# CSIT985
# Strategic Network Design

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UNIVERSITY
OF WOLLONGONG
AUSTRALIA

# Lecture 9:
# Network Design

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# Overview

- Design Process
- Vendor, Equipment, and service-provider evaluations
  - Developing goals
  - Developing criteria for technology evaluations
  - An architectural approach to network design
  - Network architecture design elements
  - Guidelines and constraints
  - Making technology choices for the design
- Network layout
- Design traceability
- Design metrics

# Design Process

# Concepts

- What is network design?
  - Network design is the culmination of two processes

# Design Process

- Consisting of
  - Evaluations of vendors, equipment, service-providers
    - Are built on the technology and equipment type/class selections obtained from the architecture process
  - Network layout
    - Combines topology, technology, equipment types, relationships, and strategic locations
    - The last part of the network design

# Design Products

- Network blueprints
- A component plan
- Vendor, vendor equipment, and service-provider selections
- Traceability
- Metrics for measuring design success

# Design Products

- Network blueprints
  - Providing physical specification: locations of network devices, how the devices connected, physical security and secure locations, etc.
  - May consist of one or multiple diagrams.

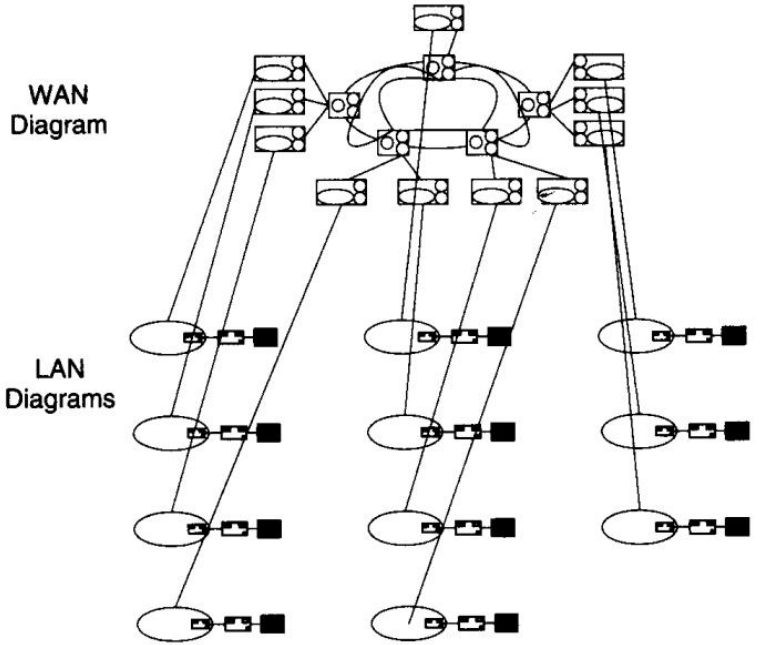



**FIGURE 10.3** Diagrams Focus on Geographical Areas of a Network



(McCabe, 2010, p.391)

# Design Products

- A component plan
  - Each function can have a component plan if your network design is described as overlays of multiple functions.
  - Describing the mechanisms, internal interactions among mechanisms and external interactions among functions.

# Design Products

- Logical Function of a Network

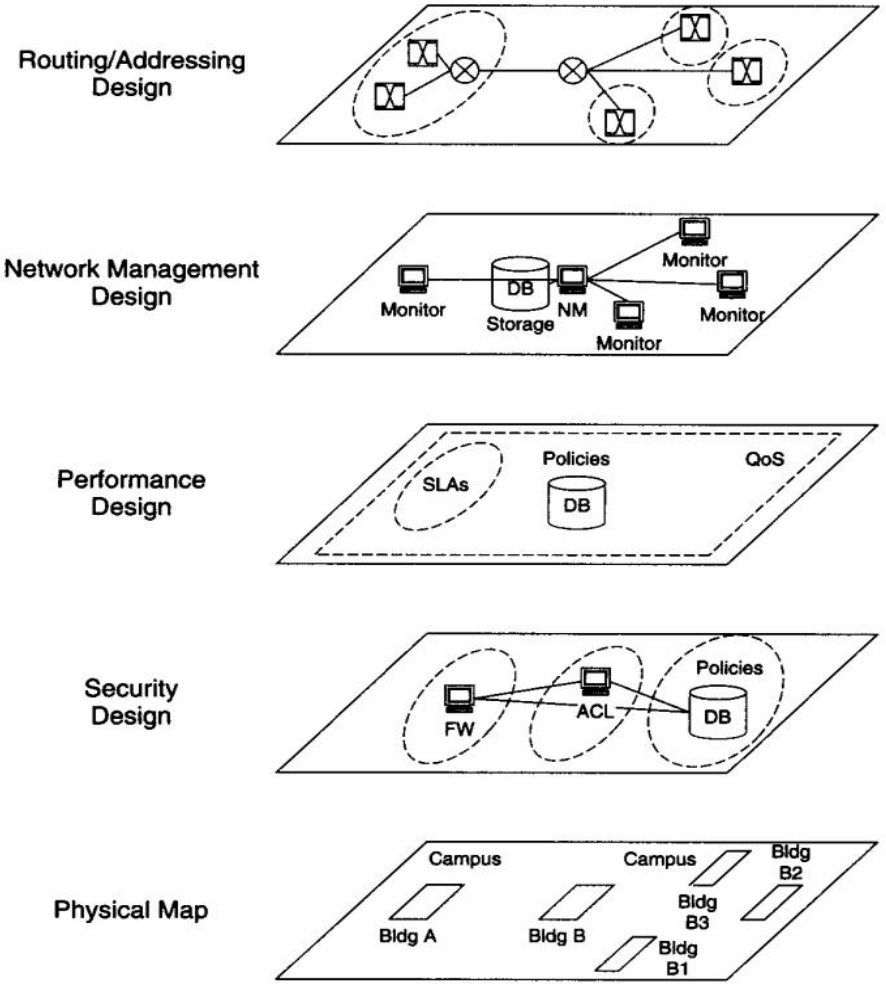



**FIGURE 10.4** Diagrams Focus on Logical Functions of Network



(McCabe, 2010, p.392)

