Internet Engineering

241-461

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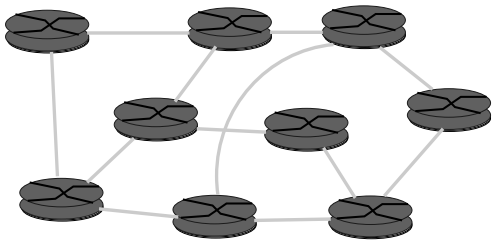
Contents

Network Management

- Large Network
  - Many Routers
  - Many Links
- Is it all working?
  - How do we know?
  - Wait for user to complain?
- Not good enough
  - Need to monitor operations
  - Need to correct problems
    - When problems detected
  - Even better
    - Predict problems in advance
    - Fix before they occur
- This is Network Management
  - Sometimes includes Network Configuration

Network Management



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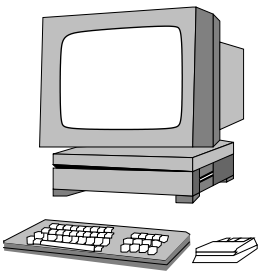

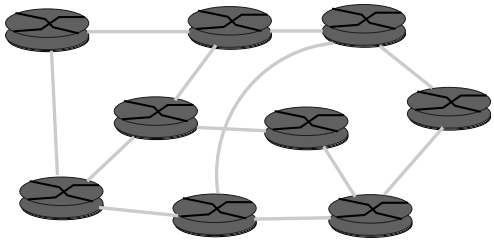

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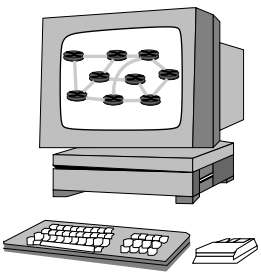

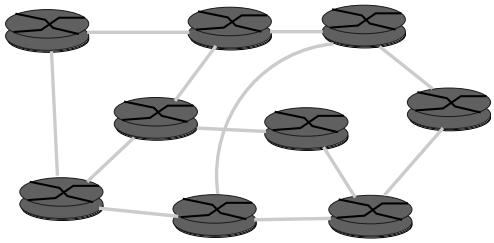

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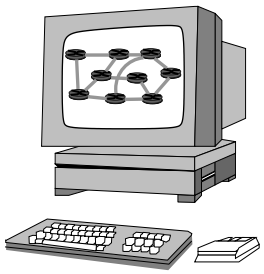

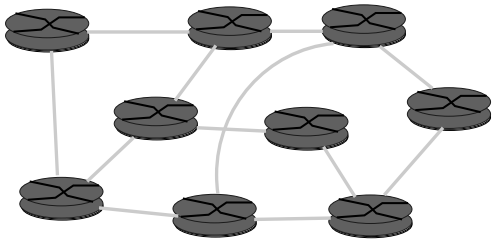

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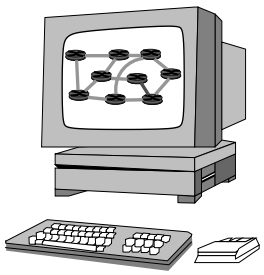

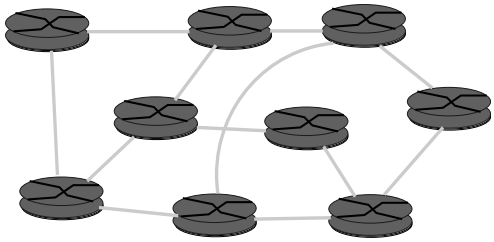

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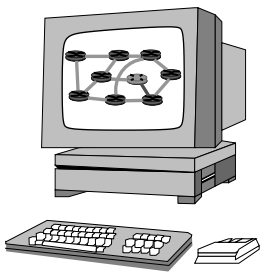
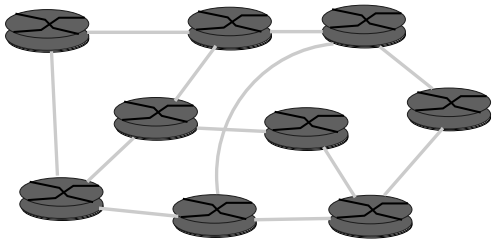




