

CS 3640: Introduction to Networks and Their Applications

Fall 2023, Lecture 9: Review of the link layer

Instructor: Rishab Nithyanand

Teaching Assistant: Manisha Keim

Announcements

- **Assignment 2**
 - Due 9/28
- **Assignment 3**
 - Will be released on 9/28; due on 10/12
- **Mid-term on 10/17**
 - Internet design principles
 - Link layer
 - Network layer

Today's class

1.

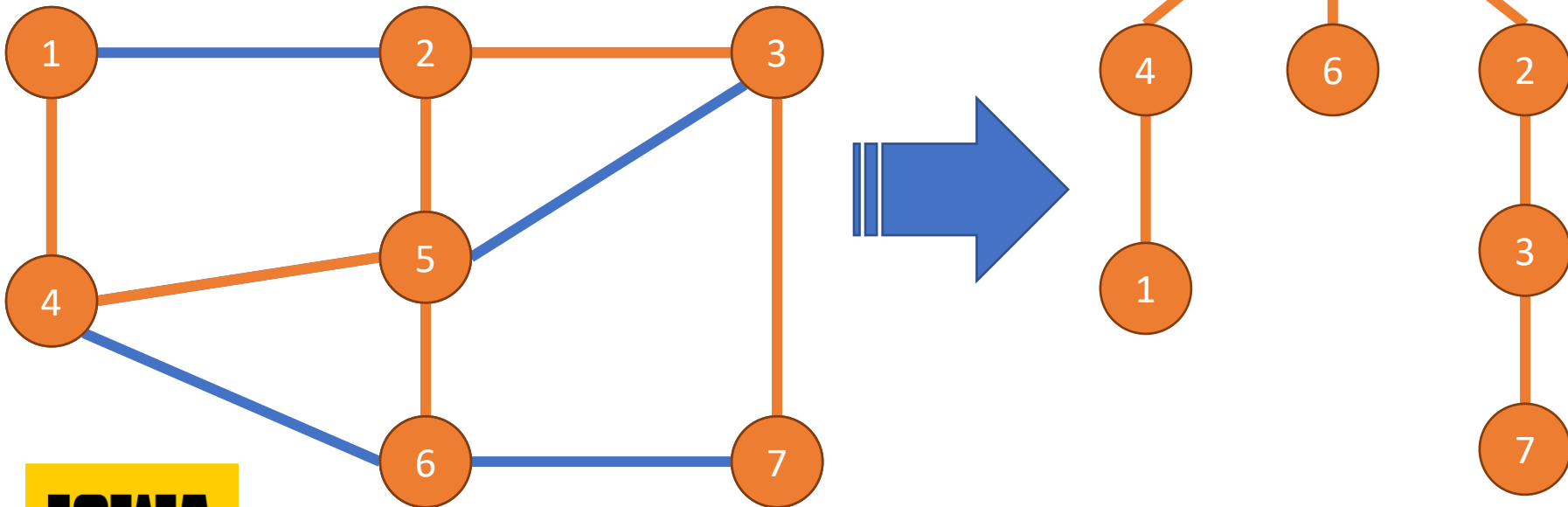
Wrapping up
link layer

2.

Link layer
fundamentals (quiz)

