Welcome to INE's Presentation of:

IP Routing Basics

Course Objectives

- Provide an understanding of what is meant by the term "Routing", why it is necessary in networks, and the actual process involved of routing data.
- Understand how routers learn the information needed to route, and where that information is stored.
- Compare and contrast different routing protocols from a high-level perspective.

Course Agenda

- Why do we need routing?
- What happens to a packet?
- Where are routes stored?
- How are routes selected?
- Contrasting Routing Protocols
  - IGP vs EGP
  - High-Level Differences
  - Distance Vector
  - Link State
  - Advanced Distance Vector
  - Path Vector

Why Do We Need Routing?

When Routing Isn't Necessary

- Devices need addresses to operate on a network
- Non-Routable Addresses
- Network applications that assume flat networks typically utilize broadcasts.
- ZeroConf (IETF) is an example of this.
  - Bonjour by Apple
  - Airplay by Apple

So what's the problem?

- Each broadcast interrupts everyone.
- Each broadcast consumes bandwidth.
- No security…every device can see every other device.
- Fault Isolation difficult to diagnose.
- The solution…break the network up into different broadcast domains…and allow devices to identify which broadcast domain they belong to.

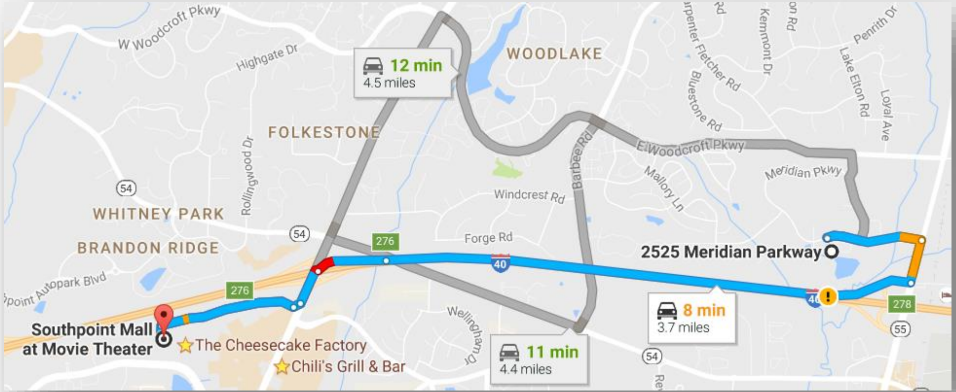
Addressing with Broadcast Domains

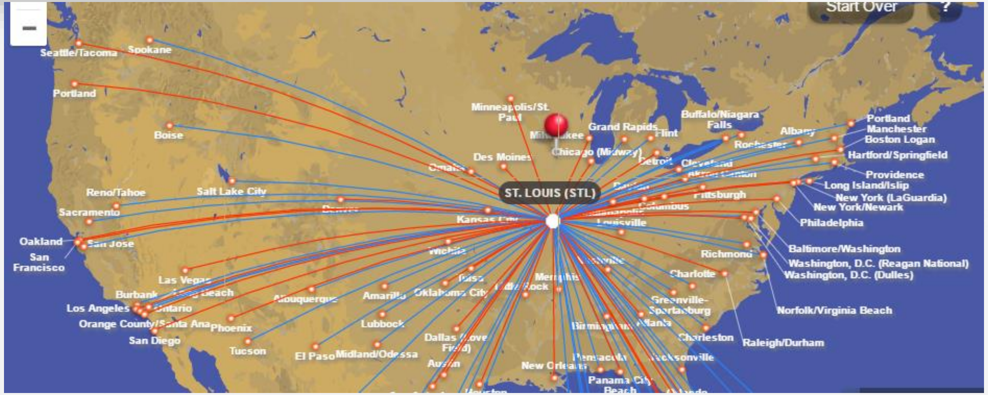
- End-to-end reachability requires Routable addresses.
- Protocols that use Routable Addresses must provide:
  - Method for obtaining an address.
  - Method for determining the local network.
  - Method for determining the address of off-network destinations.
  - Method for sending packets off-network.
  - Devices that can route packets between networks.

Identifying Routable Addresses

What Happens to a Packet?

What is it to ROUTE?