- Management Station
  - Display Network Information
    - Graphical or otherwise
  - Indicate Problems
    - Colour, Flashing, Pop-Up, ...
  - Allow investigation

Network Problems

- Problems to watch for
  - Crashed Routers
  - Faulty Links
    - Link Broken
    - High error rate
  - Routing Problems
  - Network Congestion
  - (and more)
- Data collection
  - In-Band
    - Uses network
      - Good, provided network works
      - Cheap
  - Out-of-Band
    - Uses other links
    - Dial up
      - Expensive
      - Works with broken net

Contents

- Intro to Network Management
- Collecting Statistics
- Management Information Base
- Simple Network Management Protocol
- Host Configuration
- DHCP
- IPv6

Predicting Faults

- Can
  - Wait for problem
  - Fix
  - Repeat
- Not good
  - Between problem & fix
    - network not operating
- Better
  - Watch for coming problem
    - Error rate increasing
    - Router approaching 100% CPU
    - Link usage approaching capacity
  - Correct before problem serious
    - Fix link errors
    - Add capacity

Network Capacity Monitoring

- When
  - Usage of link increasing
  - Seems to need more bandwidth
    - Expensive
- But, do we really?
  - Is it end of semester traffic
    - Does increase happen each year?
  - What is causing increase?
    - Maybe reduce demand
    - instead of increasing capacity
- To answer
  - Need to know
    - What kind of traffic
    - From where to where
    - Historical usage patterns
- Network Monitoring

Contents

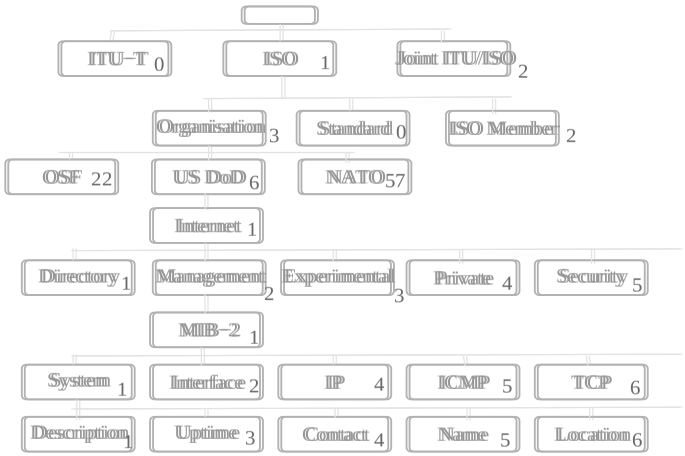
Collecting Data

- Management Information
  - Collected in Database
- Data in Database: Management Information
  - Management Information Base
- Tree Structured Database
  - Data at leaves of tree
  - Branches group related information
  - Higher levels (towards root)
    - Definition authority
- All information is named
  - Necessary to fetch over network
- All information is typed
  - So know what data represents
    - Numbers, Strings, Status. ...

Standard MIB

- Tree similar to DNS tree
  - Nodes represent management information
  - Written with root at left
- Root at top of tree
  - Major organisational nodes under root
  - Delegations down tree
    - to organisations that define data
    - Standards Bodies
      - IETF, ISO
    - Companies
      - For their equipment
- Naming uses numbers
  - Primary name source
    - No arguments
    - No meaning
- String names added
  - User-Friendly naming

Standard MIB (2)



- MIB Variables
  - .1.3.6.1.2.1.1.5

Standard MIB (2)

Object

Ide

- .iso.org.dod.internet.mgmt.mib2.system.sysName

MIB Variables

- Simple Variables
  - sysName
  - sysUptime
- Tables
  - Multiple copies of variable
  - One for each X
    - For some X
  - eg:
    - Interface type
    - One for each interface

