Data Center Network Infrastructure

Data Center Definition

- A data center
  - is a large amount of electronic equipment, such as computers and communications equipment.
  - is usually maintained by an organization for handling the data operations.
  - enables the consolidation of critical computing resources in controlled environments, under centralized management, that permit enterprises to operate around the clock or according to their business needs.

Data Center Architectural Overview

- Data centers provide the following functions:
  - Ensuring network connectivity,
    - including switches and routers.
  - Providing network and server security,
    - including firewalls and intrusion detection systems (IDSs).
  - Enhancing availability and scalability of applications,
    - including load balancers, secure sockets layer (SSL) offloaders and caches.

Critical Requirements

- Designing the data center infrastructure :
  - High Availability—Avoiding a single point of failure and achieving fast and predictable convergence times
  - Scalability—Allowing changes and additions without major changes to the infrastructure, easily adding new services, and providing support for hundreds dual-homed servers
  - Simplicity—Providing predictable traffic paths in steady and failover states, with explicitly defined primary and backup traffic paths
  - Security—Prevent flooding, avoid exchanging protocol information with rogue devices, and prevent unauthorized access to network devices

dual-homed is one of the firewall architectures for implementing preventive security.

Data Center Architecture

- The data center infrastructure must provide:
  - High port density
  - Layer 2 (Data Link layer) connectivity
  - Layer 3 (Network layer) connectivity
- It must support security services provided by
  - Access control lists (ACLs)
  - Firewalls
  - Intrusion detection systems (IDS)
- It must support server farm services such as:
  - Content switching
    - is used to scale application services by front ending servers and load balancing the incoming requests to those available servers.
  - Caching
  - Secure sockets layer (SSL)
- It must integrate:
  - Multi-tier server farms
  - Mainframes and mainframe services

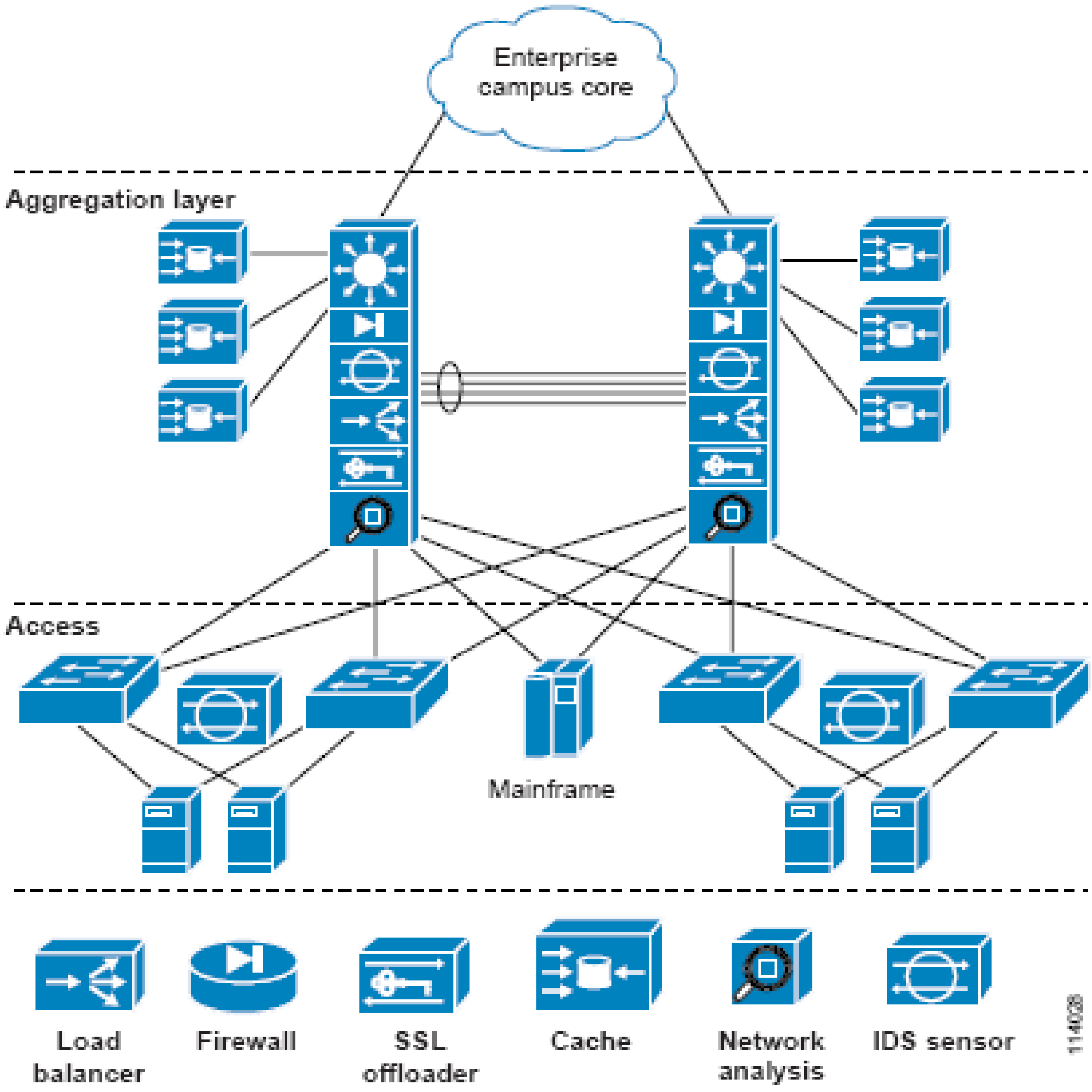
Data Center Architecture

- While the data center infrastructure must be scalable and highly available, it should still be simple to
  - operate.
  - troubleshoot.
  - easily accommodate new demands.

Data Center Architecture

- The architecture of enterprise data centers is determined by
  - the business requirements
  - the application requirements
  - the traffic load
- The extent of the data center services offered translates into the actual design of the architecture.

