CSIT985

Strategic Network Design
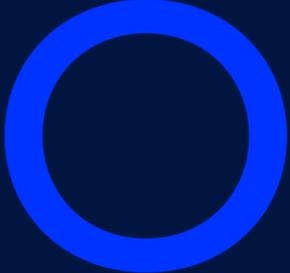
Spring 2023

UNIVERSITY
OF WOLLONGONG
AUSTRALIA

Lecture week 6:
Network Architecture

Presented by: Dr. Chau Nguyen

Lecturer, School of Computing and Information Technology, UOW

UNIVERSITY
OF WOLLONGONG
AUSTRALIA

Outline

❑ Architecture and Design

❑ Component Architectures

❑ Reference Architectures

❑ Architectural models

Architecture and Design

Requirement analysis payoff

- Objective, informed choices of network technologies and services

- Ability to match interconnection strategies to networks

- Networks and elements sized to users and applications

- Understanding of where and how to apply services in Network

- Tradeoffs made with the Big Picture in mind

- Ability to identify high and low level performance applications

A useful quote from McCabe

- '…Network architecture and design are attempts to solve nonlinear problems, and figuring out where to begin can be difficult. You cannot start at the top without some understanding of the capabilities of the individual components, and you cannot easily pick components until you understand the top-down requirements…' (*p.241*)

Another useful quote from McCabe

'…Network architecture and design development is no longer simple enough that tricks to work; it must be done in a systematic and reproducible manner. Even if the complex network architecture/design is tricked into existence, it cannot be maintained. Smart customers are beyond the stage at which they would hire a wizard to work magic…' (*p.215*)

Background

- The key to understanding where McCabe wants to take you in this chapter can be found in figure 5.8.

Process Model for Component Architecture Approach
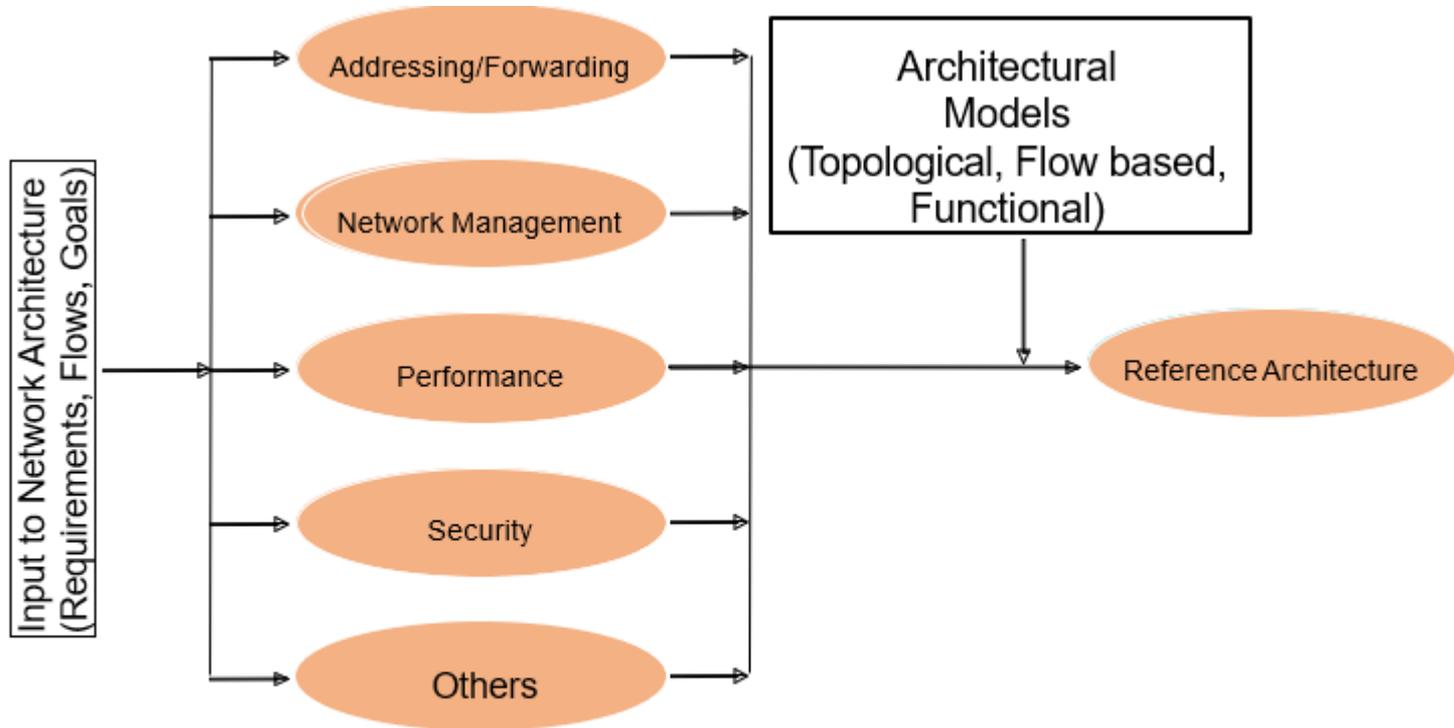
Component Architectures (Based on Network Functions)

