Protocols

- Diplomats use rules, called protocols, as guides for formal interactions
- A communication protocol is a set of rules that specify the format and meaning of messages exchanged between computers across a network
- A set of related protocols that are designed for compatibility are called protocol suite

Human and Computer Protocols

Human Protocol

Hi
Got the time?
2:00

Computer Protocol

TCP connection req.
TCP connection reply.
Get http://gaia.cs.umass.edu/index.htm
<file>
**Layered Protocol Design**

- *Layering model* is a solution to the problem of complexity in network protocols
- The model divides the network protocols into *layers*, each of which solves part of the network communication problem
  - Each layer has its own protocol!
- Each layer implements a *service* to the layer above
  - Via its own internal layer actions
  - Relying on layers provided by the layers below

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**Example: Organization of Air Travel**

- A series of steps:
  - Arrival at airport
    - baggage (check)
    - gates (load)
    - runway takeoff
    - airplane routing
  - Departure from airport
    - baggage (claim)
    - gates (unload)
    - runway landing
    - airplane routing
Organization of air travel: a different view

<table>
<thead>
<tr>
<th>Airport arrival</th>
<th>Airport departure</th>
</tr>
</thead>
<tbody>
<tr>
<td>baggage (check)</td>
<td>baggage (claim)</td>
</tr>
<tr>
<td>gates (load)</td>
<td>gates (unload)</td>
</tr>
<tr>
<td>runway takeoff</td>
<td>runway landing</td>
</tr>
<tr>
<td>airplane routing</td>
<td>airplane routing</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Layered Air Travel: Services

<table>
<thead>
<tr>
<th>Airport-to-Airport delivery of person+bags</th>
</tr>
</thead>
<tbody>
<tr>
<td>baggage-claim-to-baggage-claim delivery</td>
</tr>
<tr>
<td>people transfer: loading gate to arrival gate</td>
</tr>
<tr>
<td>runway-to-runway delivery of plane</td>
</tr>
<tr>
<td>airplane routing from source to destination</td>
</tr>
</tbody>
</table>
Distributed implementation of layer functionality

Departing airport

Arrival
- baggage (check)
- gates (load)
- runway takeoff
- airplane routing

Departure
- baggage (claim)
- gates (unload)
- runway landing
- airplane routing

Intermediate air traffic sites

Example: The ISO Reference Model

- Application
- Presentation
- Session
- Transport
- Network
- Data Link
- Physical
Layers of Interest in ISO Model

- **Layer 7: Application**
  - Application-specific protocols (e.g. ftp, http, smtp)
- **Layer 4: Transport**
  - Reliable delivery of data between computers
- **Layer 3: Network**
  - Address assignment and data routing across a network
- **Layer 2: Data Link**
  - Delivery of frames through physical network (e.g., Ethernet, Token Ring)
- **Layer 1: Physical**
  - Basic network hardware (makes sure that if you send a “1”, you receive a “1”)

Internet Protocol Stack

```
application
transport
network
link
physical
```
Layered Software Implementation

- The software for each layer depends only on the services of the software provided by lower layers.
- The software at layer \( n \) at the destination receives exactly the same protocol message sent by layer \( n \) at the sender.
Layering Principle

Each layer:
- distributed
- “entities” implement layer functions at each node
- entities perform actions, exchange messages with peers
Layering: logical communication

E.g.: transport
• take data from application
• add addressing, reliability check info to form “datagram”
• send datagram to peer
• wait for peer to ack receipt
• analogy: post office

Layering: physical communication
Messages and Protocol Stack

• On the **sender**, each layer:
  – Accepts an outgoing message from layer above
  – Adds a **header** for that layer and performs other processing
  – Passes resulting message to next lower layer

• On the **receiver**, each layer
  – Receives an incoming message from layer below
  – Removes **header** for that layer and performs other processing
  – Passes resulting message to next higher layer

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Messages and Protocol Stack

• Example: Internet stack
Control Packets

• Protocol layers often need to communicate directly without exchanging data
  – To acknowledge incoming data
  – To request next data packet
• Layers use control packets
  – Generated by layer n on sender
  – Interpreted by layer n on receiver
  – Transmitted like any other packet by layers n-1 and below