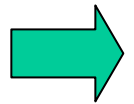


An Introduction to Computer Networks

Prof. Dina Katabi

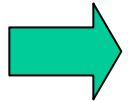
Some slides are from lectures by Nick McKeown, Ion Stoica, Frans Kaashoek, Hari Balakrishnan, and Sam Madden

Chapter Outline



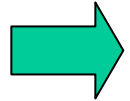
- ❖ Introduction (slides and 7.A)
- ❖ Layered Architecture (slides and 7.B & 7.D)
- ❖ Routing (slides and 7.D)
- ❖ Reliable Transmission & Flow Control (slides and read 7.E)
- ❖ Congestion Control (slides and read 7.F)

This Lecture



- ❖ What is a network?
- ❖ Sharing the infrastructure
 - ❖ Circuit switching
 - ❖ Packet switching
- ❖ Best Effort Service
 - ❖ Analogy: the mail system
 - ❖ Internet's Best Effort Service

This Lecture



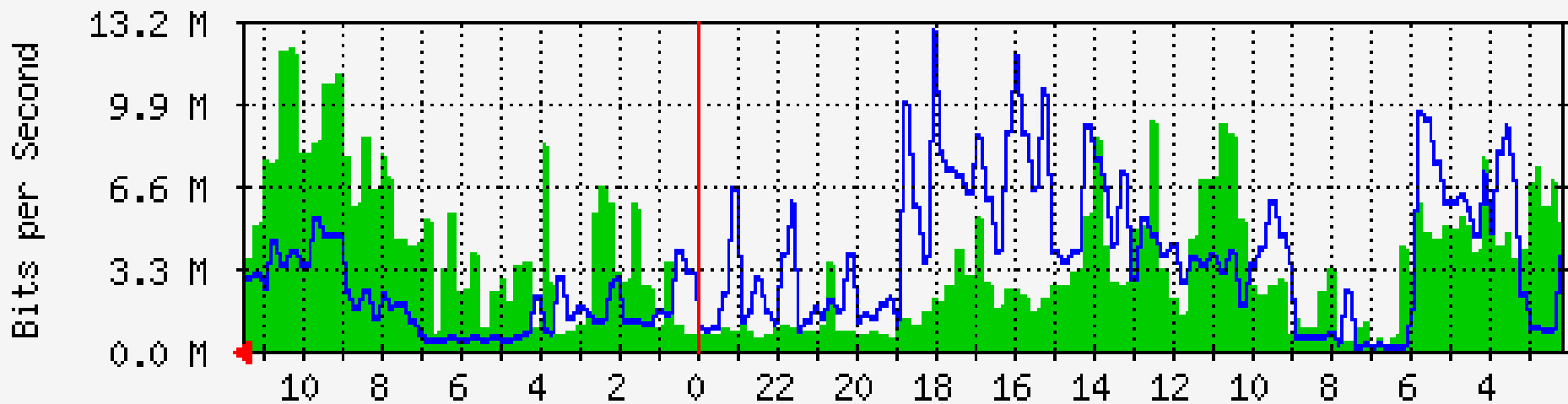
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Two ways to share

- ❖ Circuit switching (isochronous)
- ❖ Packet switching (asynchronous)

