

Lecture 2:

Layering and Framing

CSE 123: Computer Networks

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Our Problem

- Communications is more complicated than it seems
 - ◆ Modulation bits into analog signals
 - ◆ Splitting sequences of bits into packets
 - ◆ Fixing errors
 - ◆ Controlling access to network
 - ◆ Routing
 - ◆ Recovering from lost messages
 - ◆ Etc....
- Really hard to think about all of this and get it right
- Not all applications need all of it
- How to achieve interoperability?

Layering: A Modular Approach



- Sub-divide the problem
 - ◆ Each layer relies on services from layer below
 - ◆ Each layer exports services to layer above
- Interface between layers defines interaction
 - ◆ Hides implementation details (encapsulation)
 - ◆ Layers can change without disturbing other layers (modularity)
- Interface among peers in a layer is a **protocol**
 - ◆ If peers speak same protocol, they can interoperate



Key Design Decision...

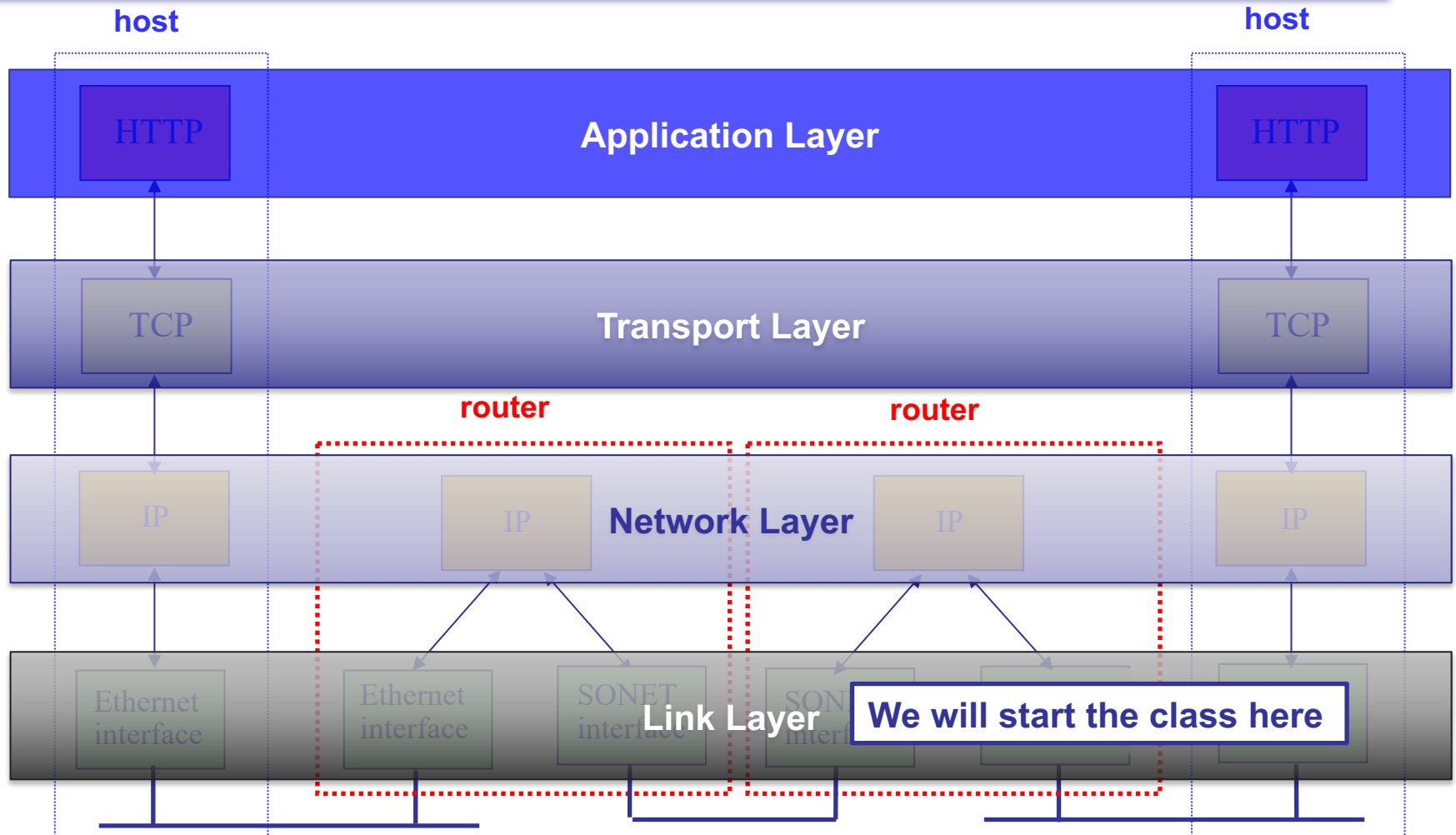
- ...how do you divide functionality across the layers?
- **End-to-end argument [Saltzer84]**
 - ◆ Functionality **should** be implemented at a **lower layer** iff it can be **correctly** and **completely** implemented there
 - ◆ Incomplete versions of a function can be used as a performance enhancement, but not for correctness
- Early, and still relevant, example
 - ◆ ARPAnet (link layer) provided:
reliable transfers across links between switches
 - ◆ Was this enough for reliable communication?
 - ◆ No, packets could still get corrupted on host-switch link, or inside of the switches
 - ◆ Hence, **still need reliability at higher layers**



