Chapter 5.6
Network and Multiplayer

Multiplayer Modes: **Event Timing**

- Turn-Based
  - Easy to implement
  - Any connection type
- Real-Time
  - Difficult to implement
  - Latency sensitive

Multiplayer Modes: **Shared I/O**

- Input Devices
  - Shared keyboard layout
  - Multiple device mapping
- Display
  - Full Screen
    - Funneling
    - Screen Swap
  - Split Screen

Multiplayer Modes: **Connectivity**

- Non Real-Time
  - Floppy disk net
  - Email
  - Database
- Direct Link
  - Serial, USB, IrD, … (no hops)
- Circuit Switched (phones)
  - Dedicated line with consistent latency
- Packet Switched
  - Internet
  - Shared pipe

Protocols: **Protocol Design**

- Packet Length Conveyance
- Acknowledgement Methodology
- Error Checking / Correcting
- Compression
- Encryption
- Packet Control

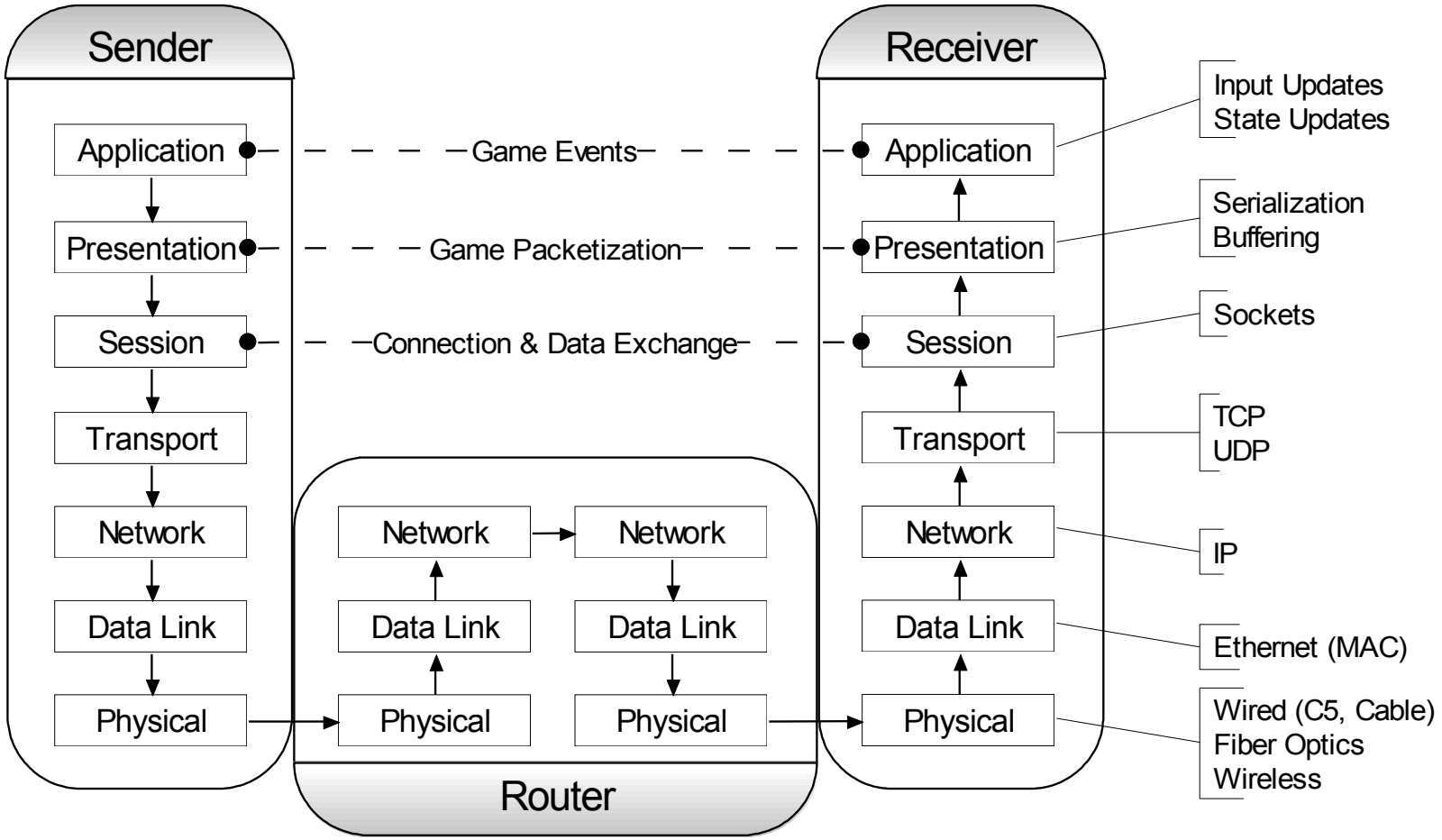
Protocols: **Packets**

- Packets
  - Header = Protocol Manifest
  - Payload
- Gottchas
  - Pointers
  - Large/Variable Size Arrays
  - ADTs
  - Integer Alignment
  - Endian Order
  - Processor dependant Intrinsic Types (int and long)
  - Unicode vs. ASCII Strings

Protocols: **Request for Comments**

- RFC web site
  - http://www.rfc-editor.org/
- Protocol Specifications
  - Definitive Resource
  - Public Criticism
  - Future Protocols

Protocol Stack: **Open System Interconnect**



Protocol Stack: **Physical Layer**

- Bandwidth
  - Width of data pipe
  - Measured in bps = bits per second
- Latency
  - Travel time from point A to B
  - Measured in Milliseconds
- The Medium
  - Fiber, FireWire, IrD , CDMA & other cell

Table: Max Bandwidth Specifications

	Serial	USB 1&2	ISDN	DSL	Cable	LAN 10/100/1G BaseT	Wireless 802.11 a/b/g	Power Line	T1
Speed (bps)	20K	12M 480M	128k	1.5M down 896K up	3M down 256K up	10M 100M 1G	b=11M a,g=54M	14M	1.5M

Protocol Stack: **Data Link Layer**

- Serializes data to/from physical layer
- Network Interface Card
  - Ethernet
  - MAC Address

Protocol Stack: **Network Layer**

- Packet Routing
  - Hops
  - Routers, Hubs, Switches
- Internet Protocol (IP)