Internet Traffic Is Bursty

Daily traffic at an MIT-CSAIL router



Max In: 12.2 Mb/s

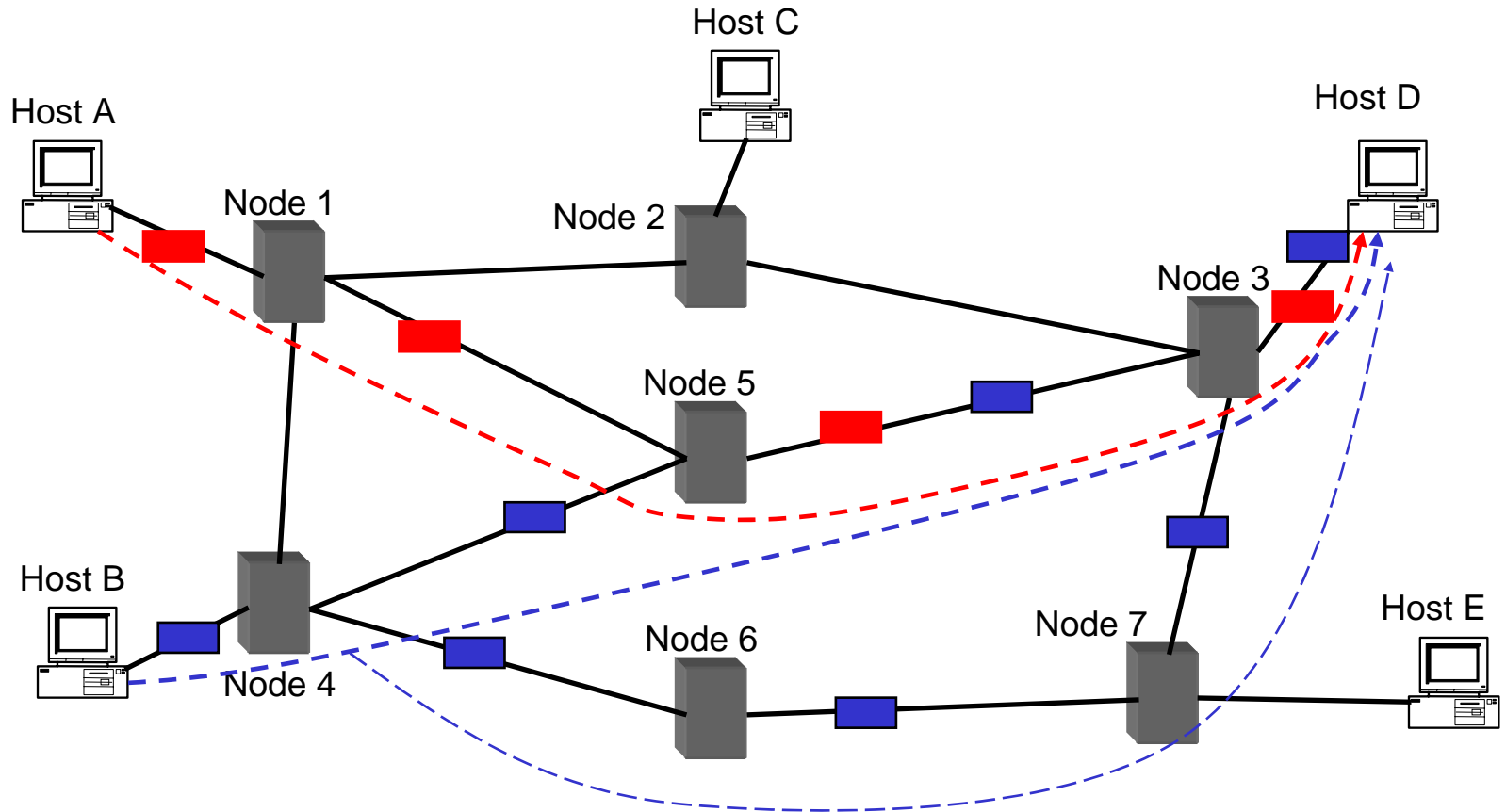
Avg. In: 2.5 Mb/s

Max Out: 12.8 Mb/s

Avg. Out: 3.4 Mb/s

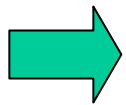
Packet switching also show reordering

Packets in a flow may not follow the same path (depends on routing as we will see later) → packets may be reordered



