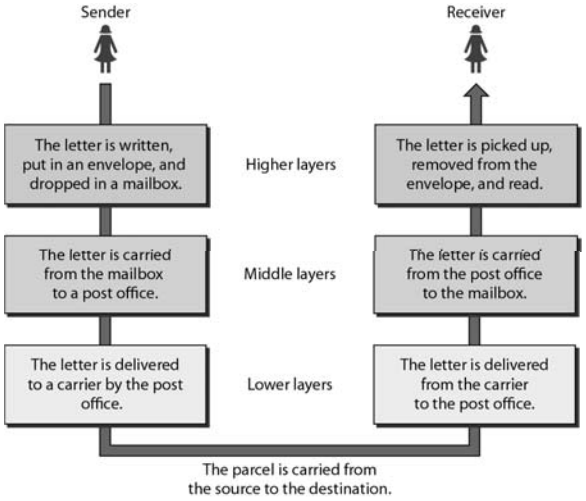
Chapter 2
Network Models

Jirasak Sittigorn
Department of Computer Engineering
Faculty of Engineering
King Mongkut's Institute of Technology Ladkrabang

LAYERED TASKS

- Sender, Receiver, and Carrier
- Hierarchy



Tasks involved in sending a letter (Fig. 2.1)

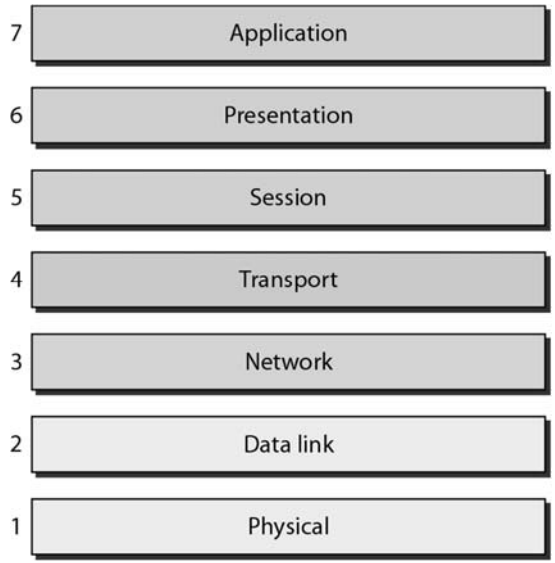
THE OSI MODEL

- History
- Layered Architecture
- Peer-to-Peer Processes
- Encapsulation

OSI Model

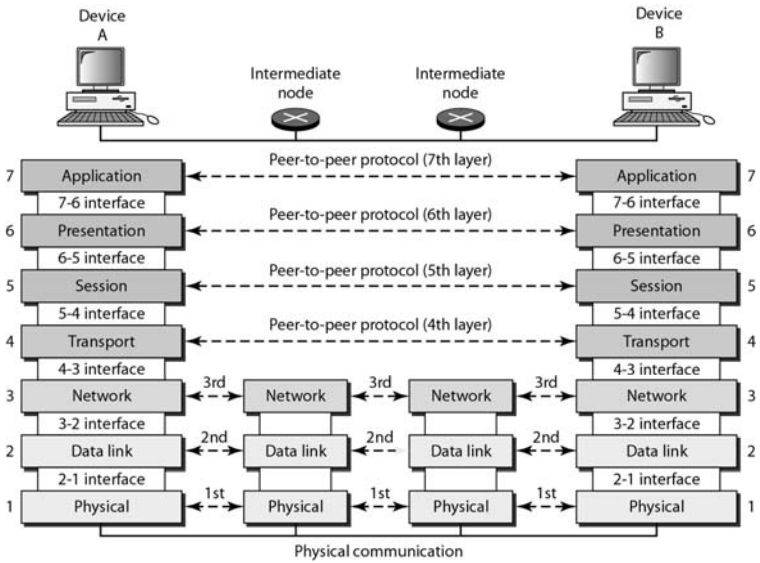
- History
  - 1970 -> ISO (International Organization for Standard)
    จัดตั้งคณะกรรมการพิจารณา architecture ที่เป็นกลางเพื่อกำหนดการเชื่อมต่อระหว่างคอมพิวเตอร์ และอุปกรณ์ต่างๆ
  - 1984 -> released in ISO 7498 document
    OSI (Open System Interconnection) -> 7 layers
- Objectives
  - Compatibility ความเข้ากันได้ของอุปกรณ์ต่างผู้ผลิตกัน
  - Flexibility มีความยืดหยุ่นต่อการเปลี่ยนแปลง เช่นการพัฒนาของเทคโนโลยี

Layered Architecture



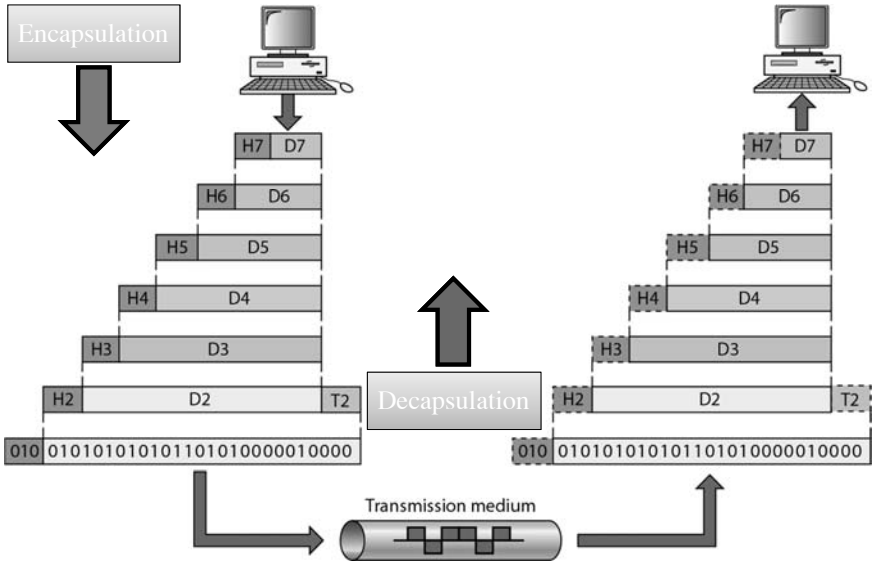
Seven layers of the OSI model (Fig. 2.2)

Peer-to-Peer Processes



The interaction between layers in the OSI model (Fig. 2.3)

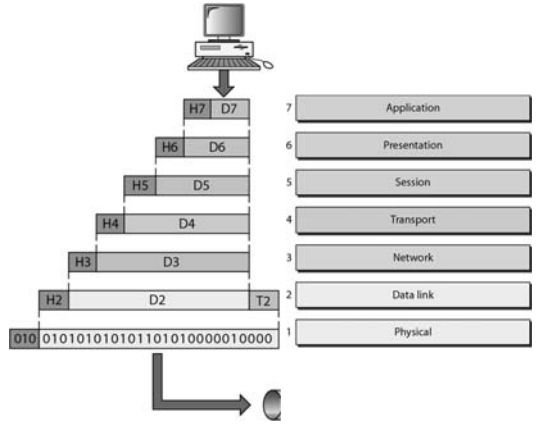
Encapsulation



An exchange using the OSI model (Fig. 2.4)

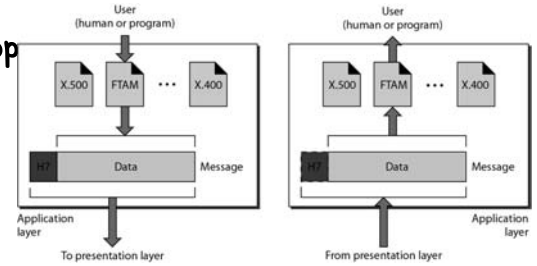
LAYERS IN THE OSI MODEL

- Physical Layer
- Data Link Layer
- Network Layer
- Transport Layer
- Session Layer
- Presentation Layer
- Application Layer
- Summary of Layers



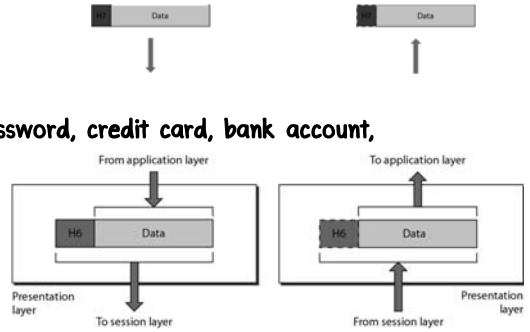
Application layer

- Responsibility
  - providing services to the user
  - User interface (Software app
  - No header or trailer
- Services
  - Network Virtual Terminal
  - File transfer, access, and management (FTAM)
  - Mail service
  - Accessing WWW