# Vendor, Equipment and Service-Provider Evaluations

# Evaluation Process

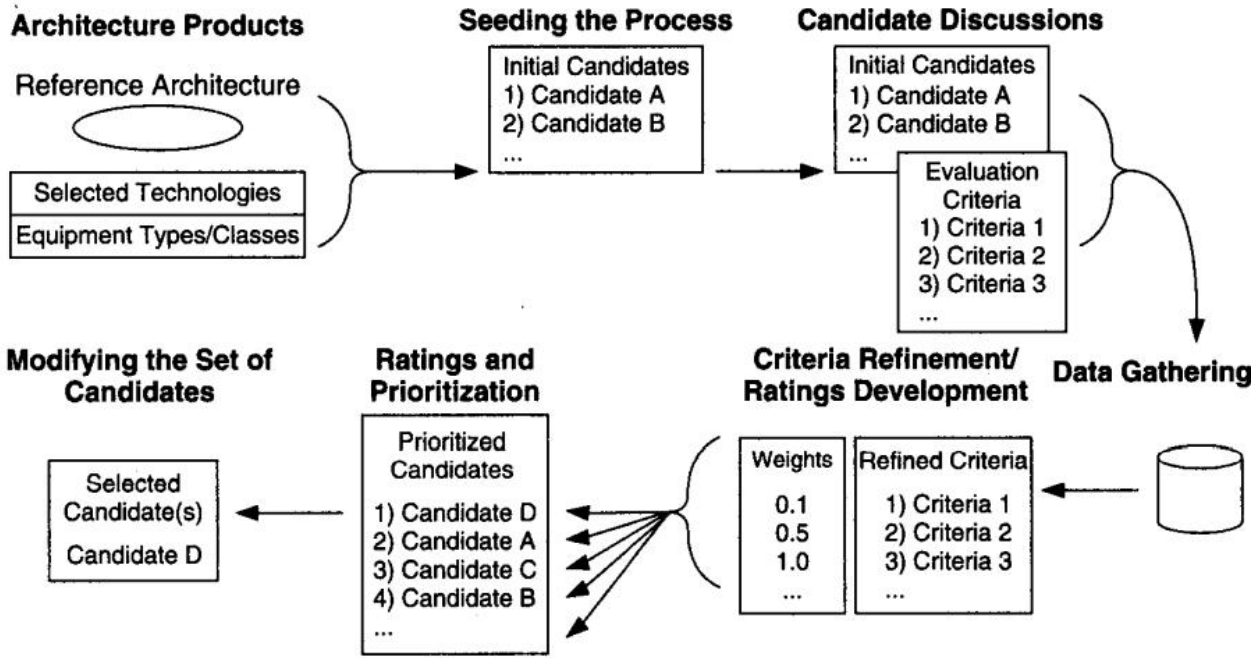



**FIGURE 10.6** Vendor, Equipment, and Service-Provider Evaluation Process



(McCabe, 2010, p.396)

# Evaluation

- The goal here is to choose the best candidates (service-providers, equipment-providers) to carry out the task.
- Defining what is “best” once again is more than just being able to fit the technical criteria – other factors such as price, reputation, backup resources are all important.

# Evaluation – Seeding Process

- Seeding the process – this means getting the process started
  - Collect and organize documentation
  - Determine the “rules” under which the evaluation will take place.

# Evaluation – Candidate Discussions

- Candidates will have questions and so will you.
- Informal channels of communication are beneficial
- However, if the process must be transparent (e.g. a government tender), informal communication needs to be monitored as it undermines transparency.
- Transparency protects against corrupt behaviour.

# Evaluation – Data Gathering

- Once again this depends on how formal you must be.
- Discussion and exchanges of documents lead to refinement of plans.
- If an official government tender these discussions are limited by what is permissible.
- For example, it is illegal to give one tendered an advantage over others by supplying restricted information.

# Evaluation – Rating Development

- An objective method is required to enable comparison between contending project proposals. E.g.

① Costs
② Technology
③ Performance
④ Risks
⑤ Scalability

} Weightings?

# Evaluation – Rating Development

- An objective method is required to enable comparison between contending project proposals. E.g.

| Criteria | Weightings |
|---|---|
| ① Costs | 20% |
| ① Technology | 30% |
| ① Performance | 30% |
| ① Risks | 10% |
| ① Scalability | 10% |

# Evaluation – Prioritization

- If done effectively, ratings should enable contending proposals to be compared and prioritized.
- Ratings and prioritization should be done independently from service providers and vendors.

# Evaluation – Prioritization

| | Evaluation Criteria | Relative Weight (0–1) | Candidates | | | | |
|---|---|---|---|---|---|---|---|
| | | | Candidate 1 | Candidate 2 | Candidate 3 | Candidate 4 | Candidate 5 |
| 1 | Initial Costs | 0.8 | 3/2.4 | 5/4 | 4/3.2 | 2/1.6 | 1/0.8 |
| 2 | Recurring Costs | 1.0 | 4/4 | 5/5 | 3/3 | 1/1 | 2/2 |
| 3 | Technologies | 0.5 | 3/1.5 | 4/2.0 | 1/0.5 | 2/1.0 | 5/2.5 |
| 4 | Standards Compliance | 0.2 | 4/0.8 | 1/0.2 | 3/0.6 | 2/0.4 | 5/1.0 |
| 5 | Risks | 0.9 | 3/2.7 | 4/3.6 | 1/0.9 | 5/4.5 | 2/1.8 |
| 6 | Performance | 0.8 | 4/3.2 | 5/4.0 | 2/1.6 | 1/0.8 | 3/2.4 |
| 7 | Available Services | 0.2 | 5/1.0 | 1/0.2 | 3/0.6 | 2/0.4 | 4/0.8 |
| 8 | Operations | 0.5 | 3/1.5 | 5/2.5 | 4/2.0 | 2/1.0 | 1/0.5 |
| 9 | Scalability | 0.1 | 5/0.5 | 1/0.1 | 3/0.3 | 2/0.2 | 4/0.4 |
| | **Candidate Totals** | | 34/17.6 | 31/21.6 | 24/12.7 | 19/10.9 | 27/12.2 |

**FIGURE 10.10** A Set of Ratings for Candidates



(McCabe, 2010, p.405)

# Evaluation – Modifying the Set of Candidates

| Rank | Candidate | Deltas | |
|---|---|---|---|
| | | Relative | Total |
| 1 | Candidate 2 | 0 | 0 |
| 2 | Candidate 1 | –4 | –4 |
| 3 | Candidate 3 | –4.9 | –8.9 |
| 4 | Candidate 5 | –0.5 | –9.4 |
| 5 | Candidate 4 | –1.3 | –10.7 |