Background

Architecture and Design

Architecture   **Design**

Broad   ←———————   Scope   ———————→   Focused

Generalised   ←———————   Level of Detail   ———————→   In Depth

Relationships ←———————   Description   ———————→   Technologies

Independent   ←———————   Location   ———————→   Dependent
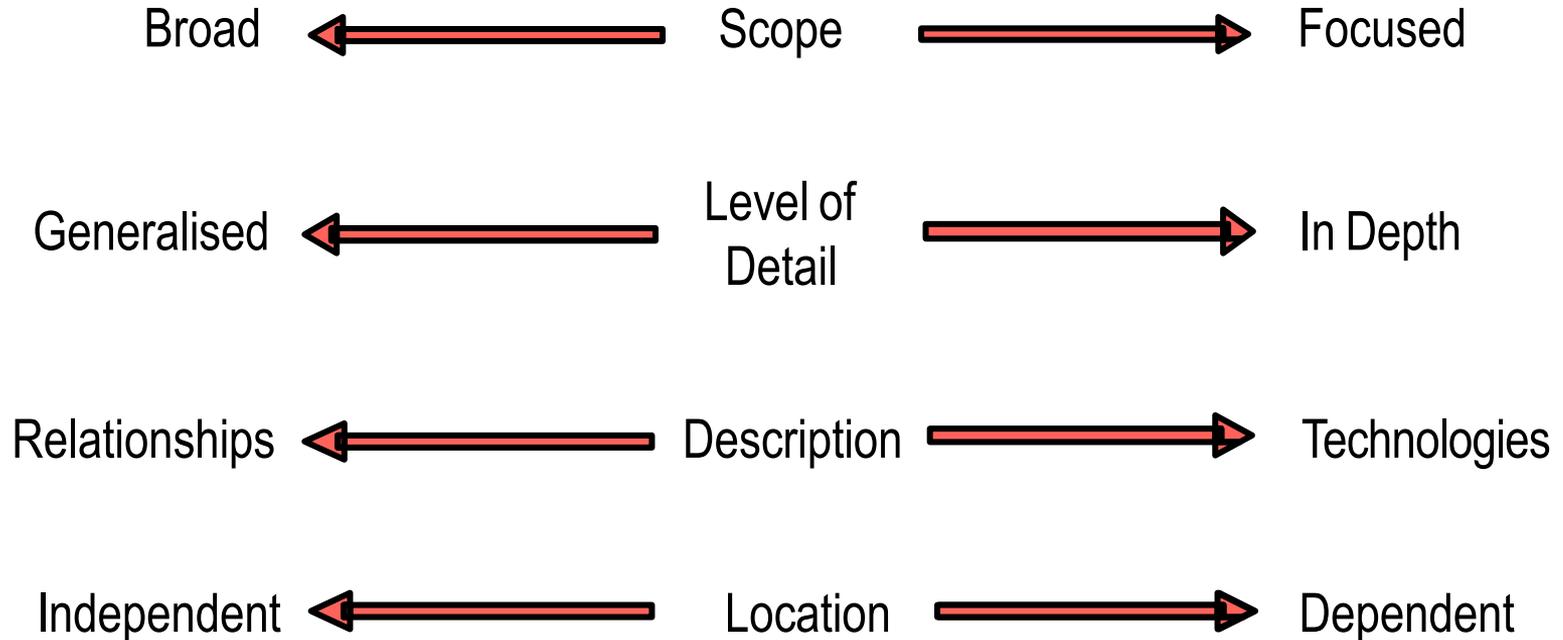
Architecture and Design

