildings (OC-48c/STM-16 or OC-192c/STM-64).

**Figure 3: Directly Connected High-performance Building Node Routers**



### Equipment Requirements

Core and building nodes require high-performance routers capable of OC-48c/STM-16 and OC-192c/STM-64 rates that provide predictable forwarding with IP service-enabling features configured, such as class of service, rate limiting, sampling, filter-based forwarding, and firewall filtering.

### Migration Steps

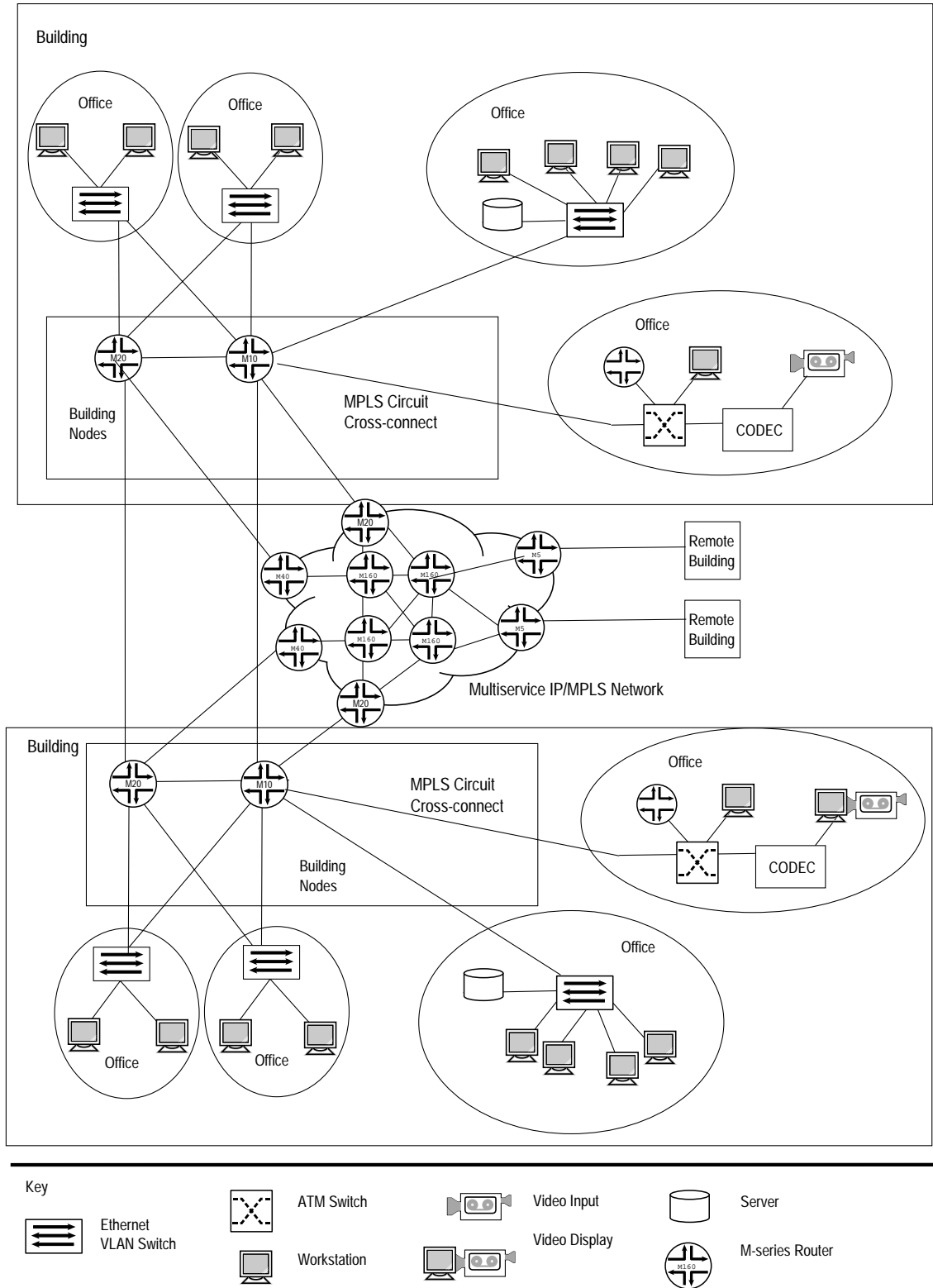
1. Connect building nodes via high-speed packet interfaces (OC-48c/STM-16, OC-192c/STM-64, and other 10-Gbps technologies), allowing forwarding over these interfaces and bypassing the ATM cloud.
2. Balance traffic between the ATM and non-ATM infrastructure.
3. Begin transitioning non-IP applications to run over the packet links using Layer 2 VPN Circuit Cross-connect technology to carry ATM cells natively across the MPLS trunks.

