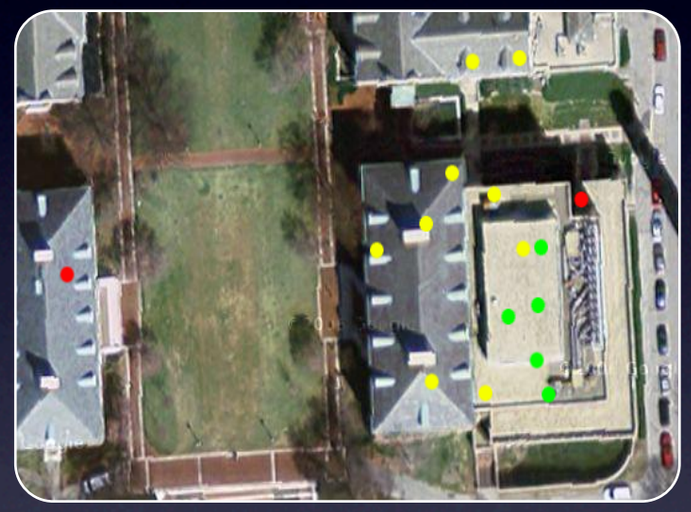
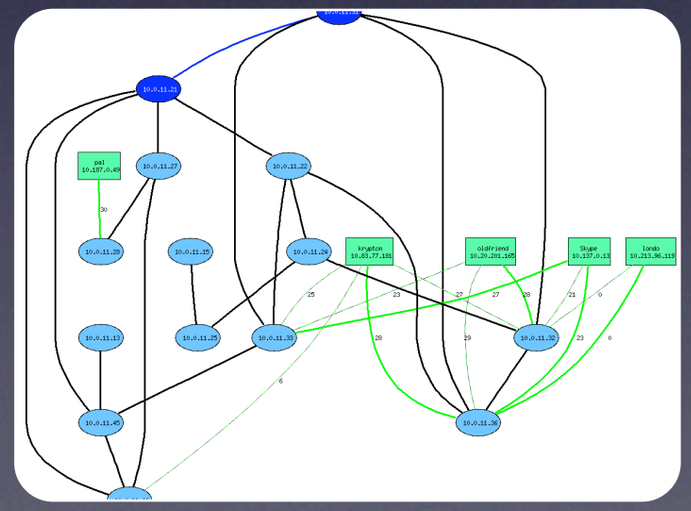
Practical Wireless Mesh Networks and Their Applications





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Joint work with:
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Access Point

Follows client-server paradigm.

For more coverage, install more access points.

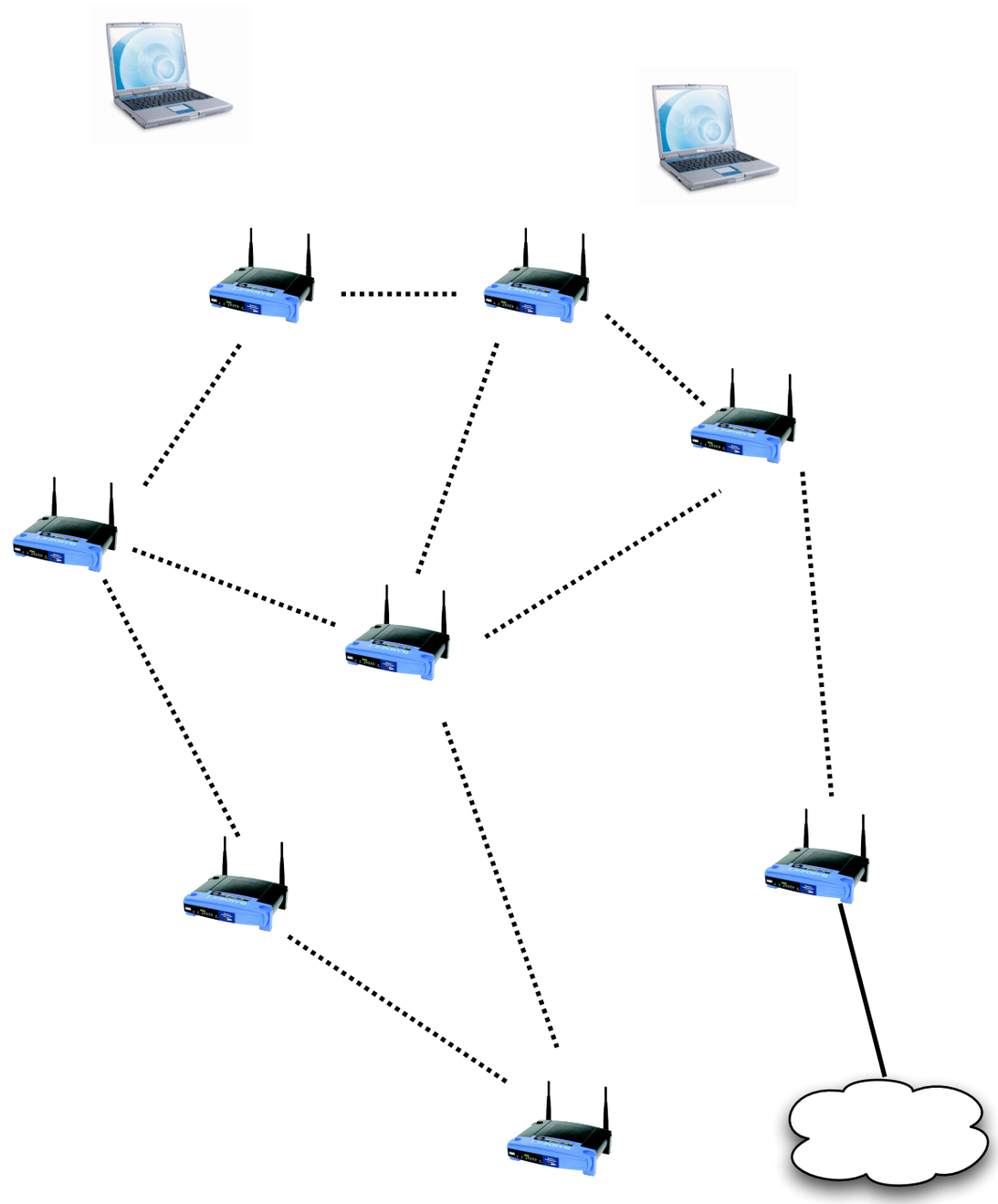
Each access point is connected to the Internet.

