COMP 3400 Mainframe Administration[1]

Christian Grothoff
christian@grothoff.org

http://grothoff.org/christian/

[1]These slides are based in part on materials provided by IBM's Academic Initiative.

Examples of Mainframe-based Networks

- ATM Cash withdrawal
- Credit purchase at a retail store or online
- Online banking

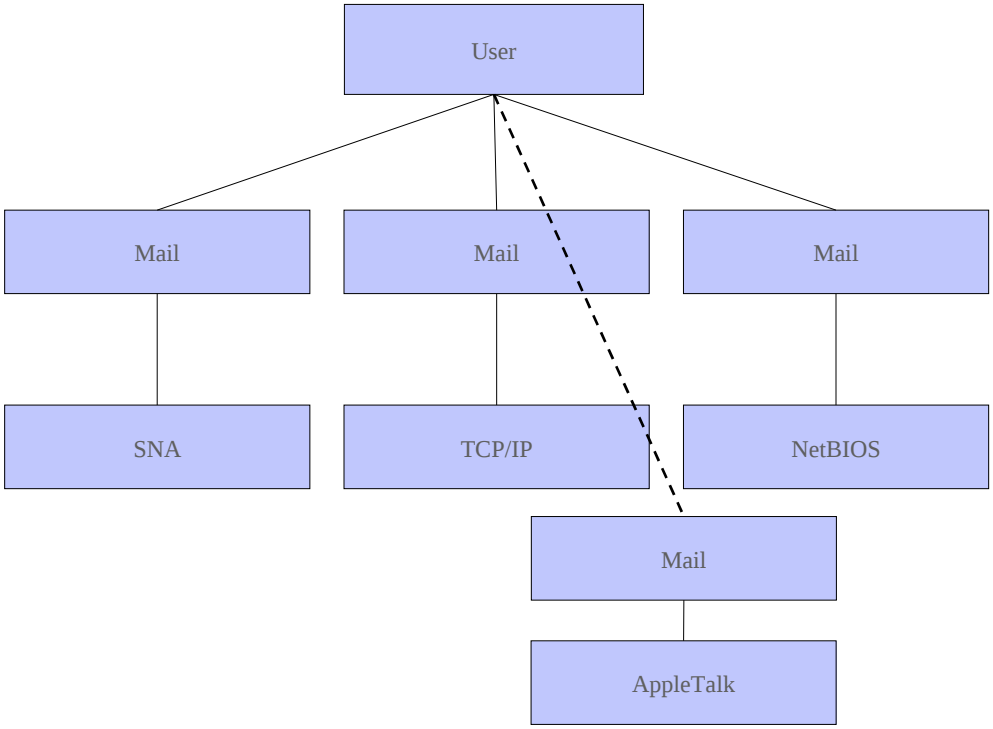
The Network Administrator

- Often separated into hardware and software
- Definition, maintenance and modification of the network
- Problem detection, isolation and correction
- Performance tuning
- Capacity planning
- Development of operational procedures
- Training of network operators

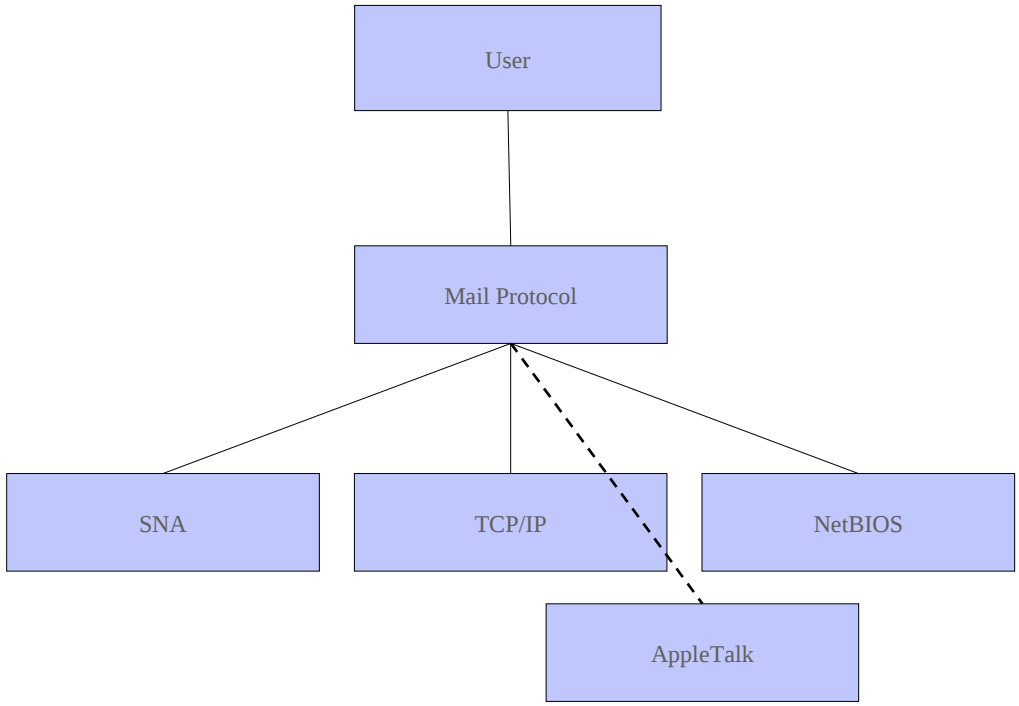
Elements of a Network

- Hardware (cables, routers, adapters)
- Software (OS, applications)
- Protocols (traffic rules)