	1 Index	2 Descr	3 Type	4 Mtu	5 Speed	6 PhysAddress	7 AdminStatus	...
1	1	Text	Ether	1500			up	
2	2	Text	Loop	30000			up	
3	3	Text	FDDI	8400			down	
4	4	Text	Token Ring	1500			up	
5	5	Text	PPP	1500			testing	

MIB Variables (2)

- Variable Name
  - Object Identifier + Instance Identifier
- Simple Variables
  - Instance Identifier is "0"
- Tables
  - Instance Identifier is table index
    - Can be several elements
- Eg:
  - sysName .1.3.6.1.2.1.1.5.0
  - ifNumber .1.3.6.1.2.1.2.1.0
  - ifType .1.3.6.1.2.1.2.2.1.3.3
  - ifDescr .1.3.6.1.2.1.2.2.1.2.5

Contents

SNMP

- Simple Network Management Protocol
  - Not very simple
    - Never mind...
- Manager

SNMP

- Simple Network Management Protocol
  - Not very simple
    - Never mind...

(client)

  - The Management Station
    - And usually the human
- Agent

SNMP

- Simple Network Management Protocol
  - Not very simple
    - Never mind...

(client)

  - The Management Station
    - And usually the human

(server)

  - System that can access a MIB
    - MIB exists locally
- Manager uses SNMP to access agent
  - Fetch Variable(s)
  - Set Variable(s)

SNMP Operations

- 3 major operations
  - more exist, used less
  - GET
    - Send Instance Name of Variable
    - Receive Name & Value of Variable
      - Operates on multiple variables
      - As many as fit in packet
  - SET
    - Send Instance Name of Variable
    - Send Desired Value for Variable
      - Agent alters variable
      - if permitted
    - Receive new value of Variable
      - Altered if successful
  - GETNEXT
    - Send Object Identifier
      - Any Object Identifier
    - Receive
      - Name of next variable instance
      - Value of that variable

Powerful GetNext

- SNMP people always say
  - The powerful GetNext operator
  - When referring to GETNEXT
- Very useful operator
  - Usually used as:
    - Start with known Object Identifier
      - Make first request
    - Use ObjectId from result
      - As ObjectId for next GETNEXT request
- eg: start with
    - ifType .1.3.6.1.2.1.2.2.1.3
  - receive
    - ifType .1.3.6.1.2.1.2.2.1.3.1
  - then
    - ifType .1.3.6.1.2.1.2.2.1.3.2
    - ifType .1.3.6.1.2.1.2.2.1.3.3
  - later
    - ifMtu .1.3.6.1.2.1.2.2.1.4.1

MIB Enumeration

- Agent not required
  - to implement full MIB
  - Just parts meaningful to Agent
    - In groups
      - If part of group implemented
      - All must be
      - cannot just ignore "hard" variables
- Problem for Manager
  - How to know what parts of MIB supported?
- Answer
  - The powerful GetNext operator
- Start with .1, Use GETNEXT
    - Obtain first implemented variable
- Keep using GETNEXT
  - With variable from result
  - Until Name Error result is returned
- Manager now has complete list of supported variables

SNMP Operations

- GET
  - access to (possibly dynamic) memory
- SET
  - modifications to memory
- Agent implements MIB
  - Whatever the MIB wants to happen
  - Agent can make occur
- "Network" management can do anything
  - that computers are able to achieve
- MIB definitions exist
  - for all kinds of exotic tasks
  - standardises & proprietry

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- Host Configuration
- DHCP
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Host Configuration

- Minimum IP knowledge for host
  - IP address
  - Address of router on link
  - Usually
    - Subnet mask (Prefix length)
- To be useful
  - DNS resolver back end (cache) address
- IP address
  - must be correct for link
  - must not be duplicated
    - HOW?
- Router address
  - must be on same link
  - must be address of router
    - HOW?
- Original IP hosts
  - human configuration