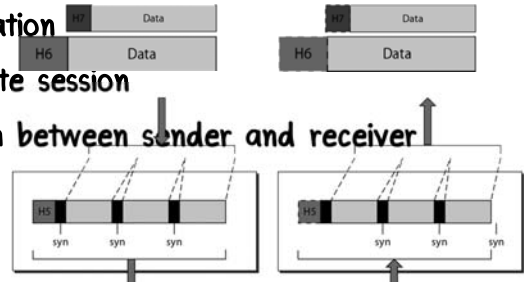
Presentation layer

- Responsibility
  - translation, compression, and encryption
  - Manage syntax (format) and semantics (format understanding) of different data format between any two systems
- Services
  - Translation of data format
    - Ex. ASCII -> non ASCII system
  - Encryption (privacy & security)
    - For sensitive information: login-password, credit card, bank account, personal information
  - Compression
    - Ex. Zip, Gif, JPEG



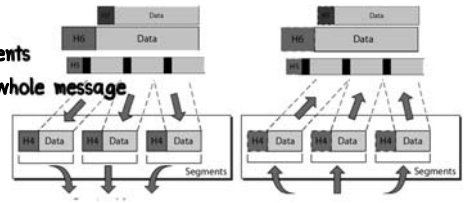
Session layer

- Responsibility
  - dialog control and synchronization
  - Establish, manage, and terminate session
  - Session = virtual communication between sender and receiver
- Services
  - Dialog control
  - Traffic control & direction control (Half duplex, Full duplex)
  - Message synchronization
  - Adding checkpoints (synchronization points) in the message stream



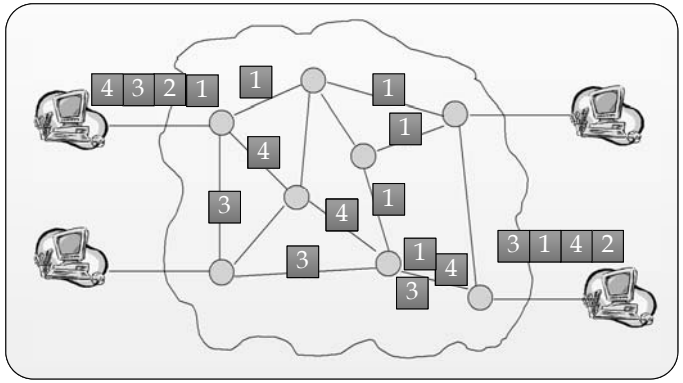
Transport layer

- Responsibility
  - delivery of a message from one process to another
  - Guarantee whole message delivery : From source to final destination
- Service
  - Service-point addressing: Port address (16 bits: 0 - 65,535 ports)
    - Each application is assigned a specific port address
  - Segmentation and Reassembly
    - Source : segment L5 data into small segments
    - Destination : reassembly small segments into a whole message
  - Connection control
    - Connectionless
    - Connection-oriented
  - Error control : error detection and correction of the entire message
  - Flow control



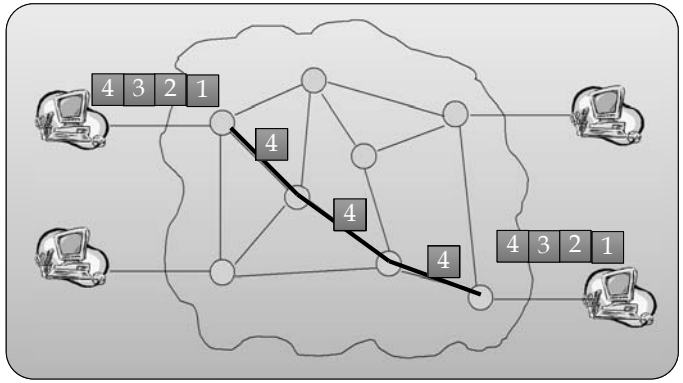
Transport layer

- Connection Control
  - Connectionless



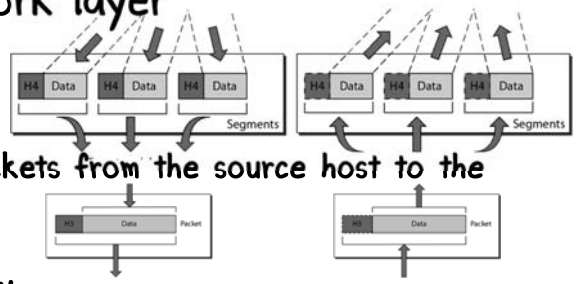
Transport layer

- Connection Control
  - Connection-oriented



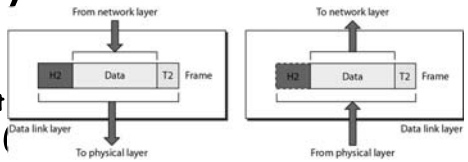
Network layer

- Responsibility
  - delivery of individual packets from the source host to the destination host
  - Guarantee packet delivery
- Service
  - Logical (Network) address (header): IP address
  - Routing packets through internetworking device
  - Router || Gateway



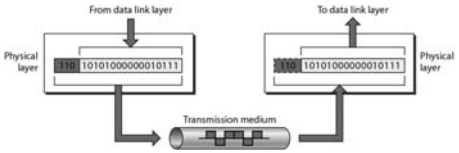
Data link layer

- Responsibility
  - moving frames from one hop (node) to the next
  - Break L3 (Network) data into reasonable size (
  - Guarantee Node-to-Node delivery (Frame Error Free)
- Service
  - Framing (adding header & trailer)
  - Physical addressing (MAC address: 12 digit hexadecimal (e.g. 080BF0AFDC09))
    - Same sender network : source & destination address
    - Outside sender network : source & connecting devices (bridge, router, gateway) address
  - Flow control: frame acknowledgement, inform buffer size, etc.
  - Error control: error detection and error correction
  - Access control: checking accessibility (ex. Multipoint connection)

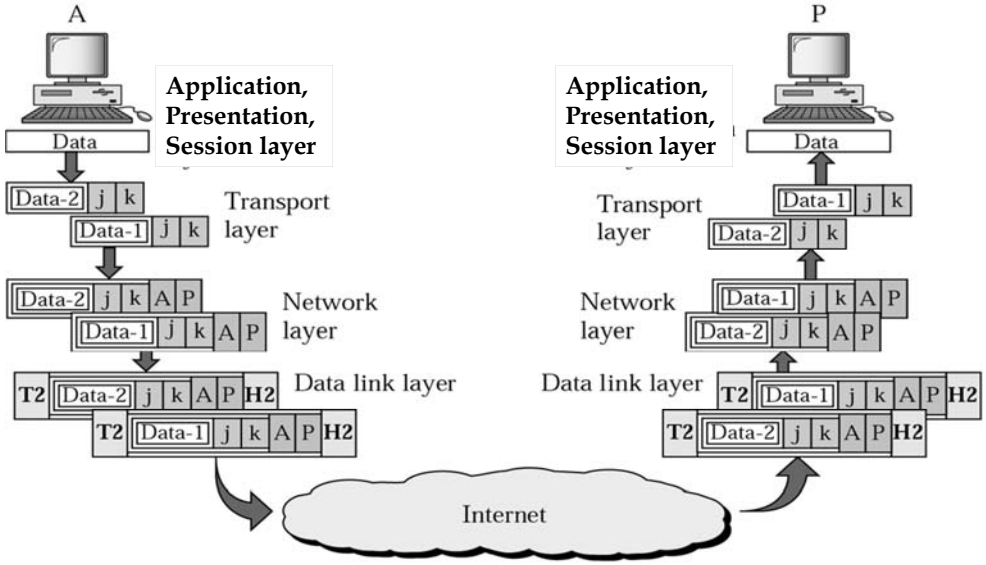


Physical layer

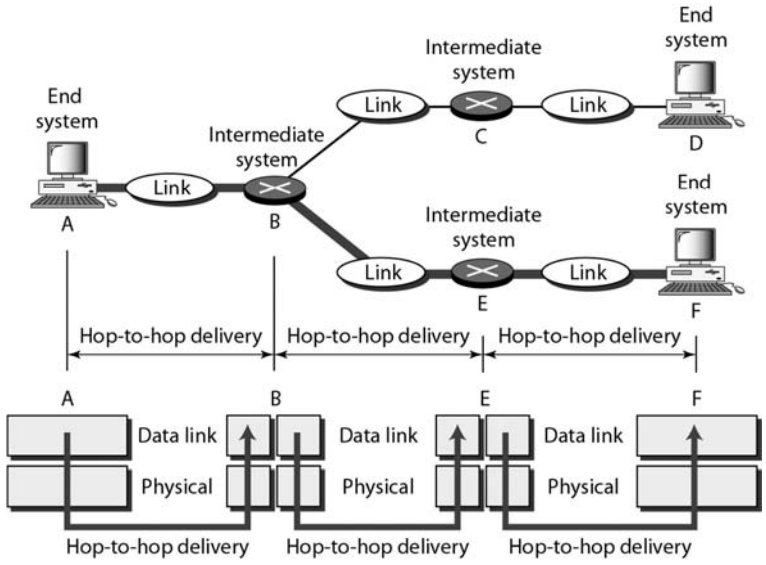
- Responsibility
  - movements of individual bits from one hop (node) to the next
  - Sending and receiving bitstream through physical medium
- Service
  - Physical characteristics of interface and medium
  - Representation of bits (encoding or modulation)
  - Data rate
  - Bit synchronization
  - Line configuration & Topology
  - Transmission mode (Simplex, Half-duplex, Full-duplex)