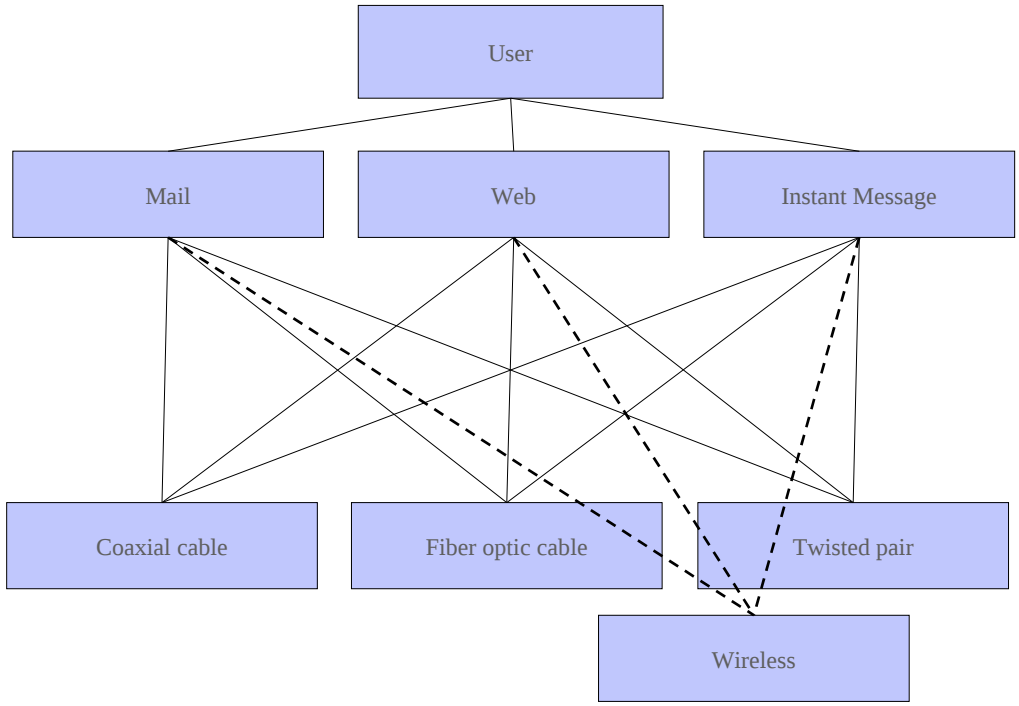
Without Boundaries



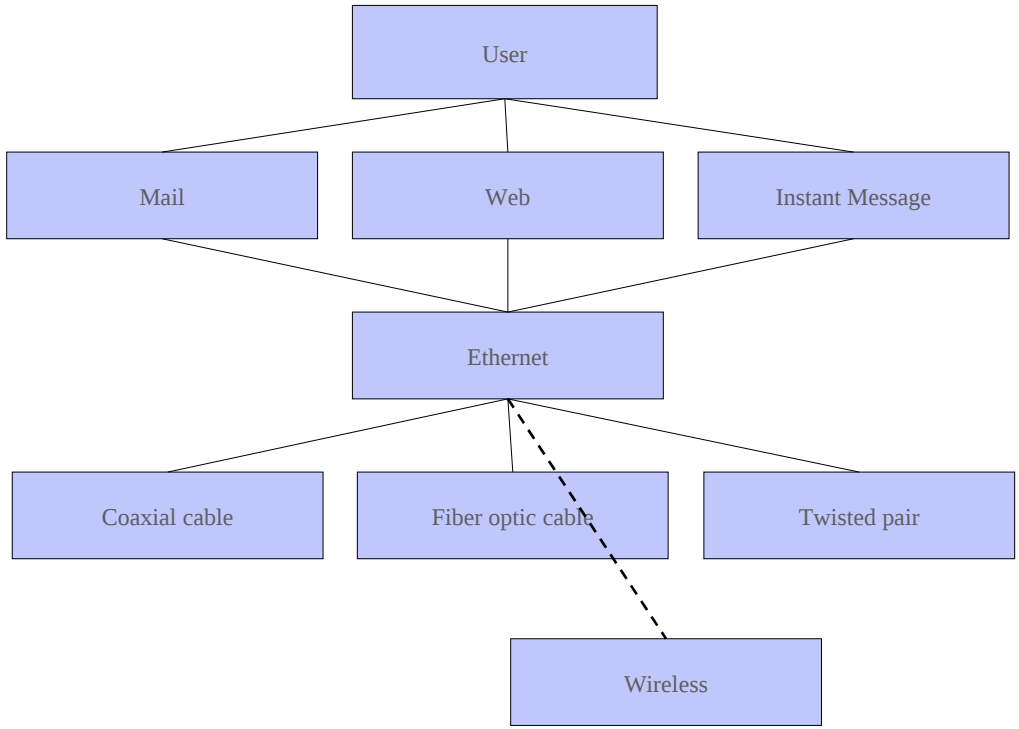
With Boundaries



Without Boundaries



With Boundaries



System z network capabilities

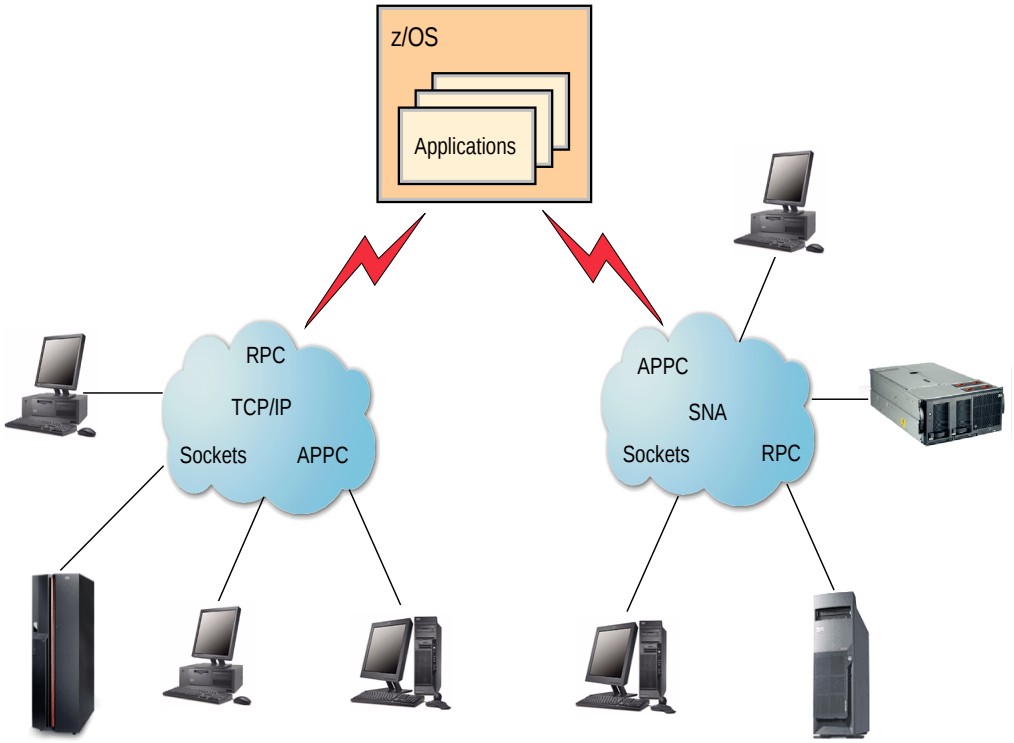
Internal:

- Guest machines (z/OS, GNU/Linux, CMS, ...)
- LPARs
- Clustering

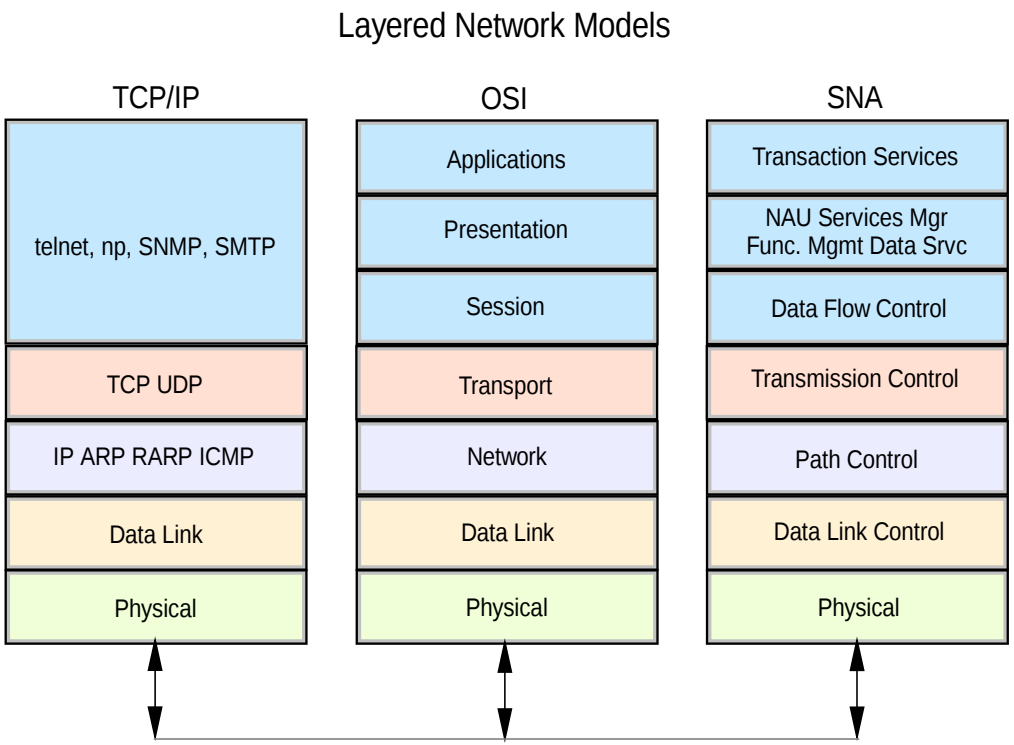
External:

- TCP/IP (software, hardware, protocols)
- Subarea System Network Architecture (SNA)
- Advanced Peer-to-Peer Networking
- Integration of SNA into IP networks (EE)

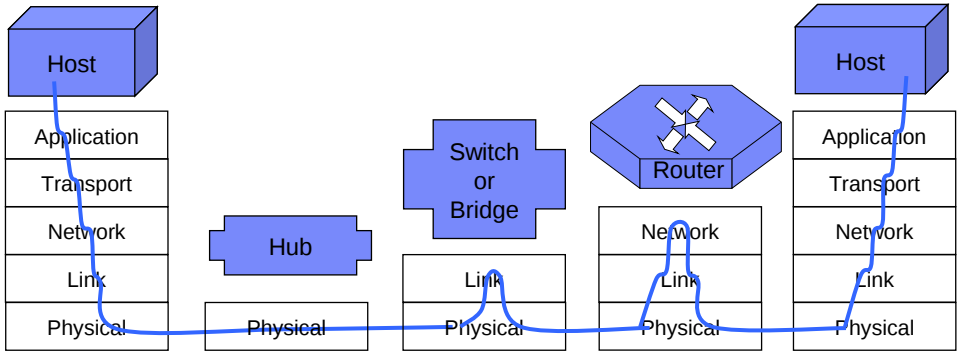
IBM Communications Server (z/OS)



