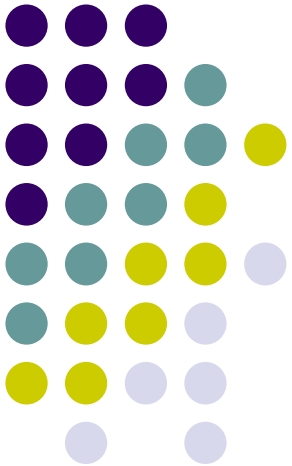
Network Management Model

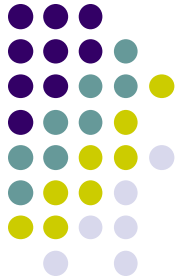
Lecture-6



Outline

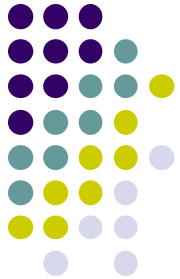
- What is network management?
- The Infrastructure for network management
- Evolution of network management
- Network implementation design
- ISO network management categories

What is network management?



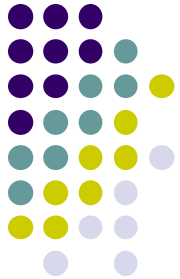
- In the early days, network was small and local
- Network manager's job includes
  - Installation: attach PCs, printers, etc. to LAN
  - Configuration: NICs, protocol stack, user app's shared printers, etc.
  - Testing: Ping was sufficient to "manage" network
  - More devices: Switch, Router
- Job was manageable

What is network management?



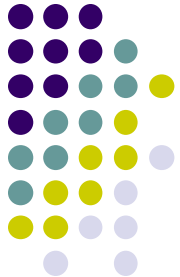
- Above only deals with configuration
- Ongoing maintenance issues
  - How to optimize performance?
  - How to handle failures and network changes?
  - How to extend network capacity?
  - How to account for network usages?
  - How to solve network security issues?

What is network management?



- In the past, the network manager might take all the responsibilities
- **Today the task has divided into specialties**:
  - Server admin
  - System admin
  - Network admin
  - Security specialist
  - Different certifications for these
    - Cisco, Cloud, Novell, Microsoft, Sun, $(ISC)^2$, RHCE etc.

What is network management?



- Today, networks are larger and more complicated, so more demands on network manager
- How to monitor and control the network effectively and timely?
  - Management tools are needed
- Network-based management tools: use the network to manage the network (remotely)
  - **To control**
    - Simple Network Management Protocol (SNMP)
    - Management Information Base (MIB)
    - Network Management System (NMS)
  - **To monitor**
    - Remote Monitor (RMON1)

What is network management?

Definition by Saydam (in Journal of Networks and System Management, published in Dec. 1996):