**FIGURE 10.11** Rankings of the Candidates after Evaluation



(McCabe, 2010, p.406)

# Developing Goals

Common design goals include the optimization of

- Deployment and operation costs
- Security
  - Maximizing security across network
  - Mapping security to a particular groups needs
  - Providing multiple security models

# Developing Goals

- One or more performance characteristics
- Ease of use and manageability
- Adaptability to new and changing user, application and device needs
- Supportability

# Developing Goals

- As always there are trade-offs
  - Increased security for cost
  - Minimized costs for lower performance
- Initial conditions can indicate design goals
  - New networks are free of requirements and constraints of existing networks
  - Upgrades must consider constraints and requirements of existing network
  - Scope of project may require building a high-performance backbone

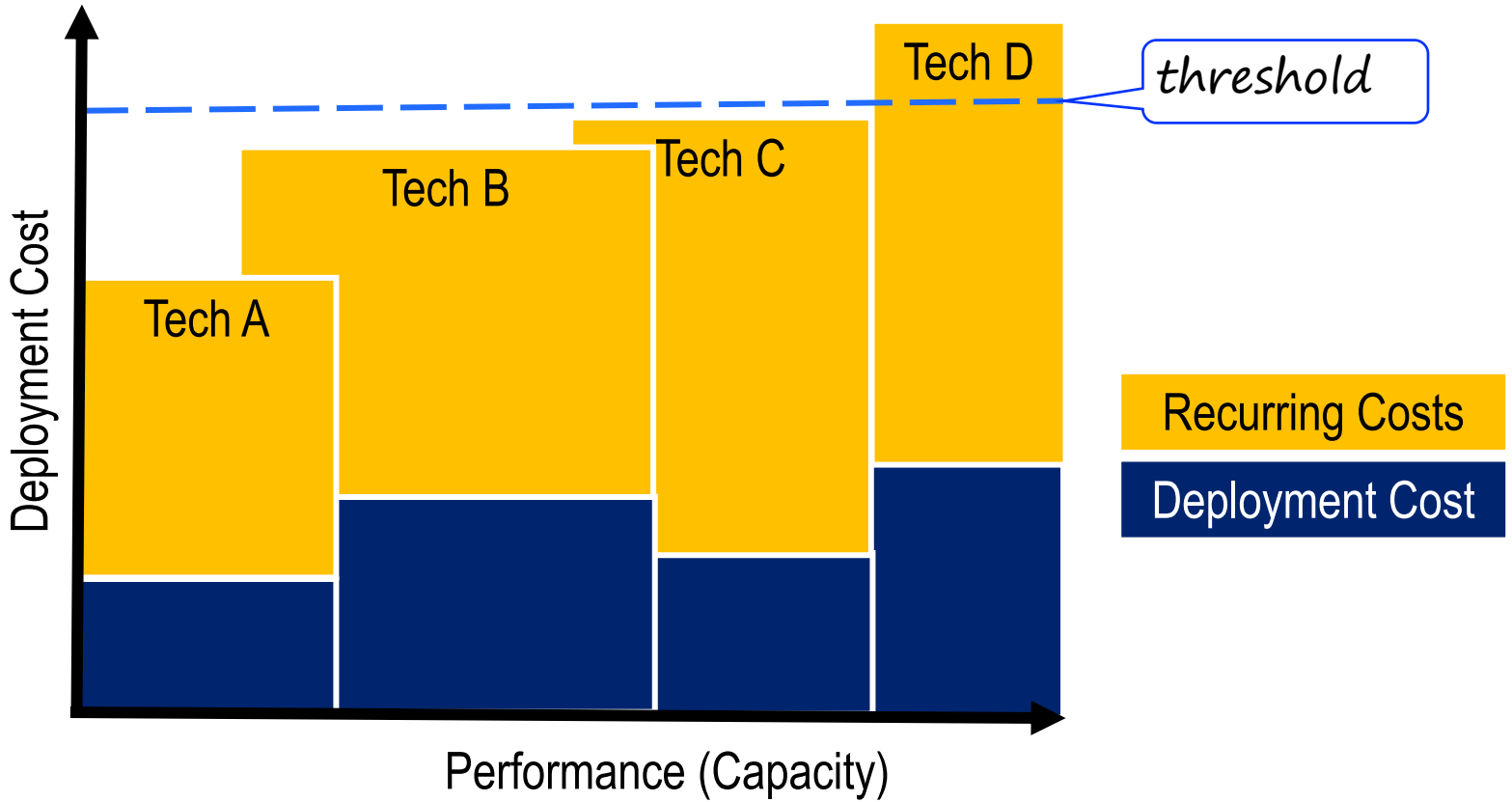
# Developing Goals

- Requirements and flow analyses can indicate goals
  - Guaranteed or predictable performance indicate high-performance solutions
  - Composite flows indicate traffic consolidation
  - Flow specs will indicate service and capacity planning needs
- Design goals can CHANGE in priority for different parts of the network

# Developing Goals

- Users may want **everything**!
  - Arbitrarily choose one or more goals
  - Attempt to show trade-offs between goals
  - Get users to prioritize goals

# Trade-offs: Cost vs Performance



# Developing Goals

- Results
  - A set of prioritized goals
  - Based upon a primary goal and one or more secondary goals
  - Primary goal will override other goals when making trade-offs
  - Choices of primary and secondary goals will drive our evaluation

# Developing Criteria for Technology Evaluation

# Developing Criteria for Technology Evaluation

- Design goals can often be used directly as evaluation criteria
  - Minimizing deployment and operation costs whilst maximizing ease of use leads to choosing technologies that are relatively simple to deploy, use and maintain

# Developing Criteria for Technology Evaluation

- Maximizing performance leads to
  - Choosing technologies that meet or exceed expected capacity, delay and/or RMA requirements
  - Maximizing RMA will indicate that higher levels of redundancy is required
  - Technologies that maximize performance will normally be more complex

# Developing Criteria for Technology Evaluation

- Primary design goals that mandate adaptability imply
  - Network needs to be dynamic
  - Technology choices will need to support dynamic behaviour
    - Rapid reconfiguration of users, groups, address assignments etc.