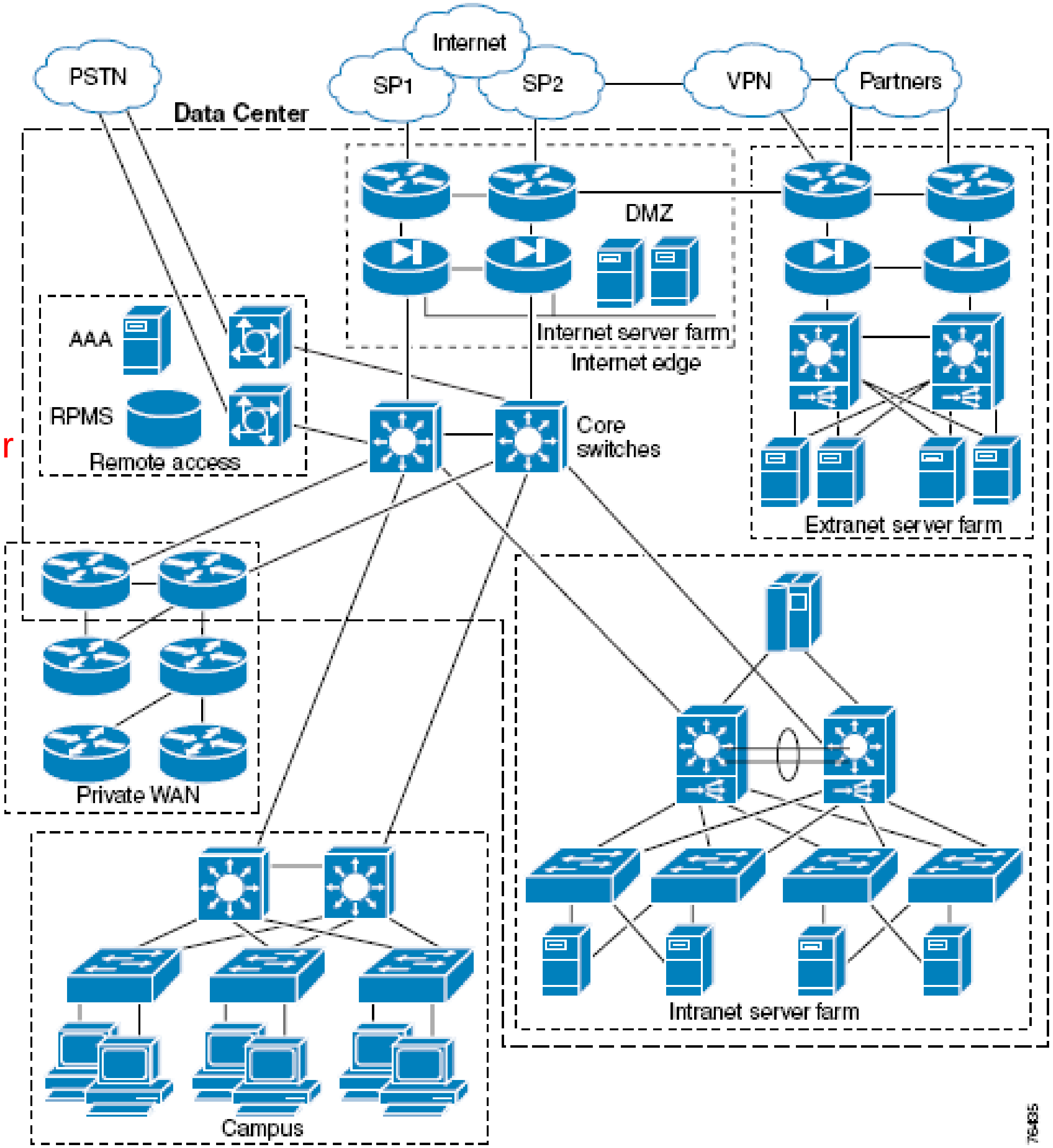
Data Center Architecture



Enterprise Network Infrastructure

- Typical Enterprise network include:
  - Campus
  - Private WAN
  - Remote Access
  - Internet server farm
  - Intranet server farm
  - Extranet server farm

Enterprise Network Infrastructure Example



Demilitarized Zone

Remote Power Manager

Enterprise Network Infrastructure

- Data centers house many network infrastructure components
  - the core switches of the campus network or the edge routers of the private WAN.

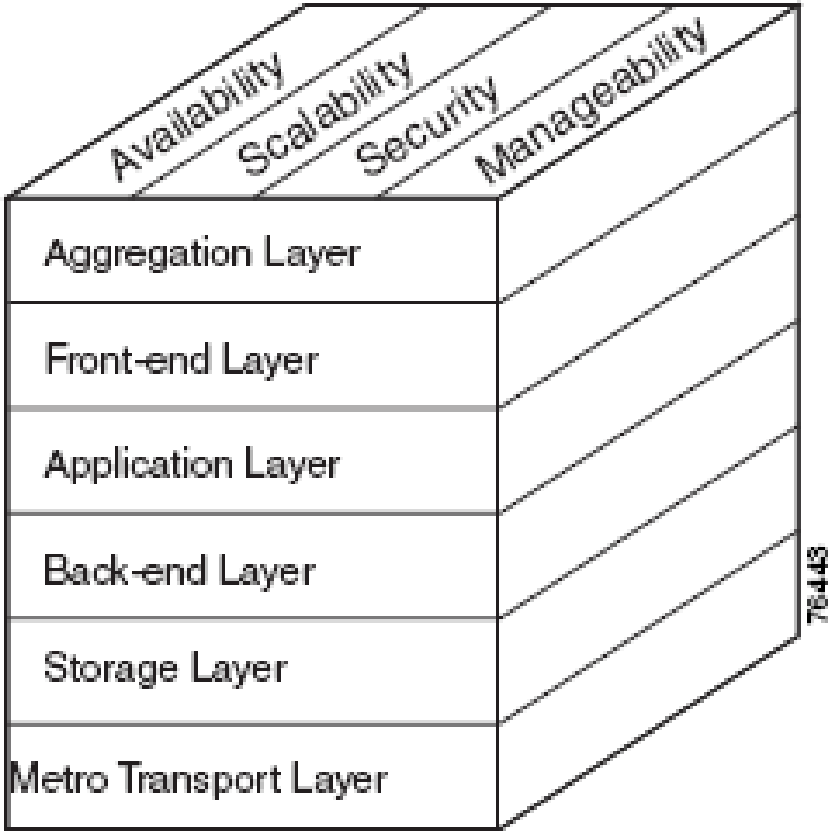
- Data Center designs include at least one type of server farm.
  - These server farms may or may not be built as separate physical entities, depending on the business requirements of the enterprise.

Enterprise Network Infrastructure

- A single data center may use a shared infrastructure, resources such as servers, firewalls, routers, switches, etc., for multiple server farm types.
- Another data center may require that the infrastructure for server farms be physically dedicated.
- Enterprises make these choices according to business drivers and their own particular needs.

Data Center Architecture

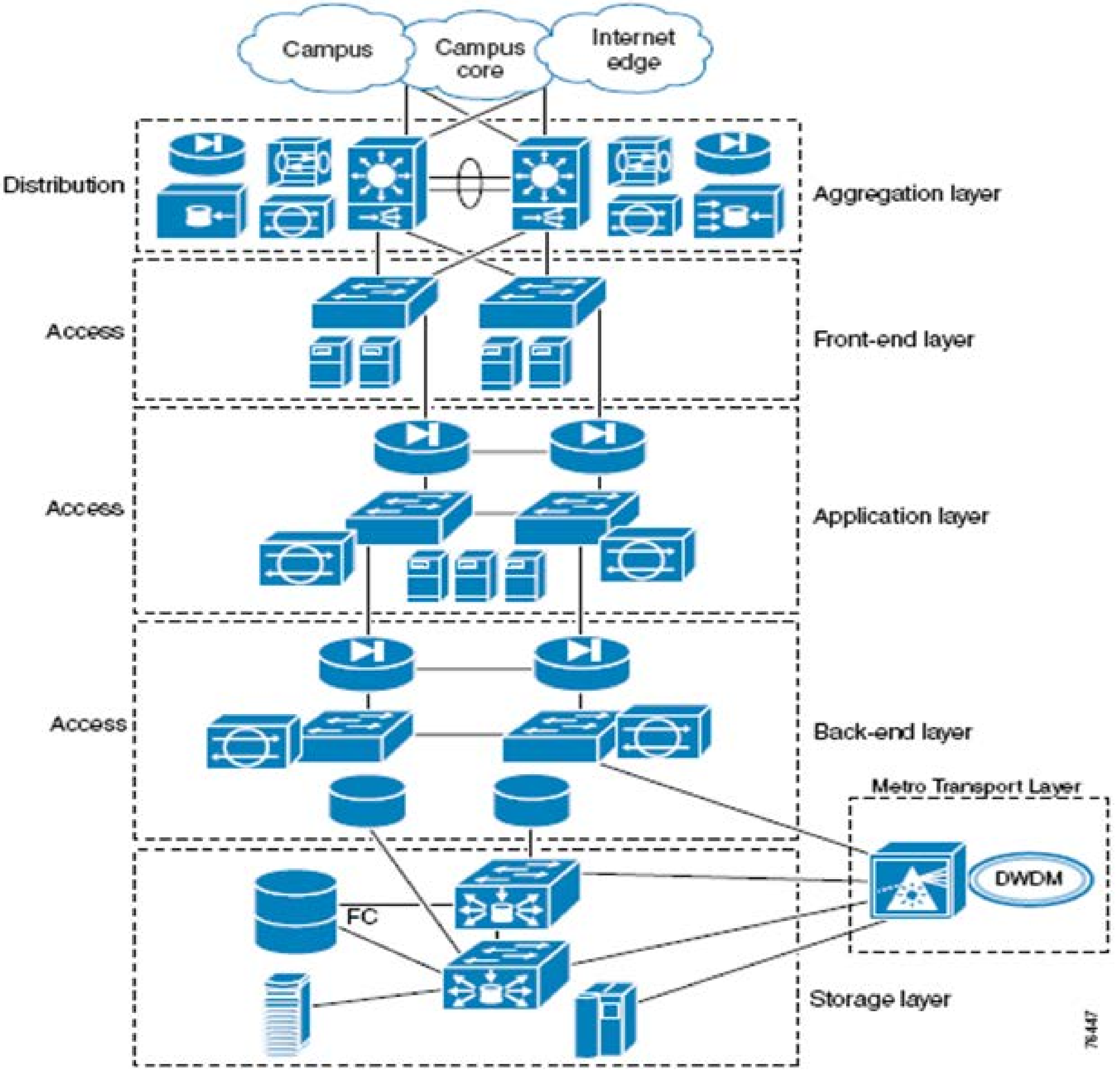
- **Four** key design criteria is used in this translation process that help you produce design goals.
- These criteria are:
  - availability
  - scalability
  - security
  - management