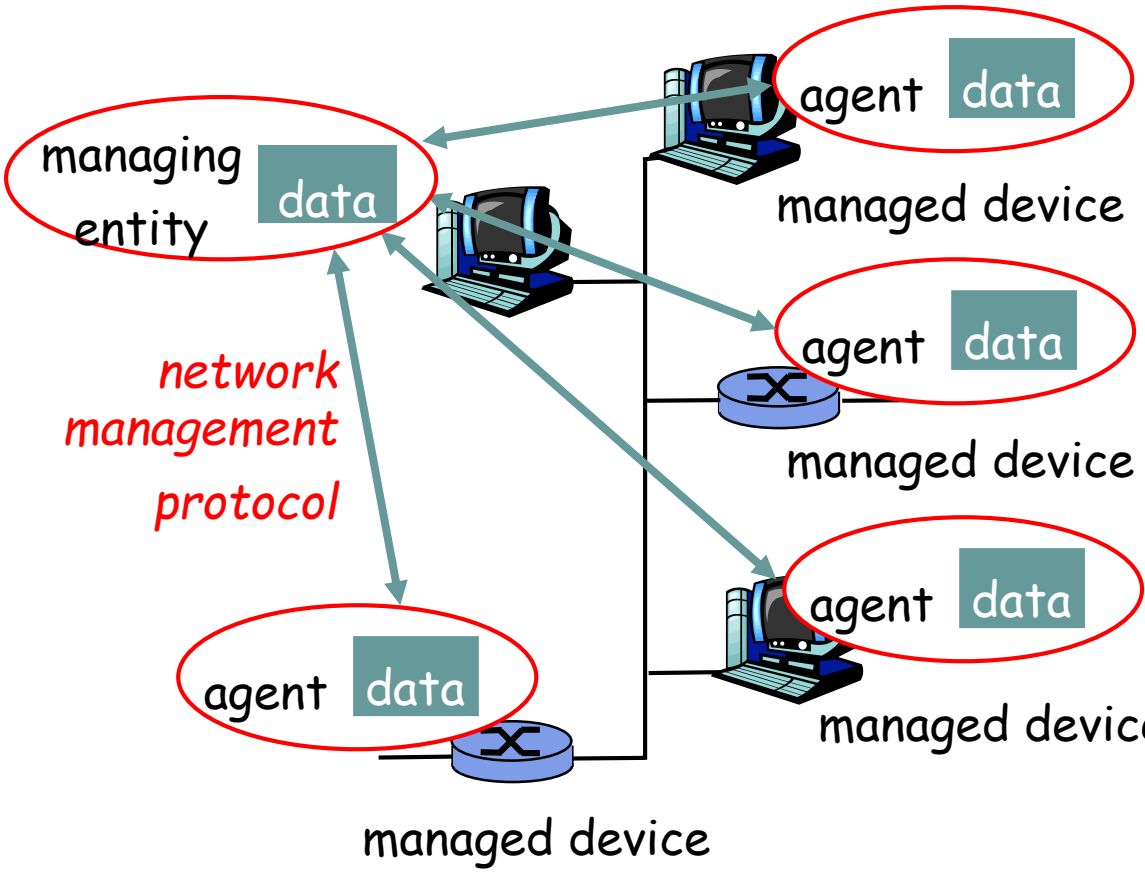
Network management includes the *deployment, integration and coordination of the hardware, software, and human elements to monitor, test, poll, configure, analyze, evaluate, and control the network and element resources to meet the real-time, operational performance, and Quality of Service requirements at a reasonable cost*.

In brief:

Network management is mostly a combination of local and remote configuration and management with software.

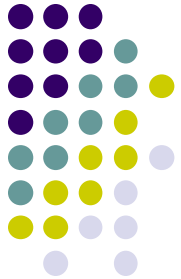
Remote network management is accomplished when one computer is used to monitor, access, and control the configuration of other devices on the network.

The Infrastructure for network management



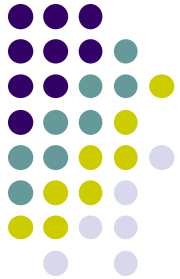
managed devices contain *managed objects* whose data is gathered into a *Management Information Base (MIB)*

The Infrastructure for network management
(TCP/IP network management model)



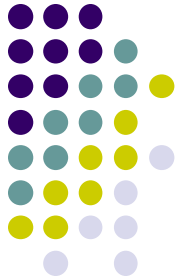
1. Managed Device
2. Management Station/Entity
3. Network Management Protocol

The Infrastructure for network management



- Managed Device
  - Devices to be monitored/controlled, e.g., router, switch, bridge, workstation.
  - Managed from a management station/entity
  - A software (agent) is installed to provide **access** to information/parameters (data) about the device, which is called Management Information Base (MIB)