Mesh Network

Clients are mobile.

Nodes are relatively stationary.

Only a **few** nodes are connected to the Internet.



What is a practical Mesh Network?

Seamless access

Any Wi-Fi device can connect, without any special software.

Fast Handoff

When moving within the network, connections don't break.

Rapid deployment

The network automatically discovers new nodes.

Cost-effective

Works with off-the-shelf wireless routers.

Introduction

Push-to-Talk

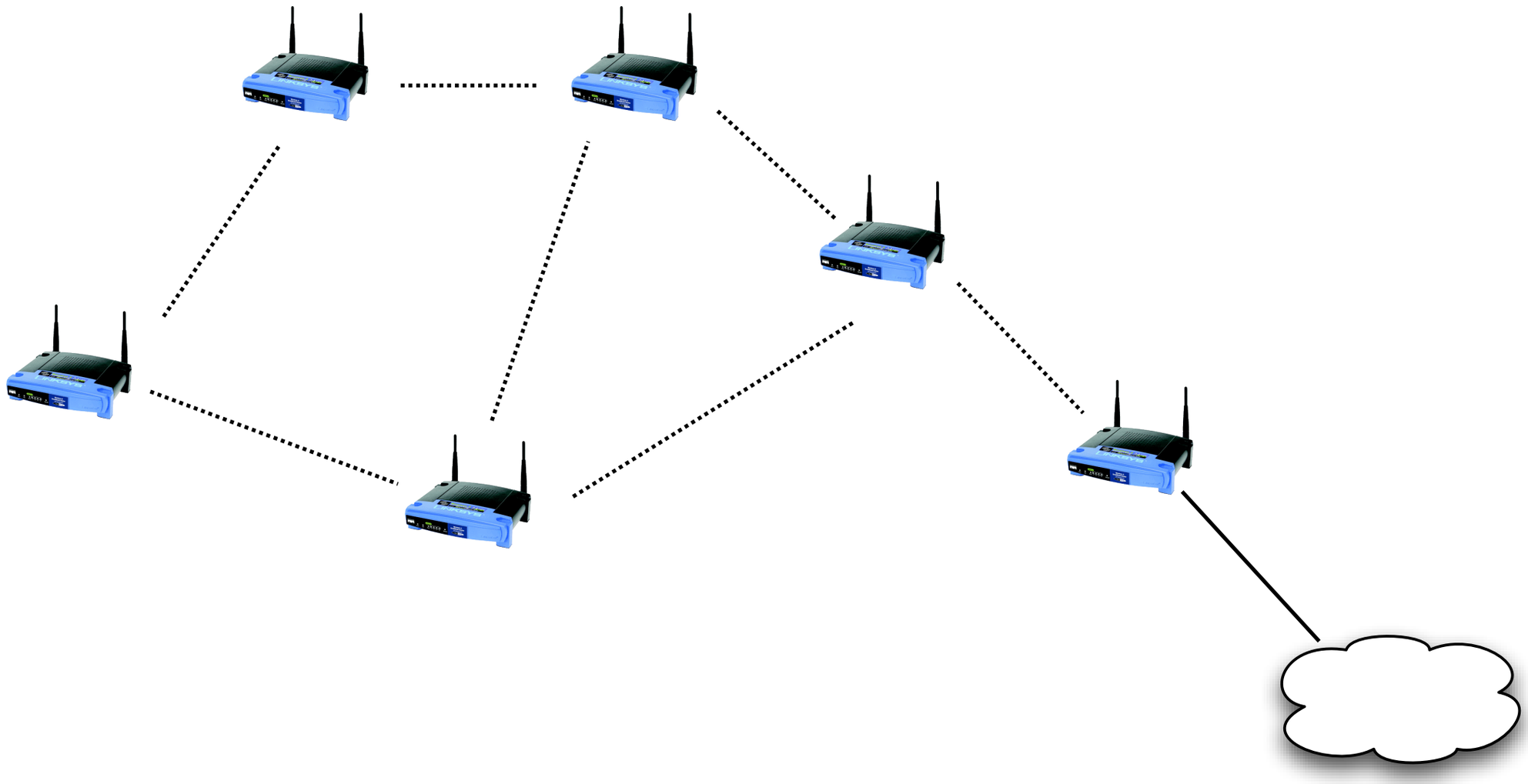
SMesh

Conclusions

The **SMesh**

Wireless Mesh System

During the handoff **multiple** access points serve the client.