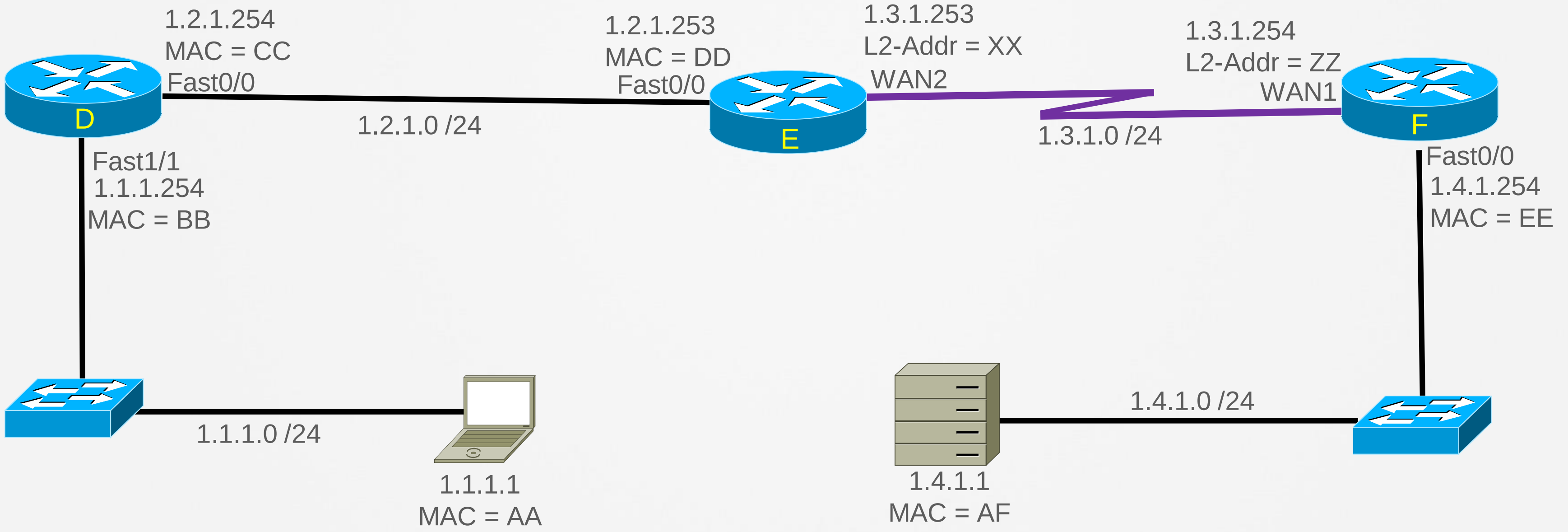




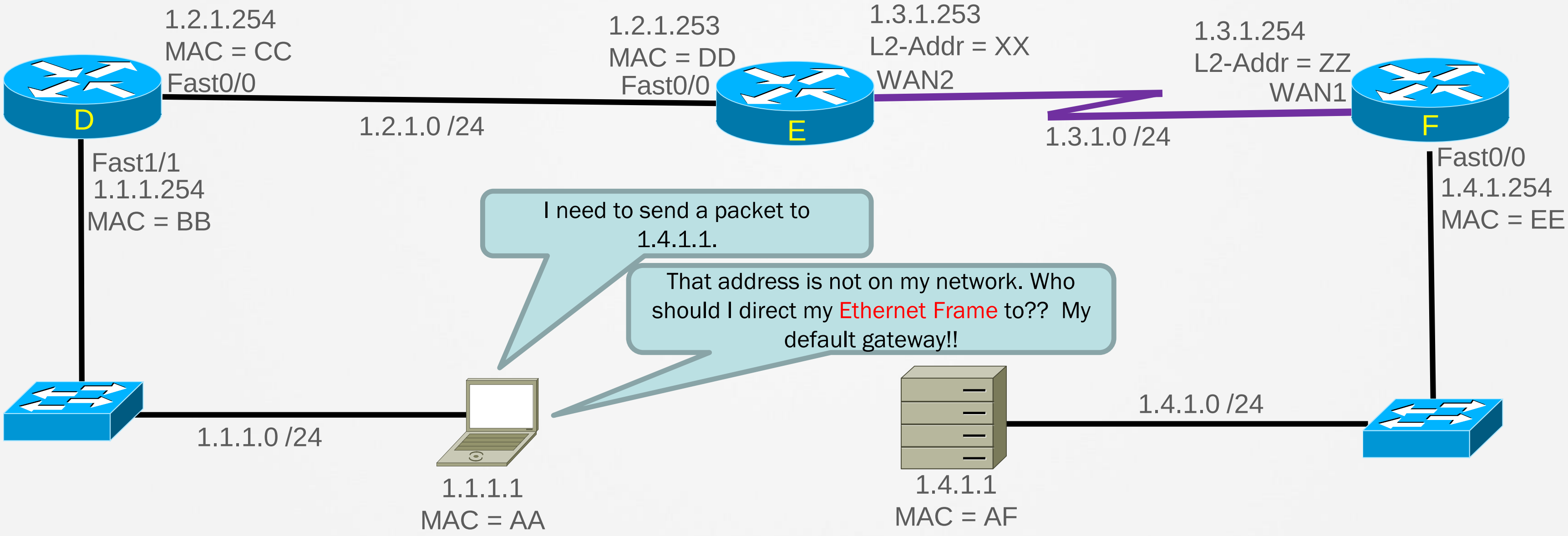
What is “Routing”?