Manual (human) Configuration

- Errors Likely
  - Most people do not know rules
  - Or simply make mistake
- In the past
  - dedicated staff
  - network specialist
    - for each computer
  - Manual configuration acceptable
    - though not desirable
- More recently
  - more computers than people
  - most users know little
    - simply expect it to work
- Need to provide automated mechanism

Early auto-configuration

- BOOTP
  - Bootstrap Protocol
- Needed by systems
  - with no human interface
  - no way to be configured
    - before booting
- Simple protocol
  - Broadcast on LAN
    - Send me my address
  - Server on LAN replies
    - Address is ...
    - Router is ...
    - Bootstrap server is ...
    - Boot File name is ...
  - Server uses MAC address of client
    - Allows it to send suitable answer
  - Answer broadcast
    - client has no address
    - cannot receive packets normally

BOOTP -> DHCP

- BOOTP too limited
  - Different systems need different data
    - netmask
    - DNS cache address
    - hostname
    - (much more possible)
- DHCP created
  - Based upon BOOTP
  - Spare space in BOOTP packet
    - used for options
  - One option is DHCP command
    - Needed for dynamic address assignment
- BOOTP
  - mac address -> IP address
    - configured for BOOTP server
  - multiple servers possible
    - all use same config file
    - all give the same answers

DHCP

- DHCP
  - mac address -> IP address
    - dynamically picked by server
  - multiple servers
    - different addresses
    - need to handle this
- Solution
  - 4 message exchange
    - Who can supply address?
      - message broadcast to everyone
    - I can: A available I can: B I can: C
      - message can be broadcast or unicast
      - unicast requires special care
    - Give me address A please
      - message broadcast to everyone
      - so servers that offered B and C see allocation
    - OK A assigned
      - message can be broadcast or unicast
      - green and purple take back offers

Re-using Addreses

- Static addresses
  - Allocated permanently
    - configured in file
    - available to system forever
- More recently
  - address shortage
  - need to conserve addresses
  - don't allocate to vanished systems
  - need to reclaim addresses
    - when no longer in use
- DHCP adds
  - Release operation
    - return address to server
  - Few clients use it
    - Must know about to be disconnected
    - often network removed first
      - or system crashes

DHCP Leases

- DHCP also adds
  - Address Lease time
    - Allocation only valid for N seconds
    - But can be renewed
      - before N seconds have passed
- Address renew
  - Give me address A please
    - sent via unicast to allocating server
  - OK A assigned
  - If address re-assignment fails
    - try again
  - If still fails
    - return to broadcast
    - search for a server again
      - repeat entire procedure
  - All done before old address lease expires
    - If lease does expire
    - Must stop using address

IPv6

- DHCP requires servers
  - servers must be configured
  - must co-operate if more than one
- Better than configuring every host
  - But not good
- IPv6 is new
  - Decided to do better
- IPv6 allows hosts to assign addresses
  - assign address to itself
- Needs network prefix
  - can be supplied by router
  - There must be a router
    - or network prefix not required

IPv6 Autoconfiguration

- Router sends Router Advertisement
  - Periodically
  - or when requested by host
    - Host can send Router Solictiation
- RA gives
  - prefix (network number)
    - validity timers
  - router address
    - if sender of RA is router
  - other information for hosts
- Host
  - takes prefix from RA (64 bit prefix)
  - MAC address
    - from LAN card (expanded to 64 bits)
  - combines using a standard rule
  - checks for duplicate address on LAN
  - assigns address to itself

IPv6 Autoconfiguration (2)

- RA repeats
  - Allows
    - updates to configurations
      - new prefix added
      - old prefix removed

        network renumbered!
    - verification router remains working
    - address lifetimes to be extended
- DHCPv6 exists
  - Not needed as much
  - Can be used for address allocation
    - For closely managed networks
  - More likely used
    - to distribute other configuration information