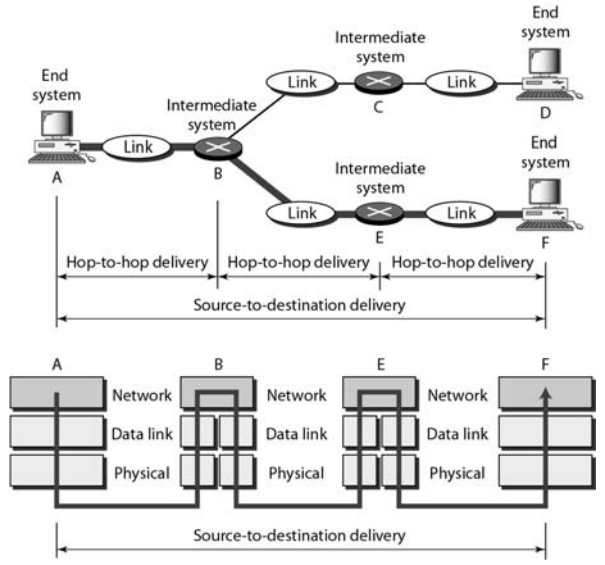
Transport and Network Layer Example



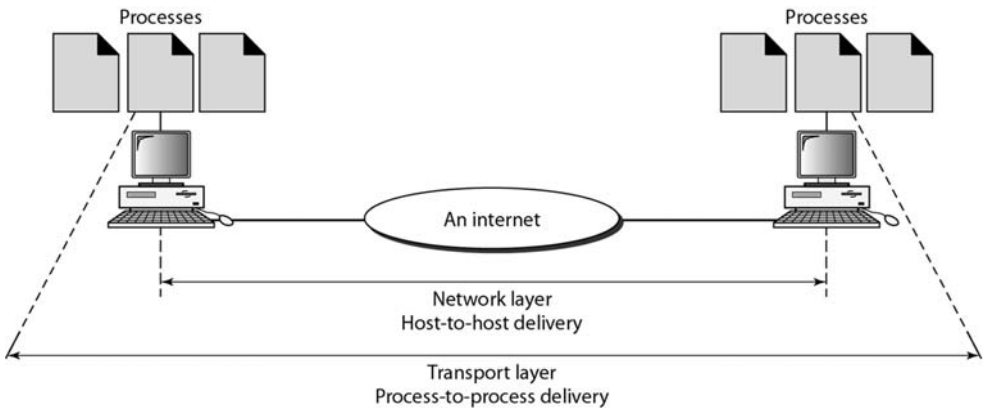
Hop-to-hop delivery (Fig. 2.7)



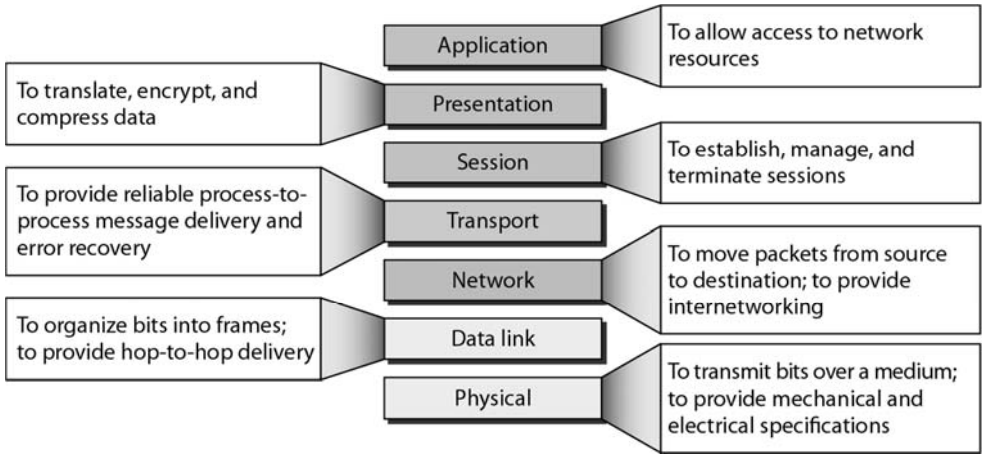
Source-to-destination delivery (Fig. 2.9)



Reliable process-to-process delivery of a message (Fig. 2.11)



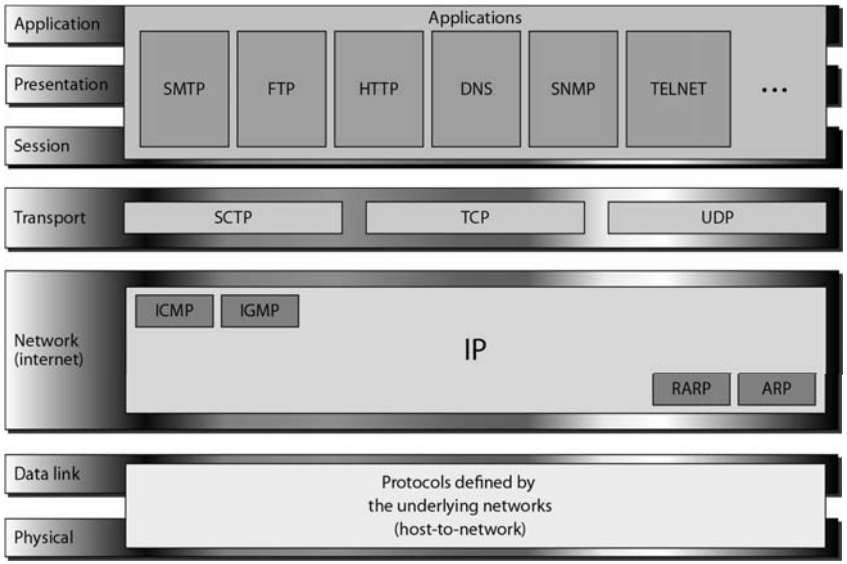
Summary of layers (Fig. 2.15)



TCP/IP PROTOCOL SUITE

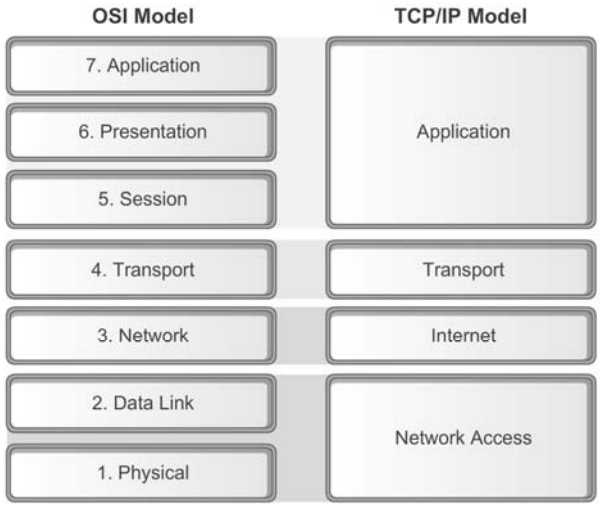
- Physical and Data Link Layers
- Network Layer
- Transport Layer
- Application Layer

TCP/IP and OSI model (Fig. 2.16)