Network Models

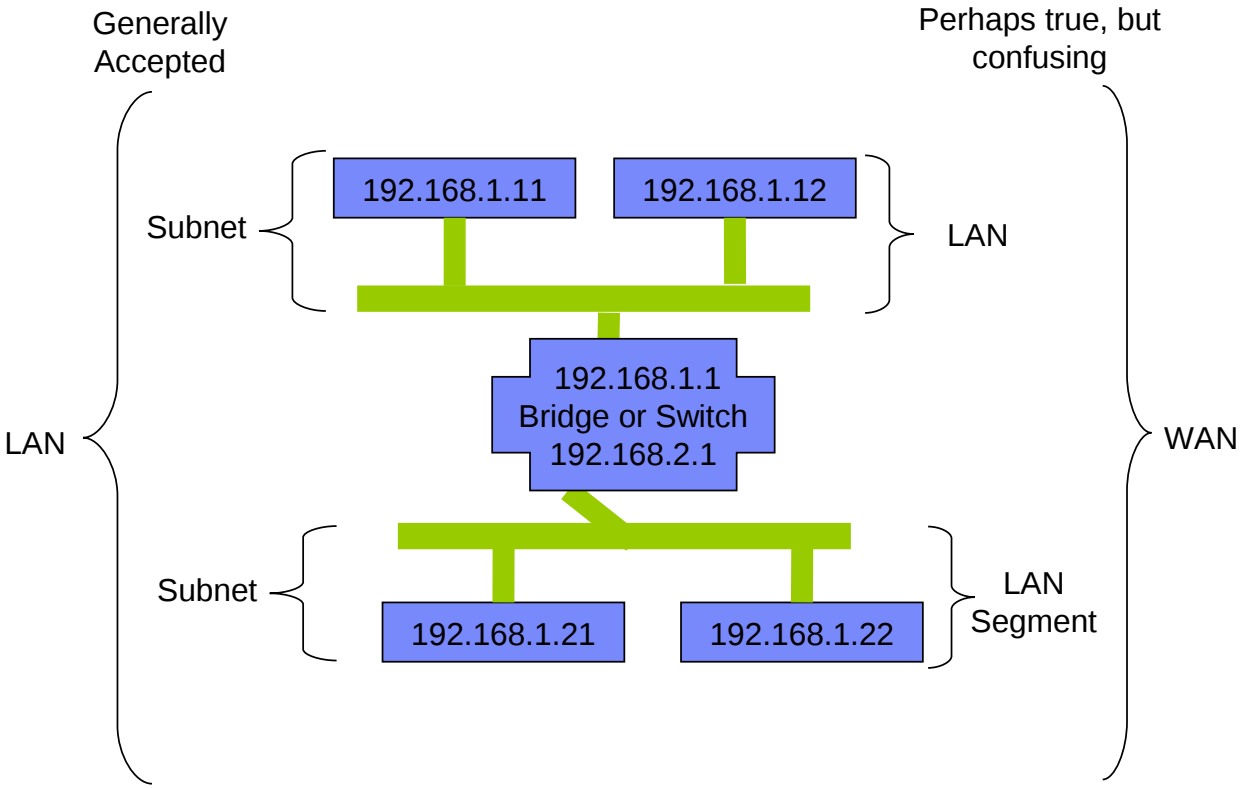


TCP/IP Hardware

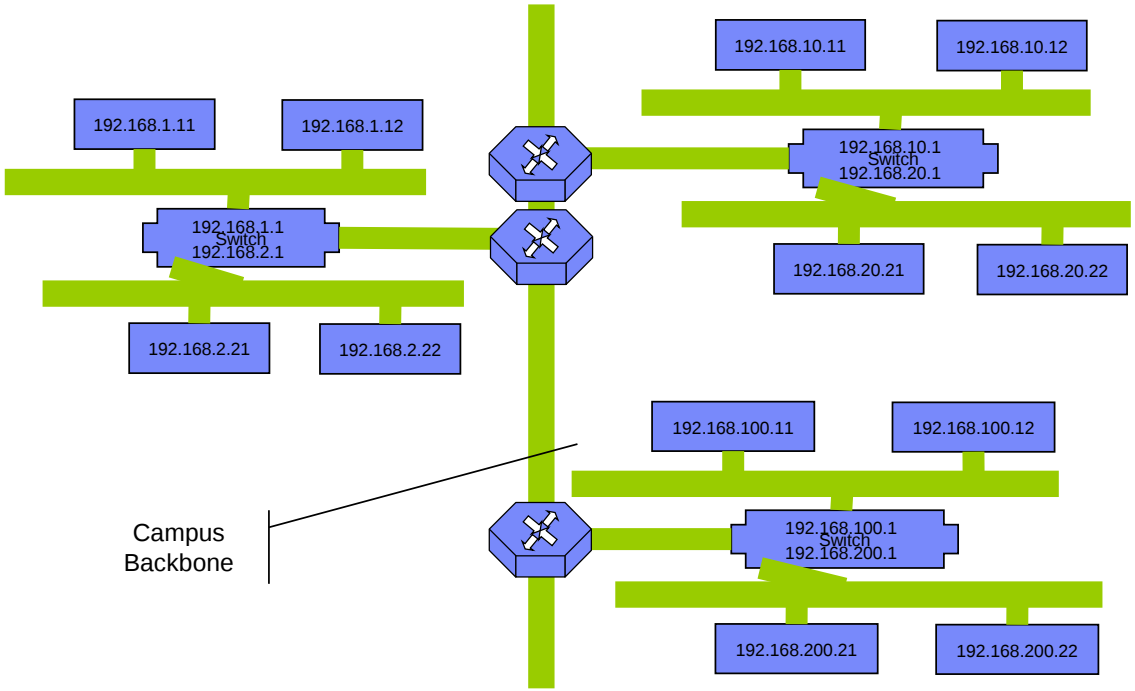


- Repeater
- Plug and play (low overhead)
- Spanning trees (restrict paths)
- Filtering
- Path selection (isolation, control)
- Multiple paths
- Filtering
- Firewall

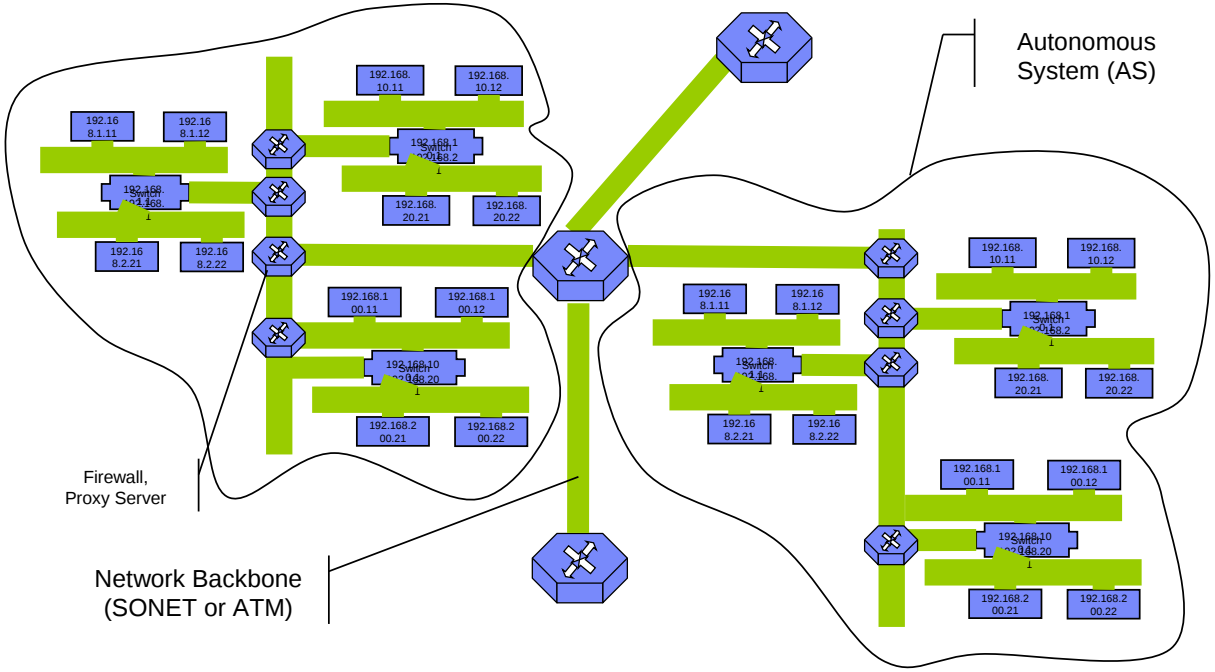
LANs and Subnets



Backbone

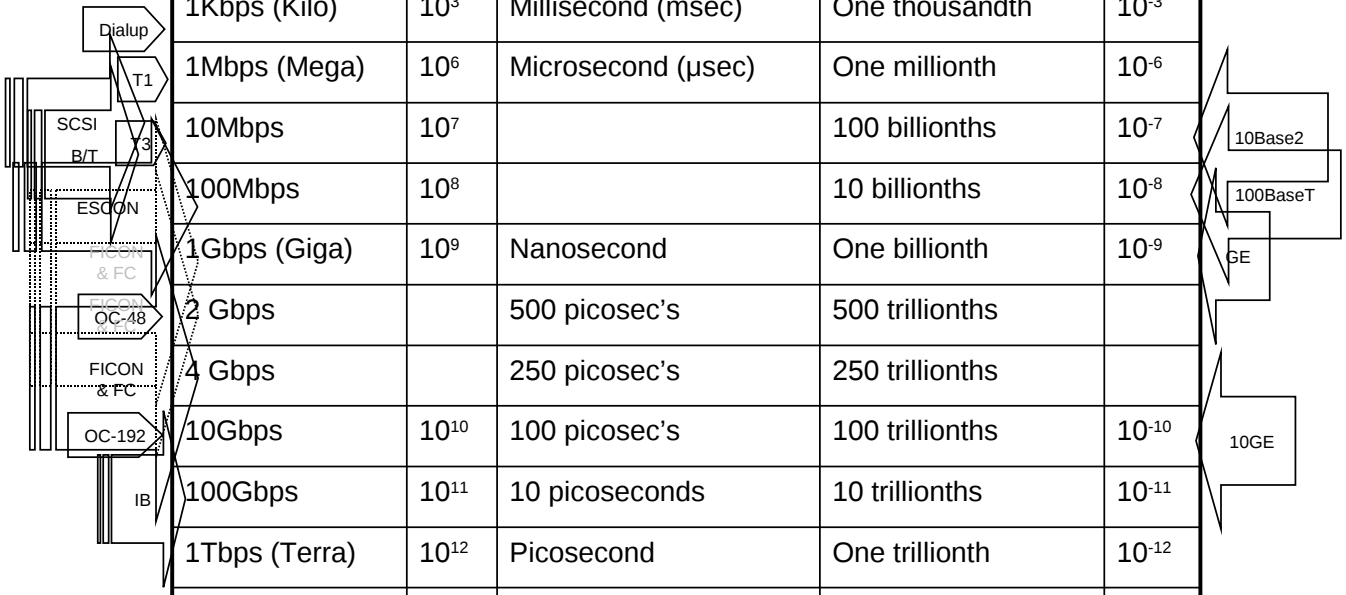

192.168.10.11
192.168.10.12
192.168.1.11
192.168.1.12
192.168.10.1
Switch
192.168.20.1
192.168.1.1
Switch
192.168.2.1
192.168.20.21
192.168.20.22
192.168.2.21
192.168.2.22
192.168.100.11
192.168.100.12
Campus
Backbone
192.168.100.1
Switch
192.168.200.1
192.168.200.21
192.168.200.22