- Process of forwarding packets between networks.
- Basic components needed to route:
  - Routable Packet (IPv4, IPv6, etc)
  - Network address
  - Subnet mask
  - Next Hop
  - Egress Interface

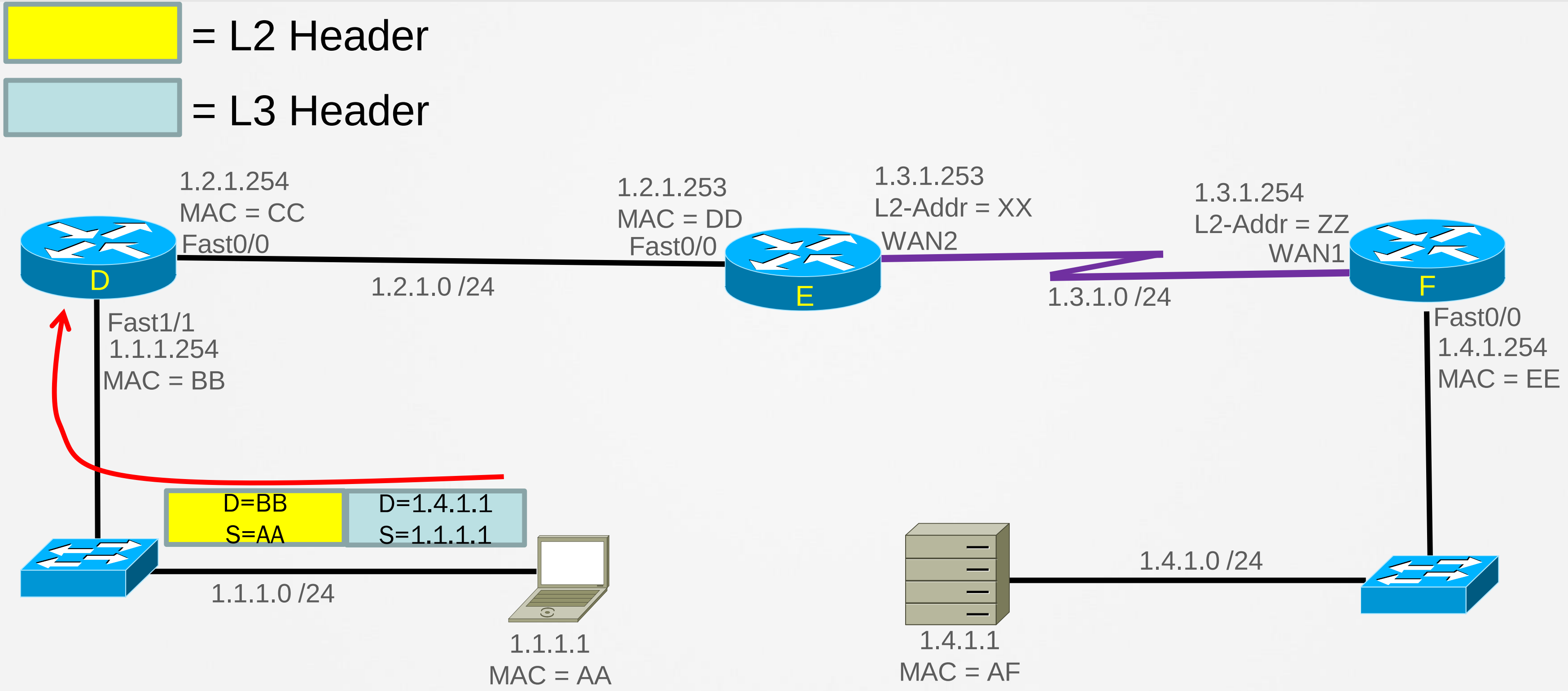
Routing: What Happens to the Packet (1)