# Developing Criteria for Technology Evaluation

- Architectures provide inputs to design goals
  - Technologies are evaluated against the reference architecture
- Flow spec leads to capacity and service planning

# Design Criteria

- Design criteria are the explicit goals that a project must achieve in order to be successful
  - In recommendation and feasibility reports the design and decision criteria determine the document's final recommendation for action
  - Managers use these criteria as their basic tool in evaluating a project's potential for success and how well it fits into the goals of the organization
  - Experts need explicit design and decision criteria in order to evaluate recommended designs of devices and test procedures.

# Design Criteria

- Primary criteria are those that constitute a successful project
  - The project will be unsuccessful if it does not meet these goals
- Secondary criteria are those features that are highly desirable but not absolutely essential

# Design Criteria

- Separating primary and secondary criteria establishes a clear hierarchy in design choices
  - Implementing one criterion makes the implementation of another infeasible or costly
  - A secondary criterion may be sacrificed in favour of a primary criterion.

# Design Criteria

- Make your design criteria short but as specific as possible
  - Avoid vague language
  - List your primary criteria first
  - Then list the secondary criteria
- Design criteria are often best displayed in bulleted lists
  - Short titles preceding the explanation
  - These titles may then be used later in the document to refer to the specific criteria being discussed

# Design Criteria

- If you number your criteria
  - Avoid referring to them later solely by number
  - This practice often confuses readers
- Use tables to show and summarize the relative effectiveness of different implementations in comparison with your design criteria

# An Architectural Approach to Network Design

# An Architectural Approach to Network Design

- Should not be confused with a detail design of the network
- Architectural design is a term that defines
  - Technologies
  - Protocols
  - Communication capabilities
  - Generic products
  - Interconnection of segments of a network

# An Architectural Approach to Network Design

- Architectural design
  - Supports the network concepts developed
  - Expands on the conceptual design
    - Where organization-wide strategic directions are set and defined
    - These are used as a way to identify the network design criteria
      - ✓ criteria that are in line with the organizations direction and technology evolution

# An Architectural Approach to Network Design – Major Considerations

- Development of
  - The conceptual design
- Linked with detailed research on
  - The business characteristics and process of the organization
  - The competition the business is facing
    - Particularly electronically
  - What new customer interaction channels are required

# An Architectural Approach to Network Design – Major Considerations

- General technology trends
  - Technology choices
  - Lifespan of all technologies that might be utilized in the architecture
- User types
  - Current and planned
  - Need to be defined

# An Architectural Approach to Network Design – Major Considerations

- Security requirements in the form of an enterprise security policy developed
- Current, planned and the potential geographic reach of the network which
  - Including locations, users and customer/partner organizations
- Definition and identification of applications that run over the converged network

# An Architectural Approach to Network Design – Major Considerations

- Analysis of
  - Current capacity of the network
  - Future requirements
- Based on
  - Services
  - Reach
  - Applications
  - Users

# An Architectural Approach to Network Design – Major Considerations

- These will provide
  - A streamlined design process
  - Alignment of the network capability with current and future business requirements

# Outcomes of an Architectural Design

- The architectural design will produce a number of outcomes
  - Design directions
  - Architecture outline/overview diagrams for the network segments detailing technology and features/functions.
- The architectural design will
  - Outline high level network topology
  - Detail interconnections of the network segments
  - Identify the protocols that will be used

# Network Architectural Design – Elements

# Network Architectural Design – Elements

- Design elements fall into two categories
  - Concept elements
    - Architecture concepts (characteristics)
  - Technology elements

# Concept Elements

- Business environment
  - Business developments and direction
  - New competitors and competitor channels
  - Current and emerging customer interaction channels
- Technology
  - Available protocol choices
  - Available/suitable generic product choices (groups)
  - Complementary technologies
  - Business applications

# Concept Elements

- Scalability
  - Scalability defined at network segment(s) level
  - Scalability rules and limits
- Dependability
  - Availability requirements
  - Recoverability parameters/requirements
  - Survivability requirements
  - Fault tolerance requirements

# Concept Elements

- Security
  - Security requirements (rules and limits set at each network segment level)
  - Security requirements for user types
- Management and maintainability
  - Management system requirements
  - Maintainability functions, restore requirements

# Concept Elements

- Compatibility
  - Compatibility requirements
  - Compatibility rules between segments
  - Legacy equipment, systems and protocols
- Limitations
  - Limits for size of network
  - Limits for volume
  - Traffic types and traffic mix

# Concept Elements

- Flexibility
  - Future reach
  - User demographics and potential changes
  - Services deployment intent
- Distribution and geography
  - Geographic boundaries of the network (e.g. distance, location)
  - Traffic distribution rules (based on geography)

# Concept Elements

- Optimization and financials
  - Cost ranges for network, operational and capital
  - Service dependability versus cost ranges
- Risks
  - Business environment risk
  - Technology risks (early, lifecycle)
  - Costs (equipment, installation, operational)

# Concept Elements

- Performance
  - Objectives for delay/latency
  - Network throughputs
  - Potential and identified impairments
- Simplicity
  - Protocol type reduction
  - Configuration parameter reduction

# Network Components

- Nodes
  - Node types
  - Assignment/identification of generic products for node types
- Links
  - Network link types
  - Assignment/identification of generic products for link types

# Network Components

- Topology
  - Node distribution, interconnection
  - Network topology for control and management, interconnections
- Interfaces
  - Applications and users
  - Other networks
  - Interface technology types
  - Protocols

# Network Components

- Services
  - Communication services types (focus on latency sensitive)
  - Security services
  - Management services
  - Mapping/overlaying services to network topology

# Network Components

- Protocols
  - Protocols for transport
  - Protocols for nodes
  - Protocols for interfaces
- Traffic mapping
  - Segmentation
  - QoS dependencies
  - Bandwidth/volumes

# Guidelines and Constraints

# Guidelines and Constraints: Predictable and/or Guaranteed Requirements

- Restricts selection of candidate technology to those that support predictable and/or guaranteed requirements
- Need to reduce variability in RMA, capacity and delay

# Guidelines and Constraints: Predictable and/or Guaranteed Requirements

- Mechanisms to consider come from the performance architecture
  - QoS levels
  - Committed information rate levels
  - Integrated Services (IntServ) and Differentiated Services (DiffServ) in IP
  - Proprietary methods