Architecture for network management



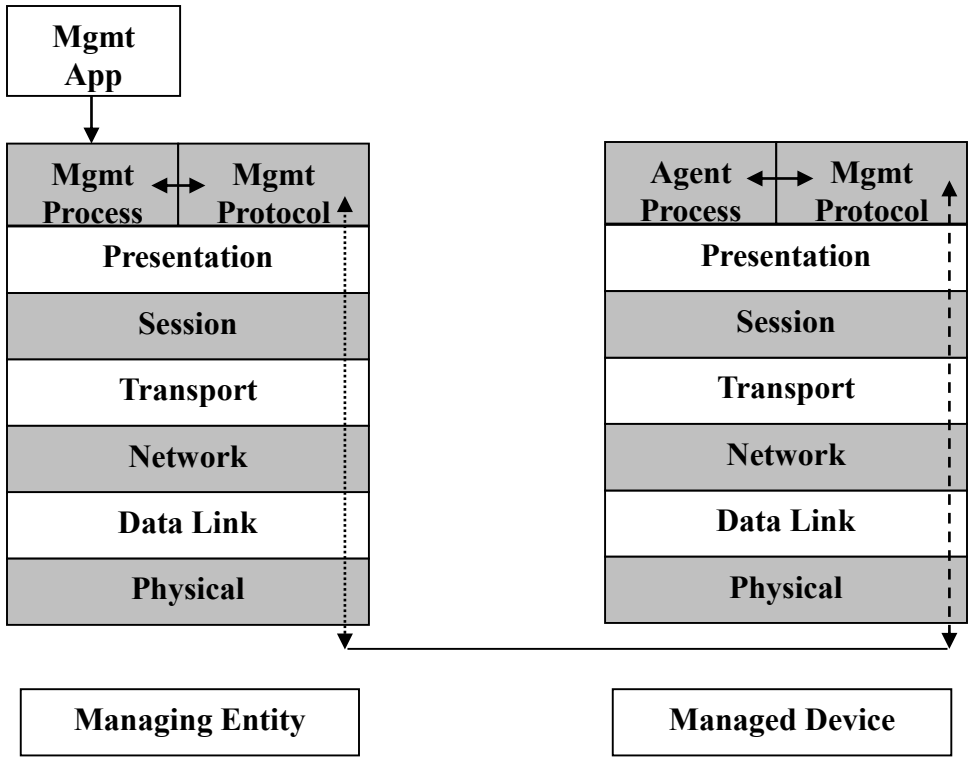
Management Station/Entity

- Is a stand-alone device
- Used by the manager/Admin to do network management
- A set of management applications for data analysis, fault recovery
- An interface by which network manager monitors and controls the network
- PC, notebook, terminal, etc., installed with a software called Network Management System (NMS)
- NMS displays/analyzes data from management agents

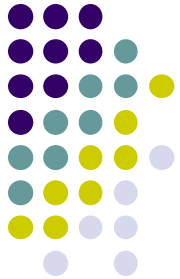
Architecture for network management

- Network Management Protocol
  - Runs between the managing entity and the managed devices
  - The managing entity can query the status of the managed devices and take actions at the devices via its agents
  - Agents can use the protocol to inform the managing entity of exceptional events
  - E.g., SNMP: Simple Network Management Protocol
- Managing agents located at managed devices are periodically queried by the managing entity through a network management protocol.

Network management example

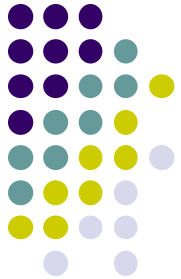


Network management example



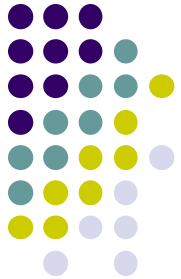
- To get value of MIB variable from mgmt agent
  1. **Mgmt app** (part of NMS) on managing entity passes request to **mgmt process**
  2. **Mgmt process** calls network **mgmt protocol** (e.g., SNMP)
  3. SNMP constructs Get-Request packet and sent it to the managed device through the network
  4. Mgmt agent on managed device receives Get-Request
  5. Agent process accesses requested value
  6. SNMP constructs Get-Response packet and sent it to managing entity through the network
  7. Mgmt process on managing entity receives response
  8. Mgmt process passes data to mgmt app

Evolution of Network Management



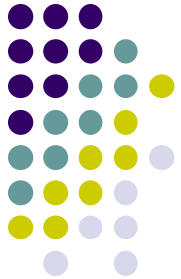
- In 1977 International Organization for Standards (ISO) began work on Open Systems Interconnection (OSI) reference model
  - Purpose was to “provide a common basis for the coordination of standards developments for the purpose of system interconnection, while allowing existing standards to be placed in perspective within the overall Reference Model”
- OSI model published in 1984 (7 years!)

