Topic: **networking fundamentals**

* Fundamental concepts
  + Encapsulation
  + Layered protocols (ISO-OSI model)
  + End-to-end communication (layer 3 and above) vs link-layer (layer 2) communication
  + …
* A network packet has the packet header followed by the packet content (aka the payload).

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| --- | --- |
| The packet **header**:   * Source address = [yang@uhcl.edu](mailto:yang@uhcl.edu) * Destination address = [someone@uh.edu](mailto:someone@uh.edu) * Protocol id = 1234… (SMTP) * Message id = 3 * Length of the payload = 5K bytes * … | The **payload**:  The actual packet content |

The two sides/ends/peers of this communication must understand each other, that is using the same language/protocol.

* Packet Switching: A packet is delivered from one end, say A, to the other end, say B, by being processed by intermediate devices through the internetwork.

NOTE: Two packets that belong to the same message are often delivered over different paths.

* **Encapsulation** occurs between two adjacent layers, when a layer n packet is handed down to the underlying layer, say layer n-1. The layer n packet becomes the payload of the layer n-1 packet.

This is the layer n packet.

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| --- | --- |
| The packet **header**:   * Source address = [yang@uhcl.edu](mailto:yang@uhcl.edu) * Destination address = [someone@uh.edu](mailto:someone@uh.edu) * Protocol id = 1234… (SMTP) * Message id = 3 * Length of the payload = 5K bytes * … | The **payload**:  The actual message |

The layer n packet will be encapsulated into the layer n-1 packet.

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| **A new header for layer n-1:**  Source address = source IP  Destination address = destination IP  Source port# = …  Destination port# = …  Protocol id = … (TCP)  … | The packet **header**:   * Source address = [yang@uhcl.edu](mailto:yang@uhcl.edu) * Destination address = [someone@uh.edu](mailto:someone@uh.edu) * Protocol id = 1234… (SMTP) * Message id = 3 * Length of the payload = 5K bytes * … | The **payload**:  The actual message |

* The **OSI model** is used as a reference network model to explain how entities interact with each other in a computer network.

A scenario: **John** is using his computer (computerJ) to send an email to Mary. **Mary** read her emails on computerM.

Assumptions:

1. John is using an email software based on the SMTP (Simple Message Transport Protocol).
2. John’s email severs is called ServerJ, and Mary’s email server is called serverM.
3. John’s default router/gateway is called rJ, and Mary’s is called rM.
4. John’s email address is [John@uhcl.edu](mailto:John@uhcl.edu), IP is jIP, and mac address is jMAC; Mary’s email address is [Mary@somewhere.org](mailto:Mary@somewhere.org), IP is mIP, and mac address is mMAC.

**Encapsulation** of network packets:

The packet (including header and payload) at certain layer becomes the payload of the packet at the layer below.

John

The message = “Hi. Mary. How are you doing?”

At Layer 7 (application layer), the packet looks like this:

|  |  |
| --- | --- |
| SMTP header  Sender: [John@uhcl.edu](mailto:John@uhcl.edu)  Receiver: [Mary@somewhere.org](mailto:Mary@somewhere.org)  Protocol id: SMTP id  Message id: …  Number of bytes in the payload: … | Data or payload  The message |

At layer 4 (transport layer), the layer 7 packet is encapsulated into a layer 4 packet.

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| --- | --- | --- |
| TCP header  Source IP: jIP  Source port#: …  Destination IP: mIP  Destination port#: …  … | SMTP header  Sender: [John@uhcl.edu](mailto:John@uhcl.edu)  Receiver: [Mary@somewhere.org](mailto:Mary@somewhere.org)  Protocol id: SMTP id  Message id: …  Number of bytes in the payload: … | Data or payload  The message |

At layer 3 (network layer), the layer 4 packet becomes the payload of the layer 3 packet.

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| --- | --- | --- | --- |
| IP header  Source IP: jIP  Destination IP: mIP | TCP header  Source IP: jIP  Source port#: …  Destination IP: mIP  Destination port#: …  … | SMTP header  Sender: [John@uhcl.edu](mailto:John@uhcl.edu)  Receiver: [Mary@somewhere.org](mailto:Mary@somewhere.org)  Protocol id: SMTP id  Message id: …  Number of bytes in the payload: … | Data or payload  The message |

Suppose John’s computer is connected to the Internet via wi-fi.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Wi-fi header  Source MAC: jMAC  Destination MAC: the MAC address of rJ  Protocol id: 802.11 | IP header  Source IP: jIP  Destination IP: mIP | TCP header  Source IP: jIP  Source port#: …  Destination IP: mIP  Destination port#: …  … | SMTP header  Sender: [John@uhcl.edu](mailto:John@uhcl.edu)  Receiver: [Mary@somewhere.org](mailto:Mary@somewhere.org)  Protocol id: SMTP id  Message id: …  Number of bytes in the payload: … | Data or payload  The message |

Understanding of the OSI model is essential.

We need to know that the attacker can not only attack the data itself (changing, stealing) but also information in those various headers (spoofing attacks).

* **End-to-end communication** occurs between programs at layer 3 and above, where the two ends/programs at the same layer speak the same language/protocol.

Application layer (layer 7): SMTP ------------------------------ SMTP

Transport layer (layer 4): TCP ----------------------------------------- TCP

Network layer (layer 3): IP --------------------------------------------------------- IP

* **Link-layer communication** refers to communication at the Data Link Layer (part of layer 2 in the OSI model), which requires a physical connection between the two ends. Examples include Ethernet (802.3), Wi-Fi (802.11), …

**Let ========= represent a physical link between two devices.**

e.g., The **sender** ========= the sender’s router/gateway ========== the next hop/router …. ========== the receiver’s router ========= the **receiver**

* Examples of Tunneling protocols: An IP packet becomes the payload of an IPSec packet. Both IP and IPSec are at layer 3 (or the network layer).