Data Center Architecture

- A layered approach to the data center design that supports N-Tier applications yet it includes other components related to other business trends.
- The layers of the architecture include:
  - Aggregation
  - Front-end
  - Application
  - Back-end
  - Storage
  - Metro Transport

Data Center Layer Architecture



s: L2-L5

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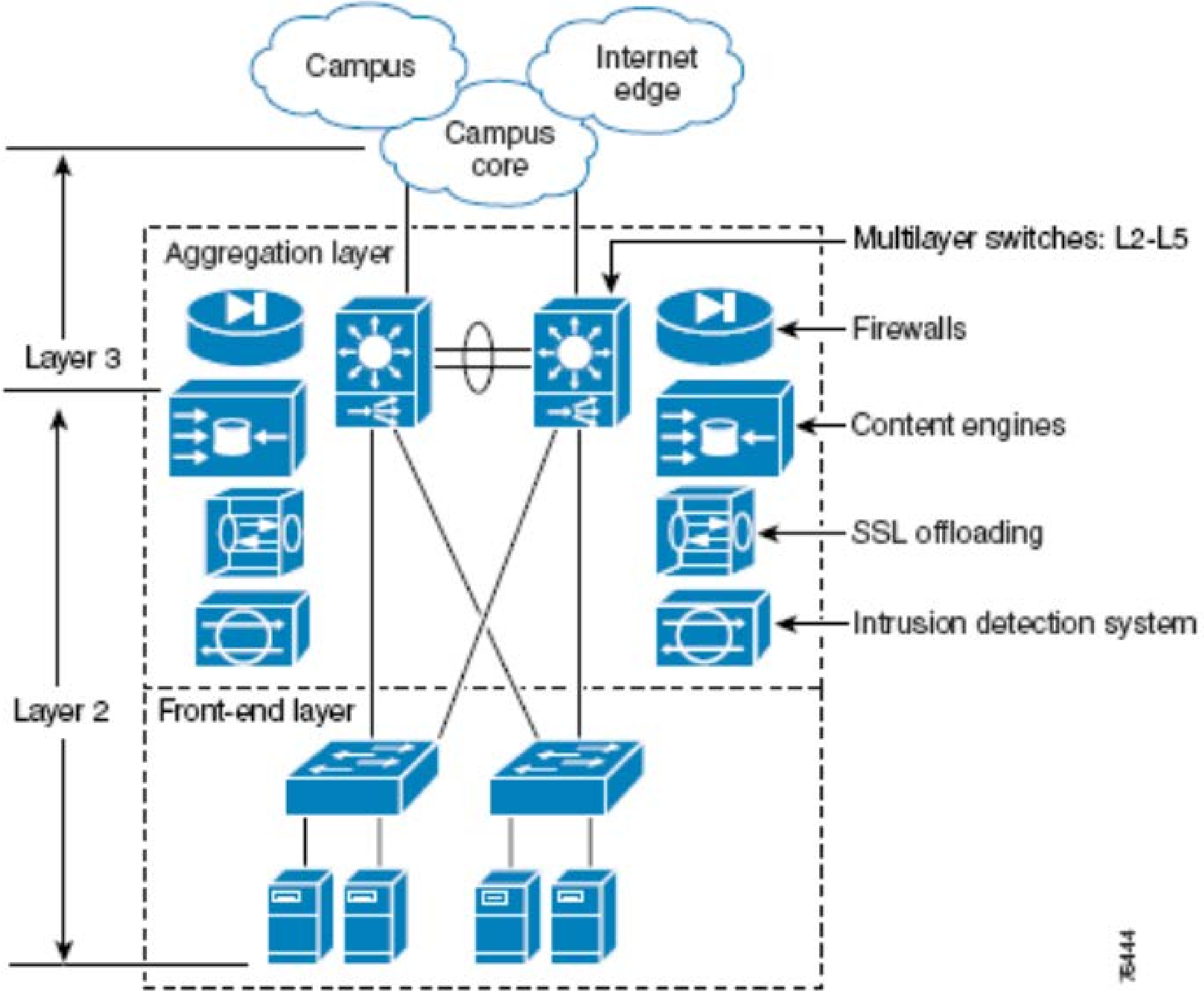
Aggregation Layer

- Provides network connectivity between the server farms and the rest of the enterprise network.
- Provides network connectivity for data center service devices.
- Supports fundamental layer 2 and layer 3 functions.

Aggregation Layer

- The aggregation layer is analogous to the campus network distribution layer.
- Data center services that are common to servers in the front-end or other layers should be centrally located in the aggregation layer for
  - predictability
  - consistency
  - manageability
- The aggregation layer includes:
  - Multilayer switches (aggregation switches) that provide the layer 2 and layer 3 functionality
  - Content switches
  - Firewalls
  - IDSs
  - Content engines
  - SSL offloaders

Aggregation Layer



Front-end Layer

- The front-end layer is analogous to the campus access layer in its functionality, and provides connectivity to the first tier of servers.
- The front-end server farms typically include
  - FTP
  - Telnet
  - TN3270
  - SMTP
  - Web servers
  - other business application servers
  - network-based application servers, such as
    - IPTV broadcast servers
    - Content distribution managers
    - Call managers

Front-end Layer Functionality

- **Multicast** and **QoS** that may be required, depend on the servers and their functions.
  - E.g., live video streaming over IP is supported, **multicast** must be enabled
  - E.g., voice over IP is supported, **QoS** must be enabled.
- Layer 2 connectivity through VLANs is required between
  - servers supporting the same application services for backup servers on different layer 2 switches
  - server and service devices such as content switches.
- Other requirements may be used
  - IDSs or host IDSs to detect intruders
  - PVLANs to segregate servers in the same subnet from each other.

PVLAN (Private-VLAN)

- Provide layer 2 isolation between ports within the same broadcast domain.
- There are three types of PVLAN ports:
  - **Promiscuous**— can communicate with all interfaces, including the isolated and community ports within a PVLAN.
  - **Isolated**— has complete layer 2 separation from the other ports within the same PVLAN, but not from the promiscuous ports.
    - PVLANs block all traffic to isolated ports except traffic from promiscuous ports.
    - Traffic from isolated port is forwarded only to promiscuous ports.
  - **Community**— communicate among themselves and with their promiscuous ports. These interfaces are separated at layer 2 from all other interfaces in other communities or isolated ports within their PVLAN.

Application Layer

- The application layer provides connectivity to the servers supporting the business logic, which are all grouped under the application servers tag.
- Applications servers
  - run a portion of the software used by business applications
  - provide the communication logic between front-end and the back-end, which is typically referred to as the middleware or business logic
  - translate user requests to commands the back-end database systems understand.

Application Layer

- The features required at this layer are almost identical to those needed in the front-end layer.

- Additional security is typically used to tighten security between servers that face users and the next layer of servers.
  - using firewall in between.

- Additional IDSs may also be deployed to monitor different kinds of traffic types.

- Additional services may require load balancing between the web and application servers typically based on layer 5 information (front-end), or SSL if the server-to-server communication is done over SSL.