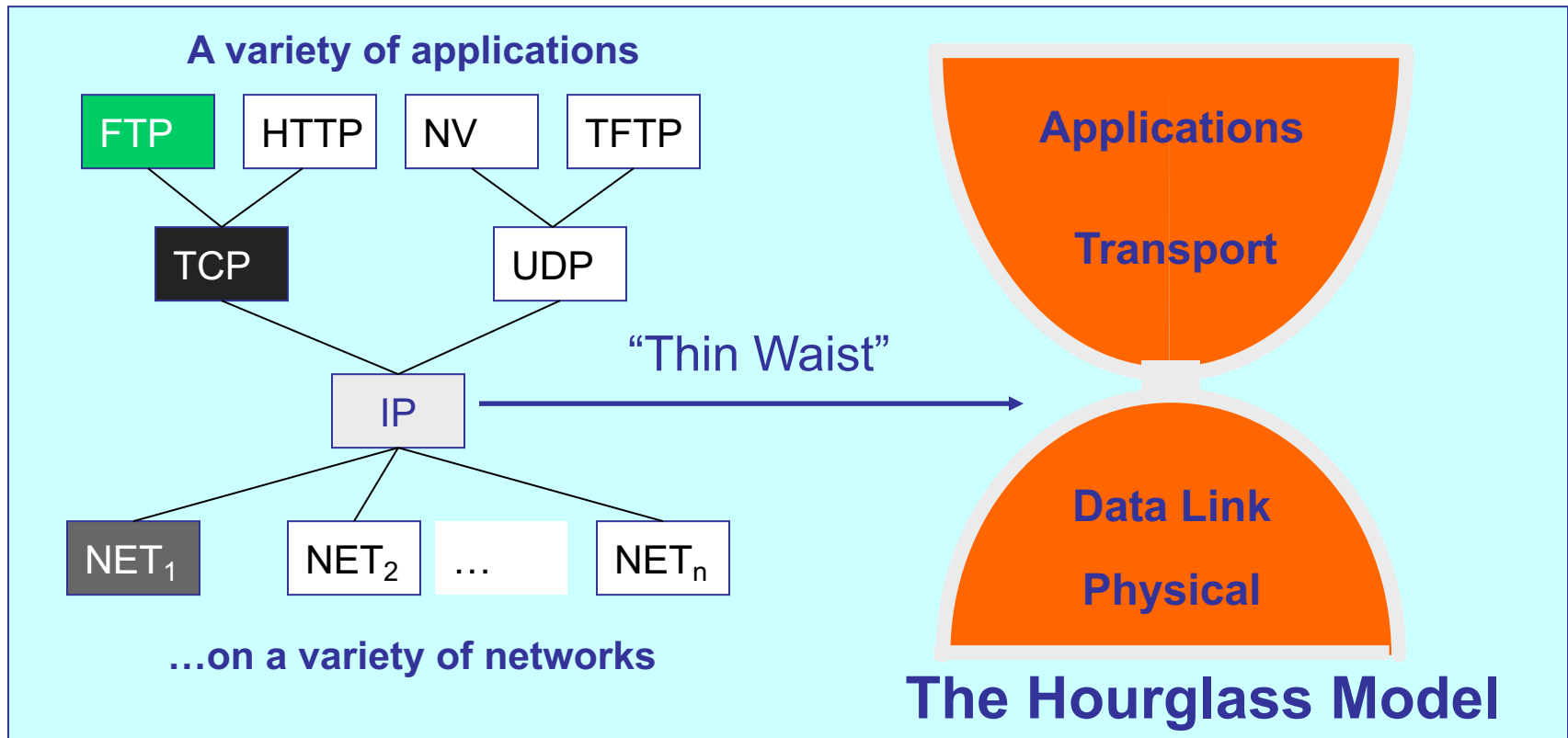
Protocol Standardization

- Communicating hosts need to speak the same protocol
 - ◆ Standardization to enable multiple implementations
 - ◆ Or, the same folks have to write all the software
- Internet Engineering Task Force
 - ◆ Based on working groups that focus on specific issues
 - ◆ Produces “Request For Comments” (RFCs)
 - » “Rough consensus and running code”
 - » After enough time passes, promoted to Internet Standards
- Other standards bodies exist
 - ◆ ISO, ITU, IEEE, etc.

TCP/IP Protocol Stack



Layering enabled growth: Internet Protocol Suite

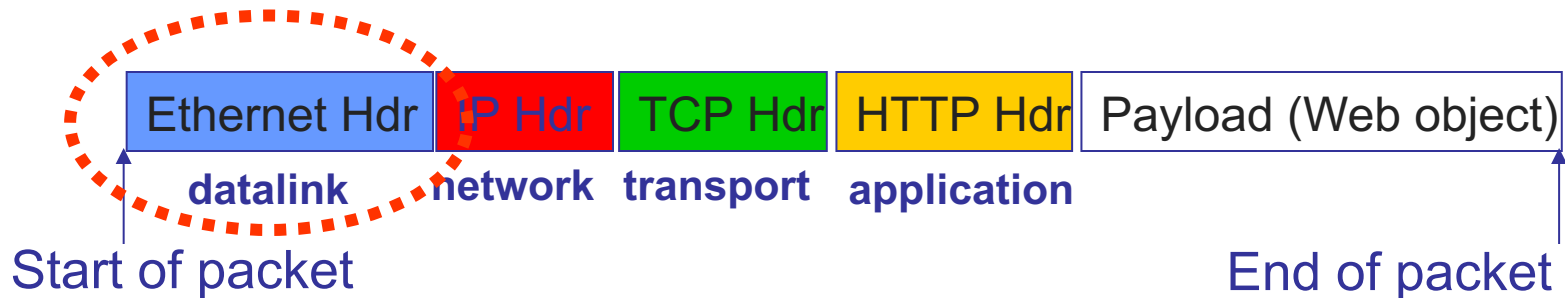


The success of the Internet (and its problems) can largely be attributed to the "thin waist"

Layer context encapsulated in packets via headers



- Typical packet in Web transfer



- Notice that layers (and thus headers) add overhead
 - ◆ Space (headers), effective bandwidth
 - ◆ Time (processing headers, “peeling the onion”), latency

Later: Phy/(MAC)Link (Layer 1)



- Signal encoding
 - ◆ Encode binary data from source node into signals that physical links carry
 - ◆ Signal is decoded back into binary data at receiving node
 - ◆ Work performed by network adapter at sender and receiver
- Media access
 - ◆ Arbitrate which nodes can send frames at any point in time
 - ◆ Not always necessary; e.g. point-to-point duplex links



For Next Class

- Read 2.4
- Project 1 out on Friday