Evolution of Network Management



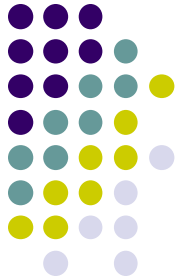
- In March 1987, effort to develop Simple Gateway Monitoring Protocol (SGMP)
  - SGMP out by November 1987
  - Could “get” and “set” variable values
- About same time Common Mgmt Information Protocol (CMIP) developed for OSI model
  - CMIP is roughly SNMP for the OSI model
- Effort to develop CMIP Over TCP (CMOT) as alternative to SGMP

Evolution of Network Management



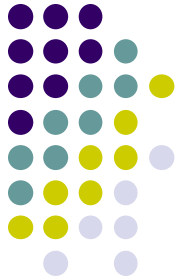
- CMIP uses Remote Operations Services Elements (ROSE)
  - ROSE is for communication with distributed apps in OSI model
- OSI mgmt process is richer and more comprehensive than that provided by SNMP
- But OSI approach is more complex and took longer to develop
  - SNMP: “keep it simple”, and it’s good enough
  - So SNMP won out in practice

Evolution of Network Management



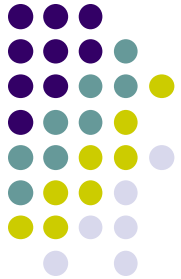
- Due to controversy/delays in OSI approach, Internet Activities Board (IAB) held meeting in 1988
  - Decided to pursue both CMOT and SGMP
  - Eventually abandoned CMOT (complexity)
- Eventually, three RFCs resulted…
- The three RFCs
  - Structure of Management Information (SMI), uses Abstract Syntax Notation One (ASN.1)
  - Management Information Base (MIB), the data structure on the mgmt agent
  - Simple Network Management Protocol (SNMP)
- By 1989, SNMP was the *de facto* standard for management of TCP/IP networks

Evolution of Network Management



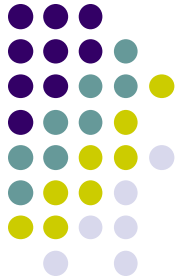
DATE	EVENT	REFERENCE
1968	ARPA funds development of packet switching networks	1. RFC 1120 Internet Activities Board. V. Cerf. Sep-01-1989. (Obsoleted by RFC 1160) 2. RFC 1160 Internet Activities Board. V. Cerf. May-01-1990. (Obsoletes RFC 1120)
1974	TCP/IP concept proposed	Cerf V., and R. Kahn, "A Protocol for Packet Network Interconnection", IEEE Trans. on Communications, Vol. COM-22, No. 5, pp. 637-648, May 1974. [Ref 26]
1976	Ethernet Developed	Metcalfe, R., and D. Boggs, "Ethernet: Distributed Packet for Local Computer Networks", Communications of the ACM, Vol. 19, No. 7, pp. 395-404, July 1976.
1978	OSI Reference Model Development Initiated	