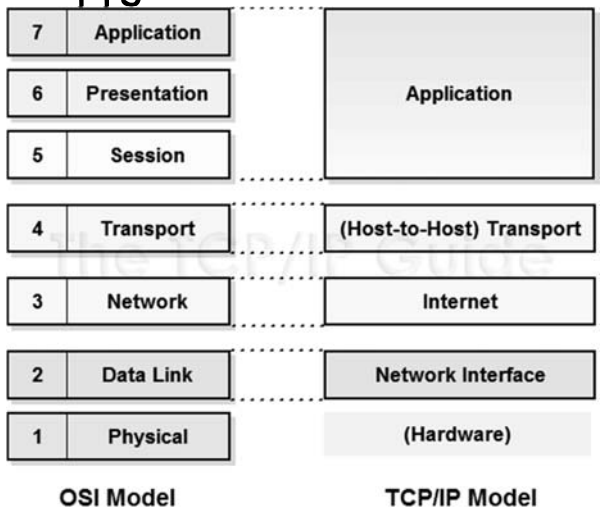
Comparison of OSI and TCP/IP

- https://www.netacad.com/



Comparison of OSI and TCP/IP

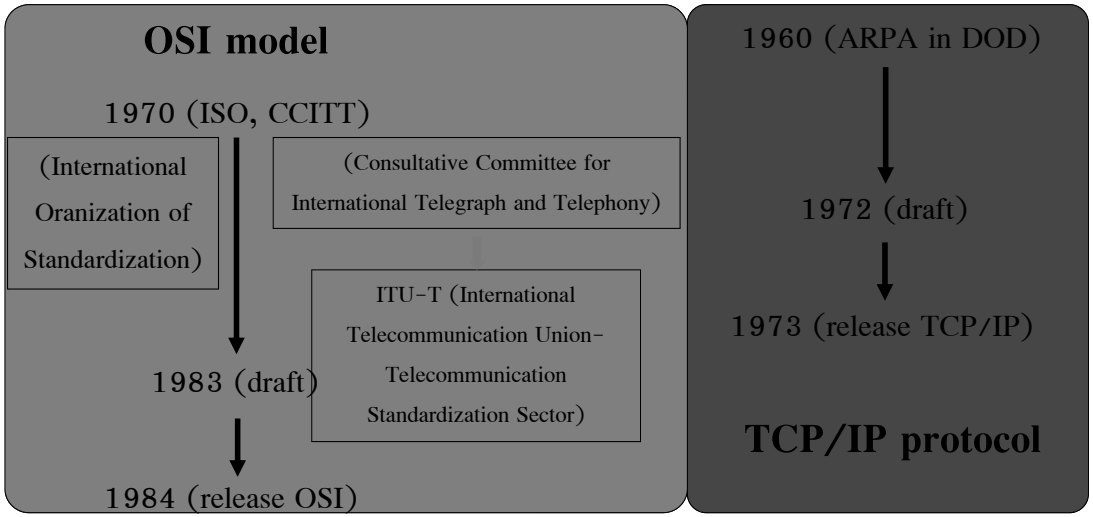
- http://www.tcpipguide.com



OSI model and TCP/IP protocol

ARPA: Advanced Research Projects Agency

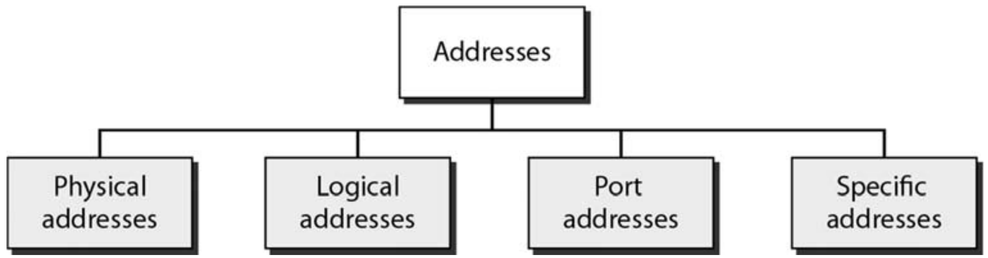
DOD : Department Of Defense



ADDRESSING

- Physical Addresses
- Logical Addresses
- Port Addresses
- Specific Addresses

Addresses in TCP/IP (Fig. 2.17)



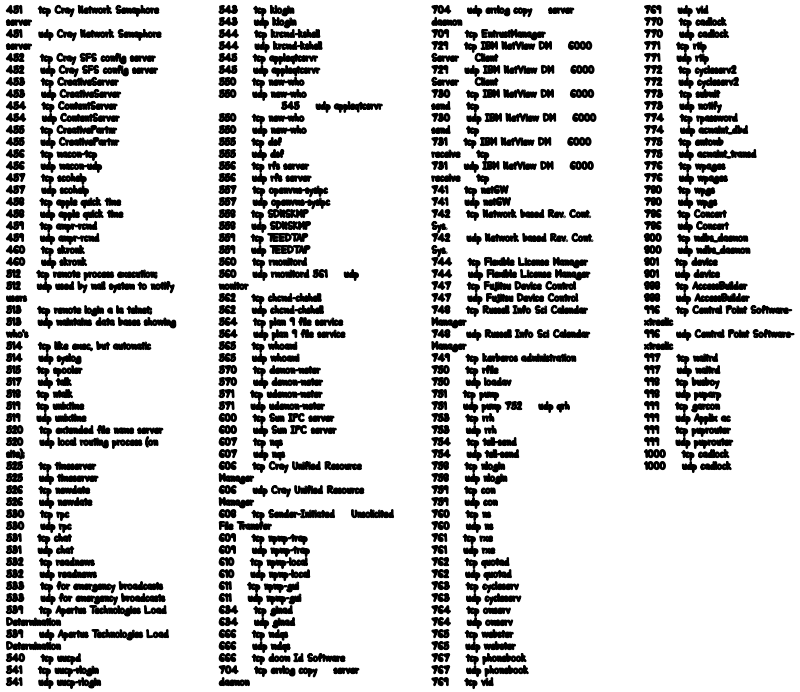
Port Address

- Handy way for computers and users to keep track of which port belongs to what program
- Ports are numbered from 0 to 65,535
  - The Internet Assigned Numbers Authority (IANA) decided to reserve the first 1024 port numbers (i.e., 0 to 1023) for requesting entities.
  - Ports 1024 - 49,151 : registered port numbers
  - Ports 49,152 - 65,535: dynamic or private port numbers
- General ways to use port number for source and destination
  - Well-known port numbers -> usually for destination port
  - Ramdomly generate -> for source port