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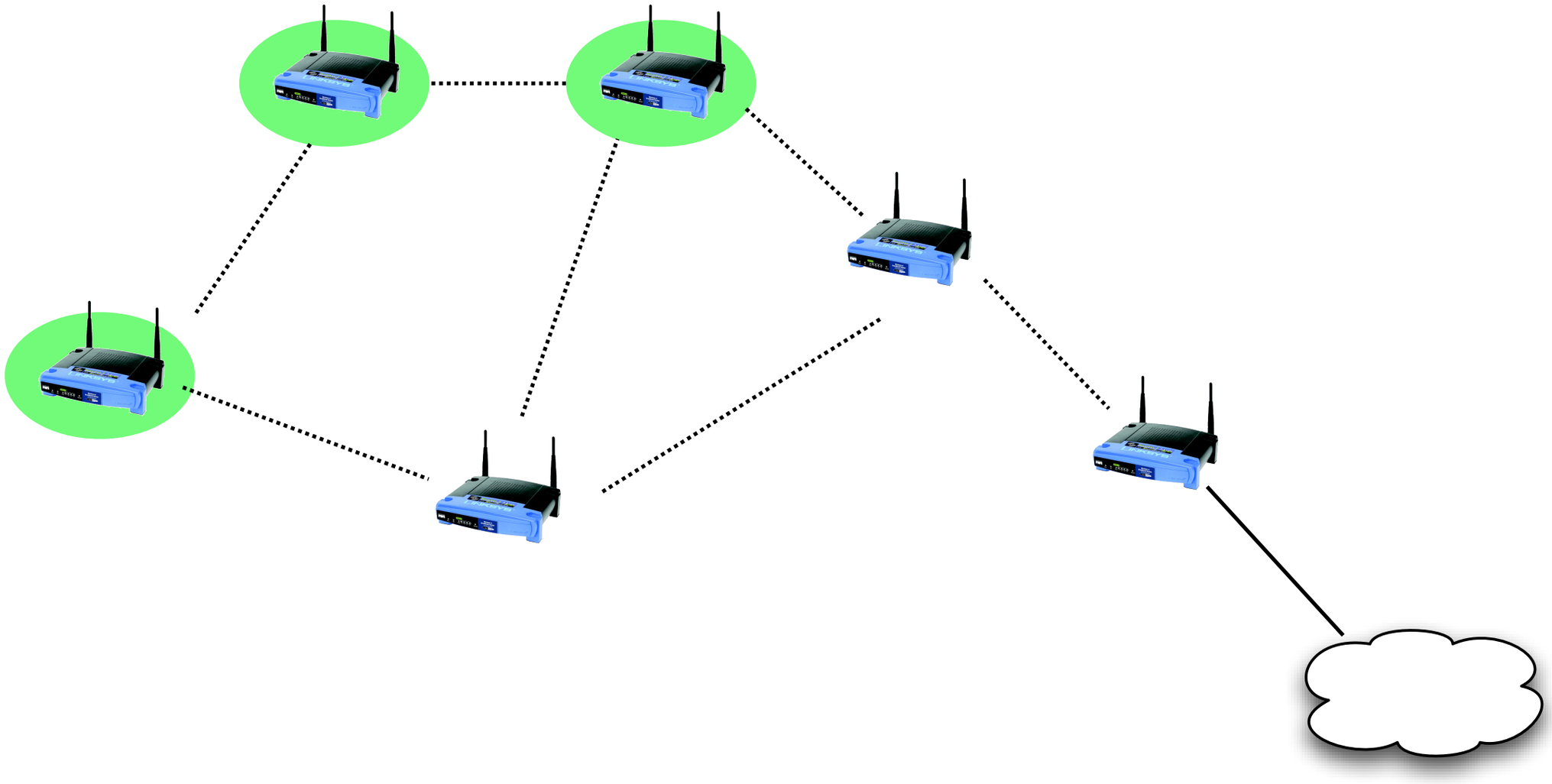

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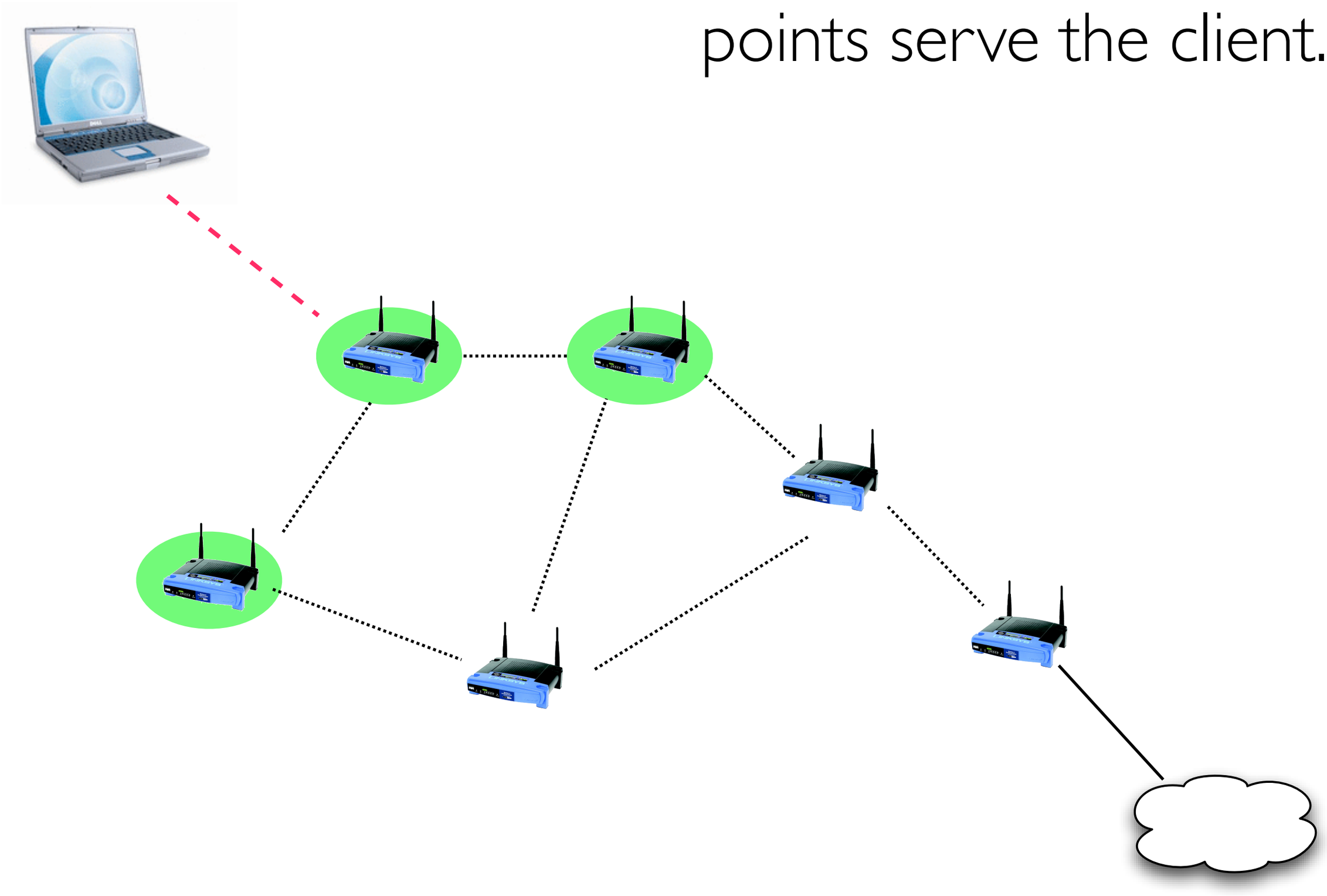