Evolution of Network Management

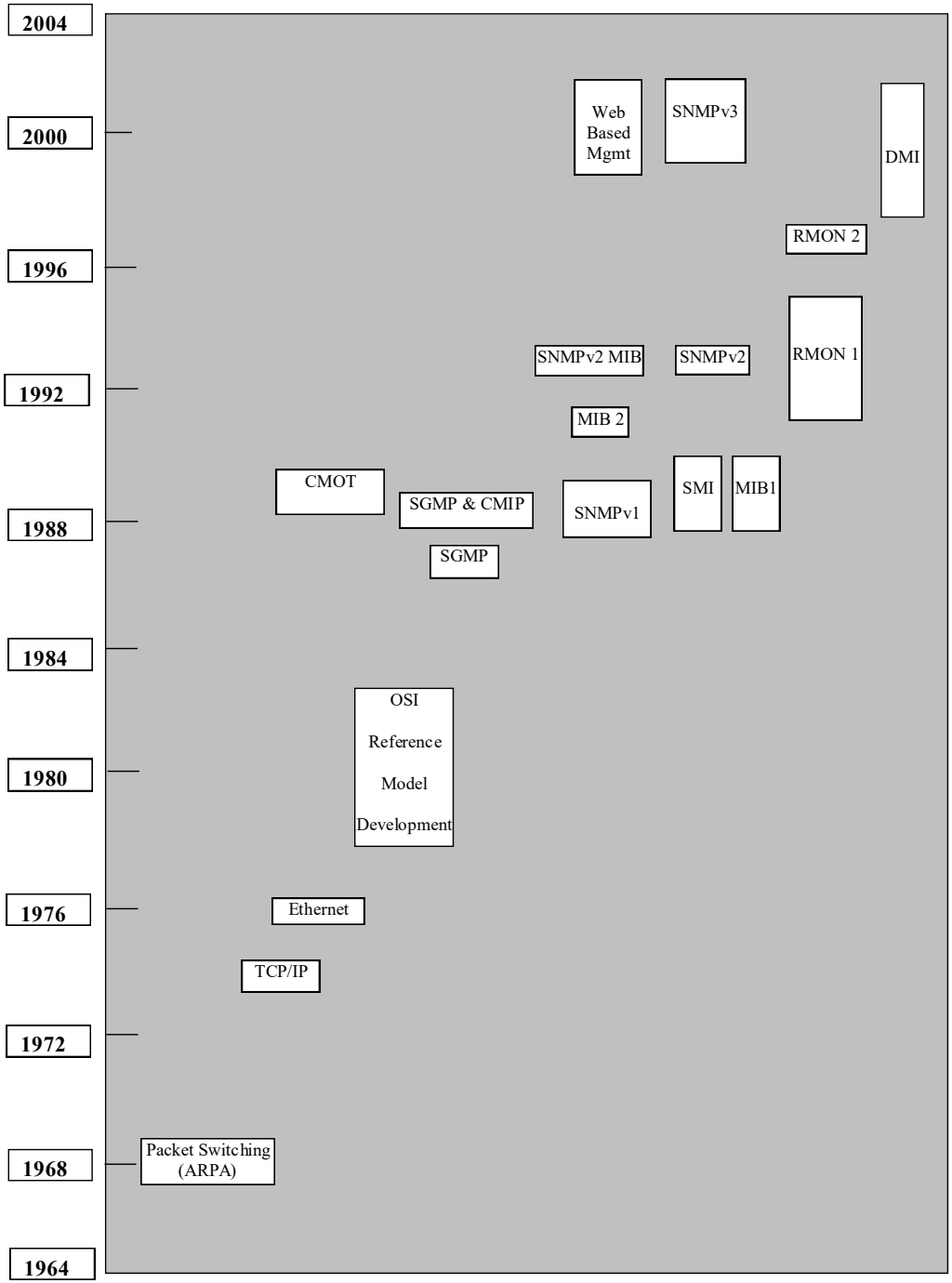


1983	OSI Reference Model becomes international standard	ISO/IEC 7498 (CCITT X.200) [Ref 1]
1987	SGMP development started ASN.1 developed	[Ref 24] ISO 8824, Parts 1-4
1988	IAB initiates study of SGMP and CMIP SNMPv1 becomes Interim Draft Standard SNMPv1 becomes Draft Standard IAB initiates development of Internet Standard Network Management Framework (SMI) Draft Standard MIB I developed	Interim RFC 1028 (SNMPv1) Draft RFC 1098 (SNMPv1) Draft RFC 1065 (SMI) Draft RFC 1066 (MIB I) [Ref 10]
1989	CMOT approach abandoned SNMP becomes the defacto standard for TCP/IP management	
1990	SMI becomes Recommended Standard SNMPv1 becomes Recommended Standard MIB I becomes Recommended Standard	RFC 1165 (SMI) RFC 1157 (SNMP) [Ref 3] RFC 1156 (MIB I) [Ref 11]
1991	MIB II RMON1	RFC 1213 (MIB II) RFC 1271 (RMON I) [Ref 12]