- The aim is to solve multidimensional problems based on systematic analysis
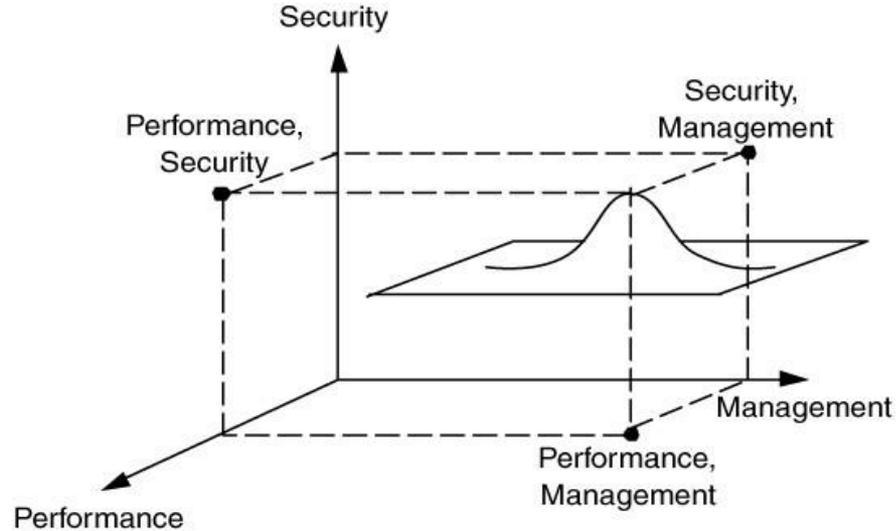
Process Model for Component Architecture Approach
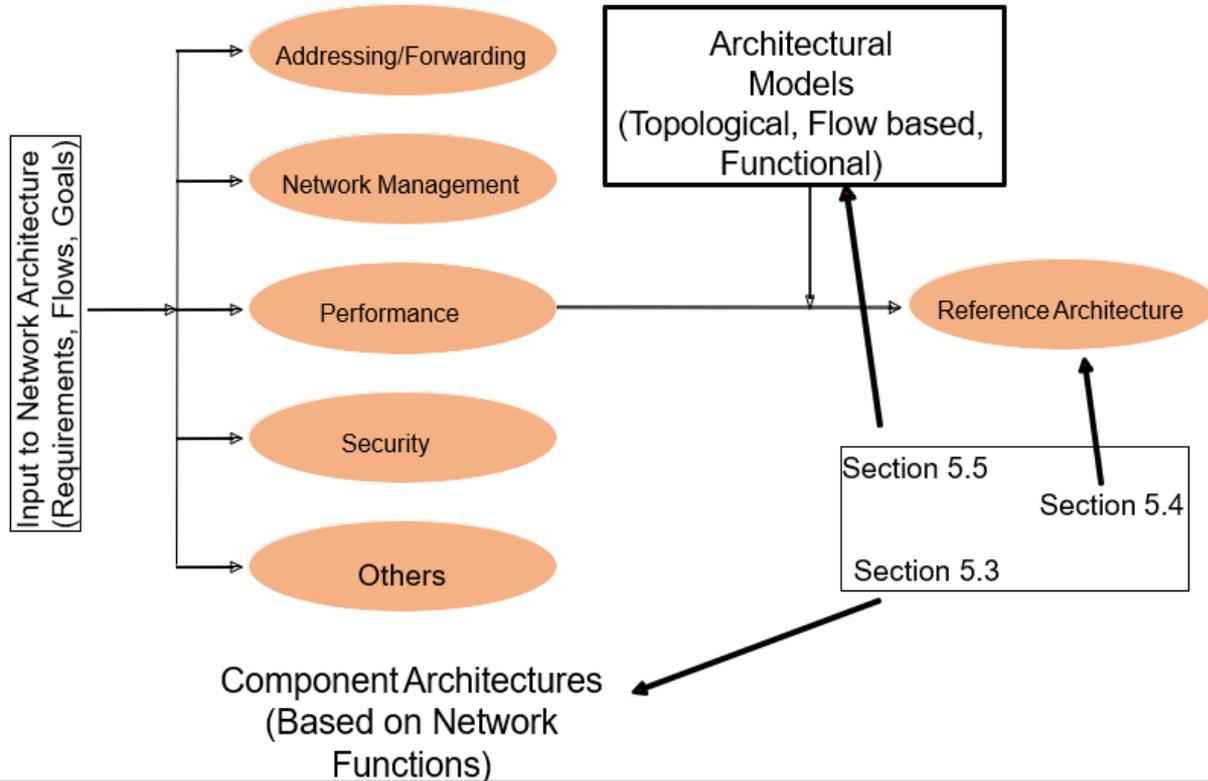
Component Architectures

Component Architectures

- Addressing and routing

- Network Management

- Performance

- Security

- Others

Component Architectures

Are made up of

- o Functions

- o Mechanisms

- o Internal relationships

Component Architectures

- Function

  o Major capability of network

- Mechanisms

  o Hardware and software that help a network achieve each capability

Component Architectures

- ## Internal Relationships

  - ### Tradeoffs and Dependencies

    - Trade-offs

      Decision points that are used to prioritise and decide which mechanisms are to be applied

    - Dependencies

      When one mechanism relies on another mechanism for its operation

    - Constraints

      Restrictions one mechanism places on another

An example of an internal trade-off

Centralized network management

is easier to implement and administer than

Distributed network management

but

is more prone to failure.