  - Contains Source & Destination IP Address
  - IPv4
    - Widespread Infrastructure
  - IPv6
    - Larger IP address

Protocol Stack: **Network Layer: IP Address**

- Unicast
  - Static
  - DHCP
- Multicast
  - Requires multicast capable router
- Broadcast
  - Local
  - Directed
- Loop Back
  - Send to self
- AddrAny
  - 0 = address before receiving an address

Protocol Stack: **Network Layer: DNS**

- Domain Name Service
  - Converts text name to IP address
  - Must contact one or more DNS servers to resolve
  - Local cache resolution possible
- Game Tips
  - Store local game cache to use when DNS out of order.
  - DNS resolution often slow, use cache for same day resolution.

Protocol Stack: **Transport Layer**

- Manage data deliver between endpoints
  - Error recovery
  - Data flow
- TCP and UDP used with IP
  - Contains Source and Destination Port
- Port + IP = Net Address
  - Port Range = 0-64k
  - Well known Ports 0-1k

Protocol Stack: **Transport Layer: TCP**

- Guaranteed Correct In Order Delivery
  - Acknowledgement system
    - Ack, Nack, Resend
  - Checksum
  - Out of Band
- Connection Required
  - Packet Window
  - Packet Coalescence
  - Keep Alive
- Streamed Data
  - User must serialize data

Protocol Stack: **Transport Layer: UDP**

- Non Guaranteed Delivery
  - No Acknowledgement system
  - May arrive out of order
  - Checksum
- Not Connected
  - Source not verified
  - Hop Count Limit = TTL (time to live)
  - Required for Broadcasting
- Datagram
  - Sent in packets exactly as user sends them

Protocol Stack: **Session Layer**

- Manages Connections between Apps
  - Connect
  - Terminate
  - Data Exchange
- Socket API live at this layer
  - Cross platform
  - Cross language

Protocol Stack: **Session Layer: Sockets**

- Based on File I/O
  - File Descriptors
  - Open/Close
  - Read/Write
- Winsock
  - Provides standard specification implementation plus more
  - Extension to spec prefixed with “WSA”
  - Requires call to WSAStartup() before use
  - Cleanup with WSAShutdown()