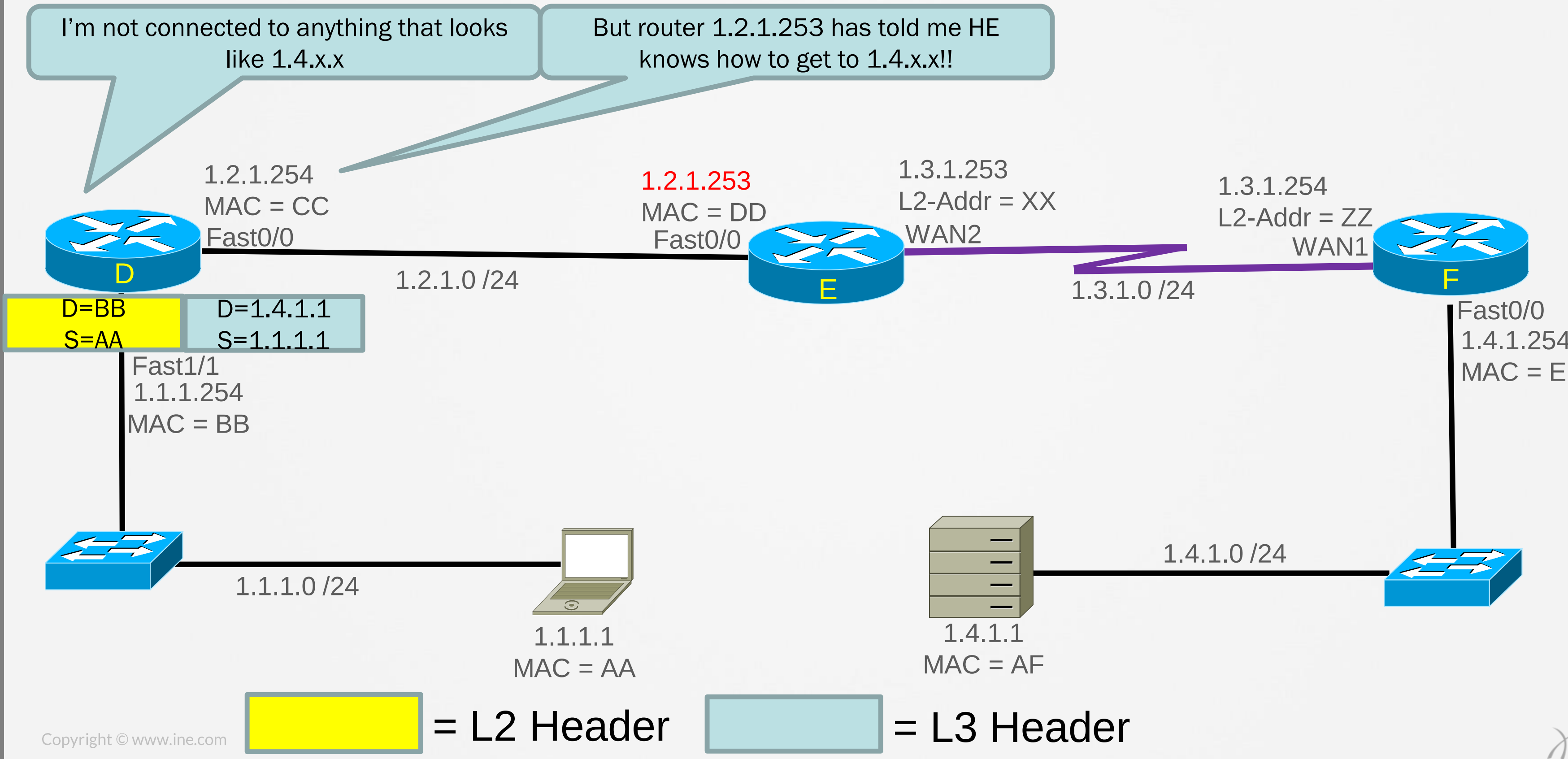
Routing: What Happens to the Packet (2)