An example of internal dependencies

	QoS	SLAs	Policies
QoS		QoS at network devices may need to enforces SLAs	QoS at network devices may need to enforces policies
SLA	Can SLA be enforceable via available QoS mechanisms		Do SLAs map to network policies?
Policies	Can Polices be enforceable via available QoS mechanisms	Are policies dependent on SLAs?	

An example of an internal constraint

- An easy to administer routing protocol such as RIP is not able to cope with large hierarchical network topologies

  (RIP: Routing Information Protocol)

Optimizing Component Architectures

- We develop component architectures to support high priority flows.

- There needs to be a transparent relationship:

  requirements → flows → component architecture

- In order to please your marker you should make sure that you emphasize the link between these parts in your major report.

Component Architectures

Function	Description of capability	Example subset of mechanism
Addressing and Routing	Provides robust and flexible connectivity between devices	Addressing: ways to allocate and aggregate address space Routing: routers, routing protocols, ways to manipulate routing flows
Network Management	Provides monitoring, configuring and troubleshooting for the network	Network Management (NM) protocols, NM devices, Ways to configure NM in the network
Performance	Provides network resources to support requirements for capacity, delay and RMA	QoS, SLA, Policies
Security	Restricts unauthorised access, usage and visibility within networks to reduce the threat and effects of attacks	Firewalls Security policies and procedures Filters and Access Control lists

Component Architectures

Function	Description of capability	Example subset of mechanism
Addressing and Routing	Provides robust and flexible connectivity between devices	Addressing: ways to allocate and aggregate address space Routing: routers, routing protocols, ways to manipulate routing flows

- **Addressing and routing**
  - **Addressing** is applying identifiers to devices at various protocol layers
  - **Routing** is learning about the connectivity within and between networks and applying this connectivity information to forward IP packets toward their destinations.

Component Architectures

Function	Description of capability	Example subset of mechanism
Network Management	Provides monitoring, configuring and troubleshooting for the network	Network Management (NM) protocols, NM devices, Ways to configure NM in the network

- **Network Management**

  o Providing functions to control, plan, allocate, deploy, coordinate, and monitor network resources.

  o Including monitoring, instrumentation, configuration, FCAPS components, in-band and out-of-band management, centralized and distributed management, scaling network management traffic, checks and balances, managing network management data, MIB selection, and integration into OSS

FCAPS: Fault, configuration, accounting, performance and security
MIB: Management Information Base
OSS: Operations Support System

Component Architectures

Function	Description of capability	Example subset of mechanism
Performance	Provides network resources to support requirements for capacity, delay and RMA	QoS, SLA, Policies

- **Performance**

  o Consists of the set of mechanisms used to configure, operate, manage, provision, and account for resources in the network that allocate performance to users, applications, and devices.

  o performance component architecture describes how network resources will be allocated to user and management traffic flows.

Component Architectures

Function	Description of capability	Example subset of mechanism
Security	Restricts unauthorised access, usage and visibility within networks to reduce the threat and effects of attacks	Firewalls Security policies and procedures Filters and Access Control lists

- **Security**

  o Is a requirement to guarantee the confidentiality, integrity, and availability of user, application, device, and network information and physical resources.

  o Some security mechanisms: security threat analysis, security policies and procedures, physical security awareness, protocol and application security, encryption, network perimeter security, remote access security, etc.