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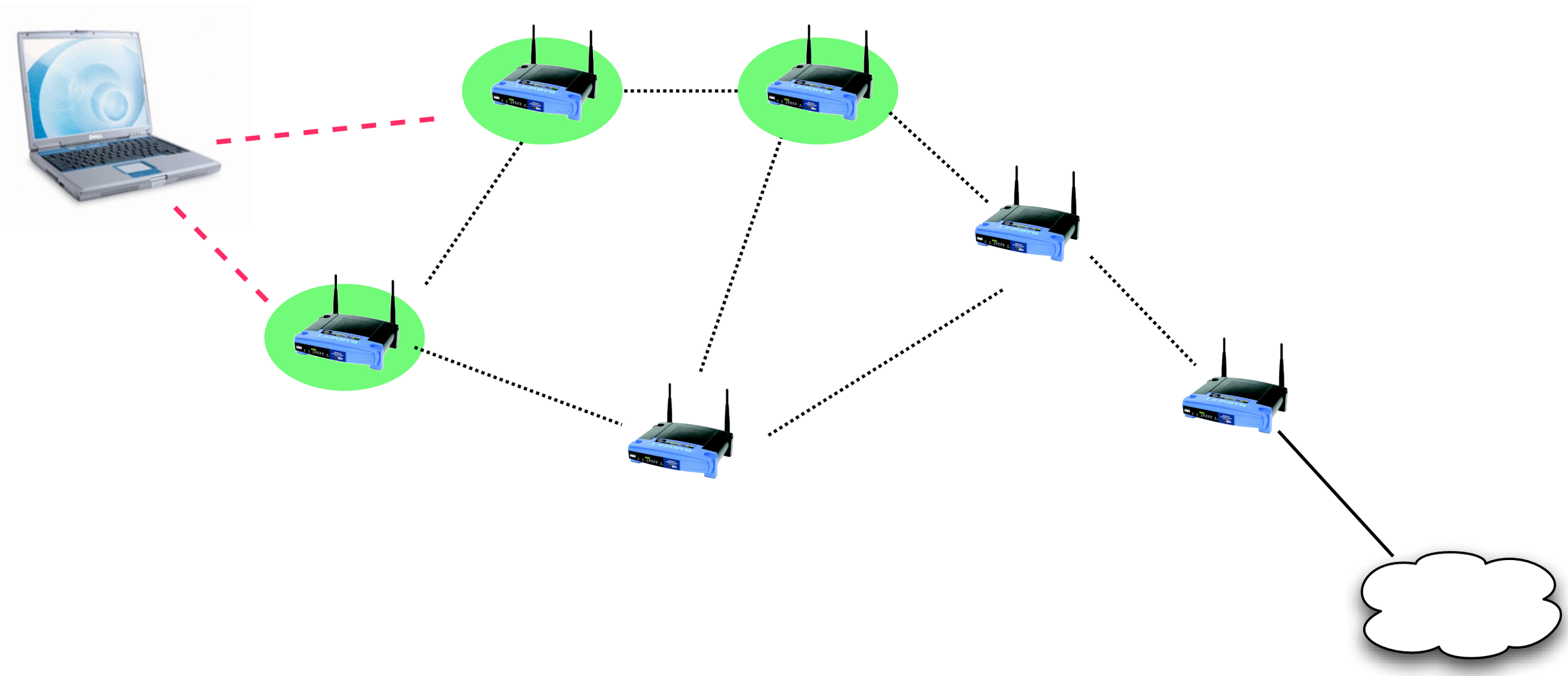

