Data and Computer Communications

Chapter 22 – Internet Applications Electronic Mail and Network Management

Eighth Edition

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Internet Applications Electronic Mail and Network Management

One of the most exciting aspects of birds' lives is how they interact with others during such social activities as defending territories, courting mates, nesting, raising young, and flocking. Birds' level of sociability changes with the seasons; they may be gregarious at certain times of year yet highly territorial at others. Some of the most fascinating behavior occurs in spring and summer when birds are engaged in breeding. During a social interaction, an individual is coordinating its activities with those of another. This inevitably requires communication.

—*Secret Lives of Common Birds,* Marie Read

Electronic Mail

- most heavily used application on any network
- Simple Mail Transfer Protocol (SMTP)
  - TCP/IP
  - delivery of simple text messages
- Multi-purpose Internet Mail Extension (MIME)
  - delivery of other types of data
  - voice, images, video clips

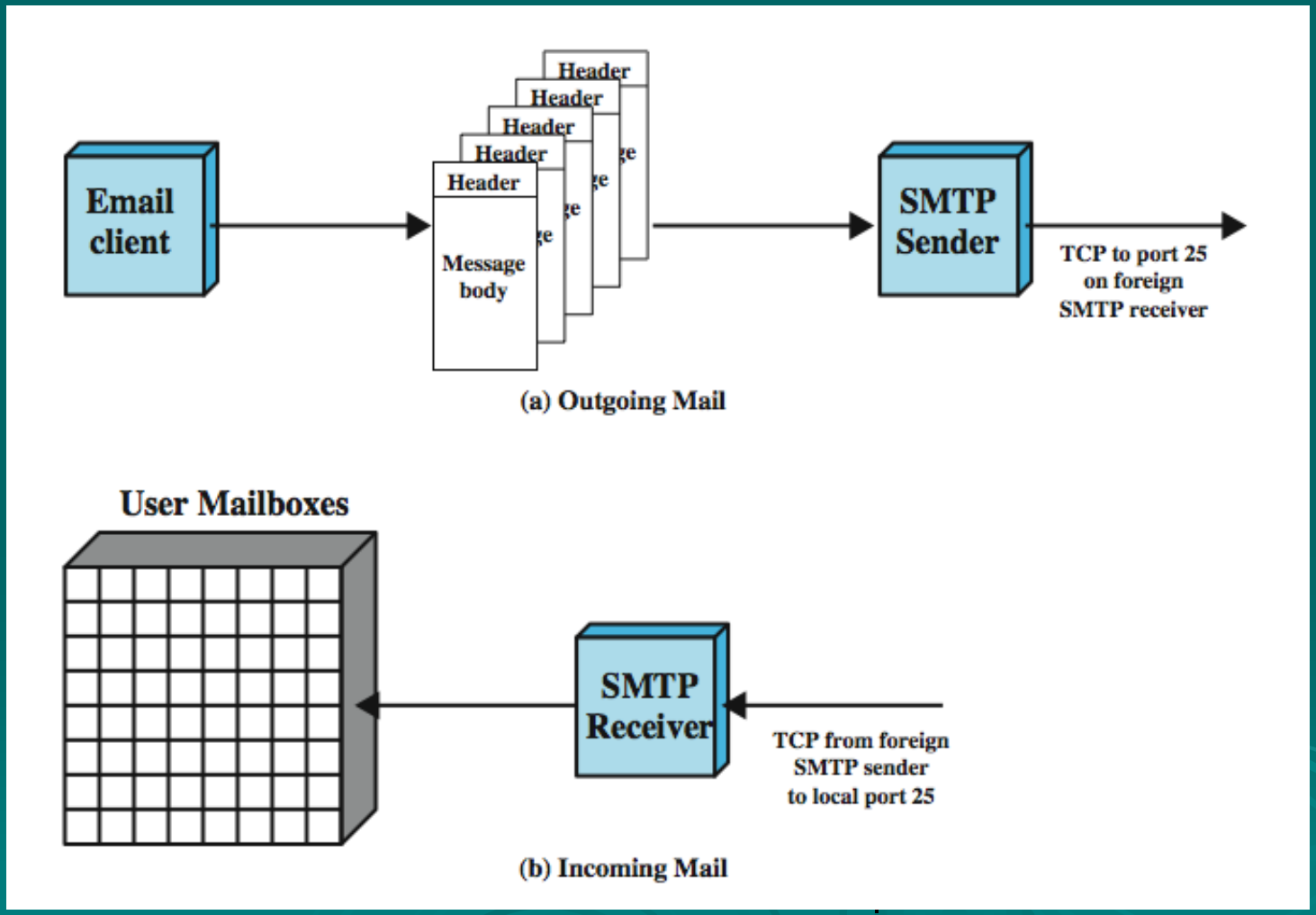
SMTP

- RFC 821
- not concerned with format of messages or data
  - covered in RFC 822 (see later)
- SMTP uses info written on envelope of mail
  - message header
- does not look at contents
  - message body
- except:
  - standardize message character set to 7 bit ASCII
  - add log info to start of message

Basic Operation

- email message is created by user agent program (mail client), and consists of:
  - header with recipient's address and other info
  - body containing user data
- messages queued and sent as input to SMTP sender program
  - yypically a server process (daemon on UNIX)

SMTP Mail Flow



Mail Message Contents

- each queued message has two parts
- message text
  - RFC 822 header with envelope and list of recipients
  - message body, composed by user
- list of mail destinations
  - derived by user agent from header
  - may be listed in header
  - may require expansion of mailing lists
  - may need replacement of mnemonic names with mailbox names
- if BCCs indicated, user agent needs to prepare correct message format

SMTP Sender

- takes message from queue
- transmits to proper destination host
  - via SMTP transaction
  - over one or more TCP connections to port 25
- host may have multiple senders active
- host must create receivers on demand
- when delivery complete, sender deletes destination from list for that message