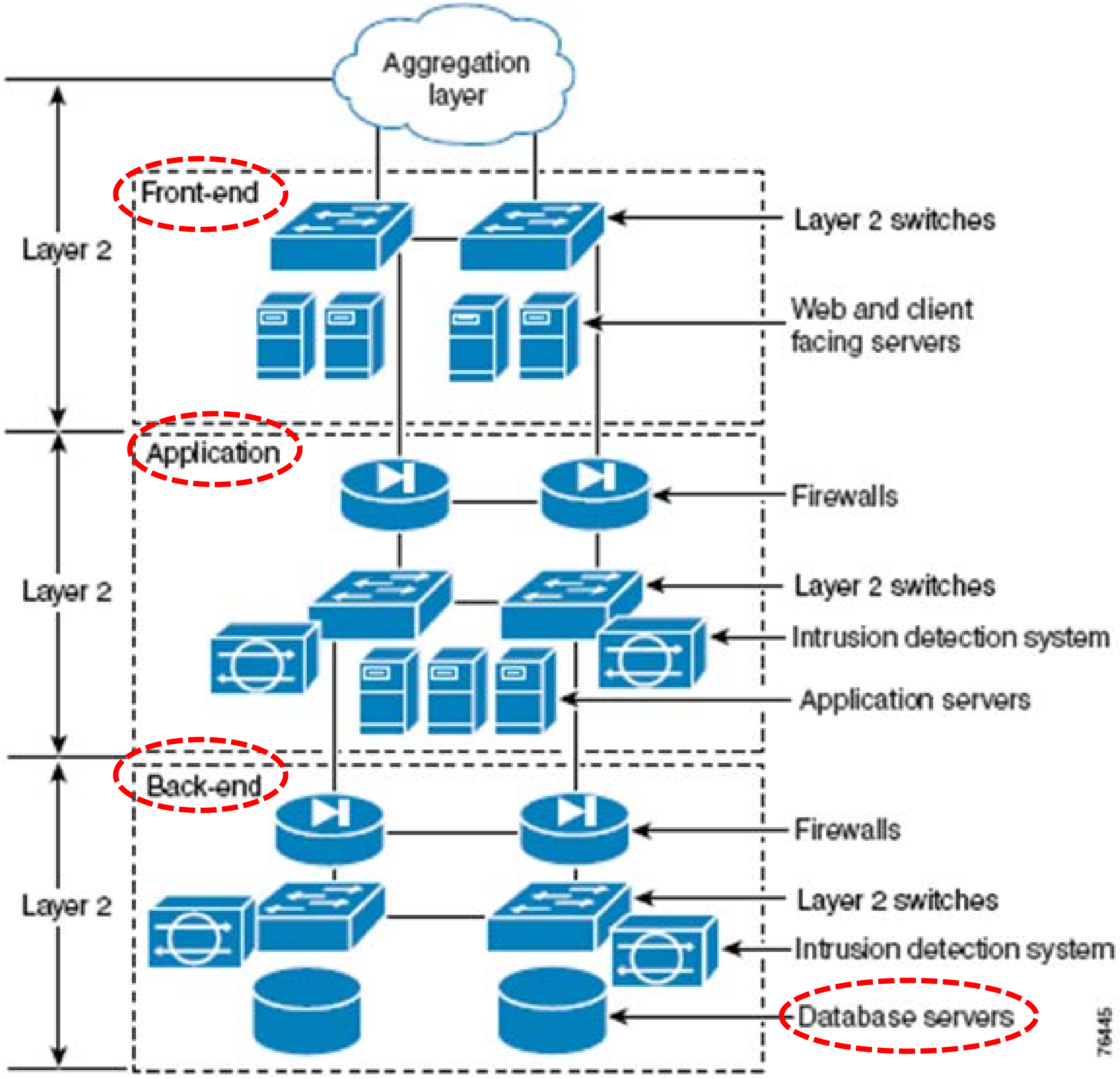
Back-End Layer

- Provides connectivity to the database servers.
  - the relational database systems that provide the mechanisms to access the enterprise's information, which makes them highly critical.

- The hardware supporting the relational database systems range from medium sized servers to mainframes, some with locally attached disks and others with separate storage.

- The security considerations are more stringent and aimed at protecting the enterprise data.

Front-End, Application and Back-End Layers



Storage Layer

- Using **Fibre-Channel (FC)** or **iSCSI** connects devices in the storage network
- Through FC switches is used for storage-to-storage communications between devices.
  - such as attached server and disk subsystems of tape units.
- iSCSI
  - provides SCSI connectivity to servers over an IP network
  - is supported by iSCSI routers, port adaptors, and IP services modules.
- FC is typically used for **block** level access, whereas iSCSI is used for **file** level access.

Metro Transport Layer

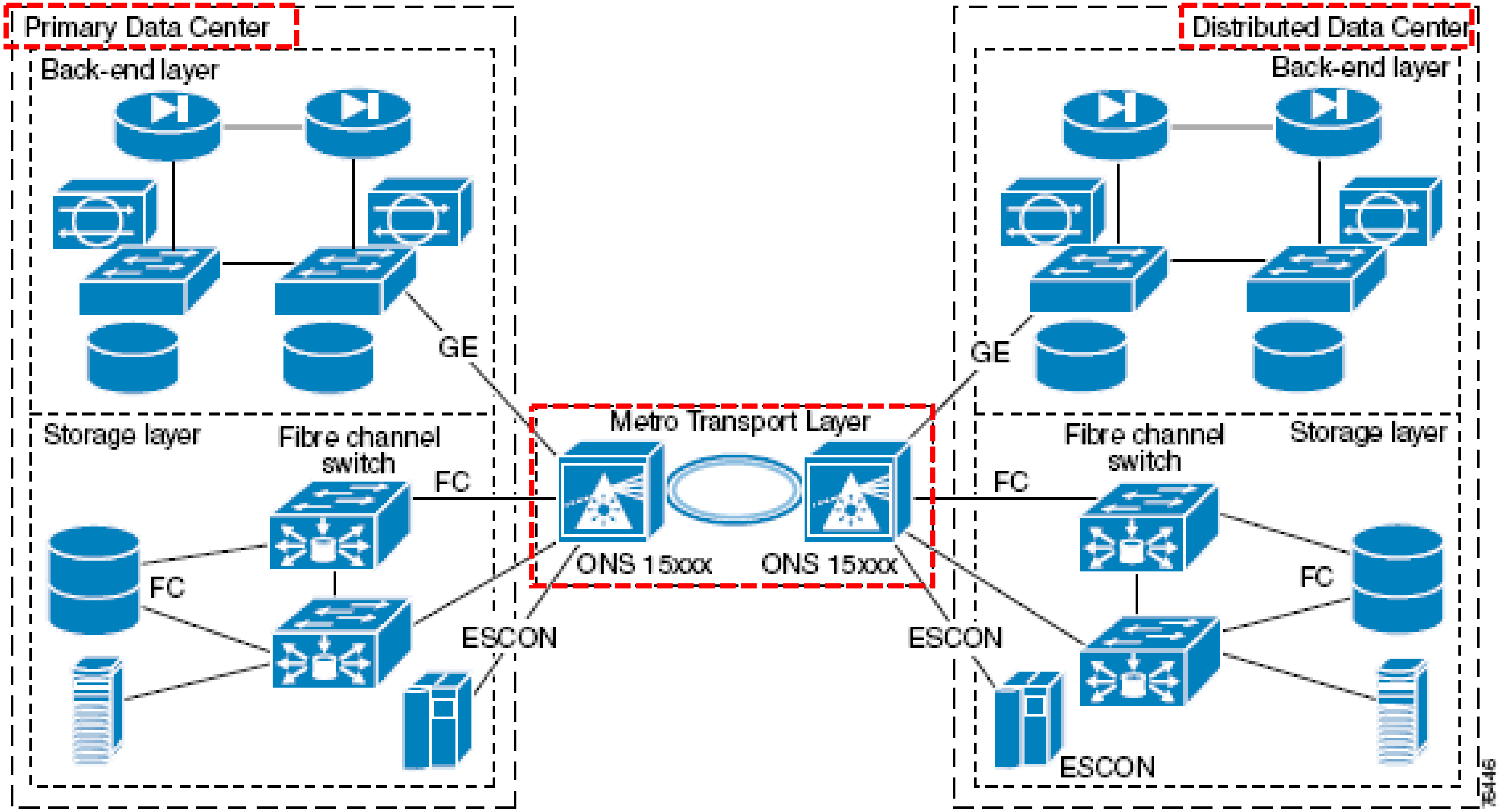
- The metro transport layer is used to provide a high speed connection between distributed data centers.
  - high speed campus-to-campus connectivity.

- Distributed data centers use metro optical technology to provide transparent transport media, which is typically used for database or storage mirroring and replication.