Process Model for Component Architecture Approach
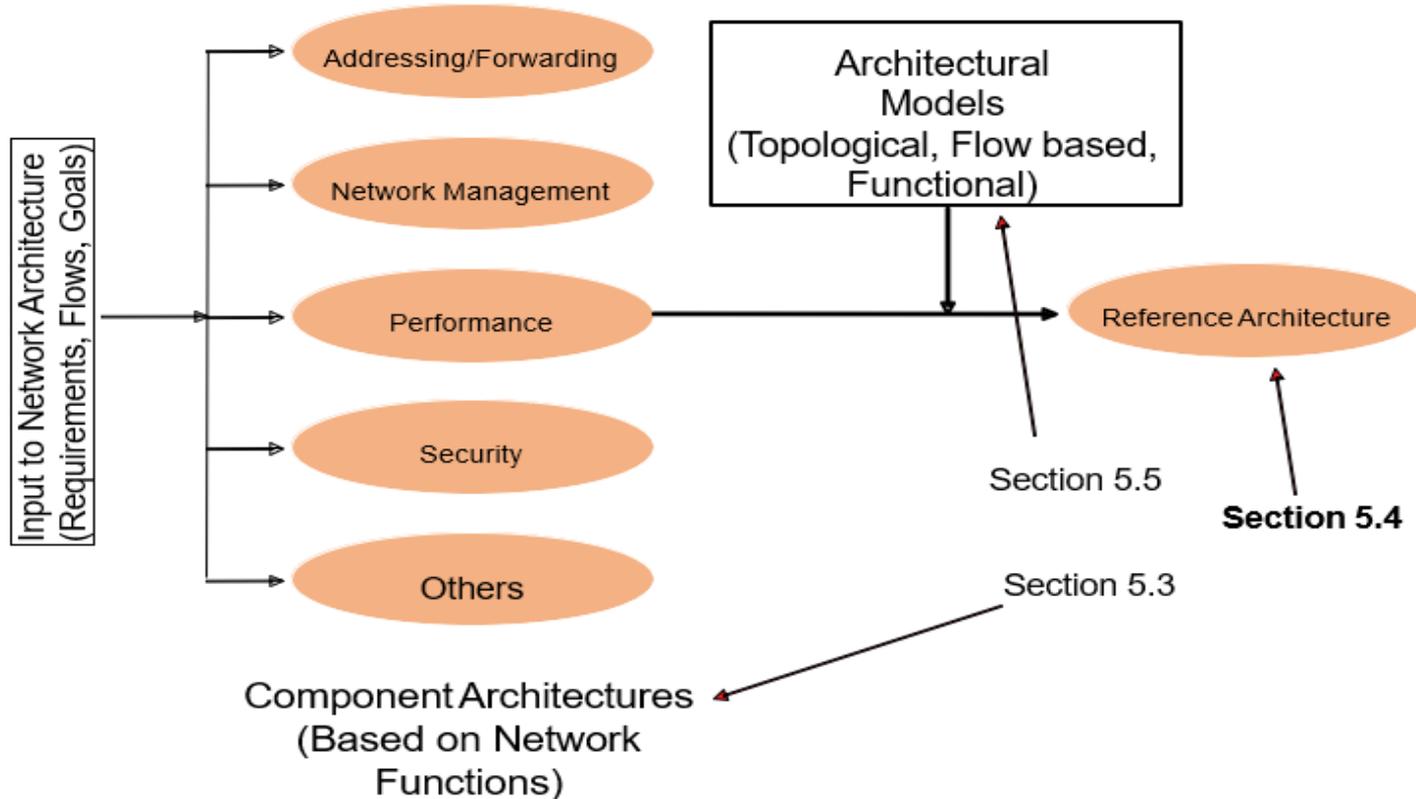
Reference Architectures

Reference Architectures

- A description of the complete network architecture

- Contains
  - All component architectures being considered
  - Compilation of all internal and external relationships

Reference Architectures

- Reference architectures combine these components and define external relationships between components

- (Remember that internal relationships are covered under each individual component architecture)

Reference Architectures

- **External Relationships**

  o Effects that architectures have on each other

- **The balance of the reference architecture will depend on**

  o Priorities given to functions in analysis stage

  o Priorities given to flows

Reference Architectures

- **Example**

  o The requirements analysis determined that low delay and low jitter were the primary goals

  o Delay performance is affected by

    • Network management

    • Security

    • Routing

  o Hence the final architectural decisions for these will need to made so that they support the primary goal

Optimizing the Reference Architecture

- **Performance and Security**

  o Inspection and control of network traffic and access

  o As security mechanisms increase

  o Performance decreases

  o Security can reduce end-end performance of an application.

Optimizing the Reference Architecture

- **Network Management and Security**

  o Network management devices need access to network devices which represents a potential security "hole".

  o Additional security required for in-band management will affect performance

Optimizing the Reference Architecture

- **Network Management and Performance**

  o In-band network management directly impacts the performance of user traffic flows.

  o A problem happens in centralized network architectures, as all management traffic flows are aggregated to a common management device.

Optimizing the Reference Architecture

- **Network Addressing/routing and Performance**

  o Performance can be closely coupled with routing.

  o When routing protocol simplicity is a high priority, performance may be decoupled from routing.