- when all destinations processed, message is deleted

Sending Optimizations

- if message destined for multiple users on a given host, it is sent only once
  - delivery to users handled at destination host
- if multiple messages ready for given host, a single TCP connection can be used
  - saves overhead of setting up and dropping connection

Possible Errors

- host unreachable
- host out of operation
- TCP connection fail during transfer
- sender can re-queue mail
  - give up after a period
- faulty destination address
  - user error
  - target user changed address
  - redirect if possible
  - inform user if not

SMTP Protocol - Reliability

- used to transfer messages from sender to receiver over TCP connection
- attempts to provide reliable service
- no guarantee to recover lost messages
- no end to end acknowledgement to originator
- error indication delivery not guaranteed
- generally considered reliable

SMTP Receiver

- accepts arriving message
- places in user mailbox or copies to outgoing queue for forwarding
- receiver must:
  - verify local mail destinations
  - deal with errors
- sender responsible for message until receiver confirm complete transfer
  - indicates mail has arrived at host, not user

SMTP Forwarding

- mostly direct transfer from sender host to receiver host
- may go through intermediate machine via forwarding capability
  - sender can specify route
  - target user may have moved

Conversation

- SMTP limited to conversation between sender and receiver
- main function is to transfer messages
- rest of mail handling beyond scope of SMTP and may differ between systems

SMTP System Overview

- commands and responses exchanged between sender and receiver
- initiative with sender
  - establishes TCP connection
- sender sends a command to receiver
  - e.g. HELO<SP><domain><CRLF>
- generates exactly one reply
  - e.g. 250 requested mail action ok; completed

SMTP Commands

SMTP Replies

- positive completion reply (2xx)
  - e.g. 220 <domain> Service ready
  - e.g. 250 Requested mail action okay, completed
- positive intermediate reply (3xx)
  - e.g. 354 Start mail input; end with <CRLF>.<CRLF>
- transient negative completion reply (4xx)
  - e.g. 452 Requested action not taken: insufficient system storage
- permanent negative completion reply (5xx)
  - e.g. 500 Syntax error, command unrecognized
  - e.g. 550 Requested action not taken: mailbox unavailable (e.g., mailbox not found, no access)