well known Ports

0 tcp Reserved
0 udp Reserved
1 tcp TCP Port Service Multiplexer
2 tcp Management Utility
3 tcp Compression Process
5 tcp Remote Job Entry
7 tcp Echo
7 udp Echo
9 tcp Discard
9 udp Discard
11 tcp Active Users
11 udp Active Users
13 tcp Daytime
13 udp Daytime
17 tcp Quote of the Day
17 udp Quote of the Day
18 tcp RWP rwrite
18 udp RWP rwrite
18 tcp Message Send Protocol
18 udp Message Send Protocol
19 tcp Character Generator
19 udp Character Generator
20 tcp File Transfer [Default Data]
21 tcp File Transfer [Control]
23 tcp Telnet
24 tcp any private mail system
24 udp any private mail system
25 tcp Simple Mail Transfer
27 tcp NSW User System FE
27 udp NSW User System FE
29 tcp MSG ICP
29 udp MSG ICP
31 tcp MSG Authentication
31 udp MSG Authentication
33 tcp Display Support Protocol
33 udp Display Support Protocol
35 tcp any private printer server
35 udp any private printer server
37 tcp Time
37 udp Time
38 tcp Route Access Protocol
38 udp Route Access Protocol
39 udp Resource Location Protocol
41 tcp Graphics
41 udp Graphics
42 udp Host Name Server
43 tcp Who Is
44 tcp MPM FLAGS Protocol
45 tcp Message Processing Module [recv]
46 tcp MPM [default send]
47 tcp NI FTP
47 udp NI FTP
48 tcp Digital Audit Daemon
48 udp Digital Audit Daemon
49 tcp Login Host Protocol
50 tcp Remote Mail Checking Protocol
50 udp Remote Mail Checking Protocol
51 udp IMP Logical Address Maintenance
52 tcp XNS Time Protocol
52 udp XNS Time Protocol
53 tcp Domain Name Server
53 udp Domain Name Server
54 tcp XNS Clearinghouse
54 udp XNS Clearinghouse
55 tcp ISI Graphics Language
55 udp ISI Graphics Language
56 tcp XNS Authentication
56 udp XNS Authentication
57 tcp any private terminal access
57 udp any private terminal access
58 tcp XNS Mail
58 udp XNS Mail
59 tcp any private file service
59 udp any private file service
60 tcp Unassigned
60 udp Unassigned
61 tcp NI MAIL
61 udp NI MAIL
62 tcp ACA Services
64 tcp Communications Integrator (CI)
65 tcp TACACS-Database Service
66 tcp Oracle SQL*NET
67 udp Bootstrap Protocol Server
68 udp Bootstrap Protocol Client
69 udp Trivial File Transfer
70 tcp Gopher
71 tcp Remote Job Service
71 udp Remote Job Service
72 tcp Remote Job Service
72 udp Remote Job Service
73 tcp Remote Job Service
73 udp Remote Job Service
74 tcp Remote Job Service
74 udp Remote Job Service
75 tcp any private dial out service
75 udp any private dial out service
76 tcp Distributed External Object Store
76 udp Distributed External Object Store
77 tcp any private RJE service
77 udp any private RJE service
78 tcp vettcp
78 udp vettcp
79 tcp Finger
80 tcp World Wide Web HTTP
80 tcp World Wide Web HTTP
81 tcp HOSTS2 Name Server
81 udp HOSTS2 Name Server
82 tcp XFER Utility
82 udp XFER Utility
83 tcp MIT ML Device
83 udp MIT ML Device
84 tcp Common Trace Facility
84 udp Common Trace Facility
85 tcp MIT ML Device
85 udp MIT ML Device
86 tcp Micro Focus Cobol
87 tcp any private terminal link
87 udp any private terminal link
88 tcp Kerberos
89 tcp SU MIT Telnet Gateway
90 tcp DNSIX Securit Attribute Token Map
91 tcp MIT Dover Spooler
92 tcp Network Printing Protocol
92 udp Network Printing Protocol
93 tcp Device Control Protocol
93 udp Device Control Protocol
94 tcp Tivoli Object Dispatcher
94 udp Tivoli Object Dispatcher
95 tcp SUPDUP
95 udp SUPDUP
96 tcp DIXIE Protocol Specification
97 tcp Swift Remote Virtural File Protocol
97 udp Swift Remote Virtural File Protocol
98 tcp TAC News
98 udp TAC News
99 tcp Metagram Relay
99 udp Metagram Relay
100 tcp [unauthorized use]
101 tcp NIC Host Name Server
101 udp NIC Host Name Server
102 tcp ISO-TSAP Class 0
102 udp ISO-TSAP Class 0
103 tcp Genesis Point-to-Point Trans Net
103 udp Genesis Point-to-Point Trans Net
104 tcp ACR-NEMA Digital Imag. & Comm. 300
105 tcp Mailbox Name Nameserver
105 udp Mailbox Name Nameserver
106 tcp 3COM-TSMUX
106 udp 3COM-TSMUX
106 tcp Password Server
107 tcp Remote Telnet Service
108 tcp SNA Gateway Access Server
109 tcp Post Office Protocol - Version 2
110 tcp Post Office Protocol - Version 3
111 tcp SUN Remote Procedure Call
111 udp SUN Remote Procedure Call
112 tcp McIDAS Data Transmission Protocol
113 tcp Authentication Service
114 tcp Audio News Multicast
114 udp Audio News Multicast
115 tcp Simple File Transfer Protocol
115 udp Simple File Transfer Protocol
116 tcp ANSA REX Notify
116 udp ANSA REX Notify
117 tcp UUCP Path Service
118 tcp SQL Services
118 udp SQL Services
119 tcp Network News Transfer Protocol
120 tcp CFDPTKT
120 udp CFDPTKT
121 tcp Encore Expedited Remote Pro.Call
121 udp Encore Expedited Remote Pro.Call
122 tcp SMAKYNET
122 udp SMAKYNET
123 tcp Network Time Protocol
123 udp Network Time Protocol
124 tcp ANSA REX Trader
124 udp ANSA REX Trader
125 tcp Locus PC-Interface Net Map Ser
126 tcp Unisys Unitary Login
126 udp Unisys Unitary Login
127 tcp Locus PC-Interface Conn Server
128 tcp GSS X License Verification
128 udp GSS X License Verification
129 tcp Password Generator Protocol
129 udp Password Generator Protocol
130 tcp cisco FNATIVE
130 udp cisco FNATIVE
131 tcp cisco TNATIVE
131 udp cisco TNATIVE
cisco-sys 132 tcp cisco SYSMAINT
cisco-sys 132 udp cisco SYSMAINT
133 tcp Statistics Service
133 udp Statistics Service
134 tcp INGRES-NET Service
135 tcp Location Service
135 udp Location Service
136 tcp PROFILE Naming System
137 tcp NETBIOS Name Service
137 udp NETBIOS Name Service
138 tcp NETBIOS Datagram Service
138 udp NETBIOS Datagram Service
139 tcp NETBIOS Session Service
139 udp NETBIOS Session Service
140 tcp EMFIS Data Service
140 udp EMFIS Data Service
141 tcp EMFIS Control Service
141 udp EMFIS Control Service
142 tcp Britton-Lee IDM
142 udp Britton-Lee IDM
143 tcp Interactive Mail Access Protocol v2
144 tcp NewS
144 udp NewS
145 tcp UAAC Protocol
145 udp UAAC Protocol
146 tcp ISO-IP0
146 udp ISO-IP0
147 tcp ISO-IP
147 udp ISO-IP
148 tcp CRONUS-SUPPORT
148 udp CRONUS-SUPPORT
149 tcp AED 512 Emulation Service
149 udp AED 512 Emulation Service
150 tcp SQL-NET
150 udp SQL-NET
151 tcp HEMS
152 tcp Background File Transfer Program
152 udp Background File Transfer Program
153 tcp SGMP
153 udp SGMP
154 tcp NETSC
154 udp NETSC
155 tcp NETSC
155 udp NETSC
156 tcp SQL Service
157 tcp KNET VM Command Message Protocol
158 tcp PCMail Server
159 tcp NSS-Routing
159 udp NSS-Routing
160 tcp SGMP-TRAPS
160 udp SGMP-TRAPS
161 udp SNMP
162 udp SNMPTRAP
163 tcp CMIP TCP Manager
163 udp CMIP TCP Manager
164 tcp CMIP TCP Agent
s164 udp CMIP TCP Agent
165 tcp Xerox
165 udp Xerox
166 tcp Sirius Systems
166 udp Sirius Systems
167 tcp NAMP
167 udp NAMP
168 tcp RSVD
168 udp RSVD 169 udp SEND
170 tcp Network PostScript
170 udp Network PostScript
171 tcp Network Innovations Multiplex
171 udp Network Innovations Multiplex
172 tcp Network Innovations CL 1
172 udp Network Innovations CL 1
173 tcp Xyplex
173 udp Xyplex
174 tcp MAILQ
174 udp MAILQ
175 tcp VMNET
175 udp VMNET
176 tcp GENRAD-MUX
176 udp GENRAD-MUX
177 udp X Display Manager Control Protocol
178 tcp NextStep Window Server
178 udp NextStep Window Server
179 tcp Border Gateway Protocol
180 tcp Intergraph
180 udp Intergraph