Protocol Stack: **Session Layer: Socket Design**

- Modes
  - Blocking
  - Non-Blocking
- Standard Models
  - Standard
  - Select
- Extended Models
  - Windows
    - WSAEventSelect
    - I/O Completion Ports
  - Unix
    - Poll
    - Kernel Queues

Protocol Stack: **Presentation Layer**

- Prepares App Data for Transmission
  - Compression
    - Pascal Strings
    - String Tables
    - Float to Fixed
    - Matrix to Quaternion
  - Encryption
  - Endean Order
    - When used cross platform or cross language
  - Serialize
    - Pointers
    - Variable Length Arrays

Protocol Stack: **Presentation Layer: Buffering**

- Packet Coalescence
- Induced Latency
- Dead Data
- Large Packets

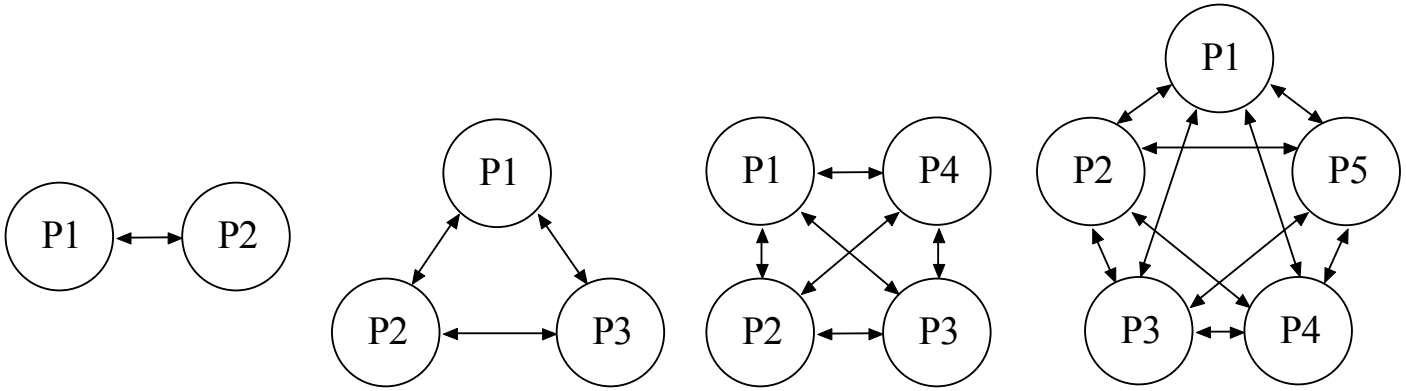
Protocol Stack: **Application Layer**

- Handles Game Logic
- Update Models
  - Input Reflection
  - State Reflection
- Synchronization
  - Dead Reckoning
  - AI Assist
  - Arbitration

Real-Time Communications: **Connection Models**

- Broadcast
  - Good for player discovery on LANs
- Peer to Peer
  - Good for 2 player games
- Client / Server
  - Good for 2+ player games
  - Dedicated lobby server great for player discovery

Real-Time Communications: **Peer to Peer vs. Client/Server**



2 players
1 connection

3 players
3 connections

4 players
6 connections

5 players
10 connections

N = Number of players

	Broadcast	Peer/Peer	Client/Server
Connections	0	$\sum_{x=1}^{N-1} x$	Client = 1 Server = N

	Broadcast	Peer/Peer	Client/Server
Send	1	N-1	Client = 1 Server = N
Receive	N-1	N-1	Client = 1 Server = N

Real-Time Communications: **Asynchronous Environments**

- Thread
  - Priority
  - Suspension
  - Pooling
- Critical Section & Mutex
- Signal & Event
- Data Sharing
  - volatile keyword
  - Interlocked Inc/Dec

Security: **Encryption Goals**

- Authentication
- Privacy
- Integrity

Security: **Encryption Methods**

- Keyed
  - Public Key
  - Private Key
  - Ciphers
- Message Digest
- Certificates
- IPSec

Security: **Copy Protection**

- Disk Copy Protection
  - Costly Mastering
  - Invalid/Special Sector Read
- Code Sheets
- Watermarking