Connection Setup

- sender opens TCP connection with receiver
- once connected, receiver identifies itself
  - 220 <domain> service ready
- sender identifies itself
  - HELO
- receiver accepts sender's identification
  - 250 OK
- if mail service not available, step 2 returns:
  - 421 service not available

Mail Transfer

- sender may then send one or more messages
- MAIL command identifies originator
  - gives reverse path to used for error reporting
  - receiver returns 250 OK or fail/error message
- one or more RCPT commands identifies recipients for the message
- DATA command transfers message text
  - end of message shown by line containing just period .

Example SMTP Transfer

- S: MAIL FROM:<Smith@Alpha.ARPA>
- R: 250 OK
- S: RCPT TO:<Jones@Beta.ARPA>
- R: 250 OK
- S: RCPT TO:<Green@Beta.ARPA>
- R: 550 No such user here
- S: RCPT TO:<Brown@Beta.ARPA>
- R: 250 OK
- S: DATA
- R: 354 Start mail input; end with <CRLF>.<CRLF>
- S: Blah blah blah…
- S: …etc. etc. etc.
- S: <CRLF>.<CRLF>
- R: 250 OK

Closing Connection

- two steps
- sender sends QUIT and waits for reply
- then initiate TCP close operation
- receiver initiates TCP close after sending reply to QUIT

RFC 882 Email Format

- message has envelope and contents
- envelope contains information required to transmit and deliver message
- content defined by RFC822
- message is sequence of lines of text
  - uses general memo framework
    - multiple header lines, rigid format, then arbitrary text body
  - each header line has form:
    - keyword: arguments

Example Message

Date:Tue, 16 Jan 1996 10:37:17 (EST)
From: “William Stallings” <ws@host.com>
Subject:The syntax of RFC 822
To: Smith@otherhost.com
Cc: Jones@Yet-another_host.com

This is the main text, delimited from the header by a blank line.

Multipurpose Internet Mail Extension (MIME)

- extension to RFC822 to resolve issues like:
- SMTP can not transmit executables
- can not transmit text including international characters (e.g. â, å, ä, è, é, ê, ë)
- servers may reject mail over certain size
- ASCII to EBCDIC translation not standard
- SMTP gateways to X.400 can not handle non-text data in X.400 messages
- some SMTP implementations do not adhere to standard

Overview of MIME

- five new message header fields
  - MIME version
  - Content type
  - Content transfer encoding
  - Content Id
  - Content Description
- number of content formats defines
- transfer encoding defined

Content Type/Subtype

- Text body - in given character set
- Multipart - body contains multiple parts
- Message
- Image
- Video
- Audio
- Application

Multipart MIME Example

From: John Smith <js@company.com>
To: Ned Jones <ned@soft.com>
Subject: Sample message
MIME-Version: 1.0
Content-type: multipart/mixed; boundary="simple boundary"

This is the preamble. It is to be ignored, though it is a handy place for mail composers to include an explanatory note to non-MIME conformant readers.
--simple boundary

This is implicitly typed plain ASCII text. It does NOT end with a linebreak.
--simple boundary
Content-type: text/plain; charset=us-ascii

This is explicitly typed plain ASCII text. It DOES end with a linebreak.

--simple boundary--
This is the epilogue. It is also to be ignored.