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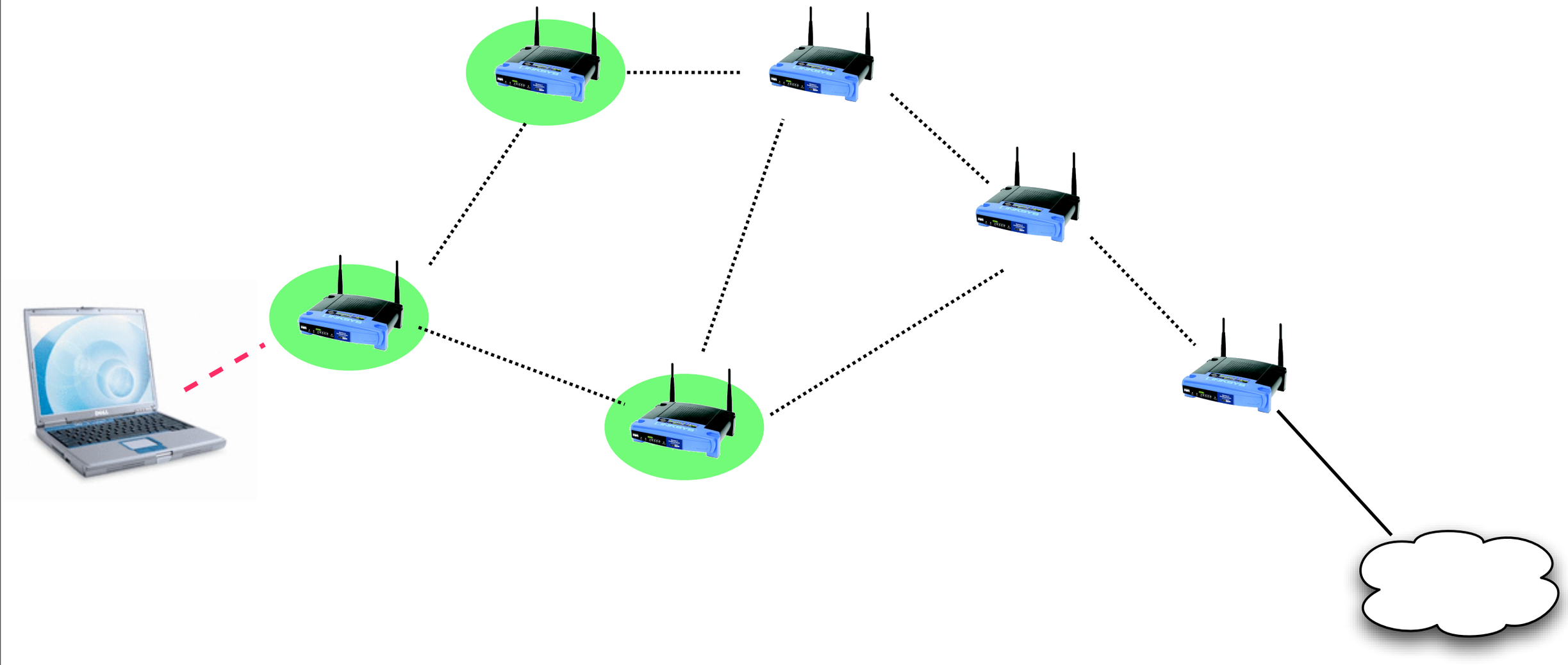