Metro Transport Layer

- The high speed connectivity needs are for synchronous communications or asynchronous communications, which one depends on the recovery time expected when the primary data location fails.
- The most common business drivers to use distributed data centers and their connectivity is for
  - disaster recovery plans
  - business continuance plans

Metro Transport Layer



ESCON:Enterprise Systems Connection

Data Center Services

- These services include:
  1. Infrastructure service: layer 2, layer 3, intelligent network services and data center transport
  2. Application optimization services: content switching, caching, SSL offloading, and content transformation
  3. Storage: consolidation of local disks, network attached storage, storage area networks
  4. Security: access control lists, firewalls, and intrusion detection systems
  5. Management: management devices applied to the elements of the architecture

Infrastructure Services

- All core features for the functions and services of data center infrastructure.
- The infrastructure features are organized as follows:
    - Metro
    - Layer 2
    - Layer 3
    - Intelligent Network Services

Metro Services

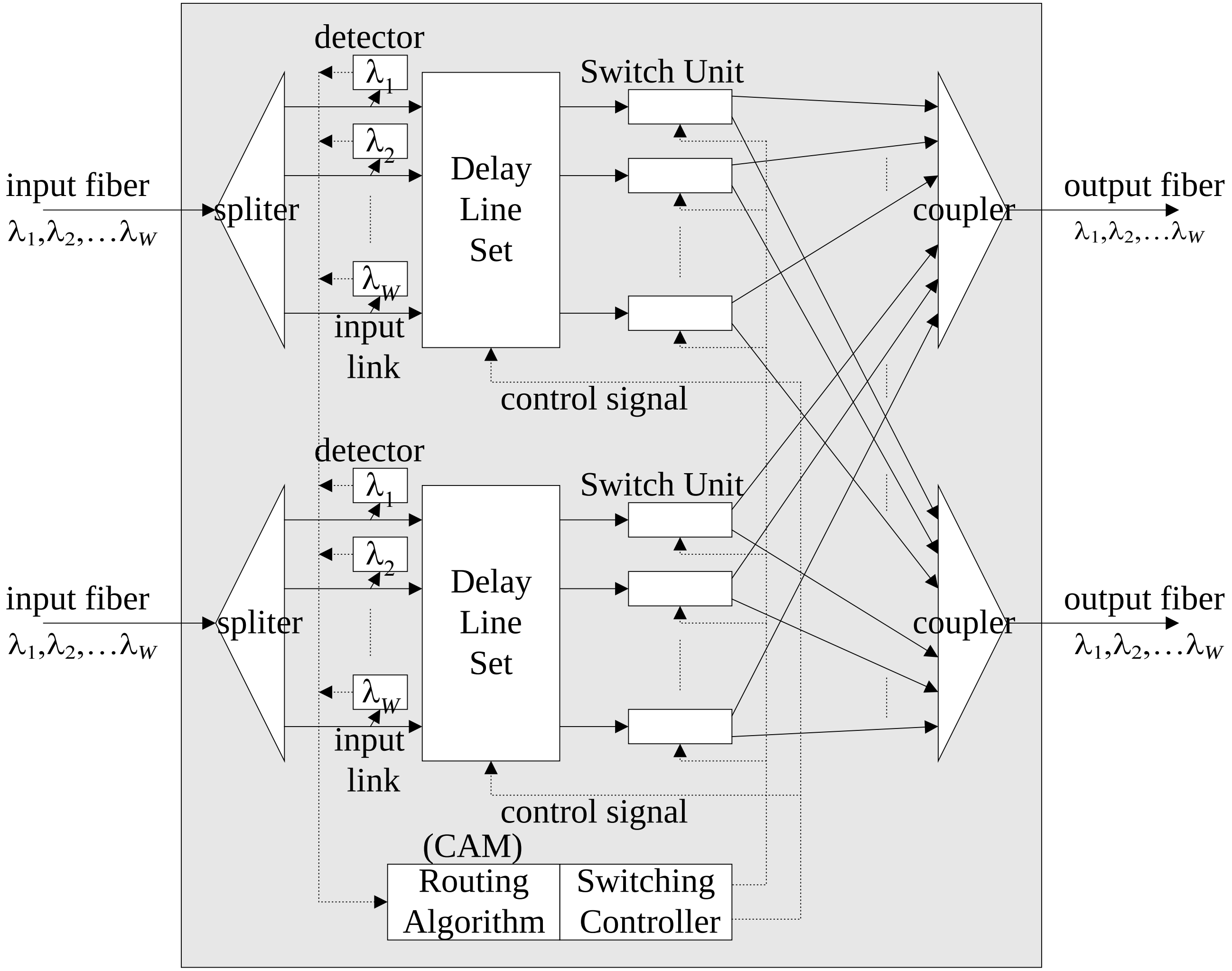
- Metro services include a number of physical media access, such as
  - Fibre-Channel
  - iSCSI
  - Metro transport technologies such as
    - Dense wave division multiplexing (DWDM)
    - Coarse wave division multiplexing (CWDM)
    - Synchronous Optical Networking (SONET)
    - 10GE.

Metro Services

- Metro transport technologies enable a number of applications that require high bandwidth and low predictable delay.
- DWDM provides physical connectivity for a number of different physical media concurrently such as
  - Gigabit Ethernet
  - Asynchronous Transfer Mode (ATM)
  - Fibre Channel
- Some instances where this connectivity is required are for
  - long-haul storage area networks (SAN) extension over SONET or IP
  - short-haul SAN extension over DWDM/CWDM, SONET, or IP (Ethernet)

The DWDM Switch Element Architecture

- The detail architecture of a 2×2 DWDM Switch with W wavelengths in each input fiber.



Layer 2 Services

- Support the layer 2 adjacency between the server farms and the service devices
- Layer 2 domain supports
  - a fast convergence
  - loop free
  - fault tolerance
  - scalable
- LAN media access
  - Gigabit Ethernet
  - ATM
  - Packet over SONET (PoS)
  - IP over optical media

Spanning Tree Protocol (STP)

- Layer 2 domain features ensure the spanning tree protocol (STP) convergence time for deterministic topologies is in the single digit seconds, and the failover and fallback scenarios are predictable.

- The list of features includes:
  - 802.1s + 802.1w (Multiple Spanning-Tree)
  - PVST+802.1w (Rapid Per VLAN Spanning-Tree)
  - 802.3ad (Link Aggregate Control Protocol)
  - 802.1q (trunking)
  - Loop guard
  - Uni-directional link detection (UDLD)
  - Broadcast suppression

Layer 3 Services

- Layer 3 services enable fast convergence and a resilient routed network, including redundancy, for basic layer 3 services, such as default gateway support.
  - The network operation is predictable under normal and failure conditions.
- The list of available features includes:
  - Static routing
  - Border gateway protocol (BGP)
  - Interior gateway protocols (IGPs): OSPF and EIGRP
  - HSRP, MHSRP & VRRP (fault-tolerant default gateway)

Inteligent Network Services

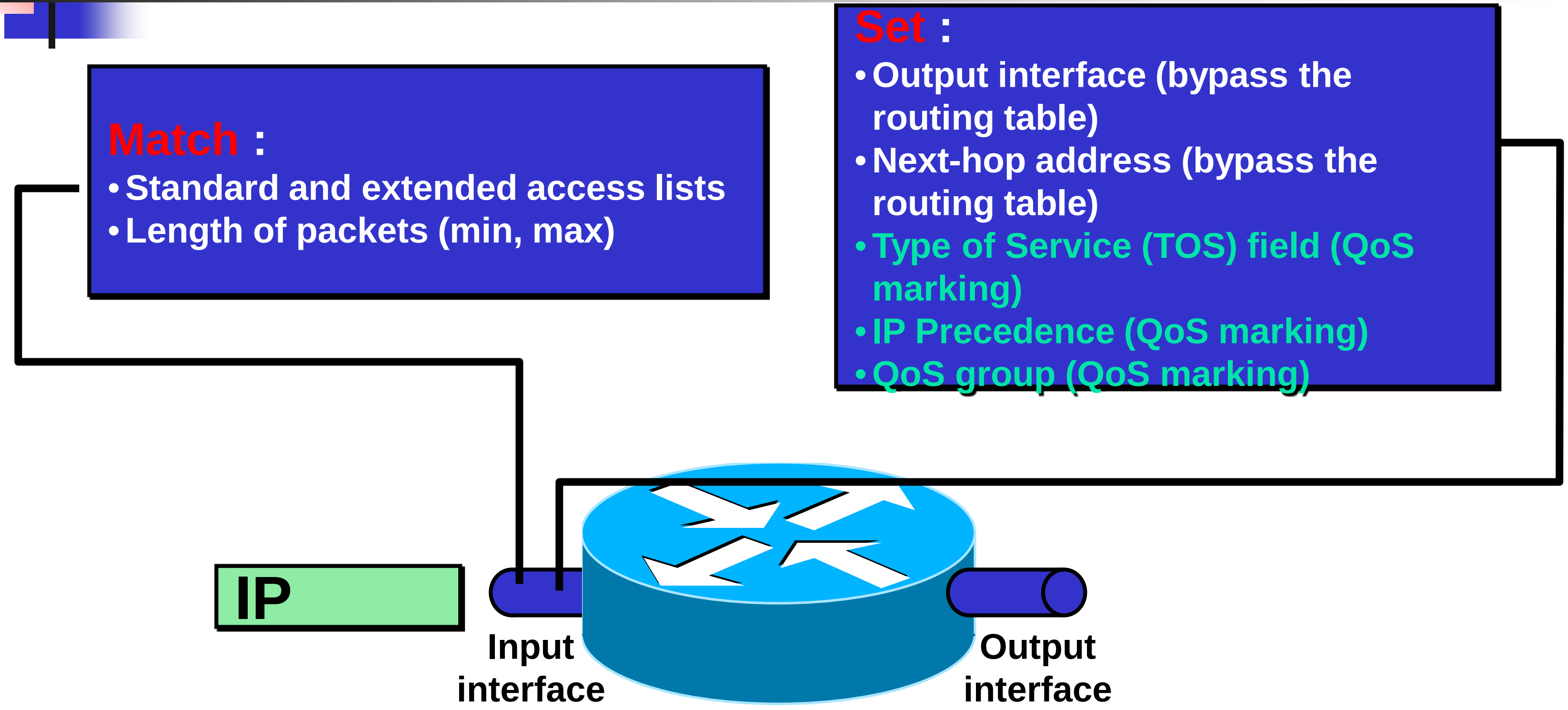
- It include a number of features that enable applications services network wide.
- The most common features are **QoS** and **Multicast**.
  - live or on demand video streaming and IP telephony.
  - the classic set of enterprise applications.