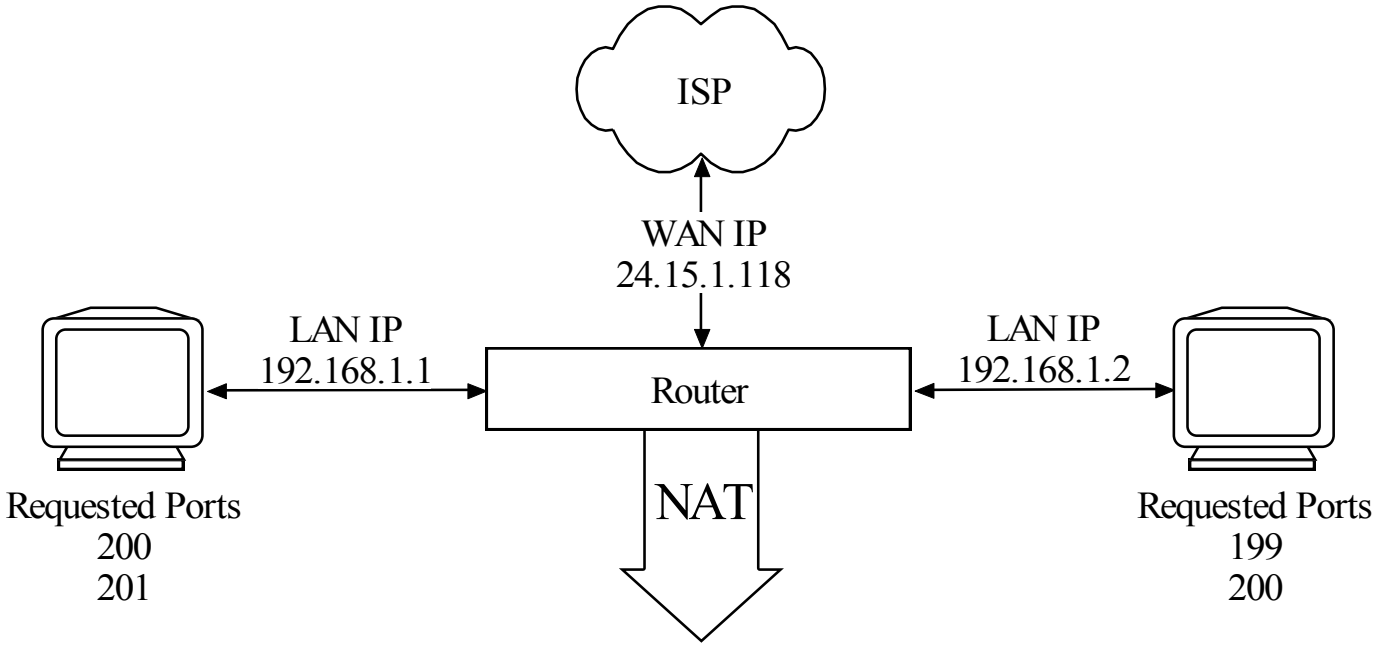
Security: **Execution Cryptography**

- Code Obfuscation
- Strip Symbols
- Heap Hopper
- Stack Overrun Execution
- NoOp Hacking
- Timer Hacking
- DLL Shims

Security: **Firewalls**

- Packet Filter
- Proxies
- Circuit Gateways

Security:
Firewalls: Network Address Translation



LAN Address	WAN Address
192.168.1.1:200	24.15.1.118:200
192.168.1.1:201	24.15.1.118:201
192.168.1.2:199	24.15.1.118:199
192.168.1.2:200	24.15.1.118:4000*

Security: **Firewalls: NAT Traversal**

- Port Forwarding
- Port Triggering
- DMZ
- Determining WAN IP

Summary: **Topic Coverage**

- Multiplayer Modes
- Protocols
- Protocol Stack
- Real-Time Communications
- Security

Summary: **Further Study**

- Socket Programming
- Serial Communication
- Server Design
- Network Gear & Infrastructure
- VOIP
- Tools of the Trade
- Unit & Public Beta Testing
- Middleware
- Databases
- Web Development
- Asynchronous Programming