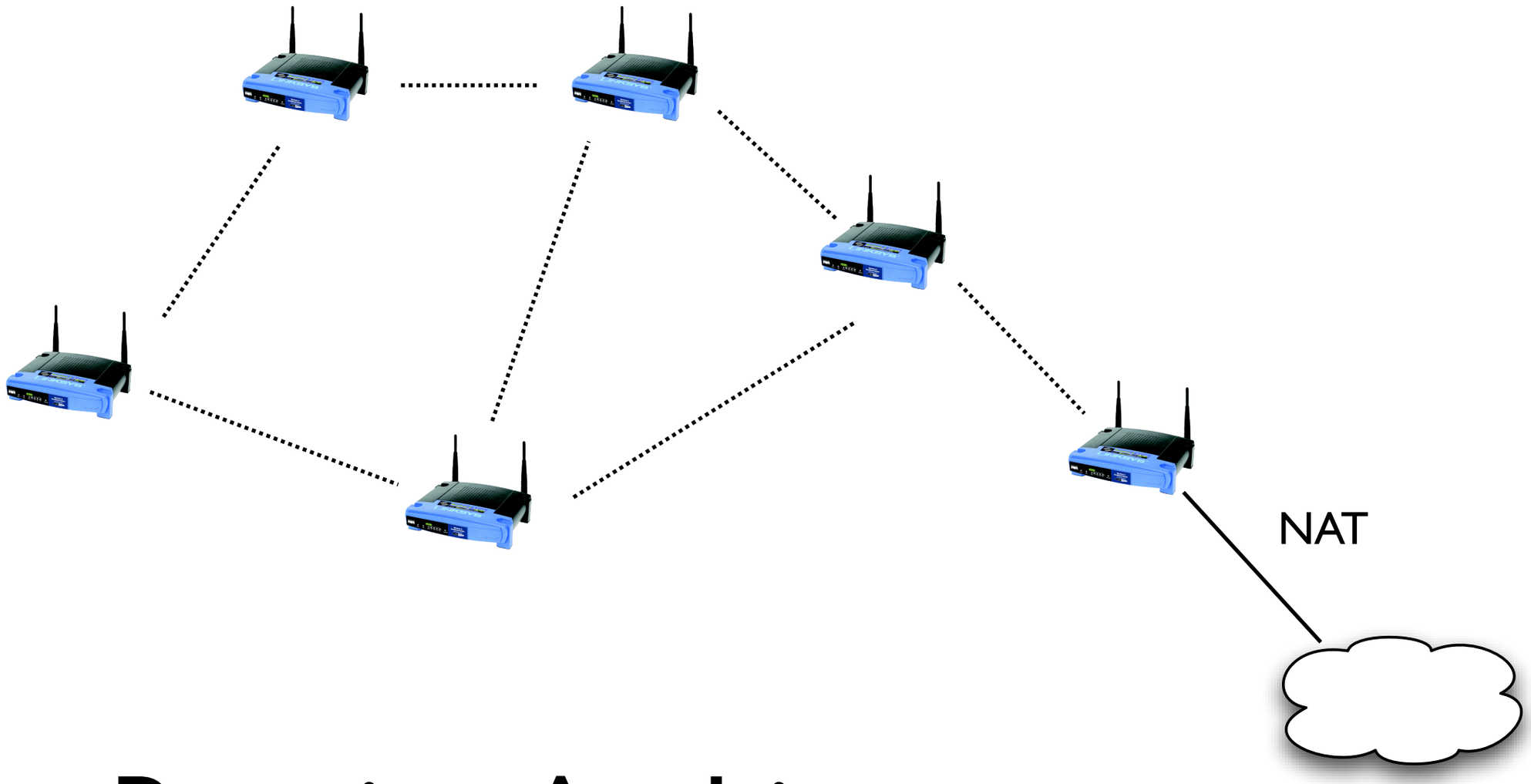