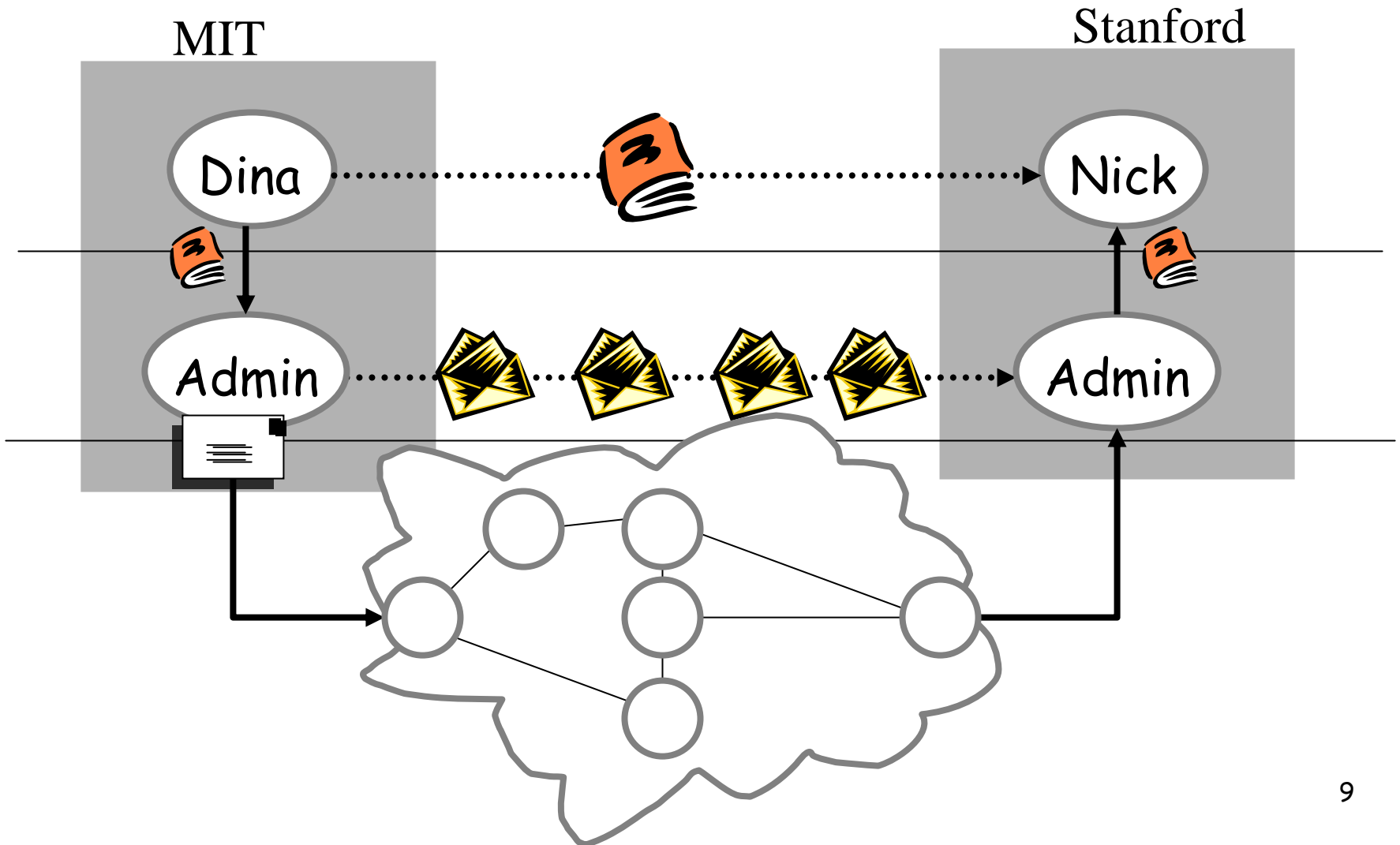
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