IntServ and DiffServ are two principle approaches to applying QoS mechanisms

# Guidelines and Constraints: Predictable and/or Guaranteed Requirements

- Candidate technologies must be capable of
  - ① Determining state of network resources and available levels of performance
  - ② Allocating and controlling network resources
  - ③ Providing mechanisms to arbitrate and priorities
  - ④ Providing mechanisms to account and bill for services
  - ⑤ Over demand

# Guidelines and Constraints: Predictable and/or Guaranteed Requirements

- Resources to be configured include
  - Buffer allocations
  - Input/output capacities
  - CPU usage

# Guidelines and Constraints: Multi-part Flow-specs

- Selection may be based on capacity planning for each flow
- Candidate technologies can be evaluated on scalability of each technology to capacity and growth expectations

# Guidelines and Constraints: Multi-part Flow-specs

- If flow contains only best-effort
  - Combined capacity should be about 60% of capacity boundary
- If flow contains predictable capacities
  - Predictable capacity approx 80%
  - or Combined best-effort to be 60%
  - Whichever is greater

# Guidelines and Constraints: Multi-part Flow-specs

- These guidelines should be moderated with experience and knowledge of the particular network
- E.g. burstiness

# Guidelines and Constraints: Constraints

- Three major constraints:
  ① Costs of each candidate technology
  ② Pre-existing networks
  ③ Implications on facilities

# Making Technology Choices

- In making technology choice, it is often useful to first segment the network into workable sizes
- Then we will use a black box method to isolate each area
- Finally apply evaluation criteria and design guidelines to each area

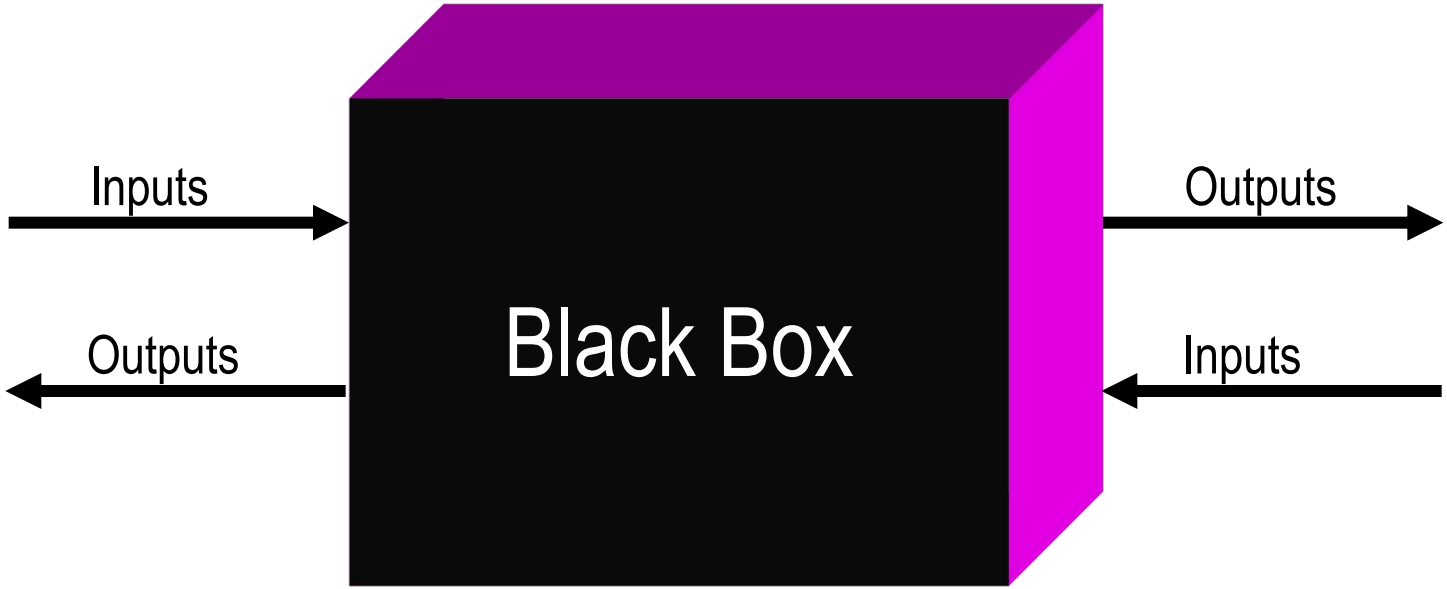
# Segmenting the Network

- Segmentation could be based upon
  - Geography
    - Countries, states, cities
    - Buildings, floors
  - Concentrations of users
    - Numbers of users
    - Groups they belong to

# Segmenting the Network

- Flow hierarchy
- Functions and features
  - Five types of areas
    - ✓WANs
    - ✓Network Access Points (NAPs)
    - ✓Core/backbone
    - ✓Specialized areas
    - ✓General areas

# Isolating Areas: Black Box Method



# Isolating Areas: Black Box Method

- This method can be applied in two ways:
  ① Using a black box to cover the area under review
  ② Using a black box to cover everything else
- Inputs and outputs to the black box equate to flows and flow information

# Isolating Areas: Black Box Method

- Method one:
  - Black box is applied to an area
  - Technologies evaluated and chosen for that area
  - Black box then moved to a new area
- Method two:
  - Black boxes are applied to one or more areas NOT under review
  - Allows visibility into the area under review

# Isolating Areas: Black Box Method

- Black box method can be used at any level in the network design
  - Hide existing network
  - Hide geographical or topological features
  - Used at edges

# Network Layout

# Network Layout

- Taking into accounts:
  - Topology and technology choices
  - Architecture and design decisions
  - Vendor, equipment, and service-provider choices
  - Strategic locations
- Developing various views of the planned network design
  - Logical diagrams
  - Physical blueprints
  - Function-specific component plans

# Network Layout – Logical Diagram

- Logical Diagrams show connectivity and relationships.
- Relationships refer to the way devices interact to provide a service, support the network and so on.
- Diagrams that focus on logical relationships do so at the expense of accuracy in physical diagrams