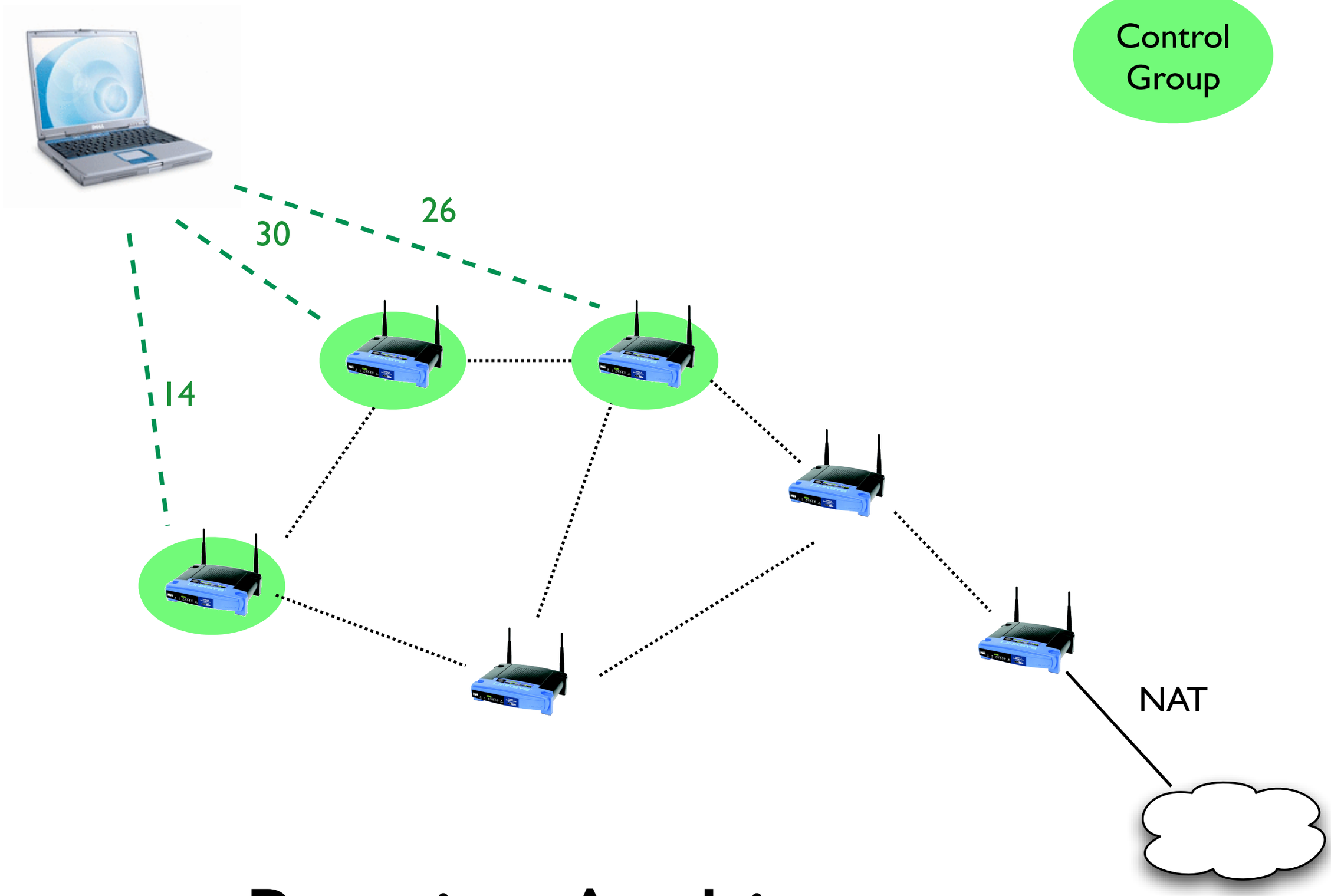
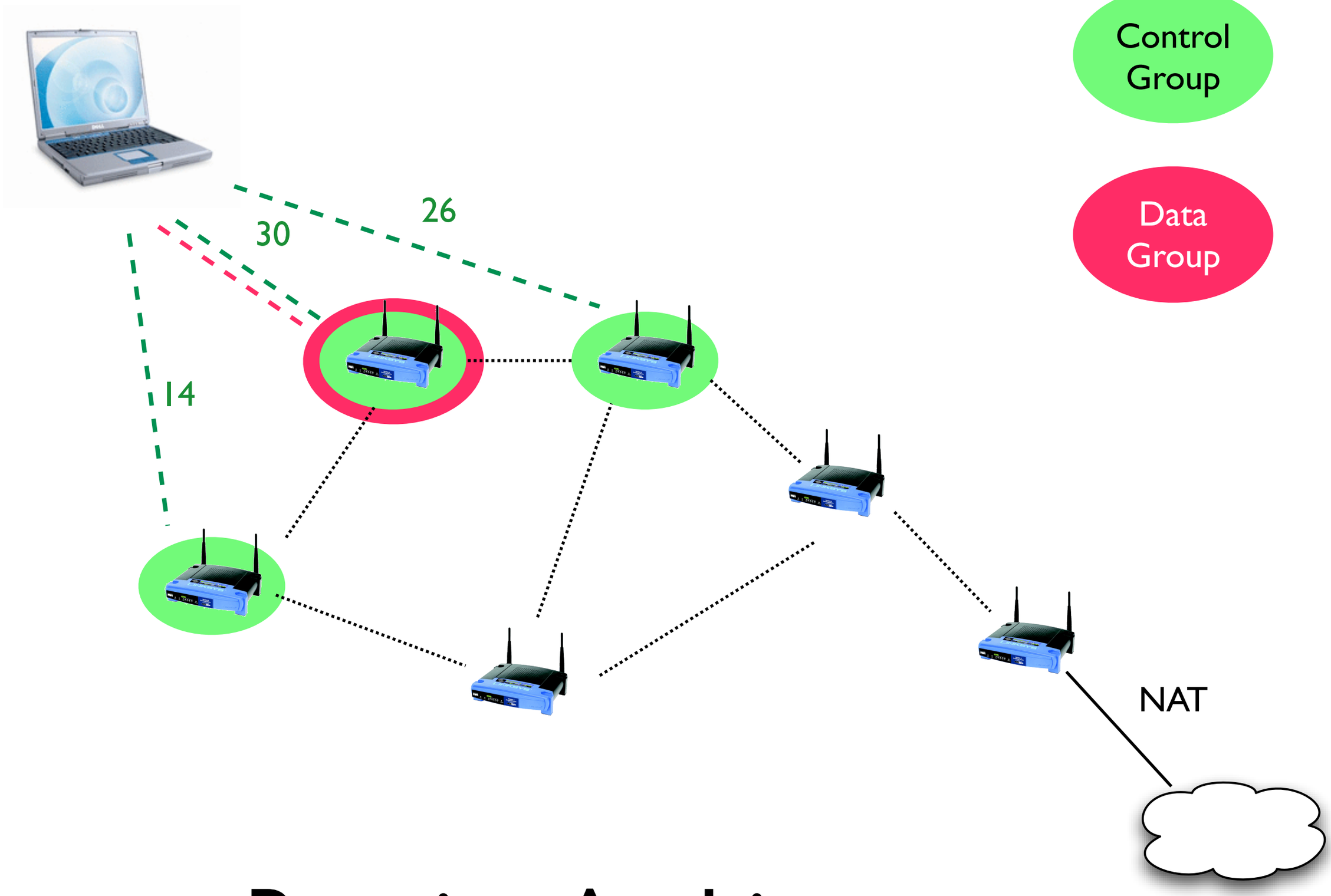