181 tcp Unify
181 udp Unify
182 tcp Unisys Audit SITP
182 udp Unisys Audit SITP
183 tcp OCBinder
183 udp OCBinder
184 tcp OCServer
184 udp OCServer
185 tcp Remote-KIS
185 udp Remote-KIS 186 tcp KIS Protocol
186 udp KIS Protocol
187 tcp Application Communication Interface
187 udp Application Communication Interface
188 tcp Plus Five's MUMPS
188 udp Plus Five's MUMPS
189 tcp Queued File Transport
190 tcp Gateway Access Control Protocol
190 udp Gateway Access Control Protocol
191 tcp Prospero Directory Service
192 tcp OSU Network Monitoring System
192 udp OSU Network Monitoring System
193 tcp Spider Remote Monitoring Protocol
193 udp Spider Remote Monitoring Protocol
194 udp Internet Relay Chat Protocol
195 tcp DNSIX Network Level Module Audit
196 tcp DNSIX Session Mgt Module Audit Redir
197 tcp Directory Location Service
197 udp Directory Location Service
198 tcp Directory Location Service Monitor
198 udp Directory Location Service Monitor
199 tcp SMUX
199 udp SMUX
200 tcp IBM System Resource Controller
200 udp IBM System Resource Controller
201 tcp AppleTalk Routing Maintenance
201 udp AppleTalk Routing Maintenance
202 tcp AppleTalk Name Binding
202 udp AppleTalk Name Binding
203 tcp AppleTalk Unused
203 udp AppleTalk Unused
204 tcp AppleTalk Echo
204 udp AppleTalk Echo
205 tcp AppleTalk Unused
205 udp AppleTalk Unused
206 tcp AppleTalk Zone Information
206 udp AppleTalk Zone Information
207 tcp AppleTalk Unused
207 udp AppleTalk Unused
208 tcp AppleTalk Unused
208 udp AppleTalk Unused
209 tcp Trivial Authenticated Mail Protocol
209 udp Trivial Authenticated Mail Protocol
210 tcp ANSI Z39.50
210 udp ANSI Z39.50
211 tcp Texas Instruments 914C 6 Terminal
211 udp Texas Instruments 914C 6 Terminal 212 udp ATEXSSTR
213 tcp IPX
213 udp IPX
214 tcp VM PWSCS
214 udp VM PWSCS
215 tcp Insignia Solutions
215 udp Insignia Solutions
216 tcp Access Technology License Server
217 tcp dBASE Unix
217 udp dBASE Unix
218 tcp Netix Message Posting Protocol
218 udp Netix Message Posting Protocol
219 tcp Unisys ARPs
219 udp Unisys ARPs
220 tcp Interactive Mail Access Protocol v3
221 tcp Berkeley rlogind with SPX auth
221 udp Berkeley rlogind with SPX auth
222 tcp Berkeley rshd with SPX auth
222 udp Berkeley rshd with SPX auth
223 tcp Certificate Distribution Center
223 udp Certificate Distribution Center
243 tcp Survey Measurement
243 udp Survey Measurement
245 tcp LINK
245 udp LINK
246 tcp Display Systems Protocol 3270
246 udp Display Systems Protocol 3270
344 tcp Prospero Data Access Protocol
345 tcp Perf Analysis Workbench
345 udp Perf Analysis Workbench
346 tcp Zebra server
347 tcp Fatmen Server
348 tcp Cabletron Management Protocol
348 udp Cabletron Management Protocol
371 tcp Clearcase
371 udp Clearcase
372 tcp Unix Listserv
372 udp Unix Listserv
373 tcp Legent Corporation
373 udp Legent Corporation
374 tcp Legent Corporation
374 udp Legent Corporation
375 tcp Hassle
375 udp Hassle
376 tcp Amiga Envoy Network Inquiry Proto
376 udp Amiga Envoy Network Inquiry Proto
377 tcp NEC Corporation
377 udp NEC Corporation
378 tcp NEC Corporation
378 udp NEC Corporation
379 tcp TIA EIA IS-99 modem client
380 tcp TIA EIA IS-99 modem server
381 tcp hp performance data collector
381 udp hp performance data collector
382 tcp hp performance data managed node
382 udp hp performance data managed node
383 tcp hp performance data alarm manager
383 udp hp performance data alarm manager
384 tcp A Remote Network Server System
384 udp A Remote Network Server System
385 tcp IBM Application
385 tcp IBM Application
386 tcp ASA Message Router Object Def.
386 udp ASA Message Router Object Def.
387 tcp Appletalk Update-Based Routing Pro.
387 udp Appletalk Update-Based Routing Pro.
388 tcp Unidata LDM Version 4
388 udp Unidata LDM Version 4
389 tcp Lightweight Directory Access Protocol
390 tcp UIS
390 udp UIS
391 tcp SynOptics SNMP Relay Port
391 udp SynOptics SNMP Relay Port
392 tcp SynOptics Port Broker Port
392 udp SynOptics Port Broker Port
393 tcp Data Interpretation System
393 udp Data Interpretation System
394 tcp EMBL Nucleic Data Transfer
394 udp EMBL Nucleic Data Transfer
395 tcp NETscout Control Protocol
395 udp NETscout Control Protocol
396 tcp Novell Netware over IP
396 udp Novell Netware over IP
397 tcp Multi Protocol Trans. Net.
397 udp Multi Protocol Trans. Net.
398 tcp Kryptolan
398 udp Kryptolan
399 tcp ISO-TSAP Class 2
399 udp ISO-TSAP Class 2
400 tcp Workstation Solutions
400 udp Workstation Solutions
401 udp Uninterruptible Power Supply
402 tcp Genie Protocol
402 udp Genie Protocol
403 tcp decap
403 udp decap
404 tcp nced
404 udp nced
405 tcp ncld
405 udp ncld
406 tcp Interactive Mail Support Protocol
406 udp Interactive Mail Support Protocol
407 tcp Timbuktu
408 tcp Prospero Resource Manager Sys. Man.
409 tcp Prospero Resource Manager Node Man.
410 udp DECLadebug Remote Debug Protocol
411 tcp Remote MT Protocol
411 udp Remote MT Protocol
412 tcp Trap Convention Port
412 udp Trap Convention Port
413 tcp SMSP
413 udp SMSP
414 tcp InfoSeek
414 udp InfoSeek
415 tcp BNet
415 udp BNet
416 tcp Silverplatter
416 udp Silverplatter
417 tcp Onmux
417 udp Onmux
418 tcp Hyper-G
419 tcp Ariel
420 udp SMPTE
421 tcp Ariel
422 tcp Ariel
423 tcp IBM Operations Planning and Control Start
424 tcp IBM Operations Planning and Control Track
425 tcp ICAD
426 tcp smartsdp
426 udp smartsdp
427 tcp Server Location
427 udp Server Location
428 tcp OCS_CMU
428 udp OCS_CMU
429 tcp OCS_AMU
429 udp OCS_AMU
430 tcp UTMPSD
430 udp UTMPSD
431 tcp UTMPCD
431 udp UTMPCD
432 tcp IASD
432 udp IASD
433 tcp NNSP
433 udp NNSP
434 tcp MobileIP-Agent
435 tcp MobilIP-MN
436 tcp DNA-CML
436 udp DNA-CML
437 tcp comscm
437 udp comscm
438 tcp dsfgw
438 udp dsfgw
439 tcp dasp Thomas Obermair
439 udp dasp tommy@inlab.m.eunet.de
440 tcp sgcp
440 udp sgcp
441 tcp decvms-sysmgt
442 tcp cvc_hostd
442 udp cvc_hostd
443 tcp https MCom
444 tcp Simple Network Paging Protocol
444 udp Simple Network Paging Protocol
445 udp Microsoft-DS
446 tcp DDM-RDB
446 udp DDM-RDB
447 tcp DDM-RFM
447 udp DDM-RFM
448 tcp DDM-BYTE
448 udp DDM-BYTE
449 tcp AS Server Mapper
449 udp AS Server Mapper
450 tcp TServer



IANA well-known reserved ports

Protocol Name	Port Number
FTP	20-data, 21
Telnet	23
SMTP	25
DNS	53
HTTP	80
POP3	110
NetBIOS	137-139

Sample port numbers for popular applications

Application	Port Number
MSN Messenger	1863
IRC	1863, 6666-6670, 7000
ICQ	4000-4001
ICQ	4000-4001
AOL Instant Messenger	5190, 6040
PCAnywhere	5631-5632
RealAudio	7070, 6970-7170
Napster	7777, 8875, 8888
Half-Life game	27,018

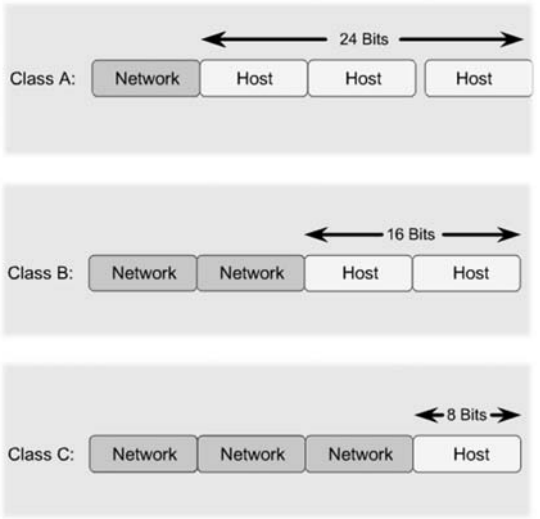
Common Windows port numbers

Protocol Name	Port Number
IE	80
POP3	110
RPC	135
NetBIOS	137-139
Server Message Block (SMB)	445
MSN Messenger	1863
Universal Plug and Play (UPnP)	5000

Logical Addresses : IP address (IPv4)

- IP Classes:
  - class A, B, C
- Class selection
  - Max. number of workstations required
- Each network
  - Must have a unique logical name (domain name)
  - Ex. www.ce.kmitl.ac.th is 161.246.4.119
- Each node or computer
  - Must have a unique host part of IP address

Logical Addresses : IP address (IPv4)



Logical Addresses : IP address (IPv4)

IP Address Class	High-OrderBits	First Octet Address Range	Number of Bits in theNetwork Address
Class A	0	0 - 127*	8
Class B	10	128 - 191	16
Class C	110	192 - 223	24
Class D	1110	224 - 239	28

Address Class	Number of Networks	Number of Hosts per Network
A	126*	16,777,216
B	16,384	65,535
C	2,097,152	254
D (Multicast)	N/A	N/A

Logical Addresses : IP address (IPv4)