Evolution of Network Management

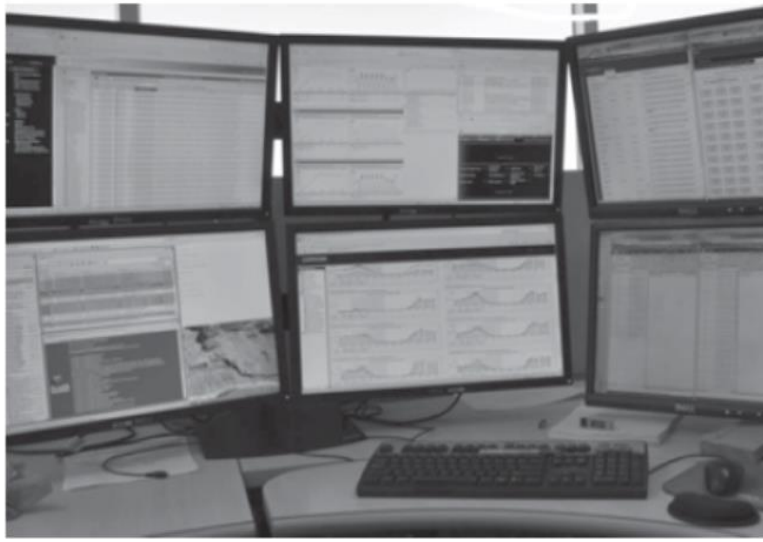


1993	SNMPv2 Proposed SNMPv2 Security SNMPv2 MIB SNMPv2 SMI	RFC 1441(SNMPv2 Management Framework RFC 1446(SNMPv2 Security Protocols RFC 1450 (SNMPv2 MIB) RFC 1442 SNMPv2 Structure of Management Information
1995	RMON I	RFC 1757 [Ref 13]
1997	RMON II	RFC2021
1998	Desktop Management Interface (DMI) Specification v 2.0s Web-based Management Initiative	1. http://www.dmtf.org/sped/dmis 2. Network Computing, Feb 2001, p57 http://www.dmtf.org/standards/standard_wbem.php
1999	SNMPv2 Management Frameworks SNMPv3 Security	RFC 2571 RFC 2574 (User-based Security Model)
2002	SNMP Management Frameworks SNMPv3 Security SNMP VACM SNMP MIB	RFC 3411, STD 62 RFC 3414 (User-based Security Model), STD 62 RFC 3415 (View-based Access Control Model), STD 62 RFC 3418, STD 62


2004
2000
1996
1992
1988
1984
1980
1976
1972
1968
1964
Web Based Mgmt
SNMPv3
DMI
RMON 2
RMON 1
SNMPv2 MIB
SNMPv2
MIB 2
CMOT
SGMP & CMIP
SNMPv1
SMI
MIB1
SGMP
OSI Reference Model Development
Ethernet
TCP/IP
Packet Switching (ARPA)