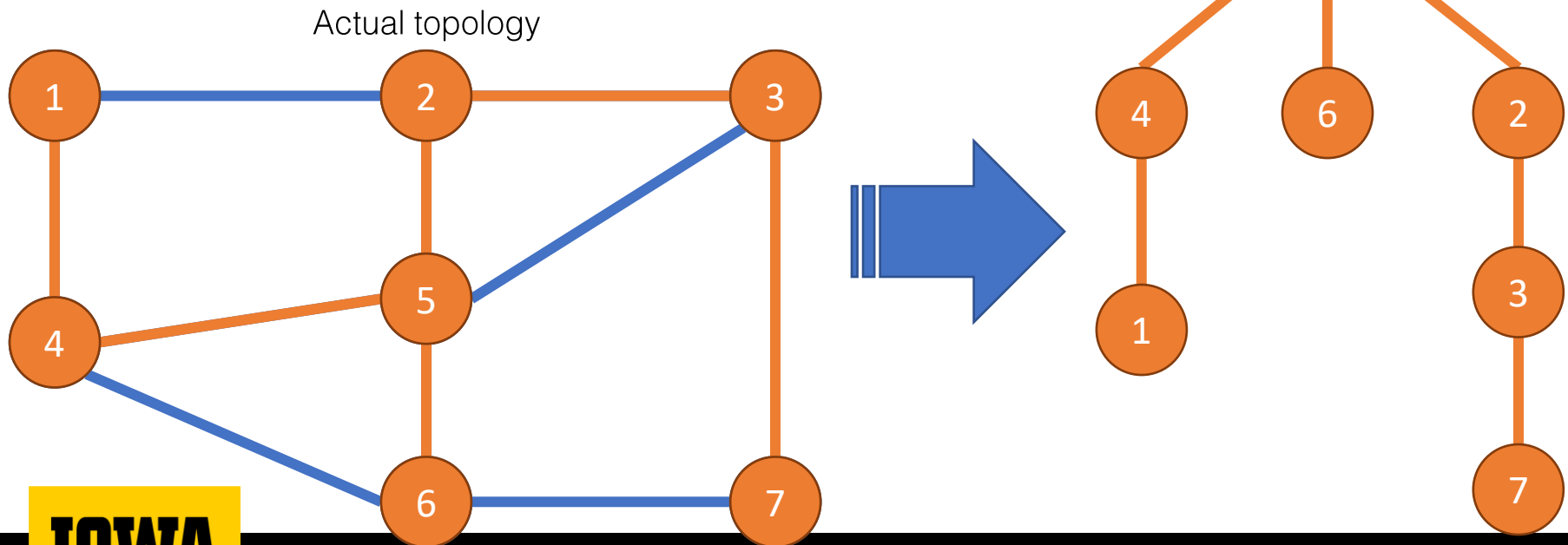
Spanning trees

- A subset of edges in a graph that:
 - Spans all nodes.
 - Does not create any cycles.



Why do spanning trees help?

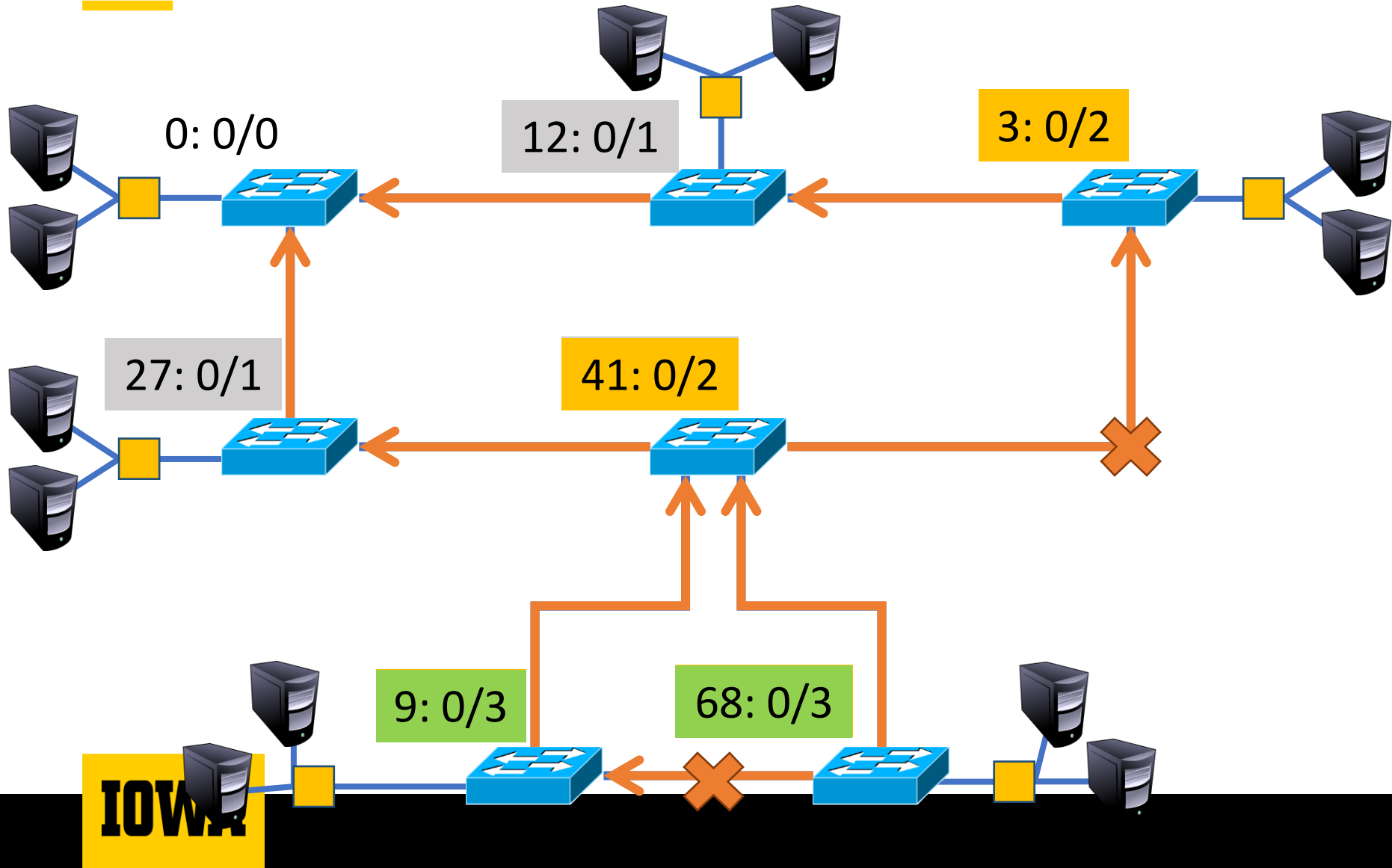
- If bridges in our topology can collectively organize their forwarding tables to make the topology seem like a spanning tree, then all loops are removed.



