Network Layer Basics

Module Goals

At the conclusion of this module, students will be able to

► explain the role of the network layer

► define the difference between the control plane and data plane

► define the difference between the traditional and SDN approaches to the control plane

The Network Layer

► the transport layer provides process-to-process (end-to-end) communication

► the network layer provides host-to-host communication

► the transport layer rides on the back of the network layer

► this is necessarily a very complex topic, as bits of the network layer are sprinkled through every device in the network
(some in software, some in hardware)

Planes

▶ there are two distinct distinct aspects of the network layer responsibilities:

  ▶ **data plane**: what a router will do with an individual packet when it arrives

  ▶ **control plane**: big picture for how per-router decisions are established in the first place

▶ it might be easier to think of them as **per-router** responsibilities (data plane) and **network-wide** responsibilities (control plane)

▶ alternatively, think of them as **reactionary** (data plane) and **planning** (control plane)

Forwarding vs Routing

► consider the problem of driving somewhere:

    ► occasionally we come to an intersection and, based on our destination, decide either to go straight or make a turn

    ► this process is repeated for every intersection between your starting and ending points

► individual decisions were made based on where you want to go and which one of those roads will get you there the fastest

► this maps directly to the processes of forwarding and routing

Forwarding vs Routing

► turn-by turn decisions are **forwarding** decisions

    ► a packet arrives at the router through some input port

    ► based on the destination, the router transmits it out a particular output port

► the big picture of why we were on that road in the first place and what the right turns are is determined by a **routing** algorithm

► in other words, routing informs forwarding

Forwarding Tables

► forwarding decisions are made by consulting a table

► looking at the destination address (or some other packet header fields) we index into the table to find out which port to use for sending the packet

► tables can be created by a human being or built and updated regularly by the routing algorithm

The Traditional Approach

► everything described so far is the traditional approach to the control plane:

    ► humans with a complete view could create the tables
    (obviously unrealistic! networks are large and dynamic)

    ► more realistic to have devices in the network collaborate to create and update the tables

► both routing and forwarding behaviors are traditionally baked into the router

Software Defined Networking

▶ the **software defined networking** (SDN) approach separates routing and forwarding behaviors

    ▶ forwarding is still done by the router, but...

    ▶ some remote system runs the routing algorithms in software and transmits them to the routers

▶ routing can be a lot more nuanced and complex

▶ we'll discuss this modern networking development more in a little while

Service Models

▶ what kinds of services could a network layer provide?

   ▶ **guaranteed delivery**
   (if I transmit a frame, it is guaranteed to get to the destination)

   ▶ **guaranteed delivery with bounded delay**
   (get your pizza in 30 minutes of less)

   ▶ **in-order delivery**
   (packets get delivered in the order I transmitted them)

   ▶ **guaranteed minimal bandwidth**
   (you can definitely have x bps)

   ▶ **security**
   (your stuff is your stuff and nobody else's stuff)

Provided Services

► the modern Internet only provides **best effort delivery**

   ► the packet will be transmitted

   ► the packet might not be delivered

   ► the packet might not arrive in the order it was transmitted

► higher level layers (TCP) can fix any problems users/applications might have

Summary

▶ the network layer is separated into the control plane (network-wide decisions) and the data plane (per-router decisions)

▶ forwarding is making a decision on how to act upon a particular packet; routing is establishing those decisions in the first place

▶ the traditional approach uses routing algorithms baked into the routers; the SDN approach outsources the routing to remote controllers