# Network Layout – Logical Diagram

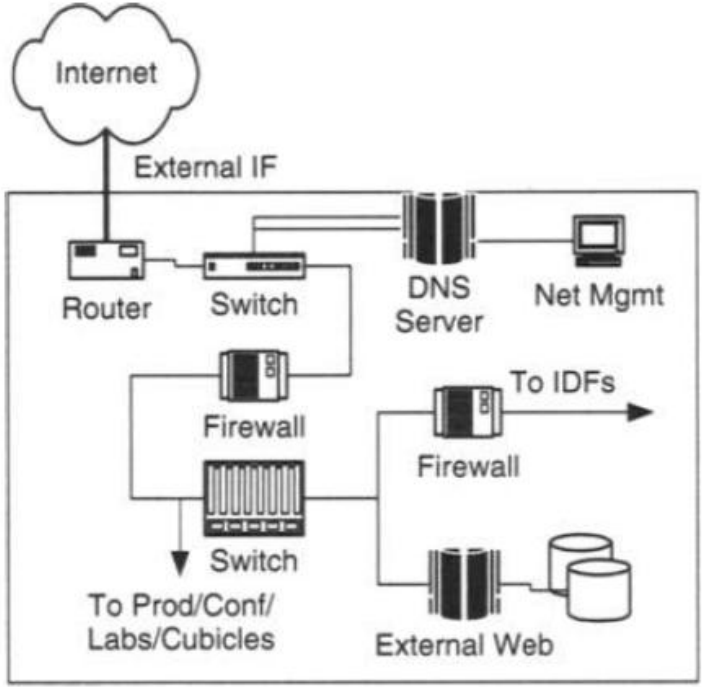


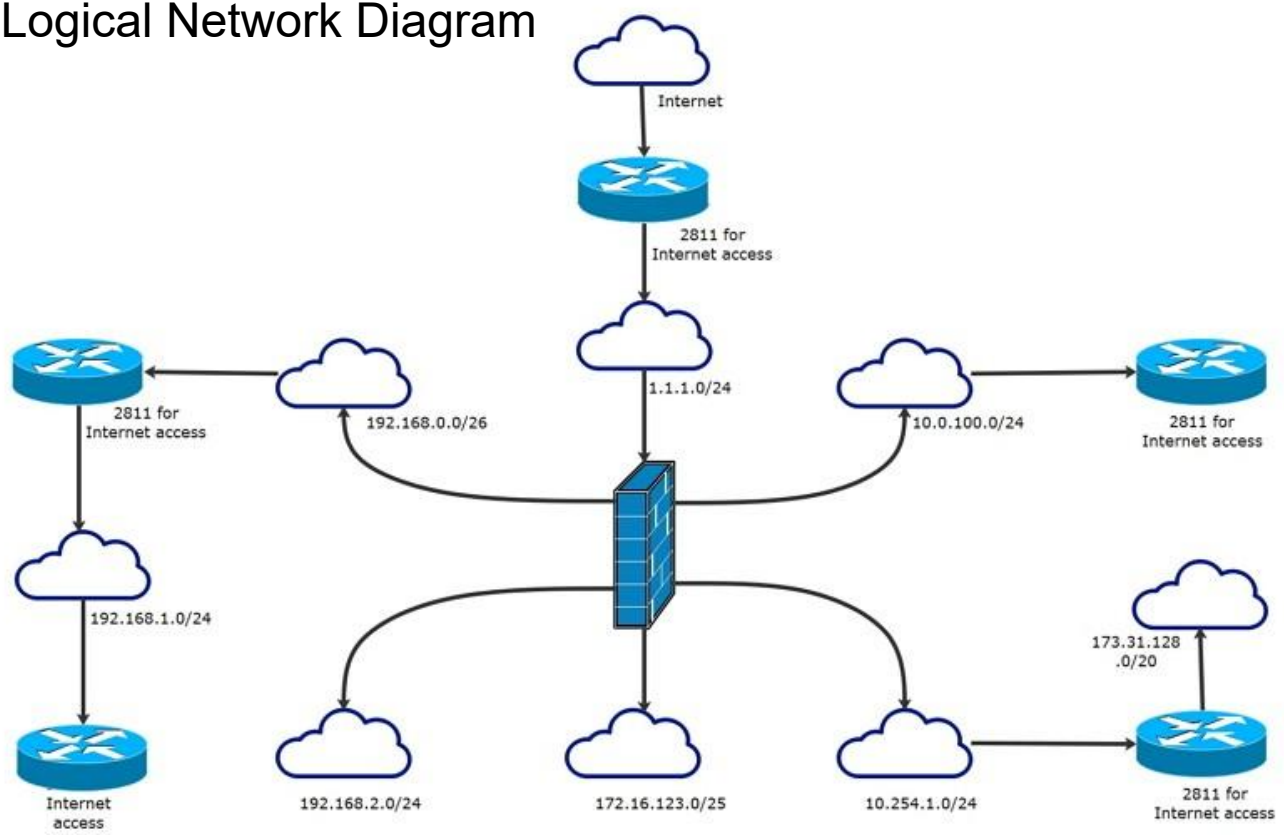

**FIGURE 10.12** A Logical Diagram of a Communications Closet



(McCabe, 2010, p.409)