How do nodes construct a spanning tree from any network topology?

- All bridges randomly elect a single bridge as the “root” of the spanning tree.
 - Example (shortest straw): All bridges pick a random number. The bridge with the smallest random number is the root.
- Each bridge finds the shortest path to this root.
 - Problem: Need to know where the root is and the shortest way to get there.
 - Solution: Broadcast your best knowledge to all neighbors. Update your knowledge. Repeat until steady state is reached.
- The union of all these paths is a spanning tree.

How do nodes construct a spanning tree from any network topology?



Bridges vs. Switches

- **Both make it possible to increase LAN capacity via the same approaches.**
 - Automatically learn and maintain forwarding tables.
- **A switch is a special case of a bridge.**
 - Bridge: Each port can be connected to either another bridge, hub, or broadcast net.
 - Switch: Each port can only be connected to a single device (an end-host or another switch).
 - You don't need MAC protocols in switches! Why?

How does the link layer frame travel from source to destination within a LAN?

- **We know how frames are forwarded within the LAN.**
 - Switches and bridges. Both rely on knowing the destination MAC address.
- **But how does the sender know the MAC address of the receiver?**
 - The Address Resolution Protocol (ARP)
 - Each end-host maintains an ARP table.
 - This is a collection of <IP address, MAC address, TTL> tuples.
 - When a packet from the network layer arrives, the link layer looks at the destination IP address and fetches the corresponding record from the ARP table.
 - **Discuss:** What if there is no entry in the ARP table?
 - Broadcast an ARP request asking for a response from the end-host owning the destination IP address.
 - ARP response has MAC address.

Discussion

- **Could the whole Internet be one big switching domain? What would this look like? What issues would appear?**
 - Constant broadcasting to locate unknown hosts (billions of these!) would be a disaster!
 - Reaching a steady state with the spanning tree would be very improbable.
 - Each switch would need to know every MAC address on the Internet! Think of the memory that would require!
- **We use IP addressing and network-layer routing to avoid these problems.**
 - Topic for the next few weeks 😊

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Core functions of the link layer

- What job does the link layer do? What header fields does it use to help it do its job?

Error handling in the link layer

- What are the approaches for detecting errors in frames? What are the limitations of each approach?
- How does the sender of a frame know if a frame was received error free? How do we improve the efficiency of this protocol?

Medium access control

- Why do we need MAC protocols?
- What is key idea behind the ALOHA protocol? What improvement does the Slotted ALOHA make? Why does it work?
- How does the CSMA/CD protocol work? Why doesn't it apply to wireless networks? How does the CSMA/CA protocol work? Why do we need the RTS/CTS variant?
- What are the hidden terminal and exposed terminal problems? What errors do they introduce? How do we solve them?

Addressing and forwarding in the link layer

- How do we address devices on the link layer? Are these addresses unique to each device?
- What are the differences between hubs, switches, and bridges?
- What is a forwarding table? How do bridges and switches create/update their forwarding tables?
- Why are loops bad in our networks? How do we prevent them from causing problems?