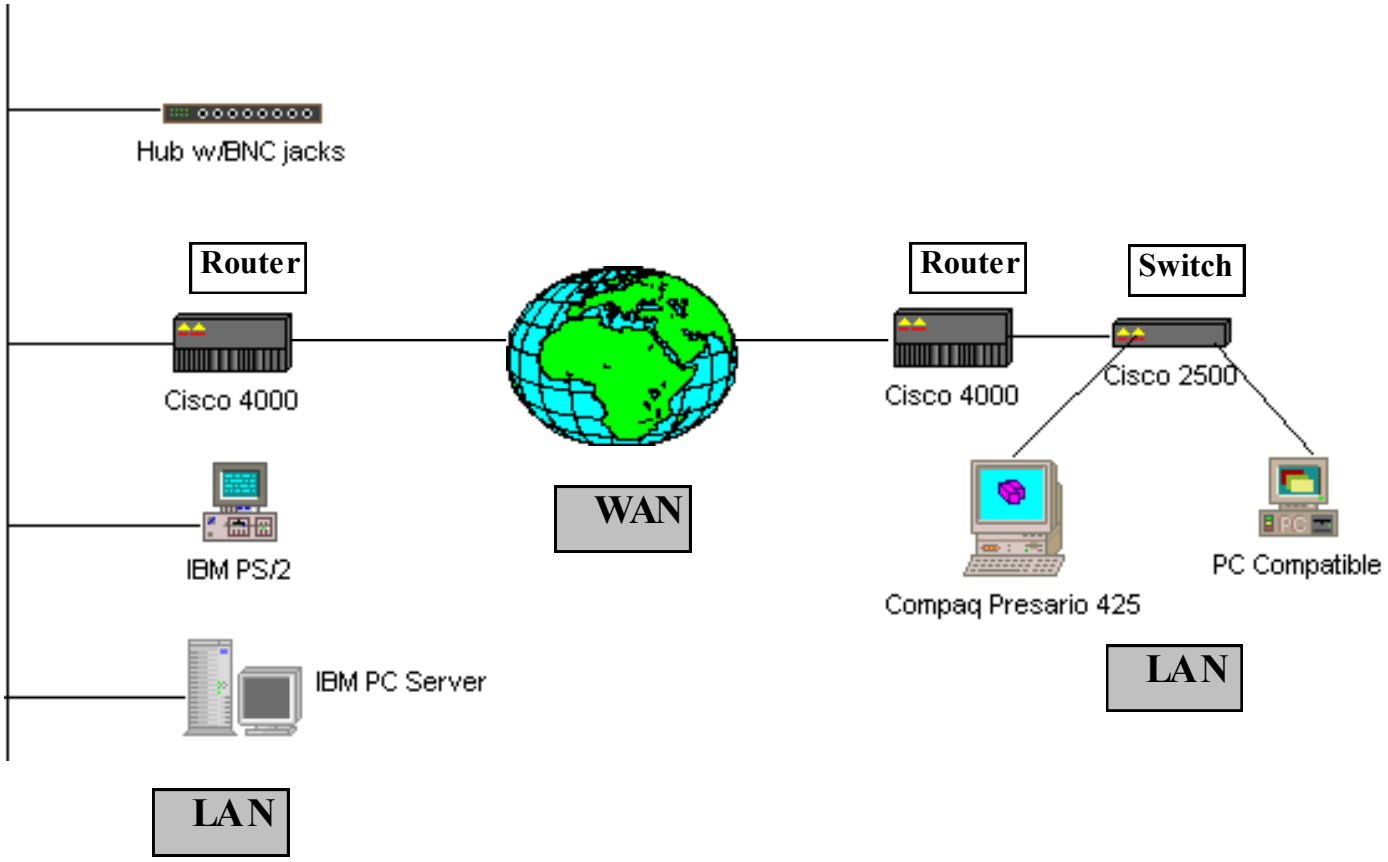
Network Implementation Strategy Design

- ISO defines five network management categories
1. *Performance management,*
2. *Fault management,*
3. *Configuration management,*
4. *Accounting management,*
5. *Security management*

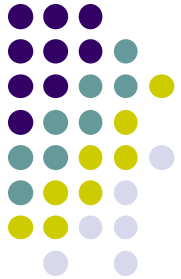


- Small network: a single LAN
  - For example, CS dept at HKBU
- Medium network: a few LANs
  - E.g., the campus network of HKBU
- Large network: geographically distributed
  - Wide-area network

Network Implementation Strategy Design

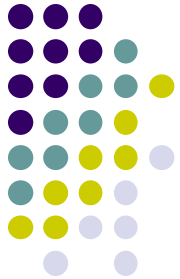


Network Implementation Strategy Design



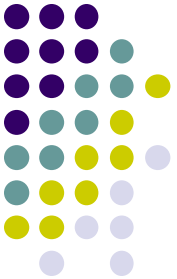
Category	Issues
Geographical Distribution	1. Office • Subnets • LAN 1. Department (many offices) • Subnets • LAN 1. Division (many departments) • LAN • WAN 1. Organization (many divisions) • Local ❑ LAN ❑ MAN ❑ WAN • National ❑ WAN • Global • WAN

Network Implementation Strategy Design



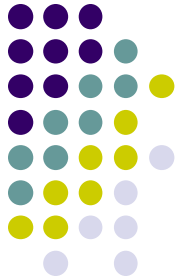
Subnets	• How many • Connectivity ❑ Bridges ❑ Switches ❑ Routers • Ethernet • Wireless • Number of receivers • 10BASET • Location of hub(s) • 10BASE2 • 10BASE5 • How many IP addresses ❑ Static addresses ❑ Addresses supplied by DHCP