Autonomous Systems



Hardware Performance

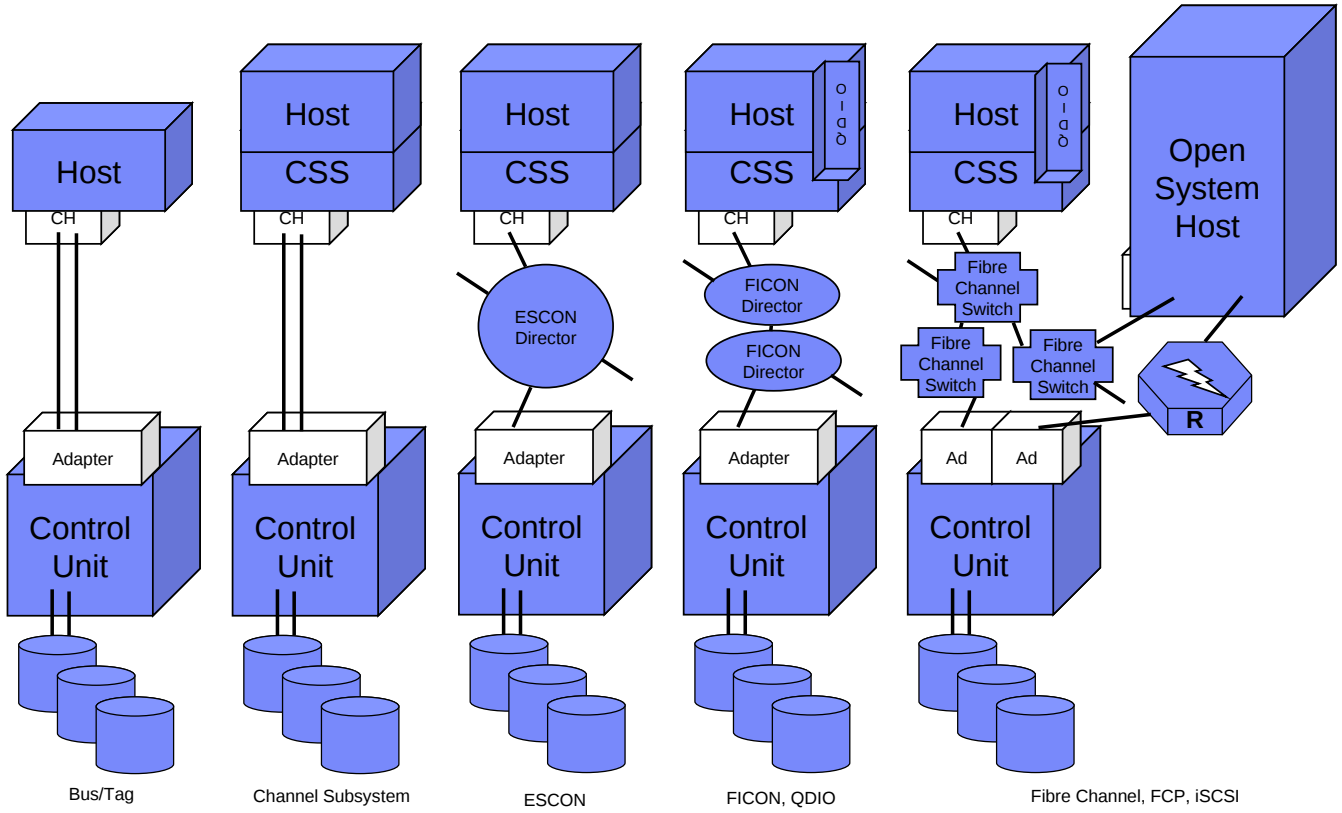
Transmission rate	Exp	One bit time	Length of bit (in seconds)	Exp
1bps	10^{0}	Second	One second	10^{0}
1Kbps (Kilo)	10^{3}	Millisecond (msec)	One thousandth	10^{-3}
1Mbps (Mega)	10^{6}	Microsecond (µsec)	One millionth	10^{-6}
10Mbps	10^{7}		100 billionths	10^{-7}
100Mbps	10^{8}		10 billionths	10^{-8}
1Gbps (Giga)	10^{9}	Nanosecond	One billionth	10^{-9}
2 Gbps		500 picosec's	500 trillionths	
4 Gbps		250 picosec's	250 trillionths	
10Gbps	10^{10}	100 picosec's	100 trillionths	10^{-10}
100Gbps	10^{11}	10 picoseconds	10 trillionths	10^{-11}
1Tbps (Terra)	10^{12}	Picosecond	One trillionth	10^{-12}
1Pbps (Peta)	10^{15}	Femptosecond	One quadrillionth	10^{-15}



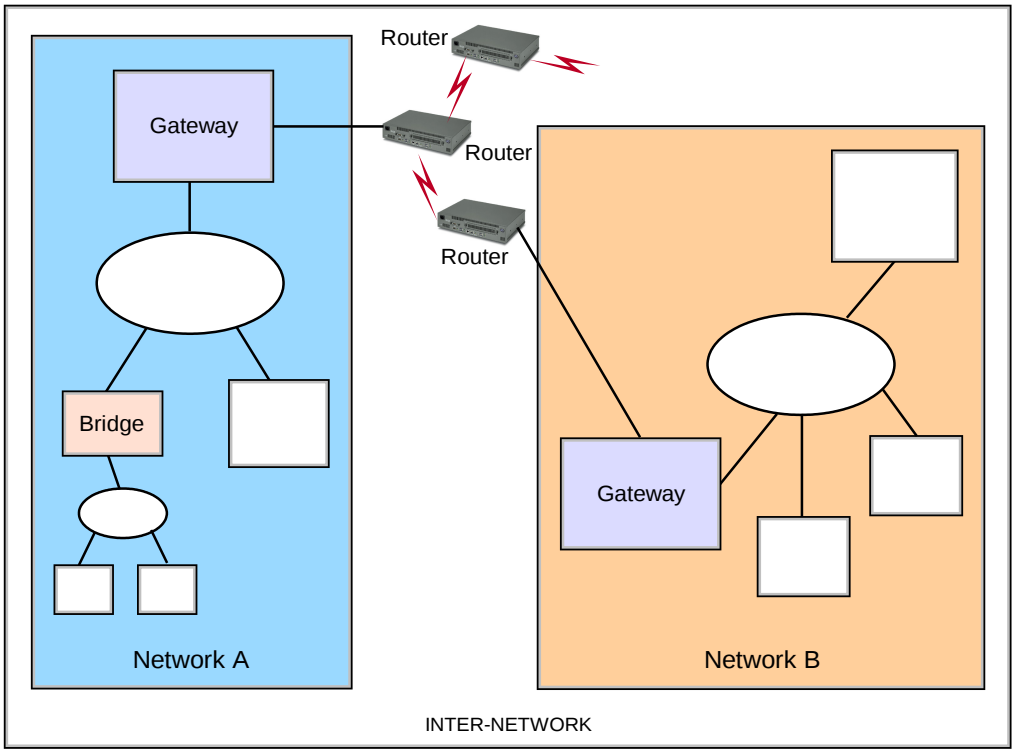
Physical Aspects

- Speed
- Distance
- Attenuation (Absorption, weakening)
- Interference
- Security
- Cost

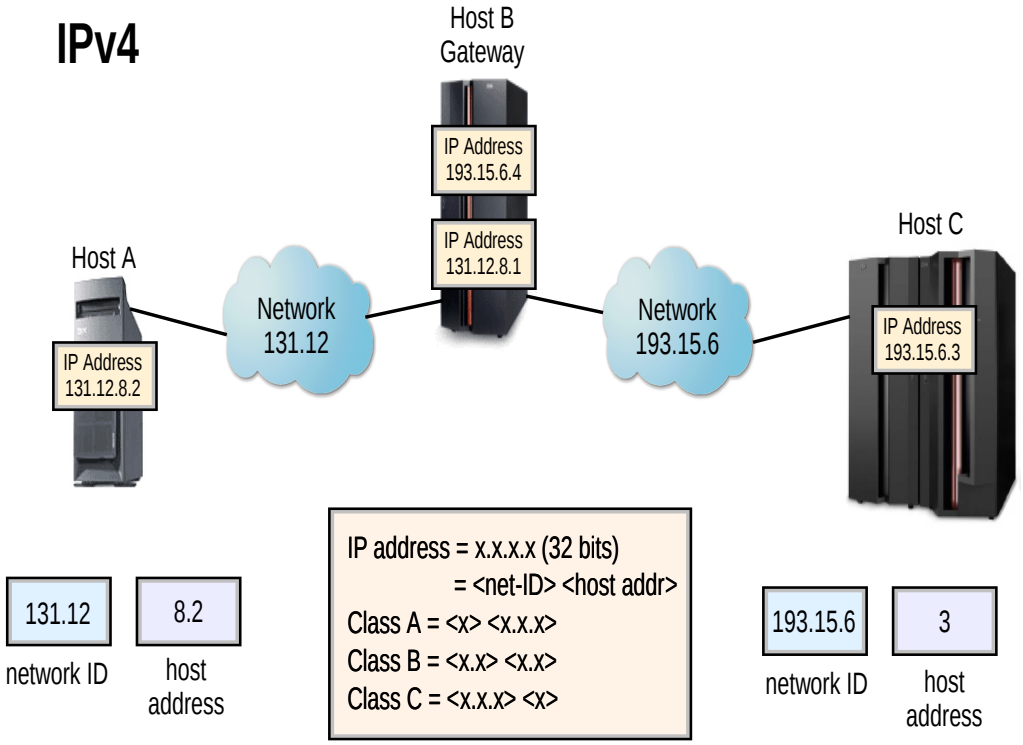
Data Channel Interconnect History



TCP/IP


Router
Gateway
Router
Router
Bridge
Gateway
Network A
Network B
INTER-NETWORK

IPv4[2]