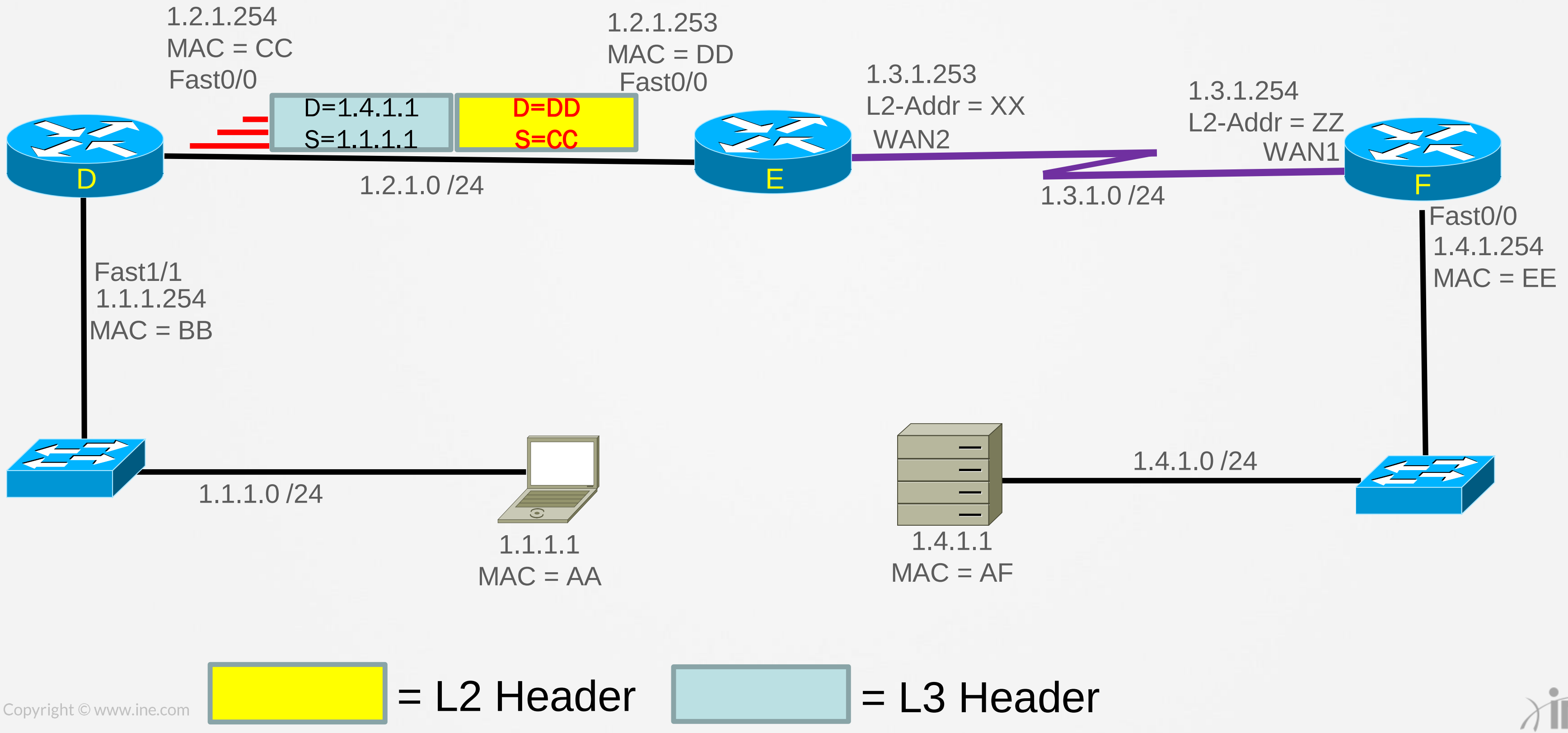
Routing: What Happens to the Packet (3)



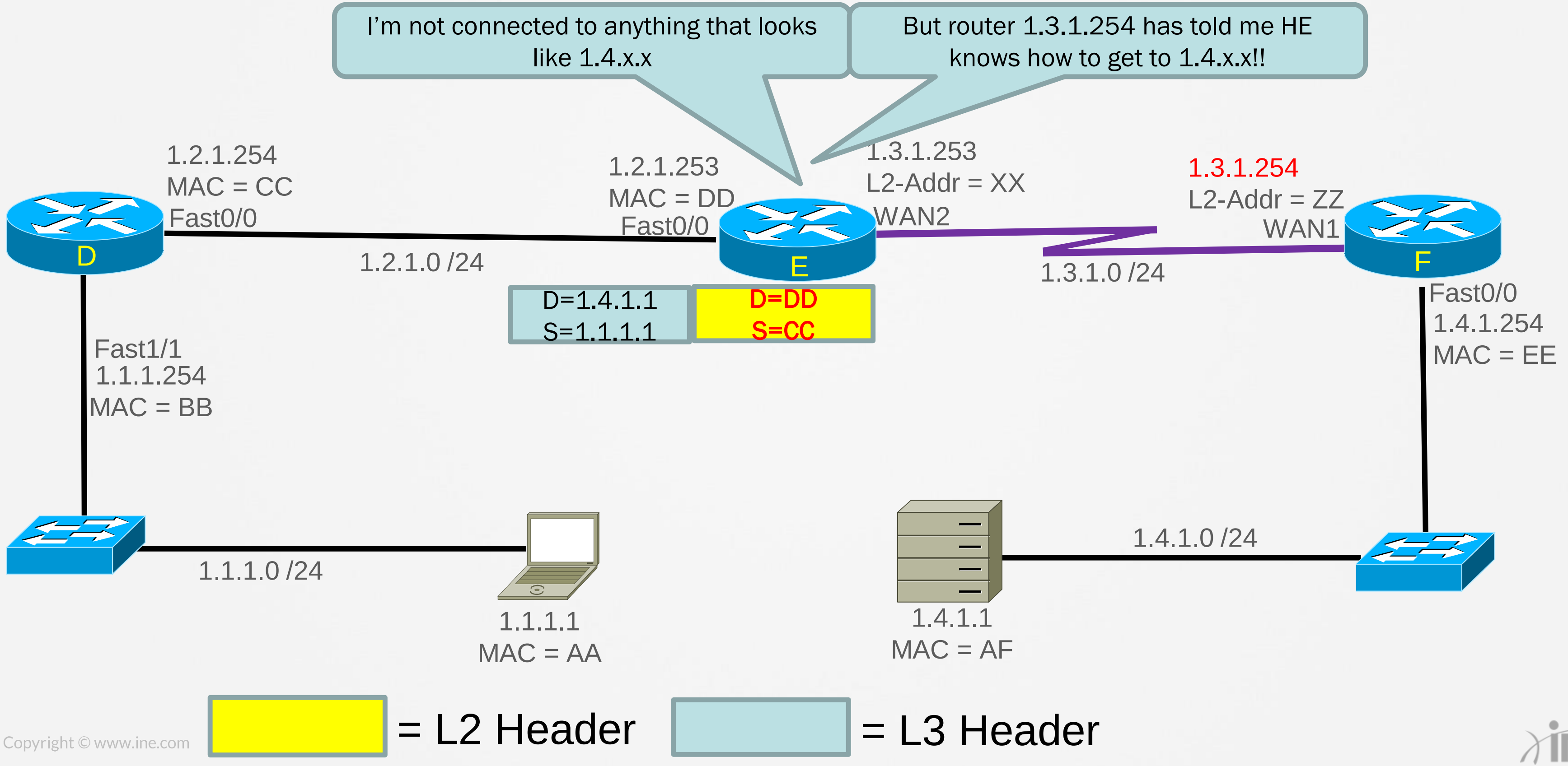
Routing: What Happens to the Packet (4)