- Other important intelligent network services include
  - Private VLANs (PVLANs)
  - Policy based routing (PBR).

Policy-based Routing

- Policy-based Routing (PBR) is a mechanism that can be used to bypass the default destination-based forwarding functionality of routers
- PBR is implemented using a route map
  - **match commands** are used to classify packets
  - **set commands** are used to process packets
- Route maps are applied to interfaces for processing of inbound packets (forwarding and/or marking)

PBR Match and Set Options



Match :

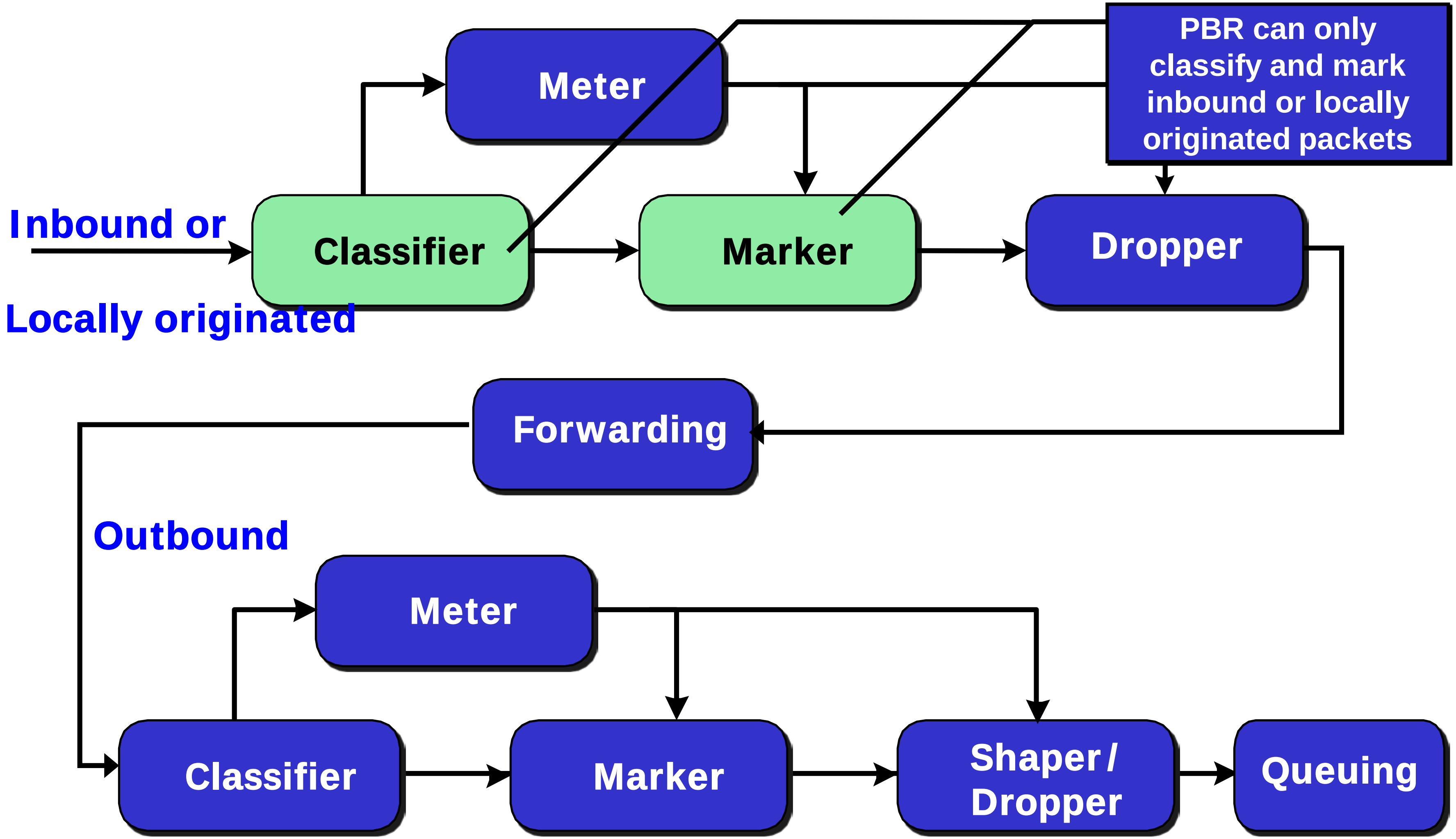
- Standard and extended access lists
- Length of packets (min, max)

Set :

- Output interface (bypass the routing table)
- Next-hop address (bypass the routing table)
- Type of Service (TOS) field (QoS marking)
- IP Precedence (QoS marking)
- QoS group (QoS marking)

- PBR has two primary applications:
  - Implementation of more complex routing paradigms than a simple destination-based forwarding
  - Classification and marking of packets for QoS purposes

PBR Capabilities



Inteligent Network Services

- QoS is important for two reasons:
  - application traffic and port based rate limiting capabilities that enforces a proper QoS service class as traffic leaves the server farms

- Multicast enables the capabilities needed to reach multiple users concurrently or servers to receive information concurrently (cluster protocols).

Application Optimization Services

- It include a number of features that provide intelligence to the server farms.
- These features permit the scaling of applications supported by the server farms and packet inspection beyond layer 3 (layer 4 or layer 5).
- The application services are:
  - server load balancing or content switching
  - caching
  - SSL offloading

Application Optimization Services

- Content switching scales application services by front ending servers and load balancing the incoming requests to those available servers.

- The load balancing mechanisms could be based on layer 4 or layer 5 information, thus allowing the partitioning of the server farms by the content.
  - A group of servers supporting video streaming could be partitioned on those that support MPEG versus the ones that support Quicktime or Windows Media.

  - The content switch is able to determine the type of request, by inspecting the URL, and forwards it to the proper server.
    - This process simplifies the management of the video servers and allows you to deal with scalability at a more granular level, per type of video server.