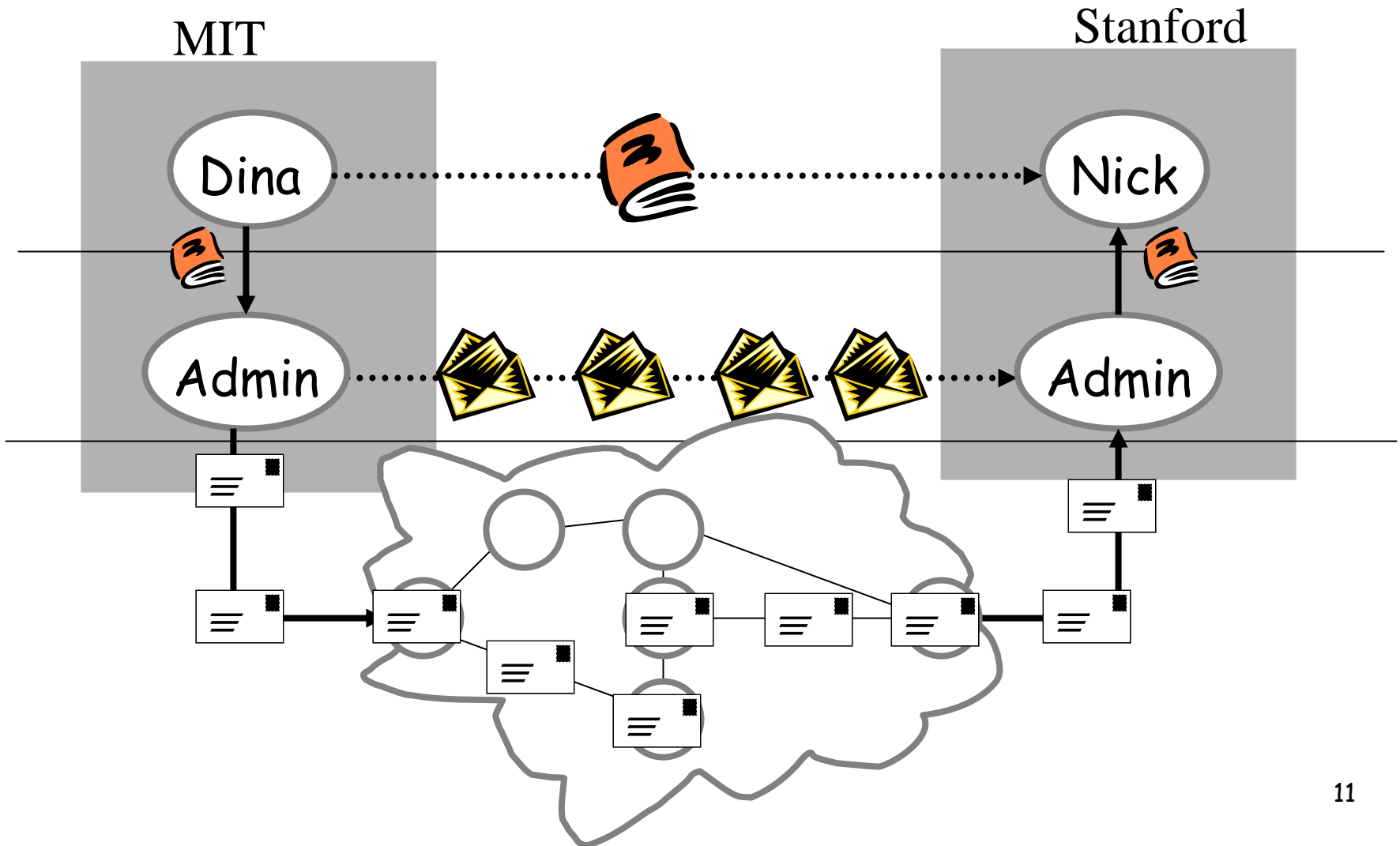
The mail system