### Phase 3: Complete the IP/MPLS Network

In phase three, eliminate ATM PVCs added in phase 1 (Figure 4) and place high-performance routers in the network core to replace the ATM switches. The high-performance routers in the building and core nodes have an MPLS control plane. This phase provides all the MPLS traffic engineering benefits without the need to provision PVCs in the ATM core. It also reduces the knowledge base required to run the network since ATM and LANE expertise, which is difficult and expensive to retain, is no longer needed.

Non-IP applications are fully migrated to run over the packet network using MPLS Circuit Cross-connect tunnels. Hence, the IP/MPLS network can transport applications with any ATM Adaptation Layer (AAL1, AAL3/4, or AAL5) over LSPs as MPLS-encapsulated ATM cells. By mapping virtual paths or virtual circuits to LSPs, traffic is transported over the packet core without modification.

Figure 4: Multiservice IP/MPLS Network



## Conclusion

Advances in routing technology are cause to re-evaluate the limitations of the IP-over-LANE/ATM model from the perspective of administrative expense, equipment expense, operational stability, and scaling capacity. Juniper Networks IP routers can deliver the required low- and high-speed interfaces, deterministic performance with IP services enabled, quality-of-service capabilities, and MPLS traffic engineering to maximize network efficiency, minimize costs, and increase customer satisfaction. We remain committed to helping you achieve these goals through smooth migration to a multiservice IP/MPLS network. For information, see [www.juniper.net](http://www.juniper.net) for the nearest sales representative or contact one of our Professional Services consultants.

## Acronyms

<b>AAL</b>	ATM Adaptation Layer
<b>ATM</b>	Asynchronous Transfer Mode
<b>BUS</b>	broadcast and unknown server
<b>CODEC</b>	coder - decoder
<b>COIN</b>	communities-of-interest networks
<b>CSPF</b>	Constrained Shortest Path First
<b>ELAN</b>	emulated LAN
<b>FDDI</b>	Fiber Distributed Data Interface
<b>IEEE</b>	Institute of Electrical and Electronics Engineers
<b>IETF</b>	Internet Engineering Task Force
<b>IGP</b>	interior gateway protocol
<b>IP</b>	Internet Protocol
<b>IPX</b>	Internetwork Packet Exchange
<b>LAN</b>	local area network
<b>LANE</b>	LAN emulation
<b>LEC</b>	LAN emulation client
<b>LECS</b>	LAN emulation configuration server
<b>LES</b>	LAN emulation server
<b>LSP</b>	label switched path
<b>LSR</b>	label switching router
<b>MPLS</b>	Multiprotocol Label Switching
<b>NBMA</b>	non-broadcast multiple access
<b>OSPF</b>	Open Shorted Path First

<b>PVC</b>	permanent virtual circuit
<b>RSVP</b>	Resource Reservation Protocol
<b>SAR</b>	segmentation and re-assembly
<b>SVC</b>	switched virtual circuit
<b>VCI</b>	virtual channel identifier
<b>VLAN</b>	virtual LAN
<b>VPI</b>	virtual path identifier
<b>VPN</b>	virtual private network

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