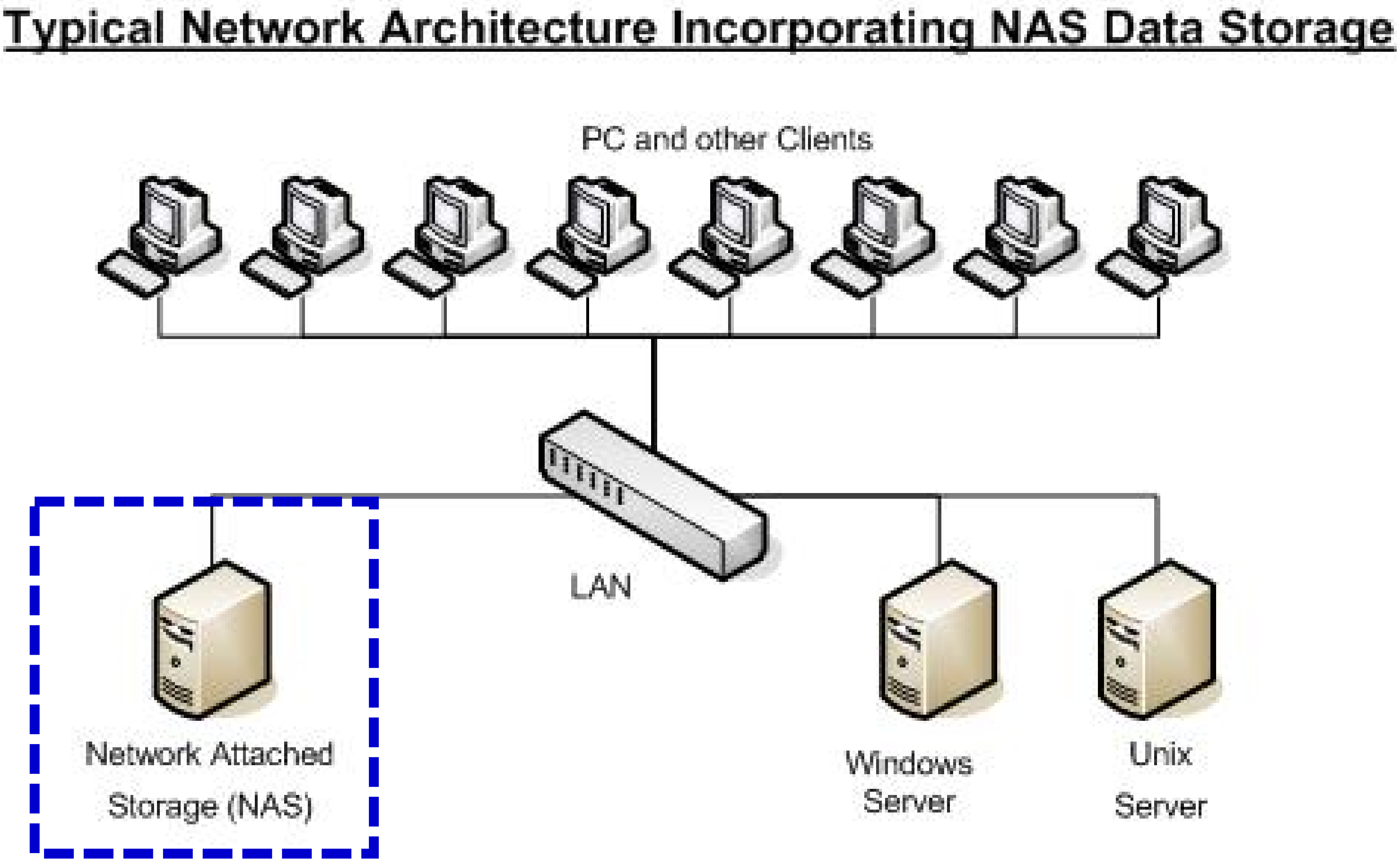
Application Optimization Services

- The process of offloading occurs transparently for both the user and the server farm.
- SSL offloading also offloads CPU capacity from the server farm by processing all the SSL traffic.
- The two key advantages:
  - The centralized management of SSL services on a single device.
  - The capability of content switches to load balance.

Storage Services

- Storage services include the storage network connectivity required for user-to-server and storage-to-storage transactions.
- The major features could be classified in the following categories:
  - Network attached storage (NAS)
  - Storage area networks (SAN) to IP: Fibre Channel and SCSI over IP
  - Localized SAN fabric connectivity (Fibre Channel or iSCSI)
  - Fibre Channel to iSCSI Fan-out

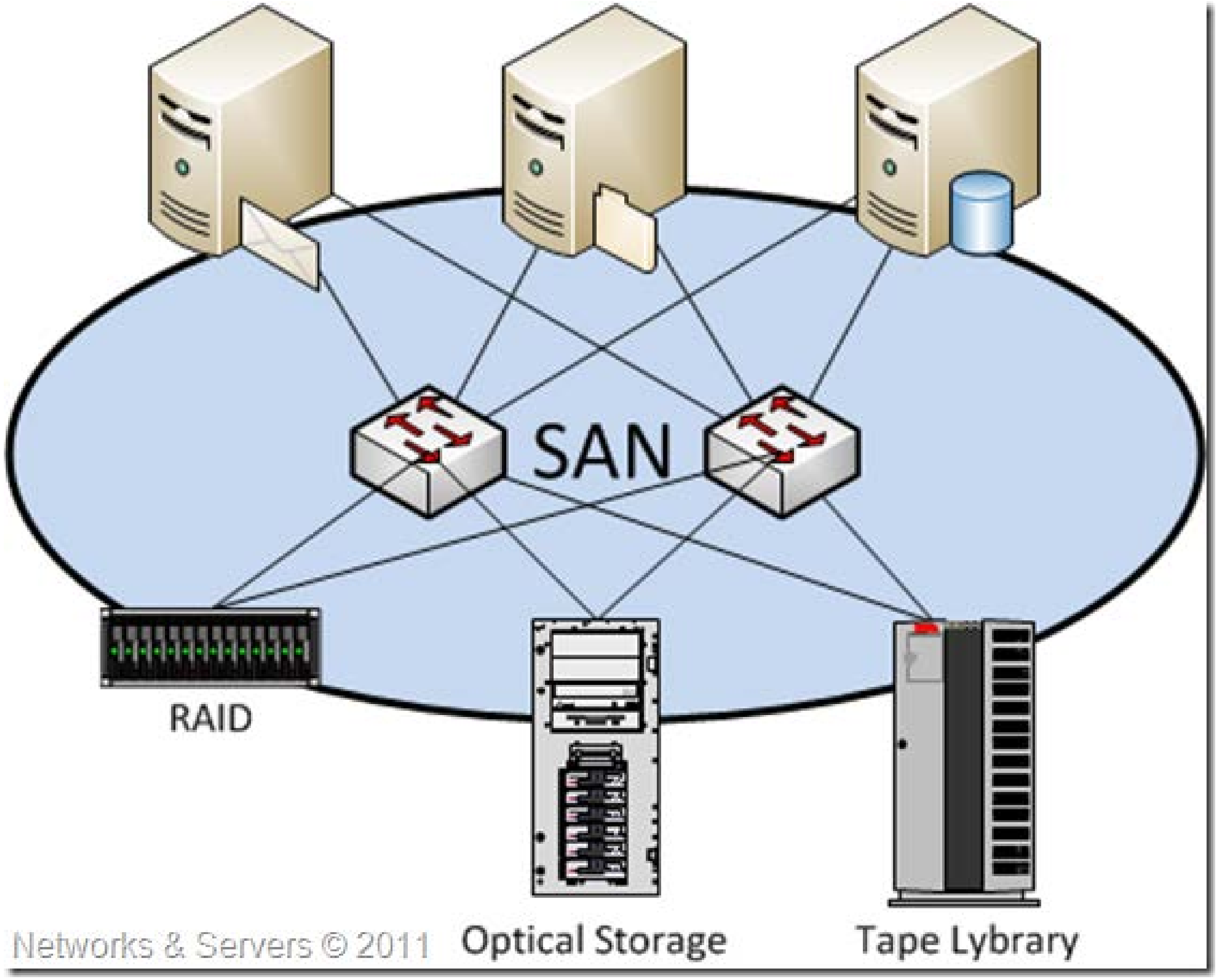
Network-Attached Storage(NAS)


Typical Network Architecture Incorporating NAS Data Storage
PC and other Clients
LAN
Network Attached Storage (NAS)
Windows Server
Unix Server