MIME Transfer Encodings

- reliable delivery over range of environments
- uses content transfer encoding field
  - 3 specify bit interpretation, other 3 encodings
- Quoted-printable
  - data largely printable ASCII characters
  - non-printing characters represented by hex code
- Base64
  - maps arbitrary binary input onto printable output
- X-token
  - named nonstandard encoding

Network Management

- networks are becoming indispensable
- more complexity makes failure more likely
- require automatic network management tools
- standards required to allow multi-vendor networks
- covering:
  - services
  - protocols
  - Management information base (MIB)

Network Management Systems

- collection of tools for network management
- single operator interface
- powerful, user friendly command set
- performing most or all management tasks
- minimal amount of separate equipment
  - i.e. use existing equipment
- view entire network as unified architecture
- active elements provide regular feedback

Simple Network Management Protocol (SNMP)

- SNMP v1 developed for managing TCP/IP (inter) networks
- defines protocol, database, other concepts
- basic concepts
  - management station or manager
  - agent
  - management information base
  - network management protocol

Management Station

- stand alone system or part of shared system
- interface for human network manager
- set of management applications
  - data analysis
  - fault recovery
- interface to monitor and control network
- translate manager's requirements into monitoring and control of remote elements
- data base of network management information extracted from managed entities

Management Agent

- equip key platforms with agent software
  - e.g. hosts, bridges, hubs, routers
- allows their management by management station
- respond to requests for information
- respond to requests for action
- asynchronously supply unsolicited information

Management Information Base (MIB)

- representation of network resources as objects
- each object a variable representing one aspect of managed object
- MIB is collection of access points at agent for management of station
- objects standardized across class of system
  - bridge, router etc.
- management station
  - retrieves values of MIB objects to provide monitoring
  - sets MIB object values to change configuration