# Process Model for Component Architecture Approach
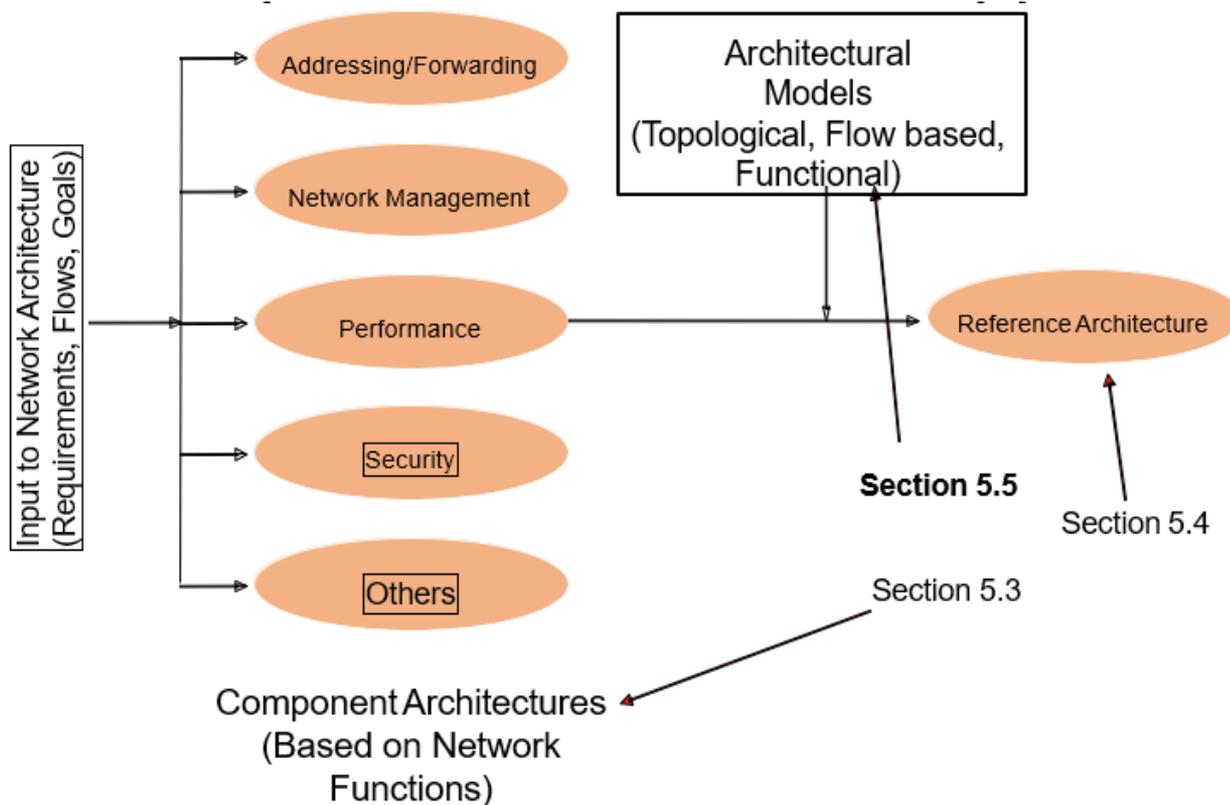
Architectural Models

Architectural Models - Topological

- McCabe suggests we begin with either of these two **topological** models.

  o LAN/MAN/WAN

    • Based on geographical size

  o Access/distribution/core

    • Based on function

Architectural Models - Topological

- LAN/MAN/WAN
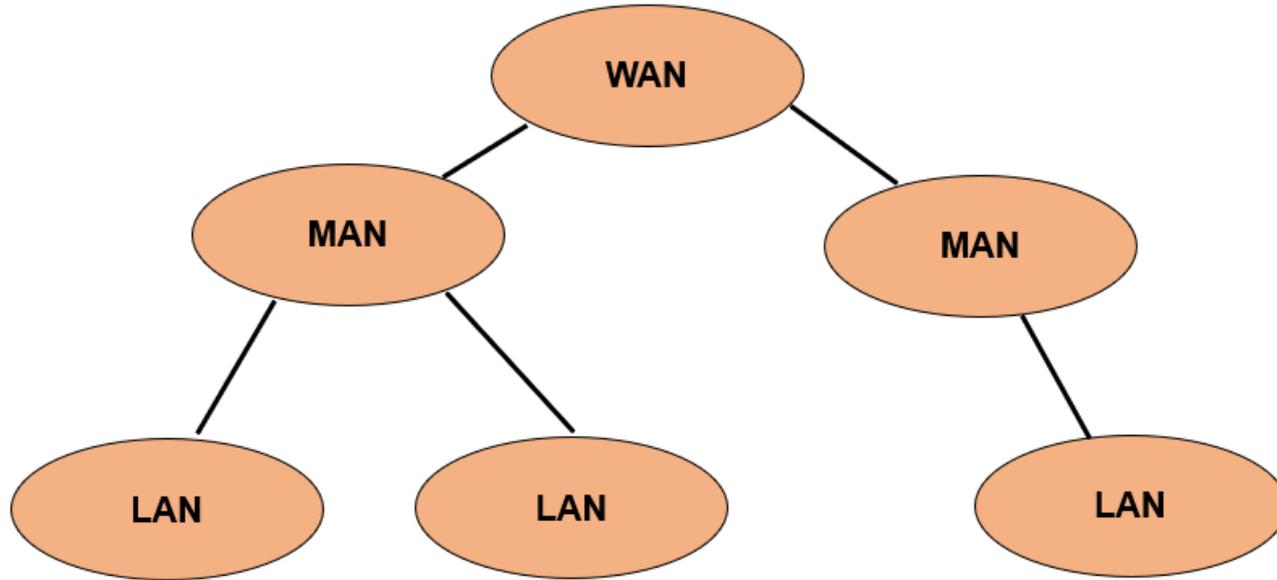
Architectural Models - Topological