NAS

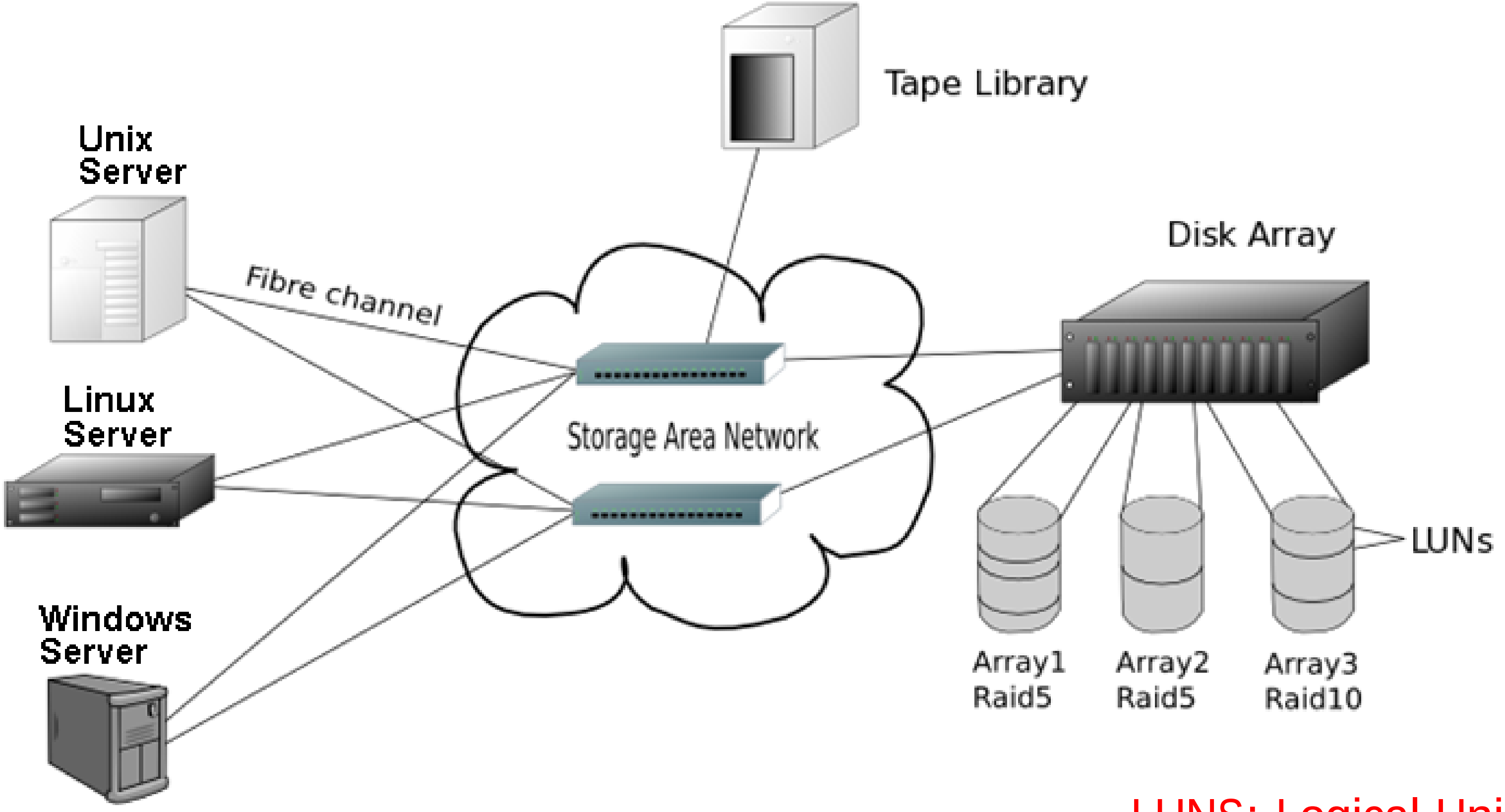
- Scalability: good
- Availability: as long as the LAN and NAS device work, generally good
- Performance: bandwidth limited by speed of LAN, traffic conflicts, inefficient protocol
- Management: easy
- Connection: homogeneous vs. heterogeneous

Storage Area Network (SAN)



Storage Area Network (SAN)

- SAN is created by using the Fibre Channel to link peripheral devices such as disk storage and tape libraries



LUNS: Logical Unit Number

Storage Services

- NAS relies on the IP infrastructure and, in particular, features such as QoS to ensure the proper file over the IP network to the NAS servers.
- SAN:
  - commonly found in data centers,
  - uses FC to connect servers to the storage device
  - transmits SCSI commands between them.
- The SAN environments need to be accessible to the NAS and the larger IP Network.

SAN compare with NAS

- Dedicated Fibre Channel network for storage
- More efficient protocol
- Higher availability
- Reduce traffic conflict
- Longer distance (up to 10 km)

Storage Services

- FC over IP (FCIP) and SCSI over IP (iSCSI) are the emerging IETF standards
  - SCSI access and connectivity over IP.
  - The transport of SCSI commands over IP enables storage-to-IP and storage-to-storage over an IP infrastructure.
- SAN remains prevalent in data center environment
- The localized SAN fabric becomes important to permit storage-to-storage block access communication at FC speeds.
- There are other features focused on enabling FC to iSCSI fan-out for both storage-to-IP and storage-to-storage interconnects.

Security Services

- Server farms suffer from external threats but also internal attacks.

- It needs to have
  - a tight security perimeter around the server farms
  - a plan to keep the security policies applied in a manner consistent with the risk and impact if the enterprise data was compromised.

- Since different portions of the enterprise's data is kept at different tiers in the architecture, it is important to consider deploying security between tiers.
  - the specific tier has its own protection mechanisms according to likely risks.

Security Services

- Utilizing a layered security architecture provides a scalable modular approach to deploying security for the multiple data center tiers.
  - The layered architecture uses the various security services and features to enhance security.

Security Services

- The goal of security services is to mitigate against threats, such as:
  - Unauthorized access
  - Denial service
  - Network reconnaissance
  - Viruses and worms
  - IP spoofing
  - Layer 2 attacks

Security Services

- The security services offered in the data center include:
  - Access control lists (ACLs)
  - Firewalls
  - Intrusion detection systems (IDS, Host IDS)
  - Authentication mechanism
  - Authorization mechanism
  - Accounting mechanisms
  - A number of other services that increase security in the data center.

ACLs

- ACLs can be applied at various points in the data center infrastructure

- ACLs prevent:
  - unwanted access to infrastructure devices
  - protect server farm services

- ACLs come in different types:
  - Router ACLs (RACLs)
  - VLAN ACLs (VACLs)
  - QoS ACLs.

- An important feature of ACLs is the ability to perform packet inspection and classification without causing performance bottlenecks.
- This lookup process is possible when done in **hardware**, in which case the ACLs operate at the speed of the media, or at wire speed.

Firewalls

- The placement of firewalls marks a clear delineation between highly secured and loosely secured network perimeters.

- The typical location for firewalls remains the Internet edge and the edge of the data center

- They are also used in multi-tier server farm environments to increase security between the different tiers.

Intrusion Detection Systems(IDS)

- IDSs proactively address security issues intruder detection and the subsequent notification are a fundamental step to highly secure data centers.
- Host IDSs enable real-time analysis and reaction to hacking attempts on applications or web servers.
- The host IDS is able to identify the attack and prevent access to server resources before any unauthorized transactions occur.

AAA

- AAA provides yet one more layer of security by
  - preventing user access unless authorized
  - ensuring controlled user access to the network and network devices by a predefined profile.
- The transactions of all authorized and authenticated users are logged for accounting purposes, for billing, or for postmortem analysis.

AAA

- Additional security considerations may include the use of the following features or templates:
  - One time passwords (OTPs)
  - SSH or IPSEC from user-to-device
  - Cisco discovery protocol (CDP) to discover neighboring Cisco devices
  - Securing virtual terminal (VTY) security
  - Default security templates for data center devices, such as
    - Routers
    - Switches
    - Firewalls
    - Content switches

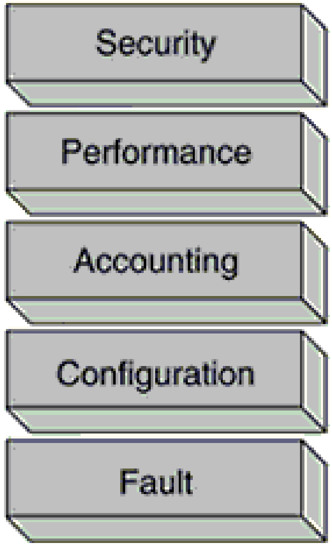
Management Services

- It include service provisioning, which depending on the specific service, requires its own set of management considerations.

- Each service is also likely supported by different organizational entities or even by distinct functional groups whose expertise is in the provisioning, monitoring, and troubleshooting of such service.

Management Services

- Managing data center services should follow a consistent and comprehensive approach.
- The **FCAPS OSI** management standard and uses its management categories to provide management functionality.
  - FCAPS is a model commonly used in defining network management functions.
- The management features focus on the following categories:
  - Fault management
  - Configuration management
  - Accounting management
  - Performance management
  - Security management



FCAPS Model