Network Implementation Strategy Design



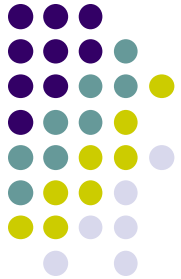
LAN	1.How many 2.Domain names 3.DNS (Domain Name Service) configuration 4.Network address 5.Subnets •How many 1.Connectivity •Switched Ethernet •Router 1.Ethernet 2.Token Ring 3.FDDI (Fiber Distributed Data Network)
MAN (Metropolitan Area Network)	1.Connectivity between LANs ❑FDDI ❑SONET(Synchronous Optical Network) ❑LAN ❑ATM ❑SMDS (Switched Multi-megabit Data Service) ❑DQDB (Dual Queue Dual Bus) ❑Ethernet

Network Implementation Strategy Design



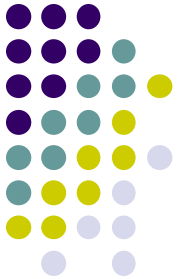
WAN	1. Connectivity between LANs or MANs ❑ PSTN ❑ X.25 ❑ TI-T3 ❑ SONET ❑ Frame Relay ❑ SMDS ❑ ATM ❑ Distribution of services

Network Implementation Strategy Design



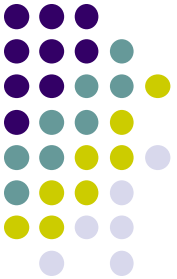
Bandwidth Requirements	1. Video Bandwidth • Constant • Time Dependent • Bandwidth on Demand 1. Audio Bandwidth • Constant • Time Dependent • Bandwidth on Demand 1. Teleconferencing Bandwidth
Media Requirements	1. Cable 2. Wireless 3. Microwave 4. Satellite 5. Optical Fiber
Technology	1. What is available now 2. Minimum required for the job 3. Technology improvements during next 5 years 4. Required to support expected growth

Network Implementation Strategy Design



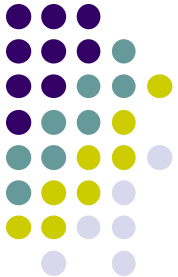
Service Level Agreements (SLA)	1. Specified bandwidth available at any time 2. Specified bandwidth available during specified time periods 3. Bandwidth on demand
Security Requirements	1. Location of firewalls 2. Firewall capabilities 3. Location of proxy servers 4. Encryption and authentication needs 5. Network Intrusion Detectors (NID)
Budget	1. To support resources of optimum network 2. To support resources of minimum network

Network Management Categories



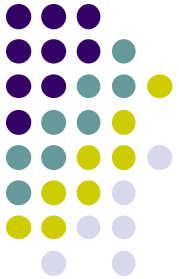
CATEGORY	METRICS
Reliability	• Transmission error rates • Dropped packets • Link failures
Faults	• Proactive prevention • Detection • Location • Correction time
Availability	• Mean time between failures (MTBF) of network
Performance	• Time to provide a response to the user ❑ Processor total use ❑ Processor interrupts/sec ❑ Processor queue length ❑ Transmit packet lengths

Network Management Categories



Throughput	• Bytes per second that a user can expect to transmit reliably. • Guaranteed throughput based on Service Level Agreement (SLA)
Data	• Packet throughput
Voice	• Ordered packet throughput
Video	• Link bandwidth • Bandwidth on demand
Use	• Packets/sec • Transactions/sec
Resource Use	• Application software • Network devices • Services • Permanent storage • CPU

Network Management Categories



CATEGORY	METRICS
Policies	• Traffic • What's Critical • How many network control packets • Which threshold alarms • Alerts on what events • What's Non-critical • Backup-what and how often • Application testing • Software upgrades-how often • Administration • Type of service availability required • Security level required • Firewall protection requirements • Network Intrusion Detection needs • Number of Software License requirements • User rights requirements and how distributed among which users.
Redundancy	• Number of redundant systems required • Critical alternate paths
User Support	• Automatic responses to user questions about procedures • Automatic responses to user questions about network problems • Automatic reporting of problems and solutions to users and to a database

References

- J. Richard Durke, *Network Management, Concepts and Practice: A Hands-on Approach*, Prentice Hall, 2004.
- J. F. Kurose and K. W. Ross, *Computer Networking: A Top-Down Approach Featuring the Internet,* 3nd Edition, Prentice Hall, 2005.