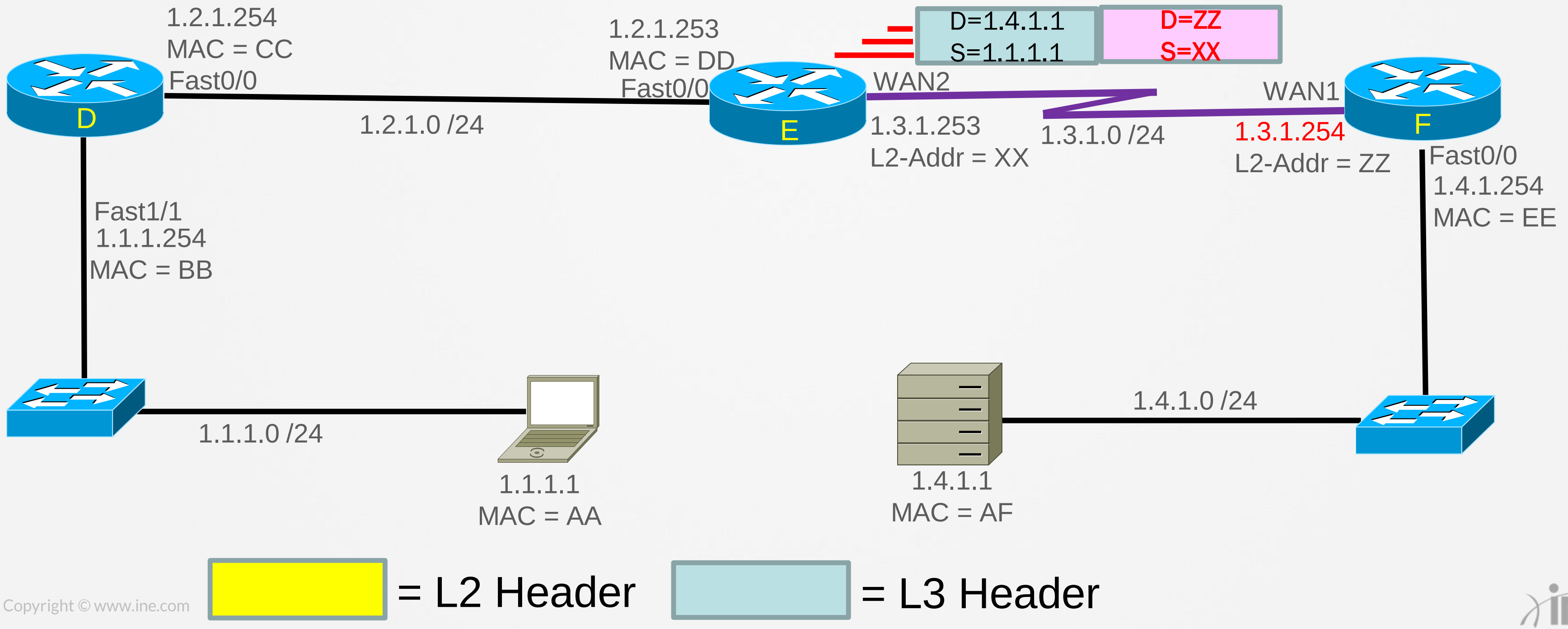
Routing: What Happens to the Packet (5)