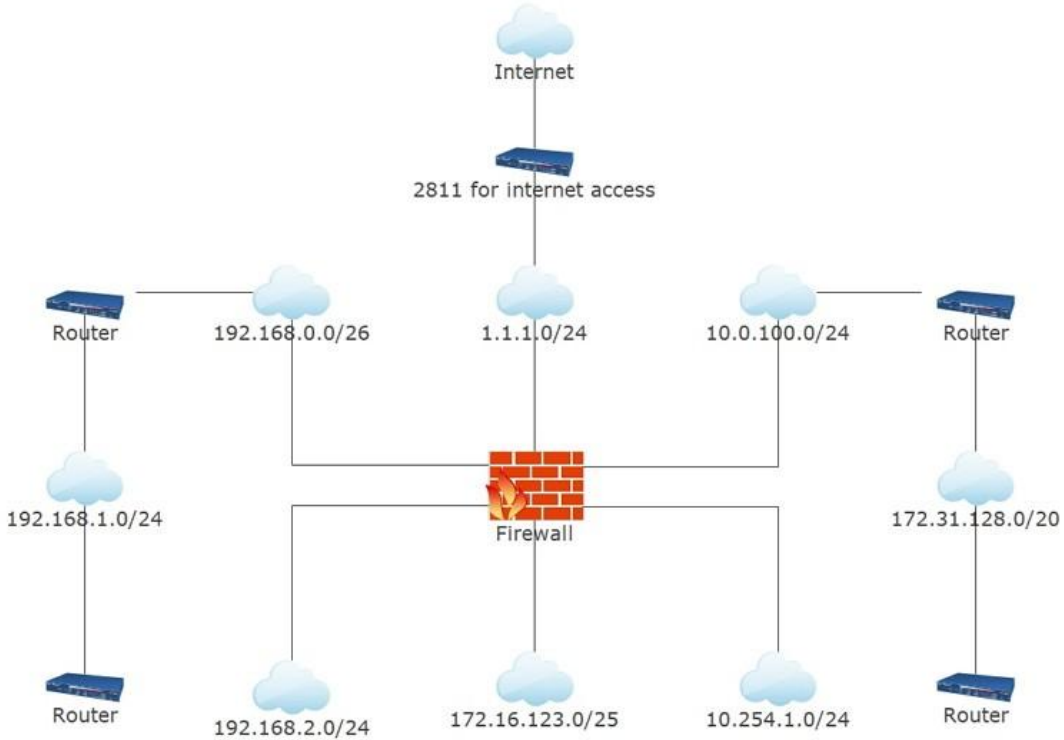
# Network Layout – Logical Diagram

- An example of Logical Network Diagram



# Network Layout – Logical Diagram

- An example of Firewall Logical Network Diagram



# Network Layout – Network Blueprints

- Network blueprints describe detailed physical aspects of the design: network devices, servers, cables, physical security.
- Network blueprints emphasize physical descriptions over logical relationships
- For example, location information such as office size etc. will be to scale

# Network Layout – Mapping Strategic Locations

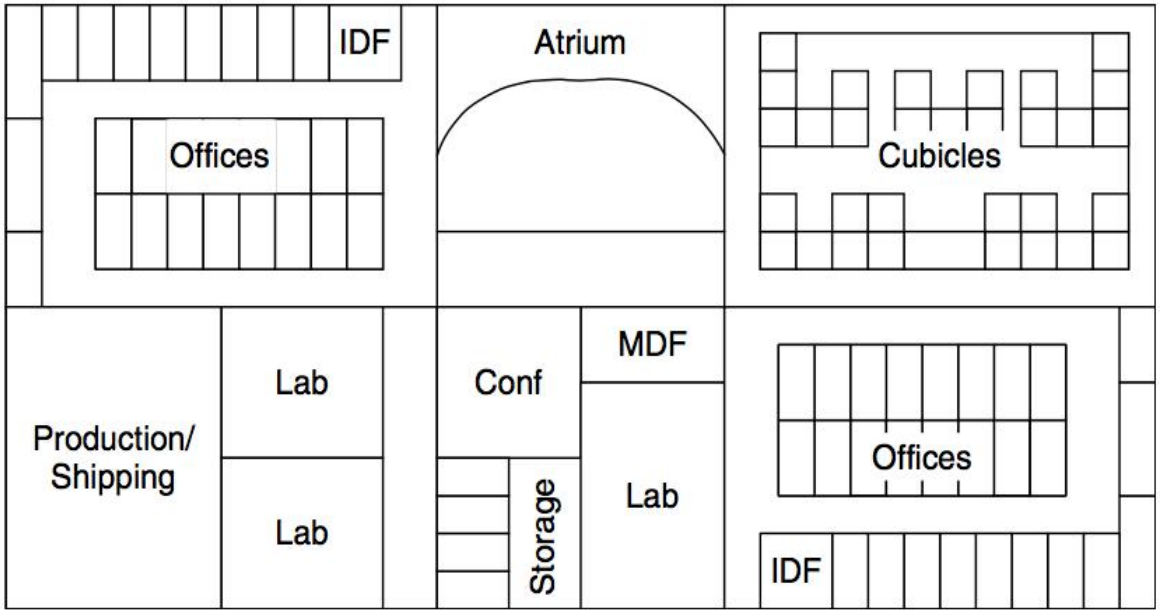



**FIGURE 10.14** An Example of a Physical Diagram for a Small Enterprise



(McCabe, 2010, p.411)

# Network Layout

- Some examples of possible strategic locations based on network function are places where:
  - Boundary points occur between security cells/zones.
  - Major components of monitoring and management are located.
  - Multiple performance mechanisms, such as QoS and policies, are needed.
  - Different classes or routers or switches interface. This indicates an aggregation of routes, networks, and/or traffic flows.
  - Multiple network functions (e.g., security, network management, performance, routing) coexist.

# Network Layout

- You should not re-invent the wheel – there is a lot of information that can assist
- E.g. Telecommunications Infrastructure Standard for Data Centers – TIA 942

# Network Layout

- Component plans are used to separate a particular function or service from the other network detail (e.g. VoIP, Network management, security architecture, VPN architecture.)
- The need for these plans will become obvious as the need arises.