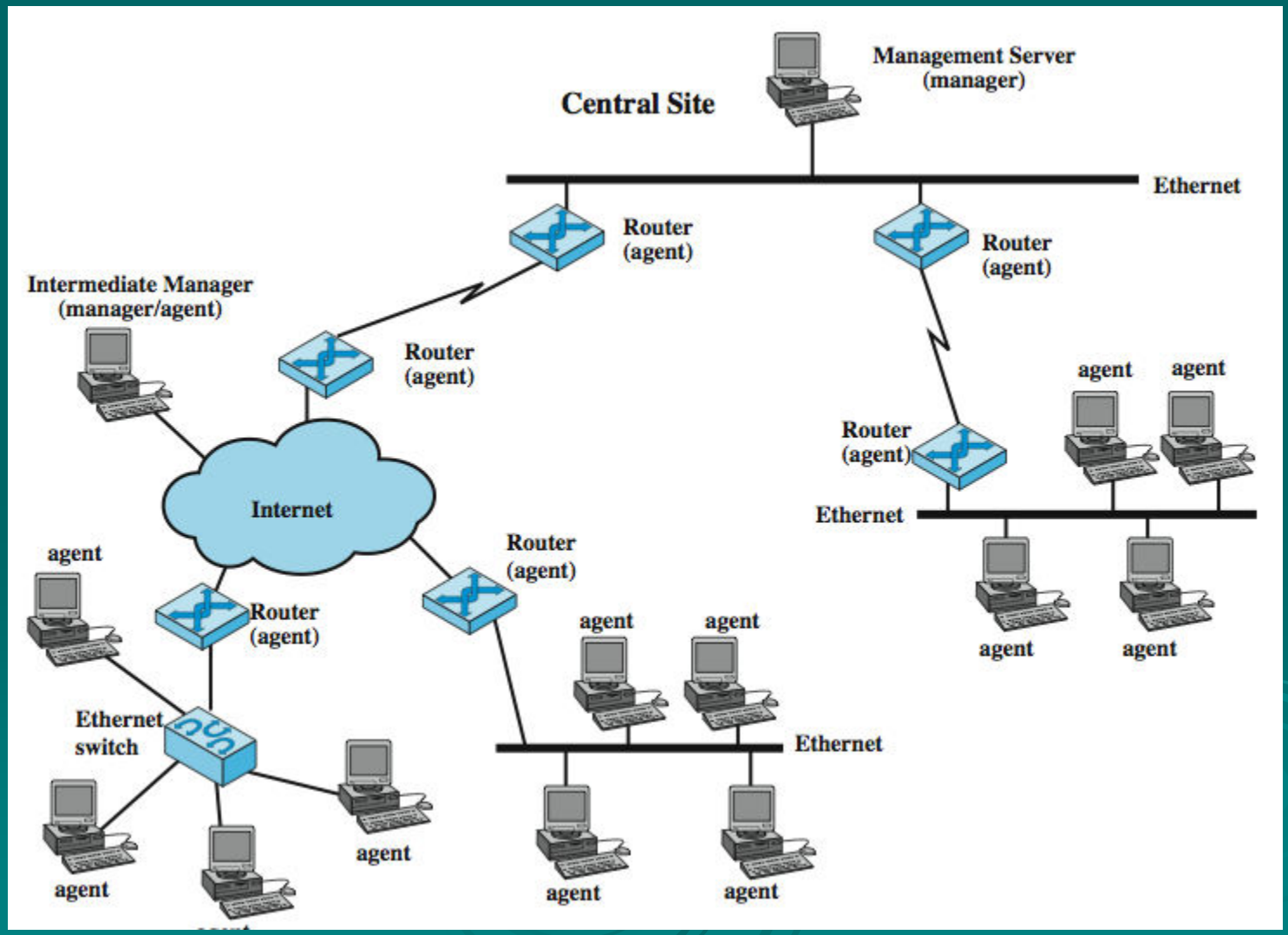
Network Management Protocol

- link between management station & agent
  - TCP/IP uses SNMP
  - OSI uses Common Management Information Protocol (CMIP)
  - SNMPv2 (enhanced SNMP) for OSI & TCP/IP
- key capabilities
  - get - management station retrieves value
  - set - management station sets value
  - notify - agent sends event notification