[2] z/OS also supports IPv6

IP – the Internet Protocol

<table>
<tr><td>Version</td><td>HDL</td><td>ToS</td><td colspan="2">Length</td></tr>
<tr><td colspan="3">Identification</td><td>Flags</td><td>Fragment offset</td></tr>
<tr><td colspan="2">TTL</td><td>T. Protocol</td><td colspan="2">Checksum</td></tr>
<tr><td colspan="5">Source IP address</td></tr>
<tr><td colspan="5">Destination IP address</td></tr>
<tr><td colspan="5">Options (optional)</td></tr>
<tr><td colspan="5">Data (Length–HDL bytes)</td></tr>
</table>

Routing

- Static – manual entry of routes into a table
- Dynamic – populate routing tables based on protocols:
  - Routing Information Protocol (RIP)
  - Open Shortest Path First (OSPF)

Routing Design Choices

- Centralized: simpler, less overhead for long-lived routes – used by SNA, B/T, ESCON
- Decentralized: better to address congestion and failures

Routing Design Choices

- Source-based: complete route is chosen at the start – used by ATM, Frame Relay, FICON, Tor
- Hop-by-hop: each hop chooses next route

Routing Algorithms

Distance Vector (Dijkstra's Algorithm):

- Many messages and steps
- Each router knows paths to all destinations
- Failures are localized
- Example: RIP

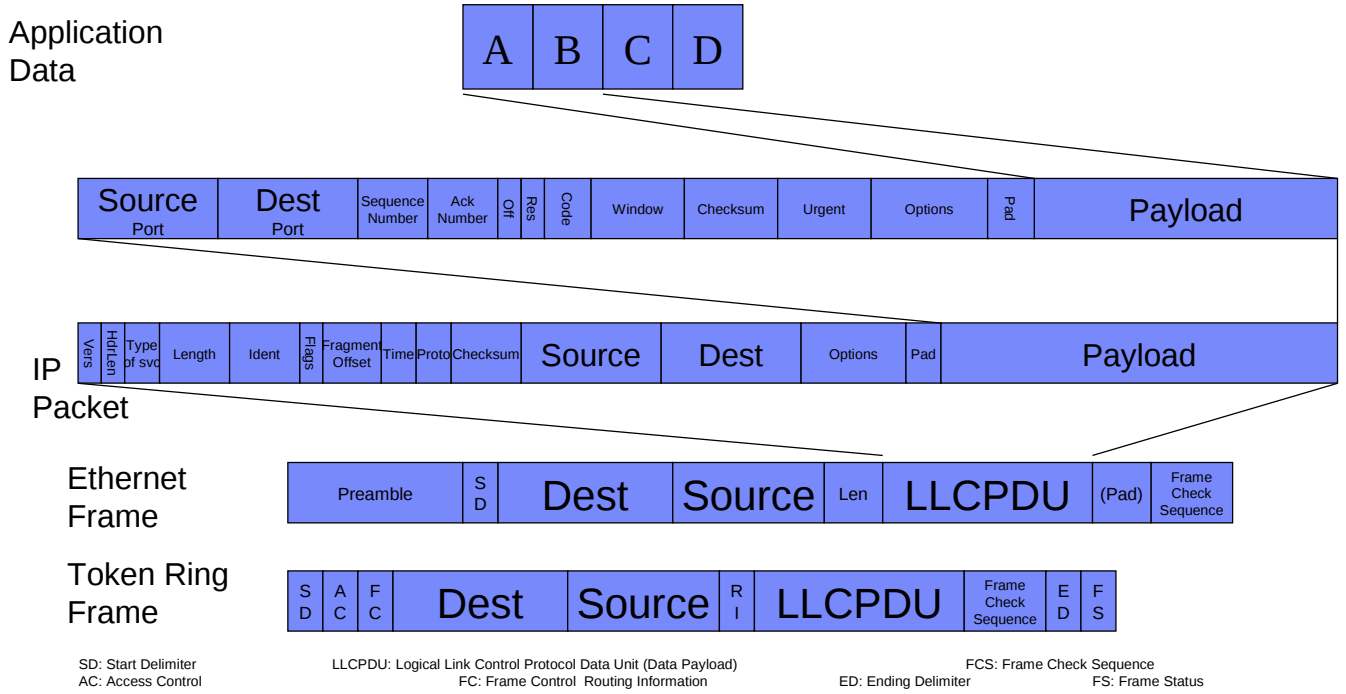
Link State (Bell's Algorithm):

- Fewer messages and steps
- Routers might not know of paths
- Failures can affect many
- Example: OSPF

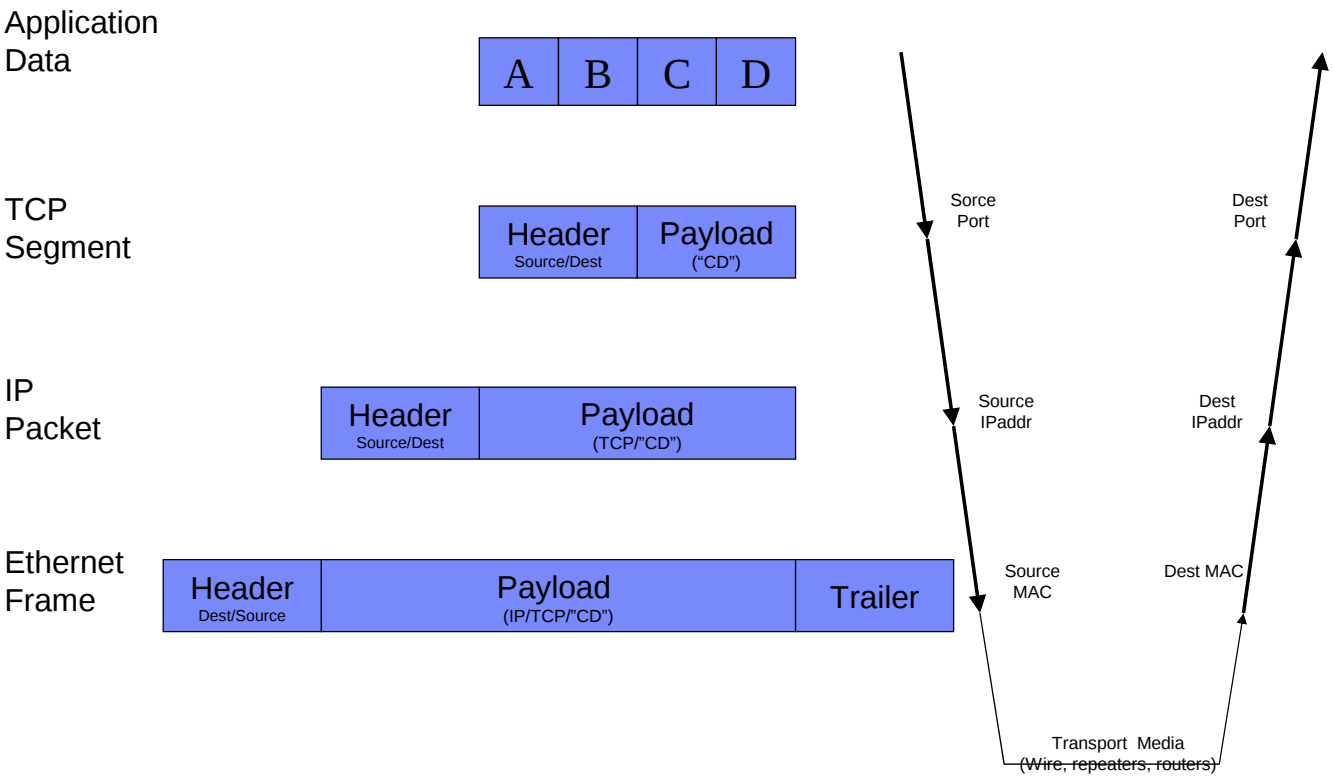
TCP – the Transmission Control Protocol

<table>
<tr><td colspan="3">Source port</td><td>Destination Port</td></tr>
<tr><td colspan="4">Sequence Number</td></tr>
<tr><td colspan="4">Acknowledgment Number</td></tr>
<tr><td>Data offset</td><td>Reserved</td><td>Flags</td><td>Window</td></tr>
<tr><td colspan="3">Checksum</td><td>Urgent Pointer</td></tr>
<tr><td>Options</td><td colspan="3">Padding</td></tr>
<tr><td colspan="4">Data</td></tr>
</table>

Encapsulation



Encapsulation and Addresses



Supported TCP/IP commands on z/OS

TCP/IP commands can be entered at the TSO ready prompt or the ISPF command shell or with prefix “o” on the z/OS UNIX shell:

- NETSTAT
- PING
- TRACERTE
- NSLOOKUP
- TELNET
- FTP

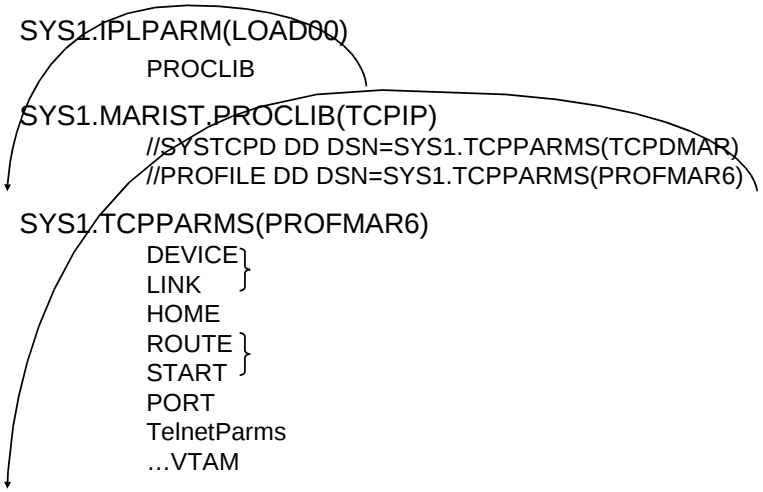
Sample JCL for TCP/IP task

```
//TCPIP    PROC
//TCPIP    EXEC PGM=EZBTCPIP,
//PROFILE DD DISP=SHR,DSN=SYS1.PARMLIB(PROFILE)
//SYSTCPD DD DISP=SHR,DSN=SYS1.PARMLIB(TCPDATA)
```

