Summer Workshop on Cyber Security

Computer Networks Security (Part 1)

Dr. Hamed Mohsenian-Rad

University of California at Riverside and Texas Tech University
August 12-16, 2013

Supported by National Science Foundation
Overview of Computer Networks

❖ Our Goal:

❖ Get “feel” and terminology

❖ Focus on the Internet

❖ What is the Internet?

❖ What is the Protocol?

❖ Layered Network Architecture.
Overview of Computer Networks

- Our Goal:
  - Get “feel” and terminology
  - Focus on the Internet
    - What is the Internet?
    - What is the Protocol?
  - Layered Network Architecture.
What is the Internet

- Millions of connected computing devices:
  - End systems / Hosts (Running Net Apps)
  - Communication Links (Wired or Wireless)
  - Routers and Switches (Forward “Packets”)
What is the Internet

- **Network of Networks**
  - ISPs
  - Institutional Networks
  - Home Networks
  - Mobile Networks

- **Internet Protocols:**
  - Control Sending & Receiving of Messages
  - E.g.: TCP, IP, HTTP, 802.11
What is a Protocol?

- **Human Protocol:**
  - “What time is it?”, “I have a question.”, …

- **Network Protocols:**
  - Machines instead of humans.

Protocols define format and order of messages sent and received among network entities, and actions taken on message transmission and message receipt.
What is a Protocol?

- Protocol define the interaction sequences over time:

  - Hi
  - Hi
  - Got the time?
  - 2:00

  - TCP connection request
  - TCP connection response
  - <file>
Protocol Layers

Networks are complex with many “pieces”:

- Hosts
- Routers
- Wired Links
- Wireless Links
- Applications
- Protocols
- Hardware
- Software
- ...
Protocol Layers

- Networks are complex with many “pieces”:
  - Hosts
  - Routers
  - Wired Links
  - Wireless Links
  - Applications
  - Protocols
  - Hardware
  - Software
  - ...

Q: How can we organize the structure of networks?
Example: Organization of Air Travel

- A series of steps are taken at **different “layers”**:

  - ticket (purchase)
  - baggage (check)
  - gates (load)
  - runway takeoff
  - airplane routing

  - ticket (complain)
  - baggage (claim)
  - gates (unload)
  - runway landing
  - airplane routing
Example: Organization of Air Travel

- Each layer implements a "service":

  - Via its own "internal-layer" actions.
Internet Protocol Stack

There are five layers in Internet Protocol Stack with different functionalities and protocols.
Internet Protocol Stack

- **Application**: Supporting network apps
  - FTP, HTTP, SMTP, Skype
Internet Protocol Stack

- **Application**: Supporting network apps
  - FTP, HTTP, SMTP, Skype
Internet Protocol Stack

- **Application**: Supporting network apps
  - FTP, HTTP, SMTP, Skype
Internet Protocol Stack

- **Application**: Supporting network apps
  - FTP, HTTP, SMTP, Skype
- **Transport**: Process-to-process data transfer
  - TCP, UDP
Internet Protocol Stack

- **Application**: Supporting network apps
  - FTP, HTTP, SMTP, Skype

- **Transport**: Process-to-process data transfer
  - TCP, UDP

They all use **TCP** Protocol for “reliable” data transmission.
(Socket Programming)
(Each socket has a port #)
Internet Protocol Stack

- **Application**: Supporting network apps
  - FTP, HTTP, SMTP, Skype

- **Transport**: Process-to-process data transfer
  - TCP, UDP

- **Network**: Routing from source to destination
  - IP, Routing Protocols
Internet Protocol Stack

- **Application**: Supporting network apps
  - FTP, HTTP, SMTP, Skype
- **Transport**: Process-to-process data transfer
  - TCP, UDP
- **Network**: Routing from source to destination
  - IP, Routing Protocols
Internet Protocol Stack

- **Application**: Supporting network apps
  - FTP, HTTP, SMTP, Skype

- **Transport**: Process-to-process data transfer
  - TCP, UDP

- **Network**: Routing from source to destination
  - IP, Routing Protocols
Internet Protocol Stack

- **Application**: Supporting network apps
  - FTP, HTTP, SMTP, Skype

- **Transport**: Process-to-process data transfer
  - TCP, UDP

- **Network**: Routing from source to destination
  - IP, Routing Protocols

- **Link**: Routing from source to destination
  - Ethernet, IEEE 802.11 (WiFi)
Internet Protocol Stack

- **Application**: Supporting network apps
  - FTP, HTTP, SMTP, Skype

- **Transport**: Process-to-process data transfer
  - TCP, UDP

- **Network**: Routing from source to destination
  - IP, Routing Protocols

- **Link**: Routing from source to destination
  - Ethernet, IEEE 802.11 (WiFi)
Internet Protocol Stack

- **Application**: Supporting network apps
  - FTP, HTTP, SMTP, Skype

- **Transport**: Process-to-process data transfer
  - TCP, UDP

- **Network**: Routing from source to destination
  - IP, Routing Protocols

- **Link**: Routing from source to destination
  - Ethernet, IEEE 802.11 (WiFi)

- **Physical**: Bit-by-bit transmission
Packets

- Network communications are essentially 0-1 bit streams:

- But we break down bit streams to small bit chunks = packets.

- The packet at each layer:
  - Can have different names (frame, segment, etc.)
  - Can have different sizes
Packets

Application → Transport → Network → Link → Physical

Message
Segment
Datagram
Frame

Application → Transport → Network → Link → Physical
Packet Headers

- Protocol at each layer adds its own “headers” for “control data”.

Diagram:
- Application
- Transport
- Network
- Link
- Physical
Packet Headers

- Protocol at each layer adds its own "headers" for "control data".
Packet Headers

- Protocol at each layer adds its own “headers” for “control data”.

Diagram:
- Application
- Transport
- Network
- Link
- Physical

Segment
- Message
- $H_T$

Used by TCP and UDP
Packet Headers

- Protocol at each layer adds its own “headers” for “control data”.

![Diagram showing packet headers at different layers]

- Message
- \( H_T \)
- \( H_N \)

Datagram

Used by IP, Routing
Protocol at each layer adds its own “headers” for “control data”.

[Diagram showing the layers of a network with headers added at each layer]
What is Next?

- For the rest of this track we will cover:
  
  - Part 2: Common Tools & Techniques in Network Security
    (Dr. Akbar Siami-Namin)
  
  - Part 3: Cyber Security in the Internet Protocol Stack
    (Dr. Hamed Mohsenian-Rad)
  
  - Part 4: Research and Education in Network Security
    (Dr. Rattikorn Hewett)