# Component Plan

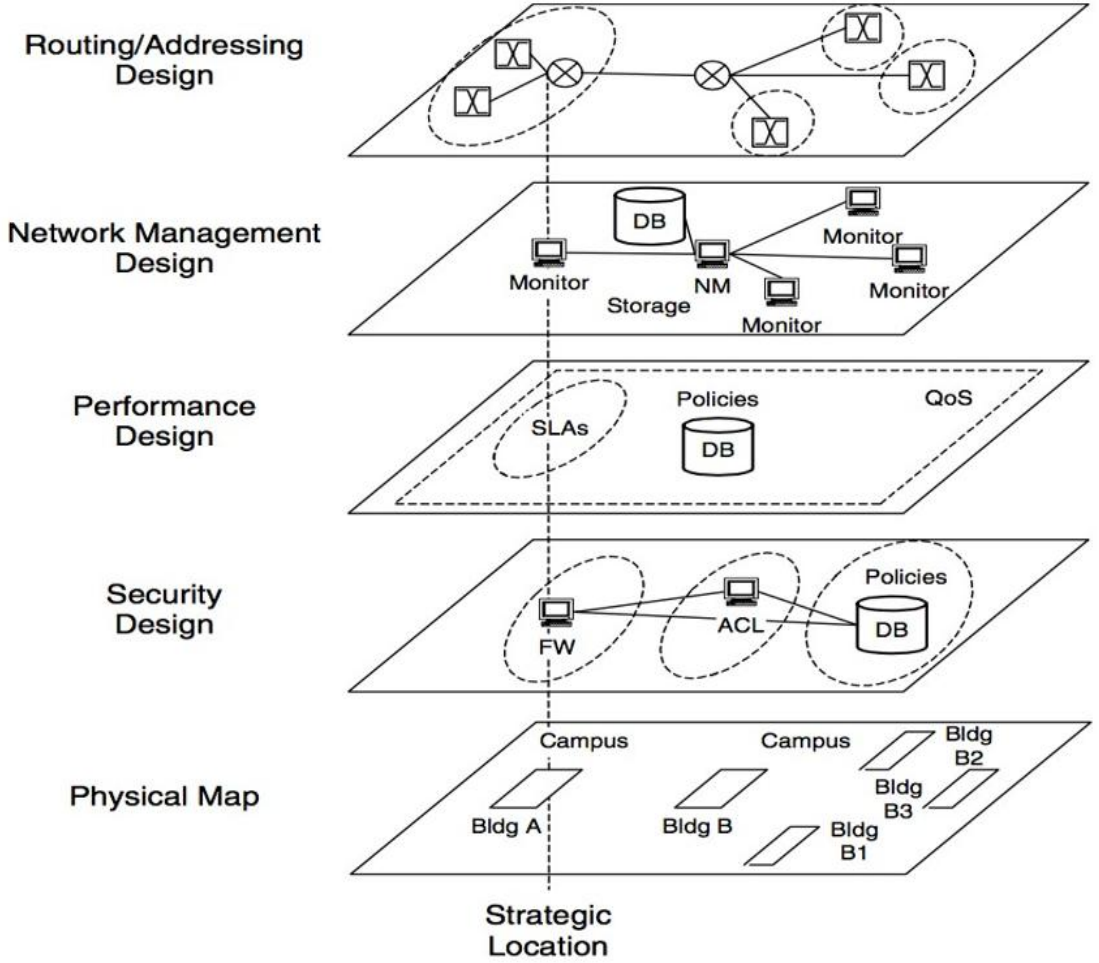


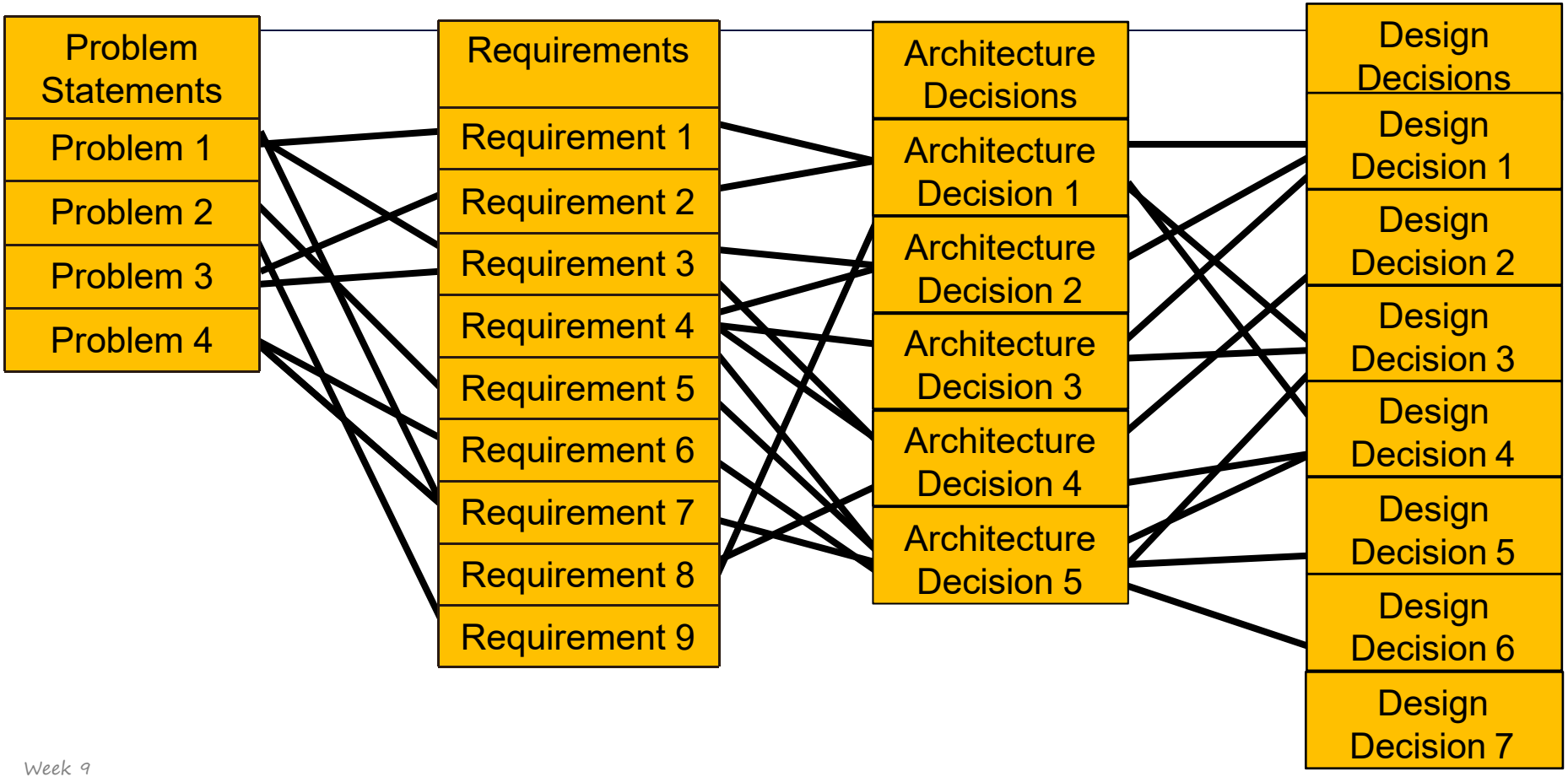

**FIGURE 10.21** Component Plan Overlays Line Up at Strategic Locations

# Design Traceability

# Design Traceability

- Design traceability enables connections to be made between analysis, architecture and design decisions.
- This aids in “defensibility” as it provides clear proof that your decision making has been objective and transparent.

# Design Traceability



# Design Metric

# Design Metric

- How can we measure our success?
- Capacity, Delay, RMA are specifications that can be measured to determine if the network exceeds minimum requirements but there is more.
- Design metrics can be described in terms of user requirements or device requirements too.

# Design Metric

- A document similar to a Service Level Agreement should be developed to summarize important performance measures

# References and Reading


- **Chapter 10** - McCabe, J. D. (2010). *Network Analysis, Architecture, and Design*. San Diego, CA, USA: Elsevier Science.

# Thank you
# Q&A ?

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