TCP/IP Configuration Files

- SYS1.IPLPARM
- SYS1.PARMLIB (IEASYSxx, BPXPRMxx, COMMNDxx)
- SYS1.PROCLIB (TCPIP, RESOLVER)
- SYS1.TCPPARMS (TCPDATA)

Finding TCPPARMS



Example: The TCP/IP Profile

SYS1.TCPPARMS(PROFILE) might read:

```
DEVICE OSAEDEV1 MPCIPA PRIROUTER
LINK OSAELNK1 IPAQENET OSAEDEV1
DEVICE OSAEDEV2 MPCIPA PRIROUTER
LINK OSAELNK2 IPAQENET OSAEDEV2
DEVICE VIPADEV1 VIRTUAL 1
LINK VIPALNK1 VIRTUAL 1 VIPADEV1
HOME
201.2.11.9 VIPALNK1
201.2.11.1 OSAELNK1
201.2.11.2 OSAELNK2
```

The Resolver

- Resolves Names to Addresses and Ports
- Test using `nslookup NAME` (omvs)
- Unix applications use the "RESOLVER_CONFIG" environment variable, configuration can also be in `/etc/resolv.conf`
- z/OS resolver has its own address space

Example: The TCP/IP Profile

ZOSKCTR.TCPPARMS(DATA) contains:

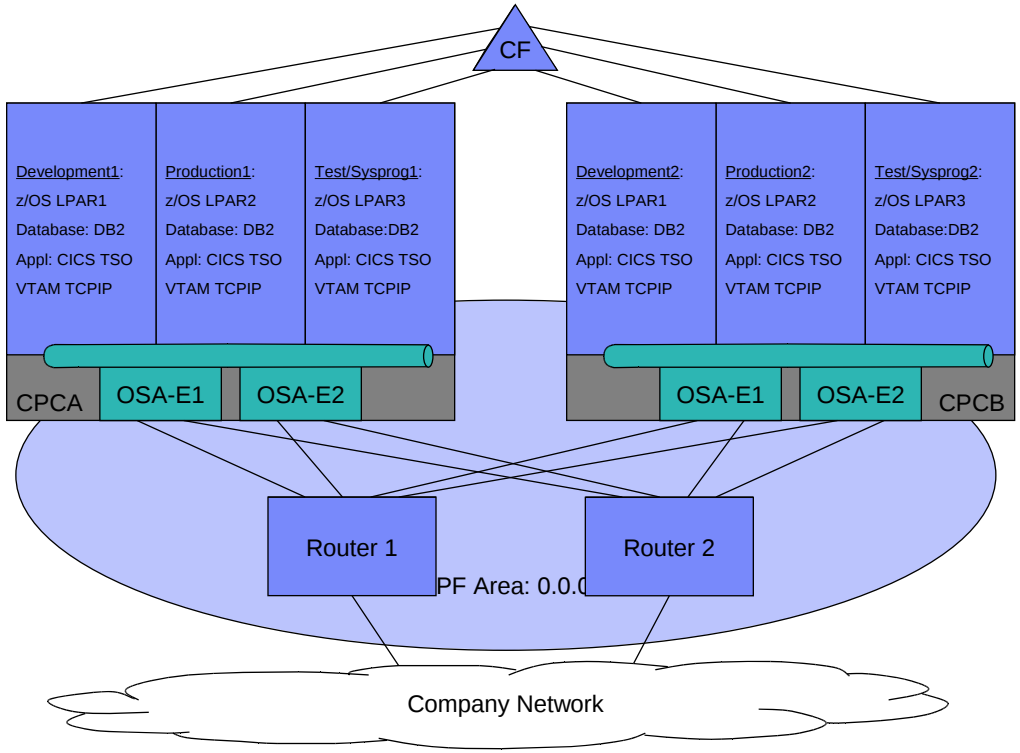
```
TCPIPJOBNAME TCPIP
HOSTNAME  ZOS.KCTR.MARIST.EDU
DOMAINORIGIN  KCTR.MARIST.EDU
NSINTERADDR  148.100.49.253
NSINTERADDR  148.100.32.40
DATASETPREFIX TCPIP
ALWAYSWTO YES
```

The FTP Server

Configured using the `FTP.DATA` set:

- Banner page
- Anonymous access
- Data set defaults
- Tracing and logging
- File system
- SSL/TLS
- Character sets

TCP/IP and Sysplex



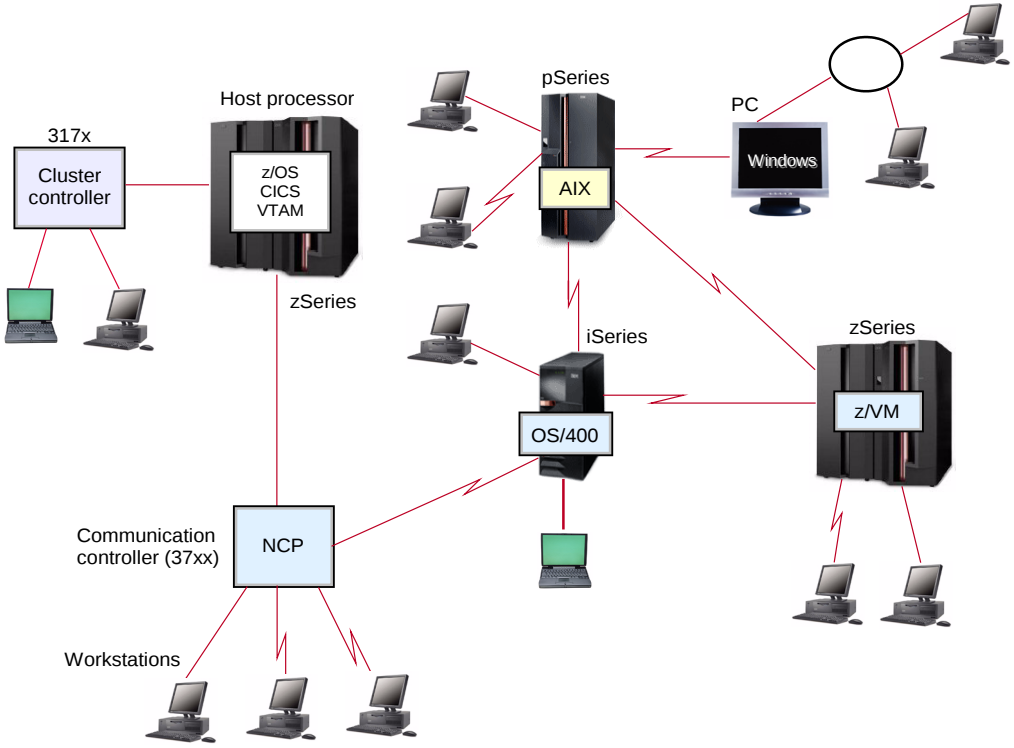
Virtual IP Addresses (VIPA)

- Independent of OSA
- Identifies application – multiple instances viewed as one
- Static VIPA – manual intervention required
- Dynamic VIPA – movement automatic or manual, can move with application; `bind()` can be used to activate
- Distributed (DRVIPA) – uses Sysplex Distributor; all application instances used

System Network Architecture (SNA)

- Introduced in 1974 by IBM
- Many companies do not want to spend the money to convert from SNA
- IBM introduced new technologies to preserve SNA and integrate it into IP (SNA over IP)

VTAM Overview



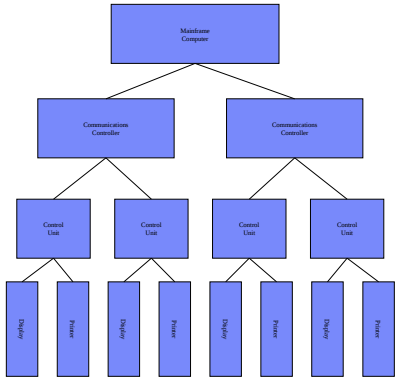
SNA Basics

There are three major implementations of SNA:

- Subarea Networking
- Advanced Peer-to-Peer Networking (APPN)
- High Performance Routing and SNA/IP (HPR)

SNA vs. TCP/IP

- Hierarchical network structure
- Subnetworks have a central point of control



SNA Terminology

- Addresses of physical nodes are called PU's ($\equiv$ TCP/IP IP addresses)
- Addresses of applications (logical nodes) are called LU's ($\equiv$ TCP/IP ports)
- *Dependent* sessions need a control point to help nodes
- *Independent* sessions are established by nodes on their own

SNA Nodes

- Nodes send and receive data from the network
- Categorized into "types" by hardware and capabilities (processors, controllers and workstations)

Physical Units (PUs)