- ## Access/Distribution/Core

  o Access (edge)
  - Where most traffic flows are generated and terminated

  o Distribution
  - Where most traffic flows are aggregated and terminated for common services

  o Core (backbone)
  - Provides transport for aggregates of traffic flows

  o Demilitarized zones and External interfaces
  - Aggregation points for traffic flows external to the network
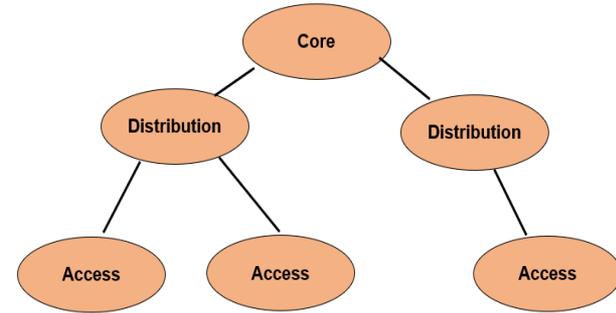
# Architectural Models – flow-based

- Flow-based models draw on requirements gathering work covered in Chapter 4
  - Peer-to-peer
  - Client-server
  - Hierarchical client-server
  - Distributed computing

Architectural Models – flow-based

Functions, features, services pushed to network edge; network focuses on bulk transport

Applications

Network

No architectural features
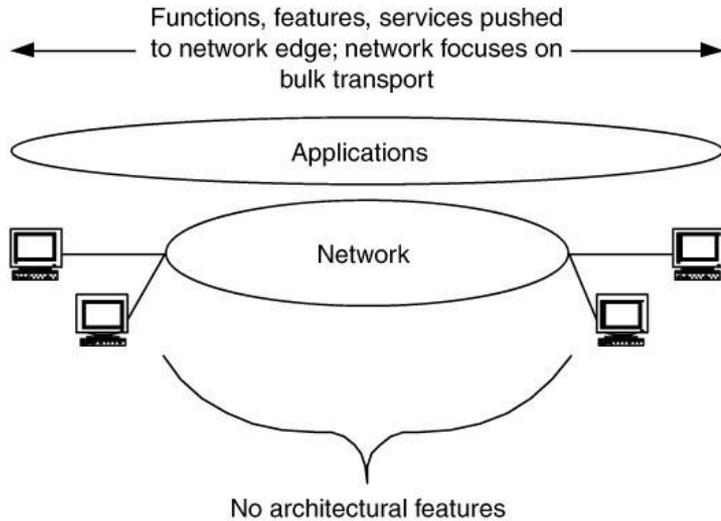
Peer-to-Peer Architectural Model

Architectural features at server interfaces, at server LAN interface, and at network between servers