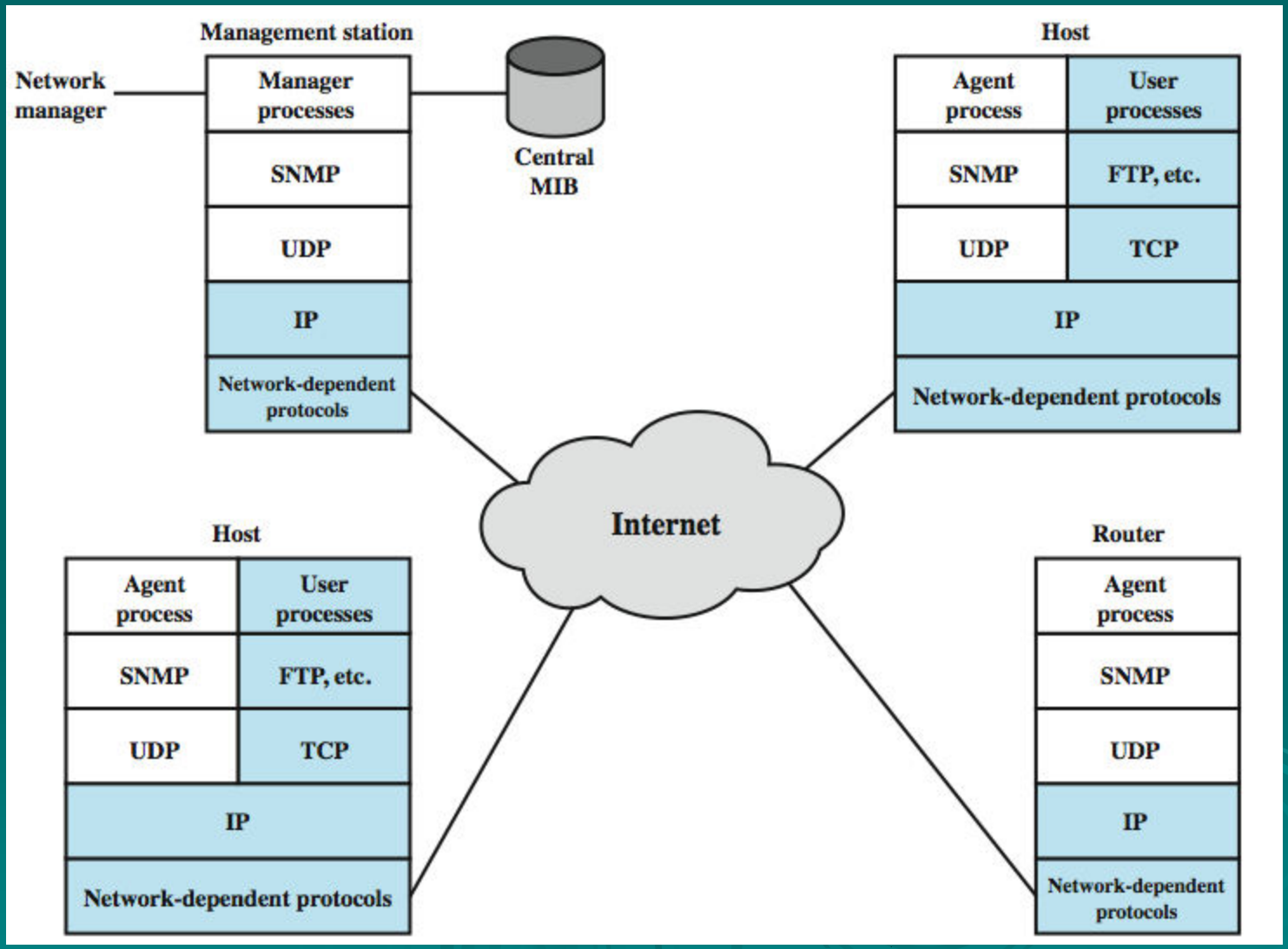
Management Layout

- may be centralized in simple network
- may be distributed in large, complex network
  - multiple management servers
  - each manages pool of agents
  - management may be delegated to intermediate manager