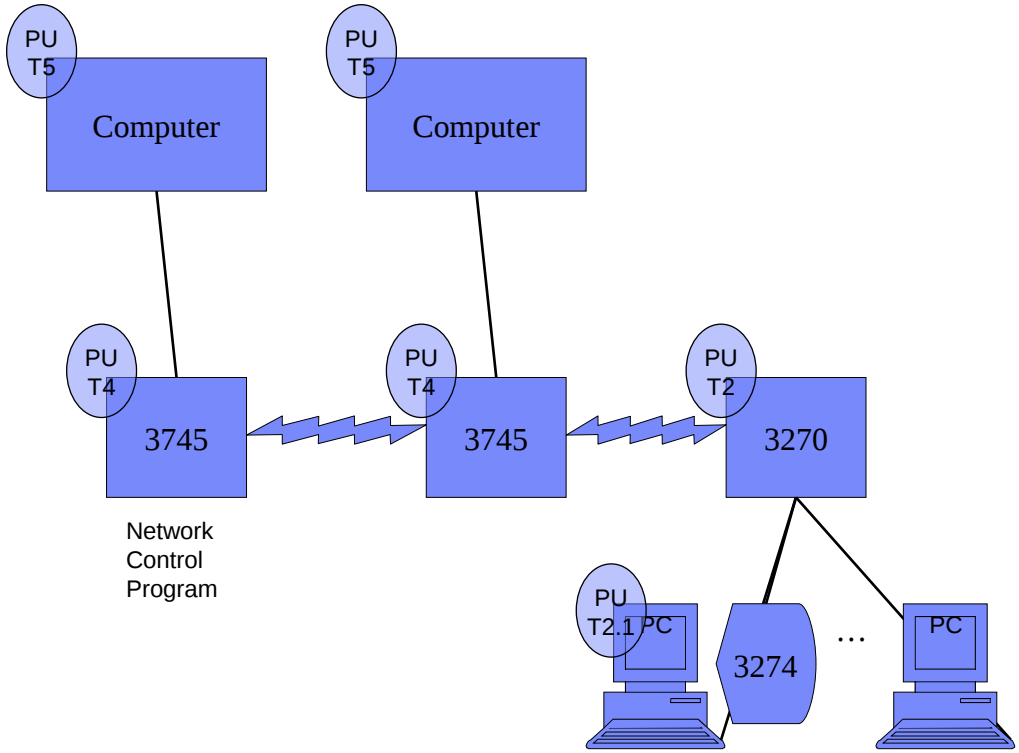
Type 5 "Host Node": Mainframe, offers session services, contains System Services Control Point (SSCP)

Type 4 "Intermediate Node": communication controller, runs NCP

Type 3 never implemented

Type 2 "Peripheral Node": displays, ATM-like systems, POS controllers

Physical Units (PUs)



Logical Units (LUs)

Ports through which users access the SNA network:

- Dependent Logical Unit types require SSCP-LU to establish LU-LU sessions
- Independent Logical Unit types do not require SSCP to establish sessions

Dependent Logical Unit Types

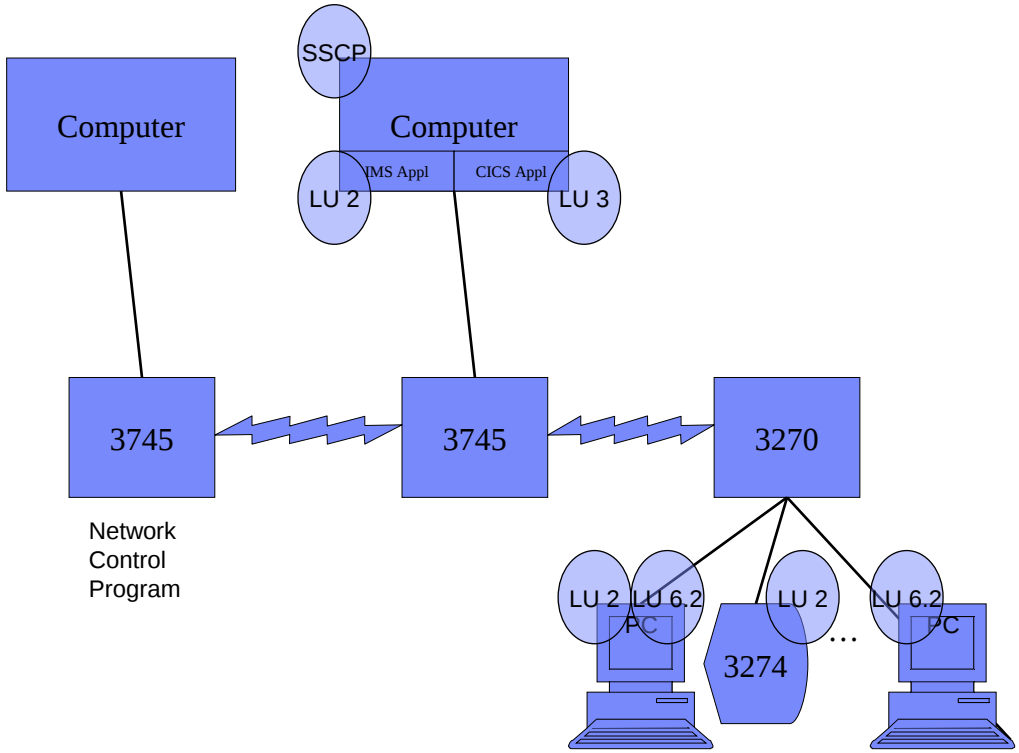
Type 1 "dumb" printer or other device

Type 2 "green screen" terminal

Type 3 "green screen" printer with data stream

Type 4 Application program (for example, text processor)

Logical Units (LUs)



System Services Control Points (SSCP)

Control points manage network resources:

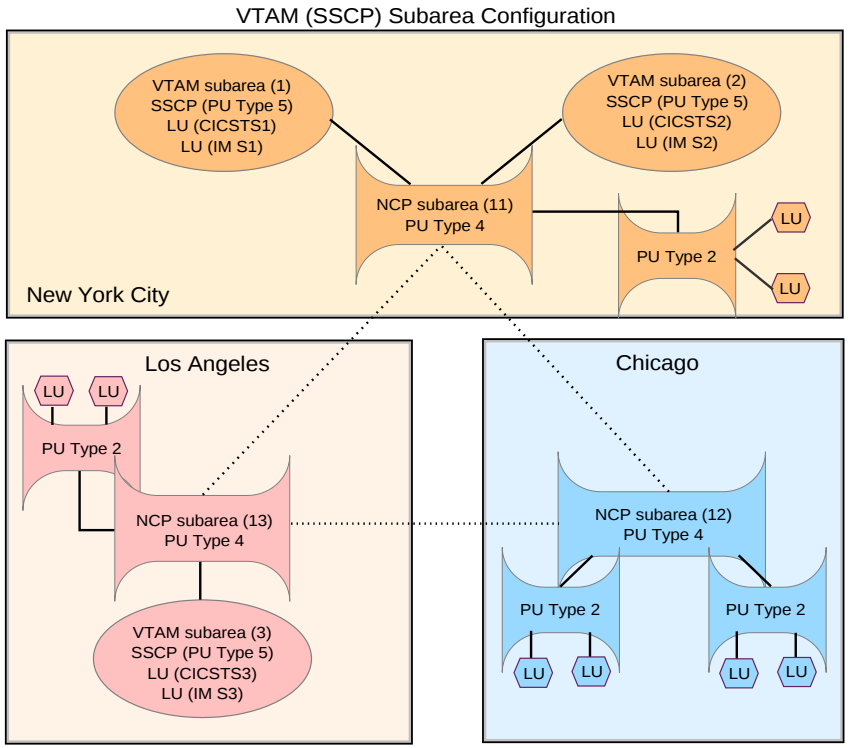
- Activates, controls and deactivates network resources in a subarea network
- Coordinates initiation and termination of sessions between applications
- Coordinates testing and status monitoring of resources

Initiating LU-to-LU sessions

Steps required to establish a LU-to-LU session:

1. SSCP-PU
2. SSCP-LU
3. Bind
4. LU-LU

Subarea Networks

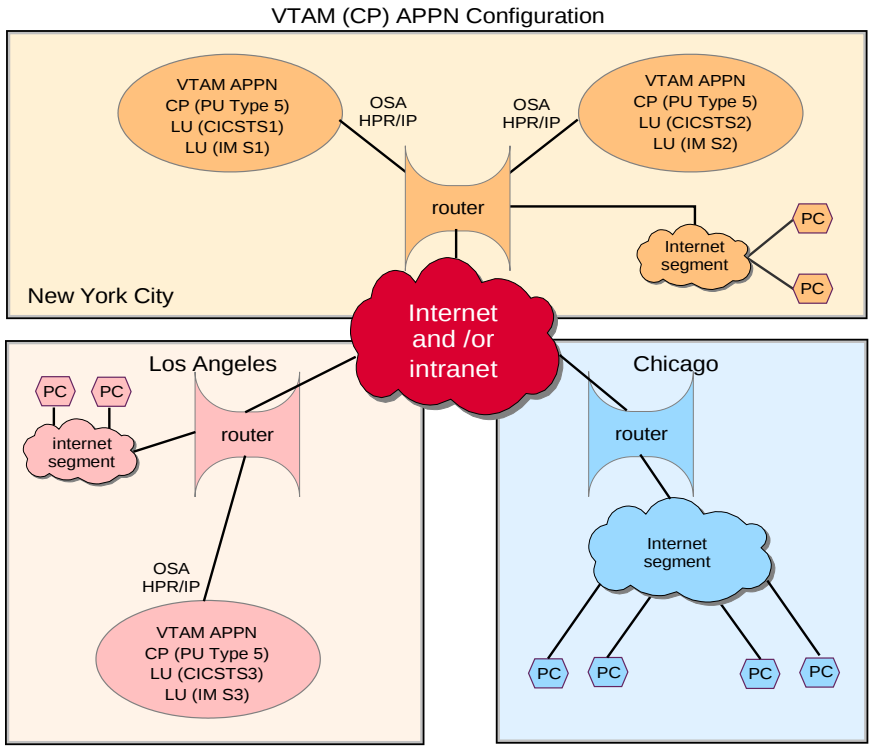


SNA Routing

SNA uses static routing:

- Routes are defined, not discovered
- Explicit (physical between subareas)
- Virtual (logical between endpoints)

Advanced Peer-to-Peer Networking (APPN)



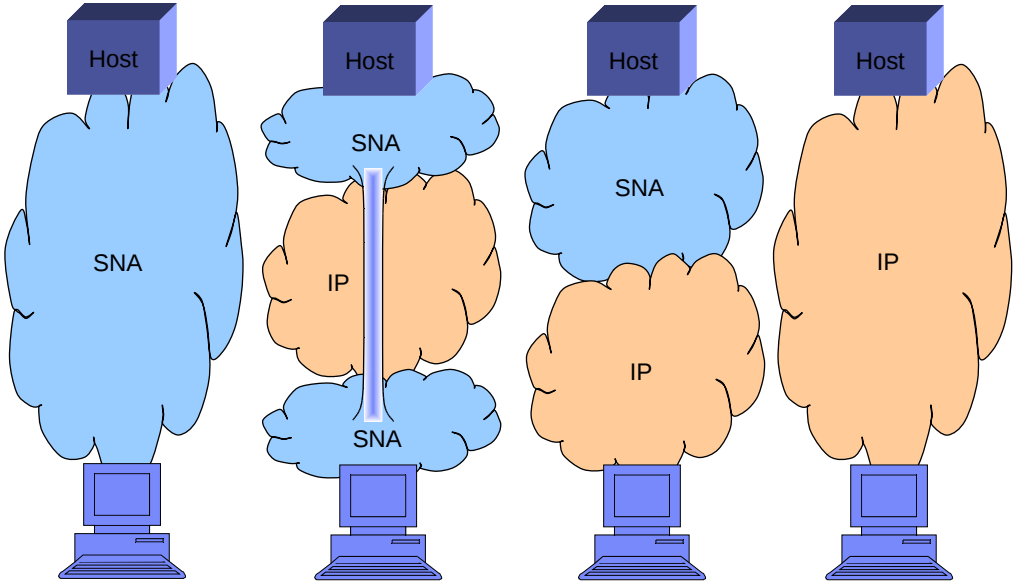
APPN Features

- Dynamic network topology, nodes are discovered, added and deleted
- Dynamic routing based on topology, class-of-service (CoS), priority
- Control Points (CP) organize inter-node information sharing, information transfer and location of network resources
- Scales to 10's and 100's (but not like TCP/IP)

Enterprise Extender

- SNA (HPR) packets are carried as UDP packets over an IP network
- 3270 data streams are carried over TCP connections to a server tha replaces the TCP transport with an SNA transport
- Replaces SNA Network Interconnect (SNI)
- Support for OSA Gigabit Ethernet cards

SNA to TCP/IP Migration



Inspecting VTAM status

DISPLAY NET,*OPTION*:

VTAMOPTS VTAM startup options
CSM Communication storage use
APPLS Status of applications
MAJNODES Status of major nodes
BFRUSE VTAM buffer usage
TOPO,LIST=SUMMARY APPN topology information
CPCP CP-CP sessions
SESSIONS Status of subarea SSCP-SSCP sessions
CDRMS Status of subarea cross domain resources
EXIT Status of VTAM exit points

3270

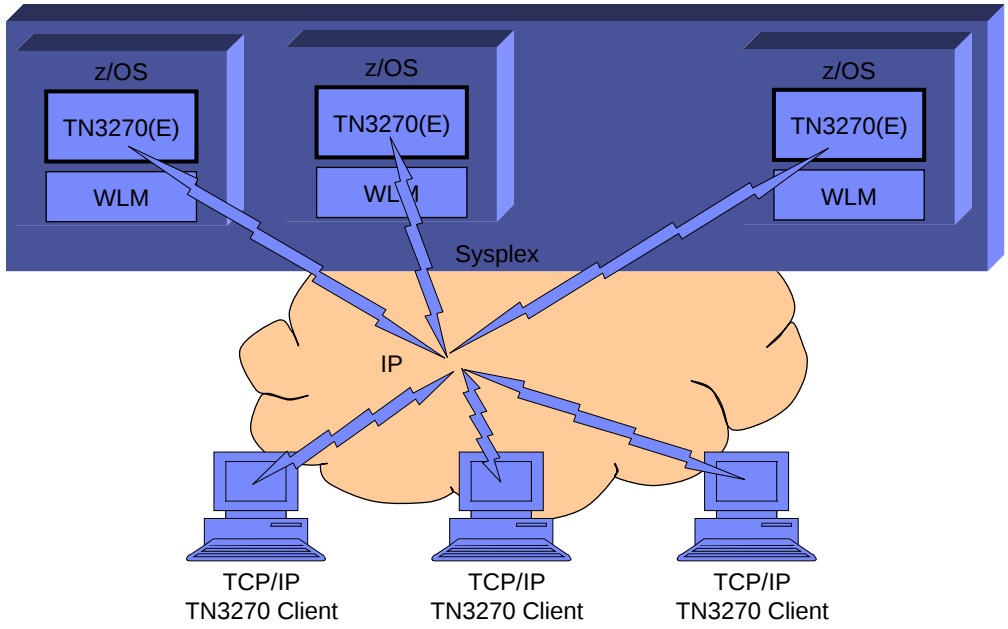
- 3270 data stream is designed primarily for transmitting data between an application program and a 3270 **display with keyboard**
- Implemented using a mapped character buffer in the device
- Data received from the application program and data to be transmitted to the application program are stored in a device buffer and displayed on the screen
- The mode of operation used by 3270 terminals is called **full screen**, which means that the buffer is transferred from the application program to the 3270 device and from the 3270 device to the application program.

3270 Data Stream

The field attribute defines the start of a field and the characteristics of the field. Field attribute defines the following field characteristics:

- Protected or unprotected
- Autoskip
- Nondisplay or display
- Intensified display
- Alphanumeric or numeric

WLM and TN3270



TN3270 Features of Communications Server

- Secure Sockets (SSL)
- Multiple ports
- IP Address to LU Name Mapping (IP Filtering)

Network Startup on z/OS

- z/OS and JES2 must be up and going
- Network devices must be varied online by z/OS
- Network should start before any application
- Parts of VTAM subsystem must start prior to TCP/IP
- EE can not be enabled until both VTAM and TCP/IP are up

Major Operator Commands

S Start

V Vary

F Modify

P Stop

Z Cancel

VARY (1/2)

```
V NET,
```

- ACT,ID=x
- INACT,ID=x

VARY (2/2)

```
V TCPIP,,TELNET,
```

- QUIESCE
- RESUME
- STOP
- ACT
- INACT

MODIFY

```
F NET,
```

- RIP,LIST,ALL — display RIP routes
- TRACE=ON — trace all RPC activity
- TRACE=OFF — disable tracing

HALT

- Z NET,QUICK — halt VTAM
- Z NET,CANCEL — abend VTAM (try QUICK first)

Network Documentation

- Network component overview diagram
- External connections
- Network naming conventions
- Network processes, tools, automation
- Change log
- Problem log

z/VM Networking

z/VM supports a range of network devices:

- Open Systems Adapter (OSA, OSA-2, OSA Express)
- HiperSockets
- Channel-to-channel (CTC)
- ...

I/O channels

- z/VM uses three I/O channels with consecutive numbers for connectivity (NICs, VLANs, etc.)
- Often only the base address needs to be explicitly specified
- Base address should be an even number

Open Systems Adapter

- Supports many network transport protocols, including 10 gigabit Ethernet, ATM and token ring
- Can have up to 640 TCP/IP stacks connected to them
- Supports Queued Direct Input/Output (QDIO) to buffer data in host's main storage

HiperSockets

- TCP/IP connectivity between virtual servers within a System z server
- No need for a physical connection
- Supports QDIO
- Extension to QDIO Hardware Facility of OSA card

Channel-to-channel connection (CTC)

- Physical connection between CECs
- Prior to guest LANs used for communication with Linux guests (required physical cables or virtual CTCs)

Guest LAN

- Similar to OSA card, except simulated in software
- Guest LAN in QDIO mode emulates an OSA-Express
- Guest LAN in iQDIO emulates HiperSockets
- Guest LANs are isolated (even on the same system) unless some member of the LAN acts as a router to other groups!

Virtual Switch

- Like a guest LAN, except that no guest needs to act as a router — VSWITCH controller guest of z/VM does it!
- Can support redundant OSA devices (fault-tolerance!)
- Can support SNA if operated in Layer 2 mode

z/VM TCP/IP support

- TCP/IP tools reside on TCPMAINT user's 592 minidisk
- `LINK TCPMAINT 592 592`
- `ACCESS 592 T`

$\Rightarrow$ Common tools like `ftp`, `netstat`, `ping`, `tracerte` available!

Note that these will only work if the network is configured properly...

z/VM TCP/IP for guests

- TCPMAINT should be logged on (`xautolog`, etc.) to enable TCP/IP for z/VM
- TCP/IP support will then be automatically available to CMS guests
- FTPSERVE is a guest that must be started to run an FTP server on top of z/VM
- Other guests may require passing a (virtual or real) OSA adapter through to the guest:

```
DEDICATE 1D00 1D00
DEDICATE 1D01 1D01
DEDICATE 1D02 1D02
```

Questions

?