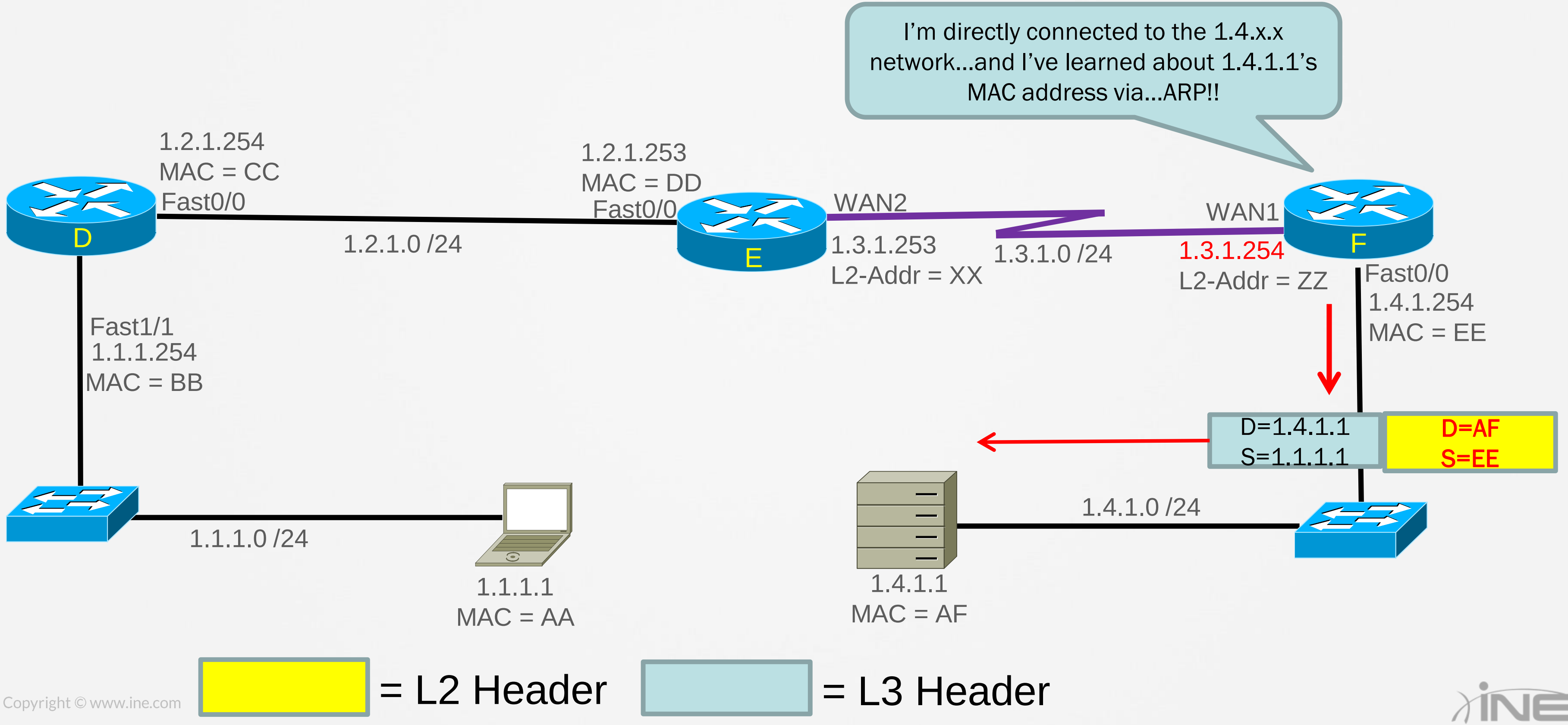
Routing: What Happens to the Packet (6)



Routing: What Happens to the Packet (7)



Routing: What Happens to the Packet (8)



Where Are Routes Stored?

Types of Routes

- Connected
- Static
- Dynamic

General Rules of Routing

- Router will only accept routes that match its own, active protocols
  - No IPv6 routes accepted if router not an IPv6 host
- Router will only use routes with reachable "next hops"
- Next-Hop must be paired with a usable L2 address.
- Routers will only use the "best" routes
- Routes must be "believable" (how do I know this route is still good?)

Where Are Routes Stored? (Part-2)

“Switching” within Routers

» Switching methods in routers:

- Process-Based Switching

```
Rtr1#sho processes 87
Process ID 87 [IP Input], TTY 0
Memory usage [in bytes]
  Holding: 13204, Maximum: 13204, Allocated: 0, Freed: 2744
  Getbufs: 0, Retbufs: 0, Stack: 9616/12000
CPU usage
  PC: 612A53B0, Invoked: 7475, Giveups: 0, uSec: 3
  5Sec: 0.00%, 1Min: 0.00%, 5Min: 0.00%, Average: 0.00%
  Age: 444776752 msec, Runtime: 24 msec
  State: Waiting for Event, Priority: Normal
```

- Fast Switching
- Cisco Express Forwarding

Forwarding Information Base

» CEF Components (FIB)

- Forwarding Information Base
- Copy of IP Routing Table

- *Show ip cef [detail]*
- *Show ip cef <ip addr> <mask> detail*

Adjacency Table

» CEF Components (Adjacency Table)

- Populated with L2 adjacency information
- Populated by L2 tables such as:

  ARP Table

  Frame-Relay Mapping Table

  P2P Header Formats

- Show adjacency <*intf type/number*> [summary | detail]
- *Show adjacency detail*

Adjacency Types

- Some adjacency types can’t be CEF switched and must be dropped, or sent to CPU for processing:
  - Glean
  - Null
  - Drop
  - Discard
  - Punt

How Are Routes Selected?