Servers, Server Farm, or Server LAN

Servers, Server Farm, or Server LAN

Network

Network

Network

Clients

Clients
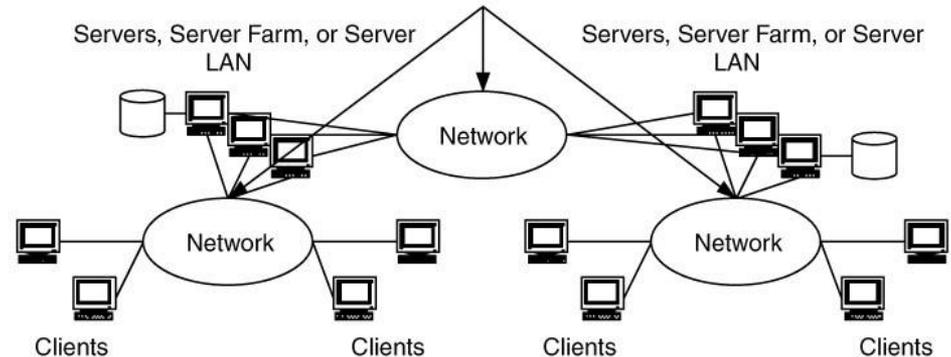
Clients

Clients

Hierarchical Client-Server Architectural Model

Architectural Models - functional

- ## Functional models

  o Service-provider architectural model is based on service provider functions

    • Privacy, security and service delivery

   • See Fig 5.16: service-provider architectural model
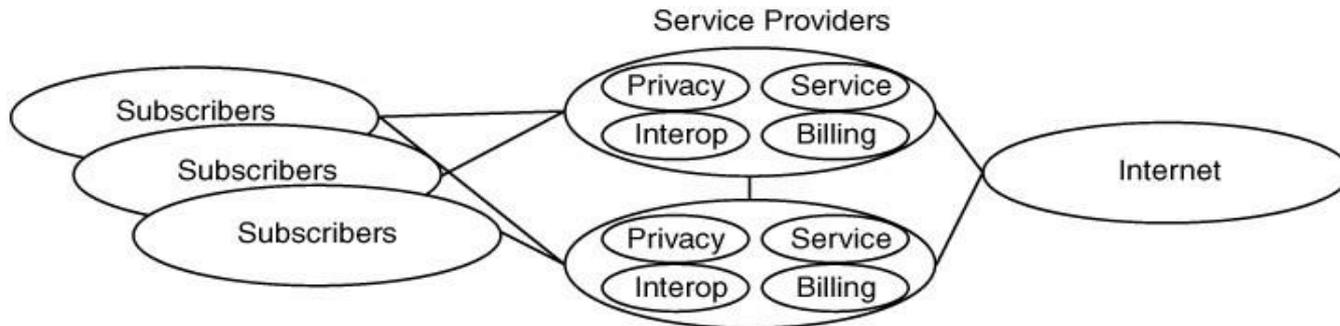
Architectural Models - functional

- ## Functional models

  - ### Intranet/extranet

    - Privacy, security, separation based on secure access

   - See Fig 5.17: Intranet/Extranet architectural model
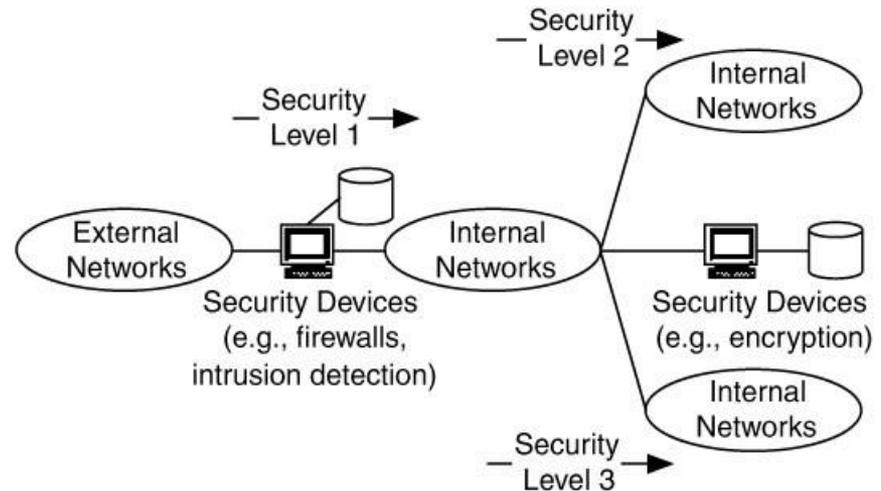
Architectural Models - functional

- Functional models

  o End-to-end – includes all the components in the path of the end-end traffic flow

    • See Fig 5.18: end-to-end architectural model
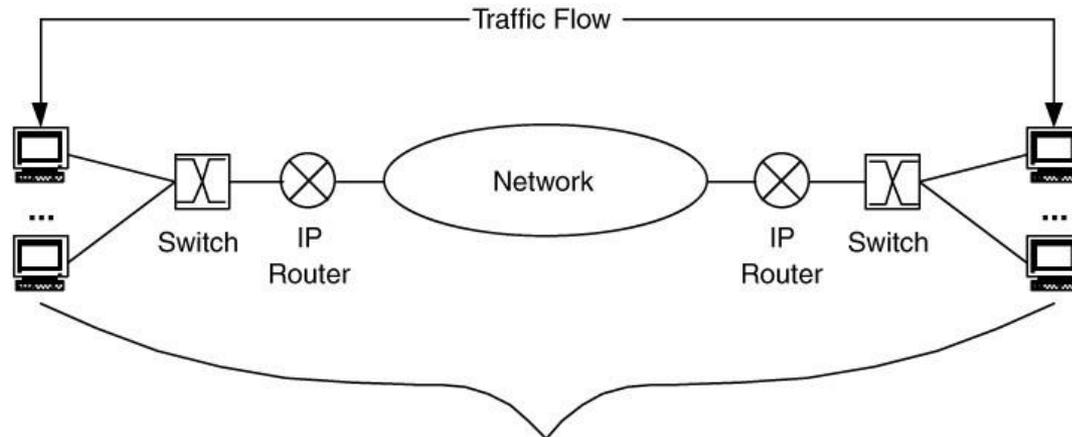
All components in the end-to-end path of the flow are considered

Recipe for Using the models

- Start with a topological model

  o Add flow-based and functional models as required

- The result of this combination is the reference architecture

- (Typically, you will need a combination of the models discussed)

References and Reading

❖ **Chapter 5 -** McCabe, J. D. (2010). *Network Analysis, Architecture, and Design*. San Diego, CA, USA: Elsevier Science.

Thank you
Q&A ?