Characteristics of the mail system

- ❖ Each envelope is individually routed
- ❖ No time guarantee for delivery
- ❖ No guarantee of delivery in sequence
- ❖ No guarantee of delivery at all!
 - ❖ Things get lost
 - ❖ How can we acknowledge delivery?
 - ❖ Retransmission
 - ❖ How to determine when to retransmit? Timeout?
- ❖ If message is re-sent too soon → duplicates

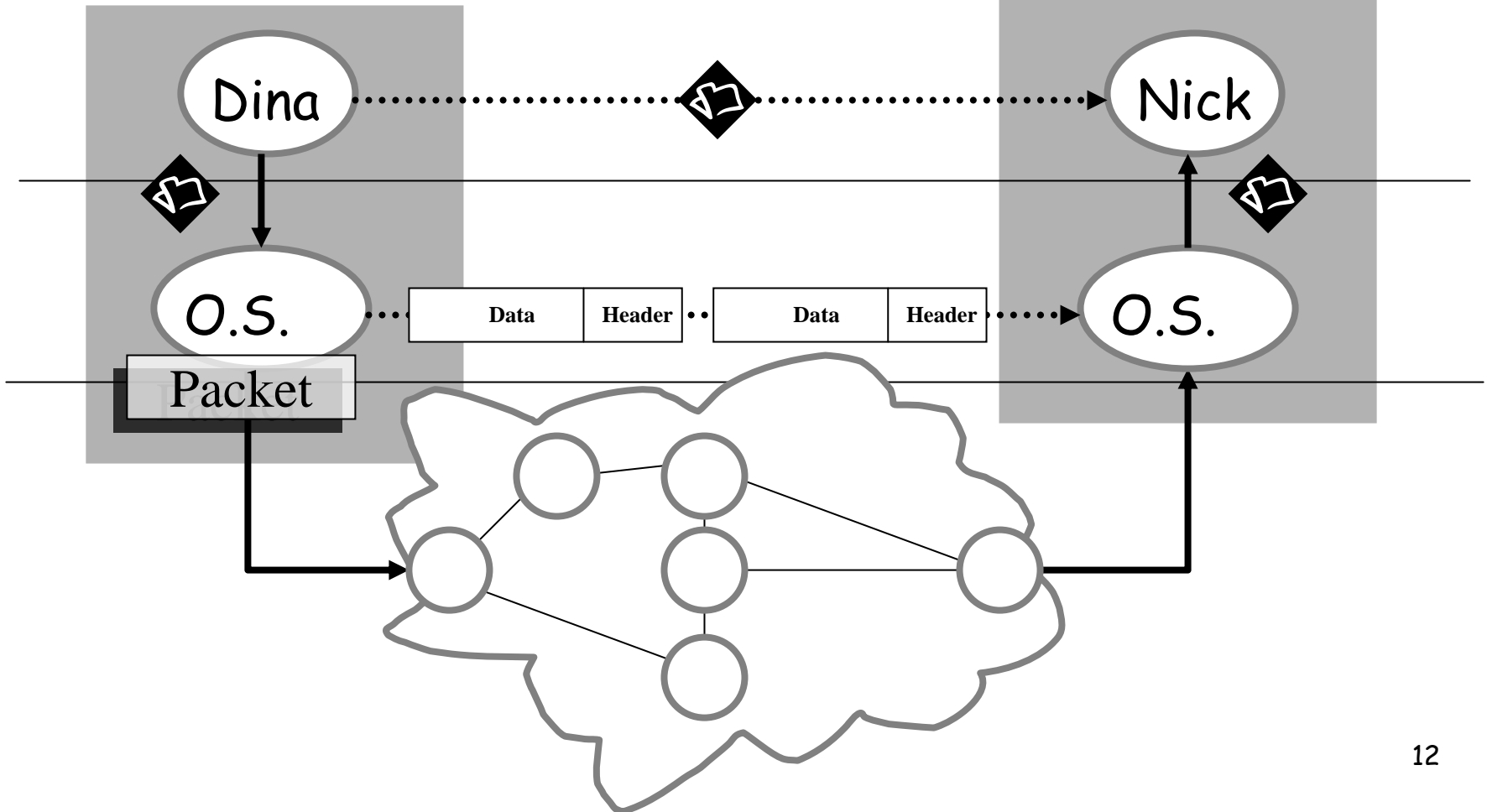
The mail system



The Internet

Nms.csail.mit.edu

Leland.Stanford.edu



Characteristics of the Internet

- ❖ Each packet is individually routed
- ❖ No time guarantee for delivery
- ❖ No guarantee of delivery in sequence
- ❖ No guarantee of delivery at all!
 - ❖ Things get lost
 - ❖ Acknowledgements
 - ❖ Retransmission
 - ❖ How to determine when to retransmit? Timeout?
- ❖ If packet is re-transmitted too soon → duplicate

Best Effort

No Guarantees:

- ❖ Variable Delay (jitter)
- ❖ Variable rate
- ❖ Packet loss
- ❖ Duplicates
- ❖ Reordering
- ❖ (notes also state maximum packet length)

Differences Between Circuit & Packet Switching

Circuit-switching	Packet-Switching
Guaranteed capacity	No guarantees (best effort)
Capacity is wasted if data is bursty	More efficient
Before sending data establishes a path	Send data immediately
All data in a single flow follow one path	Different packets might follow different paths
No reordering; constant delay; no pkt drops	Packets may be reordered, delayed, or dropped

This Lecture

- ❖ We learned how to share the network infrastructure between many connections/flows
- ❖ We also learned about the implications of the sharing scheme (circuit or packet switching) on the service that the traffic receives