Prioritizing Route Sources

Administrative Distance (AD)

- Defines trustworthiness of a routing protocol
- 8-bit numbering system
- Ranges from 0 through 255

Administrative Distance Values

Protocols	AD Value
Connected	0
Static	1
EIGRP (Internal routes)	90
OSPF	110
IS-IS	115
RIP	120
EIGRP (External routes)	170
iBGP/eBGP	200/20
Unreachable	255

Routing Metric

- Used for best path selection process
- IGPs use metric for shortest path calculation
- Lower value is preferred
- Depends on the routing protocol architecture
  - EIGRP metric = composite formula utilizing link bandwidth + delay
  - RIP metric = hop count
  - OSPF metric = link bandwidth

Contrasting Routing Protocols (IGP and EGP)

Dynamic Protocols: IGP or EGP?

- Autonomous System;
  - Collection of networks all under one administrative authority.
- IGP;
  - Interior Gateway Protocol
  - Designed to provide prefix reachability information **within** an Autonomous System
- EGP;
  - Exterior Gateway Protocol
  - Designed to provide prefix reachability information **between different** Autonomous Systems.

Contrasting Routing Protocols (High-Level Differences)

Protocol Characteristics (1)

» RPs can be classified into one-of-four categories that broadly define operational characteristics;

- Distance Vector (IGPs)
- Link-State (IGPs)
- Advanced Distance Vector (Hybrid) (IGPs)
- Path Vector (EGP)

Protocol Characteristics (2)

- Once categorized, assumptions about the protocol can be made about such things as:
  - Neighbor requirements
  - Route Maintenance (is this route still believable after some prolonged time?)
  - Visibility into network topology
  - Necessity of different data structures (tables, databases, etc)

Protocol Characteristics - Routing Updates

Incremental update

- Only changes are sent in the routing update

Full update

- All of the routing table is sent in the update

Periodic update

- Sent in the specified time interval

Triggered update

- Sent whenever change is detected

Contrasting Routing Protocols (Distance Vector)

Distance Vector

- Neighbor requirements;
  - No neighborships required
- Route Maintenance (is this route still believable after some prolonged time?)
  - Resend routes after defined interval
- Visibility into network topology
  - Knowledge of topology only extends to directly-connected routers.
- Necessity of different data structures (tables, databases, etc)
  - Database of learned routes
- Protocol Examples:
  - **RIP (v1 and v2),** IGRP (deprecated)

Contrasting Routing Protocols (Link State)

Link State (1)

- Neighbor requirements;
  - Neighborships required
- Route Maintenance (is this route still believable after some prolonged time?)
  - Periodic Hello’s between neighbors
  - Regenerate LSAs after defined interval
- Visibility into network topology
  - Complete visibility of entire topology for directly-connected areas.

Link State (2)

- Necessity of different data structures (tables, databases, etc)
  - Database of learned LSAs (Link State Database)
  - Neighbor Table
  - SPF Tree
- Protocol Examples:
  - **OSPF, ISIS**

Contrasting Routing Protocols (Advanced Distance Vector)

Advanced Distance Vector / Hybrid (1)

- Neighbor requirements;
  - Neighborships required (Link State characteristic)
- Route Maintenance (is this route still believable after some prolonged time?)
  - Periodic Hello's between neighbors (Link State characteristic)
- Visibility into network topology
  - Knowledge of topology only extends to directly-connected routers. (Distance Vector characteristic)

Advanced Distance Vector / Hybrid (2)

- Data structures (tables, databases, etc)
  - Topology Table of learned routes (Distance Vector characteristic)
  - Neighbor Table (Link State characteristic)
- Protocol Examples:
  - EIGRP

Contrasting Routing Protocols (Path Vector)

Path Vector

- Neighbor requirements;
  - Neighborships required
- Route Maintenance (is this route still believable after some prolonged time?)
  - Periodic Hello's between neighbors
- Visibility into network topology
  - No Knowledge of topology. Relies on IGP's for this.
- Necessity of different data structures (tables, databases, etc)
  - Not necessary to know at ICND1 level
- Protocol Examples:
  - **BGP**

Thank you!!