IP Address Classes

Address Class	1st octet range (decimal)	1st octet bits (green bits do not change)	Network(N) and Host(H) parts of address	Default subnet mask (decimal and binary)	Number of possible networks and hosts per network
A	1-127**	00000000-01111111	N.H.H.H	255.0.0.0	128 nets (2^7) 16,777,214 hosts per net (2^24-2)
B	128-191	10000000-10111111	N.N.H.H	255.255.0.0	16,384 nets (2^14) 65,534 hosts per net (2^16-2)
C	192-223	11000000-11011111	N.N.N.H	255.255.255.0	2,097,150 nets (2^21) 254 hosts per net (2^8-2)
D	224-239	11100000-11101111	NA (multicast)		
E	240-255	11110000-11111111	NA (experimental)		

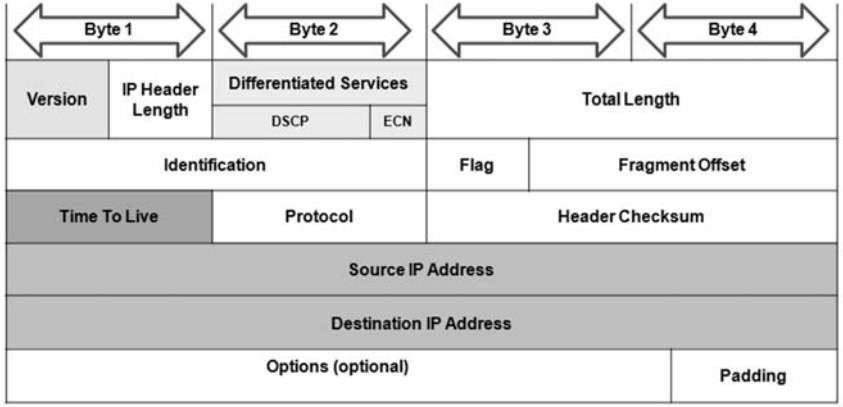
** All zeros (0) and all ones (1) are invalid hosts addresses.

Logical Addresses : IP address (IPv4)

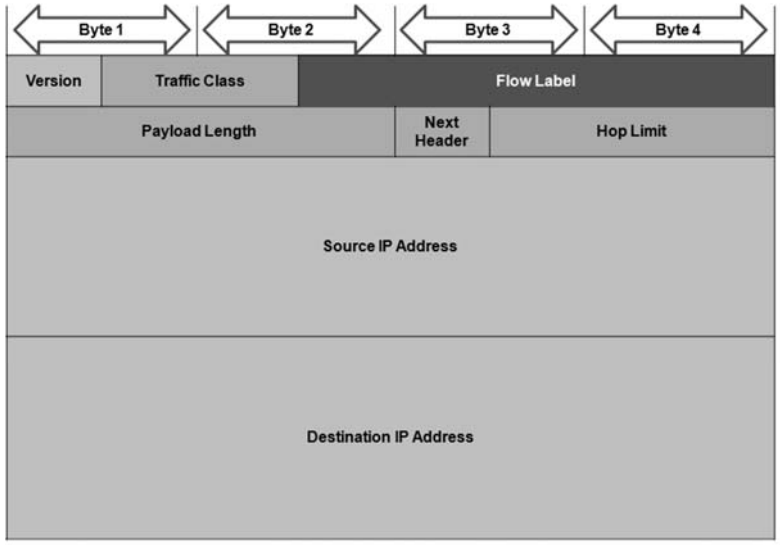
- Private addressing

Class	RFC 1918 Internal Address Range	CIDR Prefix
A	10.0.0.0 - 10.255.255.255	10.0.0.0/8
B	172.16.0.0 - 172.31.255.255	172.16.0.0/12
C	192.168.0.0 - 192.168.255.255	192.168.0.0/16

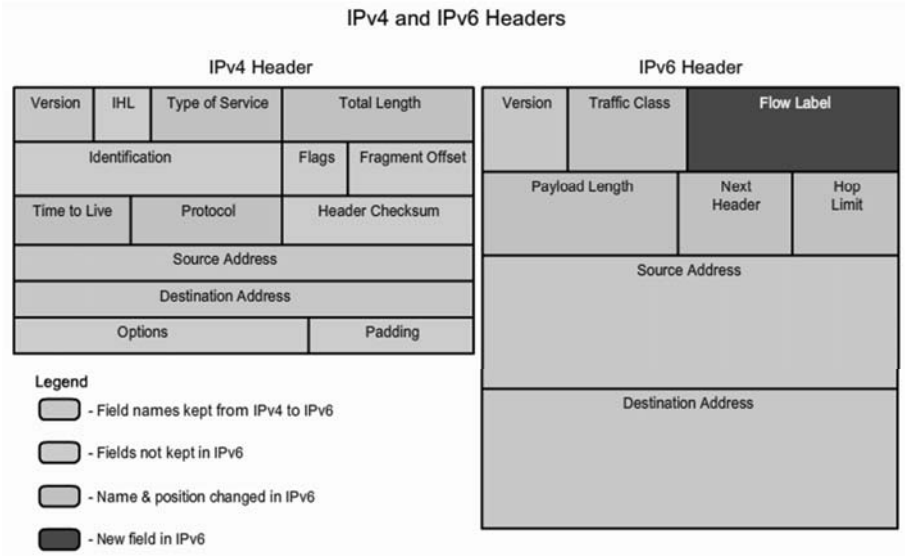
Logical Addresses : IP address (IPv4)



Logical Addresses : IP address (IPv6)



Logical Addresses : IP address

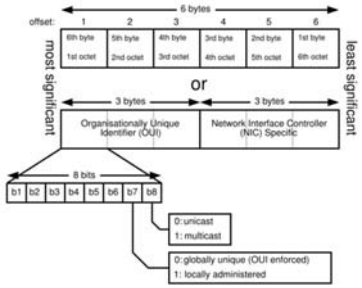


Physical Addresses : MAC Address

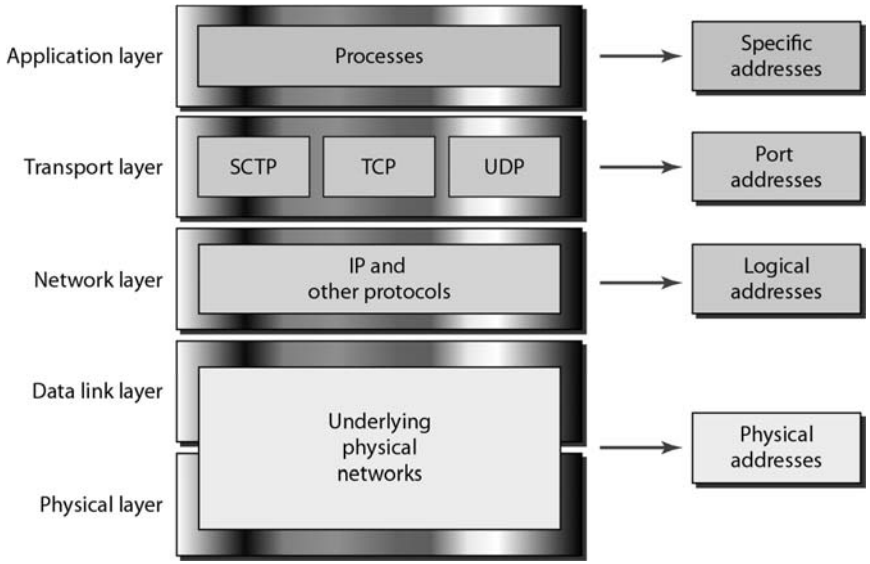
- ใน OSI Model นอกจากมี IP Address ที่ต้องตั้งค่าเพื่อทำให้อุปกรณ์สามารถเชื่อมต่อผ่านเครือข่ายคอมพิวเตอร์แล้วยังมี Address อีกประเภทที่ใช้งานในเครือข่ายได้แก่ Media Access Control Address
- MAC Address เป็น Address ที่อยู่ในลำดับชั้นการสื่อสารชั้นที่ 2 (Data Link Layer) ของ OSI Model
- สำหรับ MAC Address นั้นเป็น Address ที่ถูกกำหนดมาในตัว NIC ซึ่งมาจากโรงงานที่ผลิตออกมา ดังนั้นจึงไม่สามารถเปลี่ยนหมายเลข MAC Address ได้