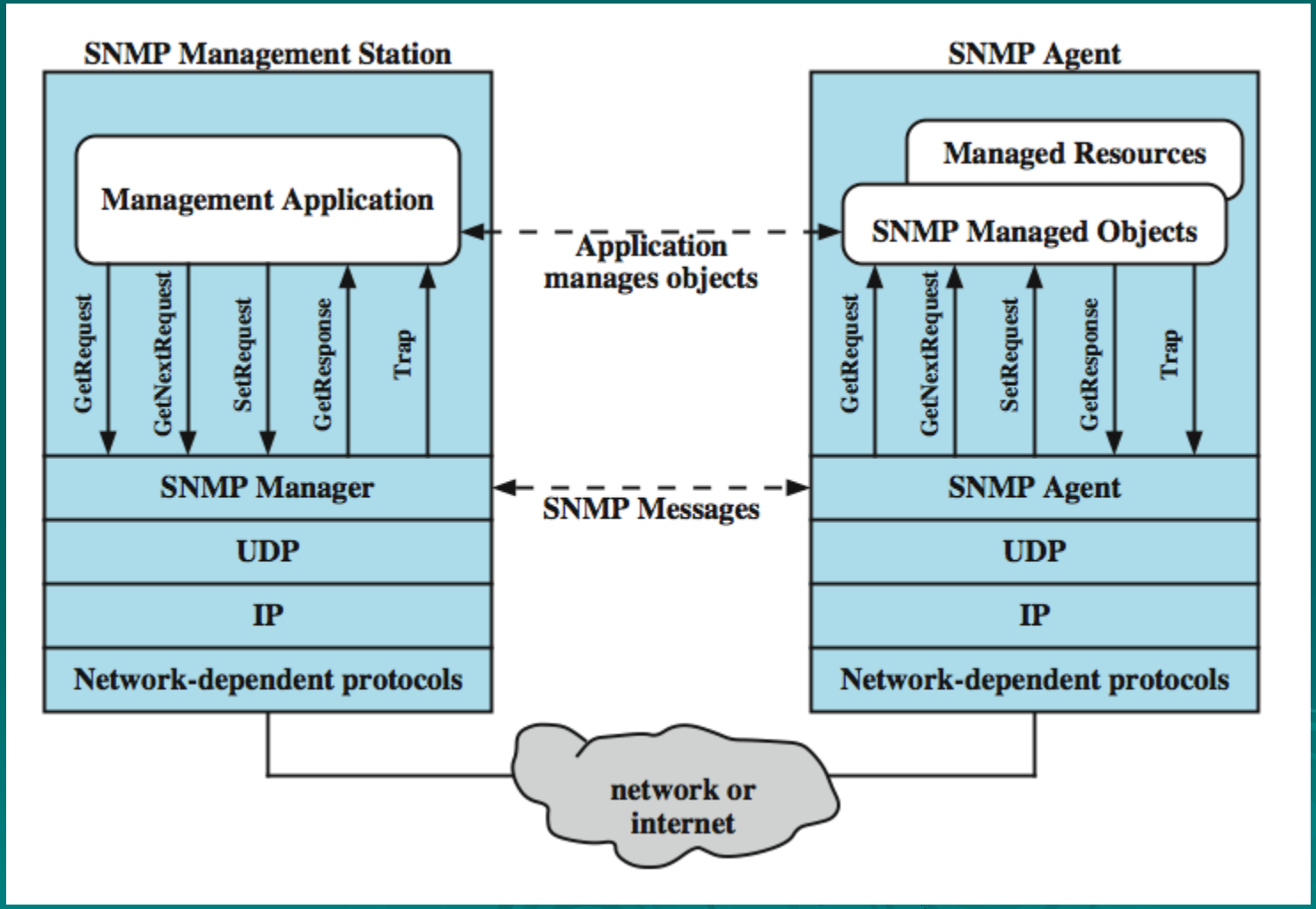
Distributed Network Management Example



SNMP Architecture



SNMP Architecture



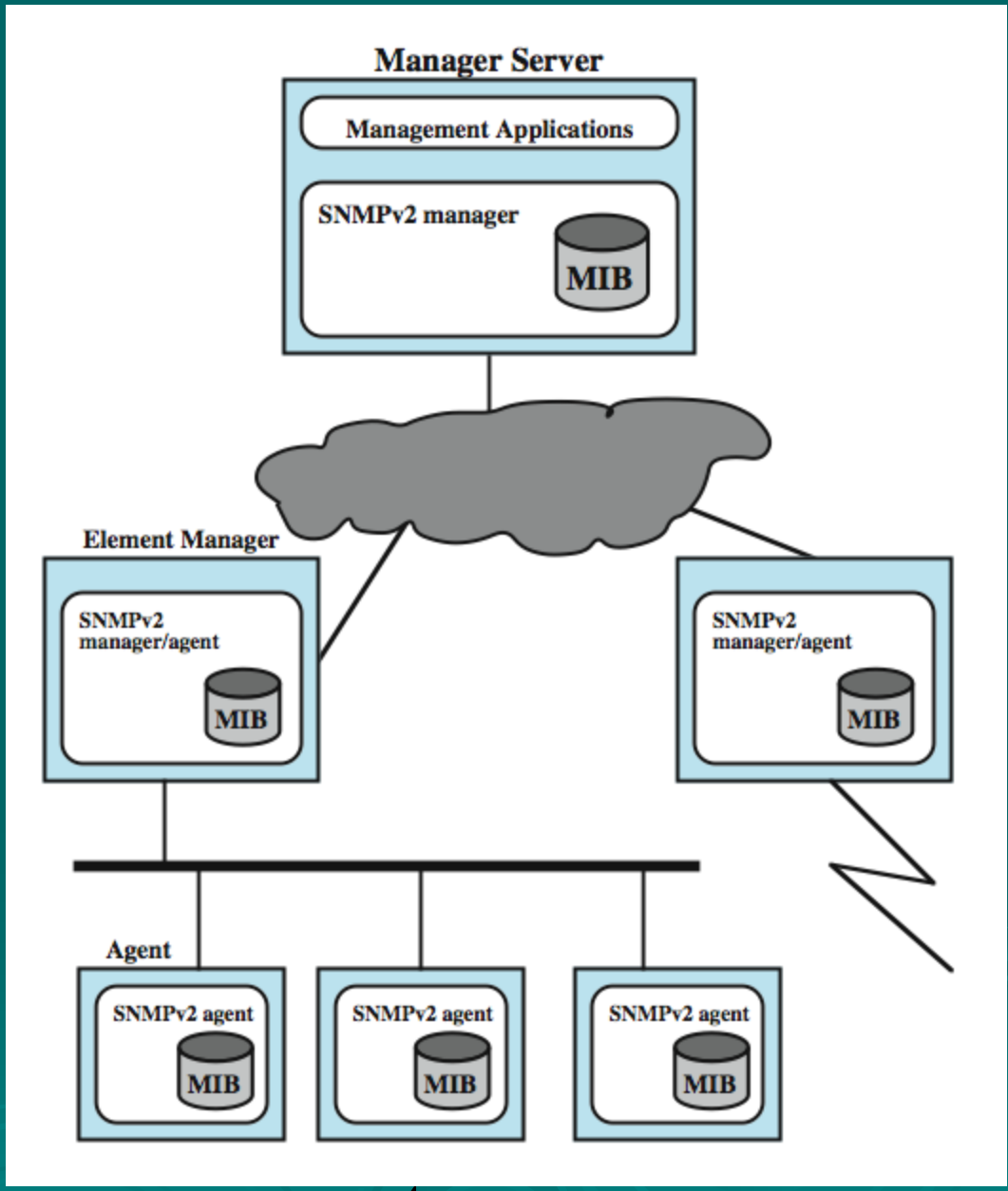
SNMP v1

- August 1988 SNMP specification issued
- stand alone management stations and bridges, routers workstations etc supplied with agents
- defines limited, easily implemented MIB of scalar variables and two dimensional tables
- streamlined protocol
- limited functionality
- lack of security
- SNMP v2 1993, revised 1996
  - RFC 1901-1908

Network Management Framework

- have framework on which network management applications can be built
  - e.g fault management, performance monitoring, accounting
- management protocol is used to exchange management information
  - e.g. SNMP v1 & v2
- each player maintains local MIB
- at least one system responsible for management
  - houses management applications

Exmple SNMP v2 Managed Config



SNMP v2

- support central or distributed management
- in distributed system, some elements operate as manager and agent
- exchanges use SNMP v2 protocol
  - simple request/response protocol
  - typically uses UDP
    - ongoing reliable connection not required
    - reduces management overhead

Structure of Management Information (SMI)

- defines general framework with which MIB defined and constructed
  - identifies data types
  - how resources are represented and named
- encourages simplicity and extensibility
  - has scalars and two dimensional arrays of scalars (tables) only
- three key elements:
  - data types, objects, object identifiers

SNMP v2 PDU Formats

Das Bild kann zurzeit nicht angezeigt werden.

SNMP v3

- addresses security issues of SNMP v1/2
- RFC 2570-2575
- proposed standard January 1998
- defines overall architecture and security capability
- to be used with SNMP v2
- defines three security services
  - authentication
  - privacy
  - access control

SNMP v3 Services

- authentication assures that message is:
  - from identified source, not altered, not delayed or replayed
  - includes HMAC message authentication code
- privacy
  - encrypts messages using DES
- access control
  - pre configure agents to provide a number of levels of access to MIB for different managers
  - restricting access to information
  - limit operations

Summary

- electronic mail
  - SMTP (RFC821) mail exchange
  - RFC822 & MIME mail content formats
- network management
  - elements and operation of SNMP v1, 2 & 3