Physical Addresses : MAC Address

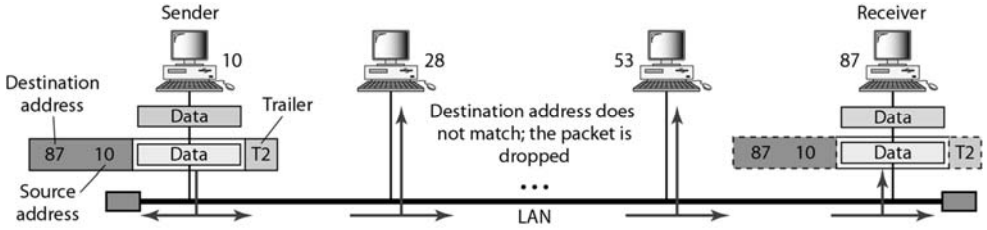
- ลักษณะของ MAC Address จะประกอบด้วยเลขฐานสองจำนวน 48 bit (6 byte) โดยแบ่งออกเป็น 6 ส่วน คั่นด้วย -
- การแสดงผล MAC Address จะแสดงเป็นเลขฐานสิบหก ดังนั้นจะเห็นเป็นเลขฐานสิบหกจำนวน 12 ตัว (เลขฐานสิบหก 6 คู่)
  - ตัวอย่างเช่น : 00-11-25-99-AF-44



Relationship of layers and addresses in TCP/IP (Fig. 2.18)



Physical addresses (Fig. 2.19)



Example 2.2

- As we will see in Chapter 13, most local-area networks use a 48-bit (6-byte) physical address written as 12 hexadecimal digits; every byte (2 hexadecimal digits) is separated by a colon, as shown below:

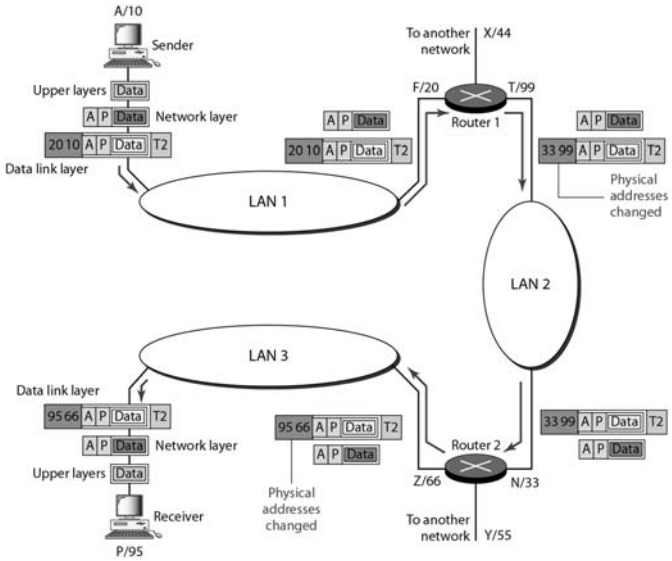
07:01:02:01:2C:4B

A 6-byte (12 hexadecimal digits) physical address.

Example 2.3

- Figure 2.20 shows a part of an internet with two routers connecting three LANs. Each device (computer or router) has a pair of addresses (logical and physical) for each connection. In this case, each computer is connected to only one link and therefore has only one pair of addresses. Each router, however, is connected to three networks (only two are shown in the figure). So each router has three pairs of addresses, one for each connection.

Figure 2.20 IP addresses



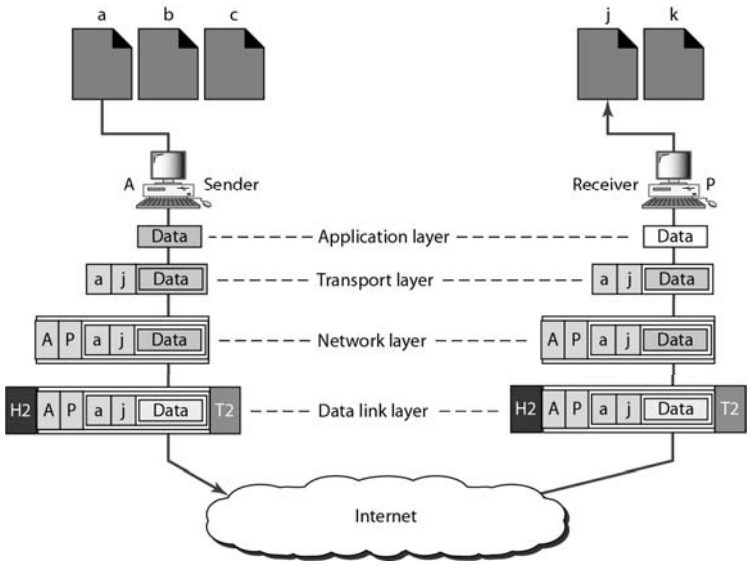
Note

- The physical addresses will change from hop to hop, but the logical addresses usually remain the same.

Example 2.4

- Figure 2.21 shows two computers communicating via the Internet. The sending computer is running three processes at this time with port addresses a, b, and c. The receiving computer is running two processes at this time with port addresses j and k. Process a in the sending computer needs to communicate with process j in the receiving computer. Note that although physical addresses change from hop to hop, logical and port addresses remain the same from the source to destination.

Figure 2.21 Port addresses



Example 2.5

- As we will see in Chapter 23, a port address is a 16-bit address represented by one decimal number as shown.

753

A 16-bit port address represented as one single number.

Note

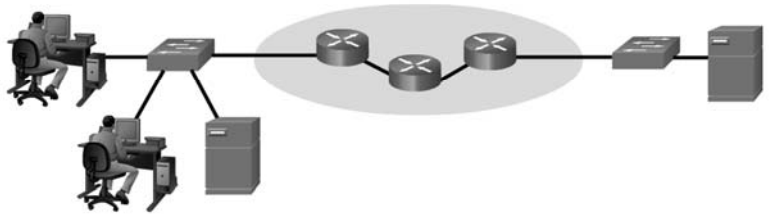
- The physical addresses change from hop to hop, but the logical and port addresses usually remain the same.

Communicating with Device / Same Network

Data Link Ethernet Frame Header — Network Layer IP Packet Header

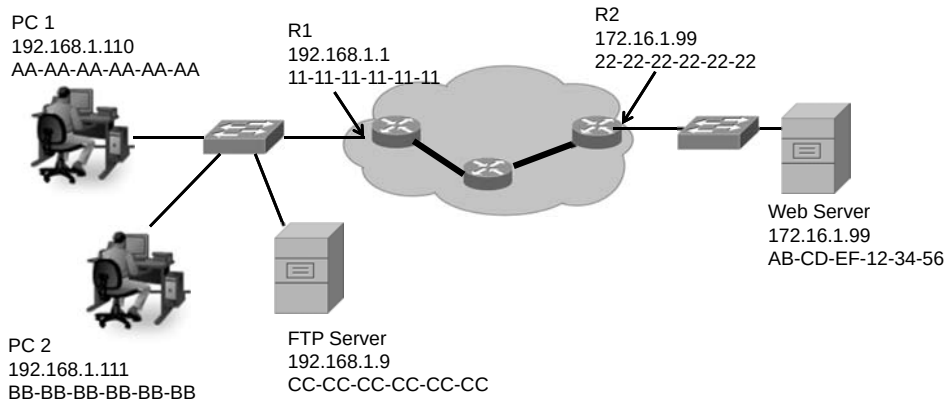
Destination	Source	Source		Destination		Source	Dest.	Data
CC-CC-CC-CC-CC-CC	AA-AA-AA-AA-AA-AA	Network 192.168.1.	Host 110	Network 192.168.1.	Host 9	???	21	

PC1
192.168.1.110
AA-AA-AA-AA-AA-AA



FTP Server
192.168.1.9
CC-CC-CC-CC-CC-CC

Default Gateway



Communicating Device / Remote Network

Data Link Ethernet Frame Header — Network Layer IP Packet Header

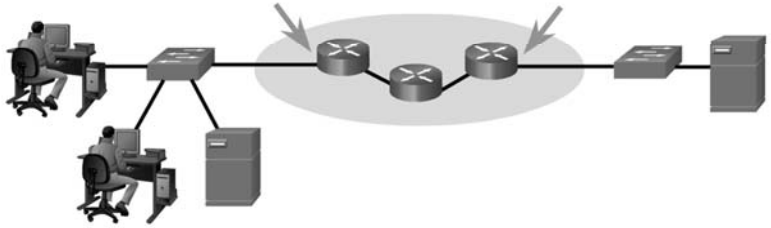
Destination	Source	Source		Destination		Source	Dest.	Data
11-11-11-11-11-11	AA-AA-AA-AA-AA-AA	Network 192.168.1.	Device 110	Network 172.16.1.	Device 99	???	80	

PC1
192.168.1.110
AA-AA-AA-AA-AA-AA

R1
192.168.1.1
11-11-11-11-11-11

R2
172.16.1.99
22-22-22-22-22-22

Web Server
172.16.1.99
AB-CD-EF-12-34-56



Activity

- ให้ นศ. แสดงลำดับ และรายละเอียดการสื่อสารระหว่างเครื่องคอมพิวเตอร์