Routing Architecture



Routing Architecture

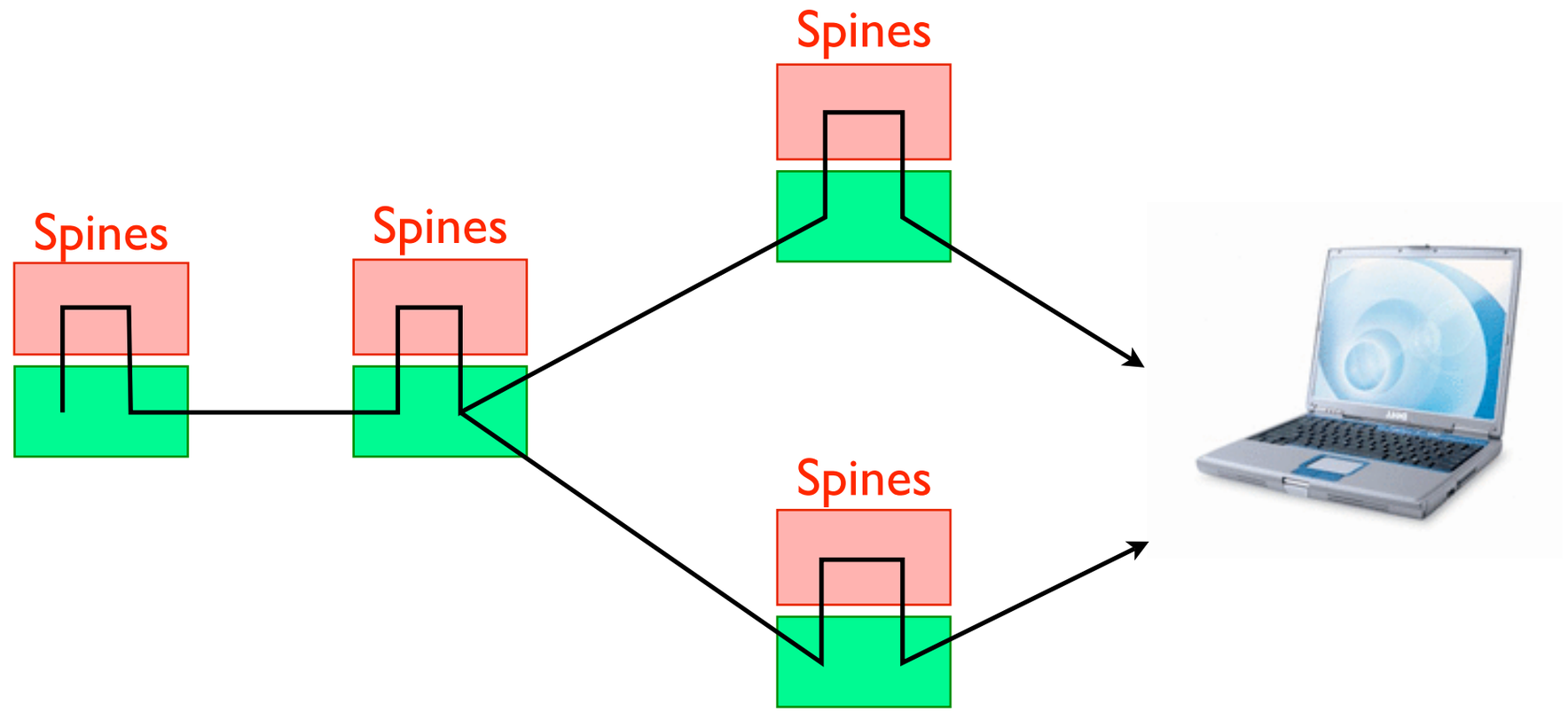


Routing Architecture

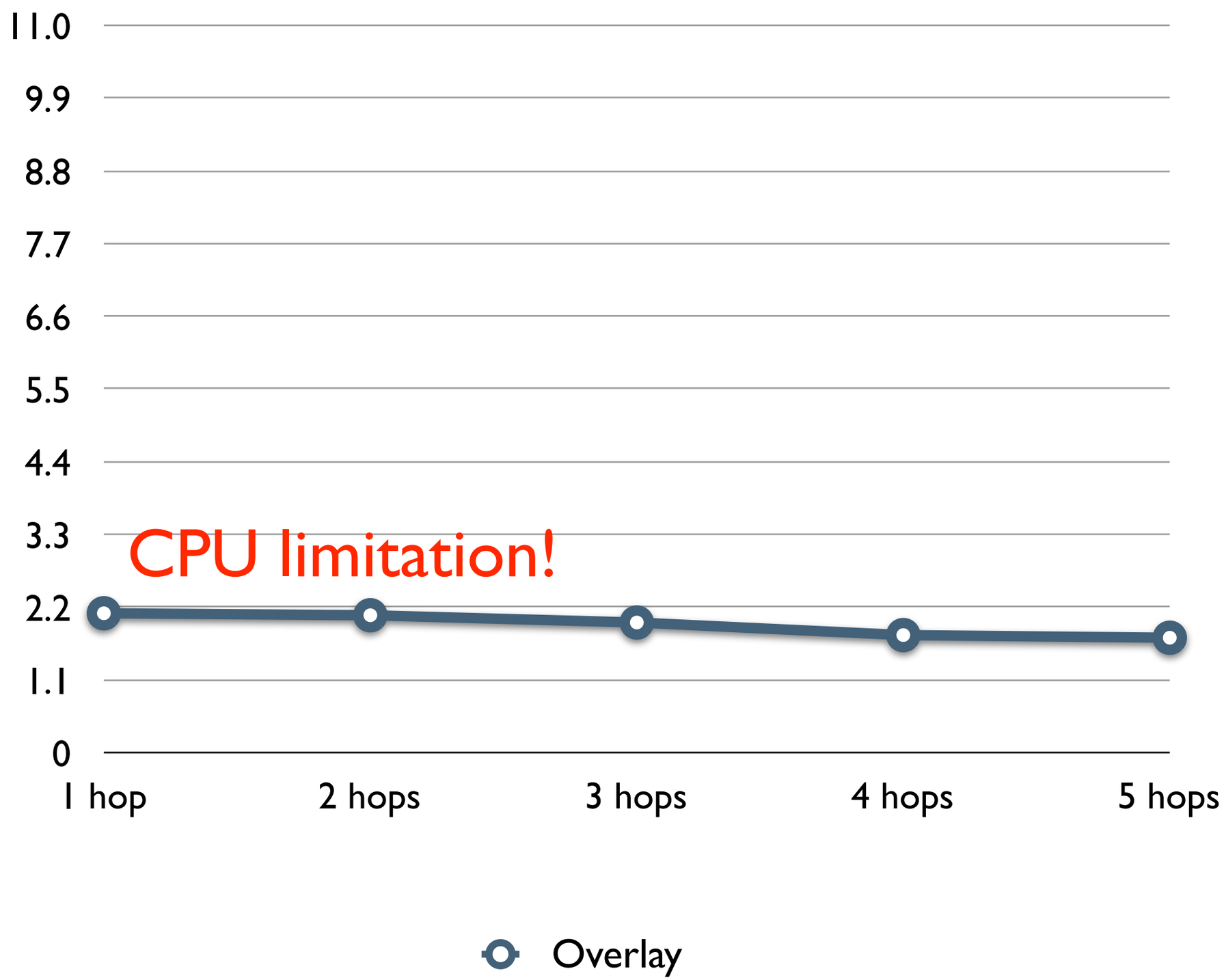
In a **user space** messaging system all the packets are moved to application level.

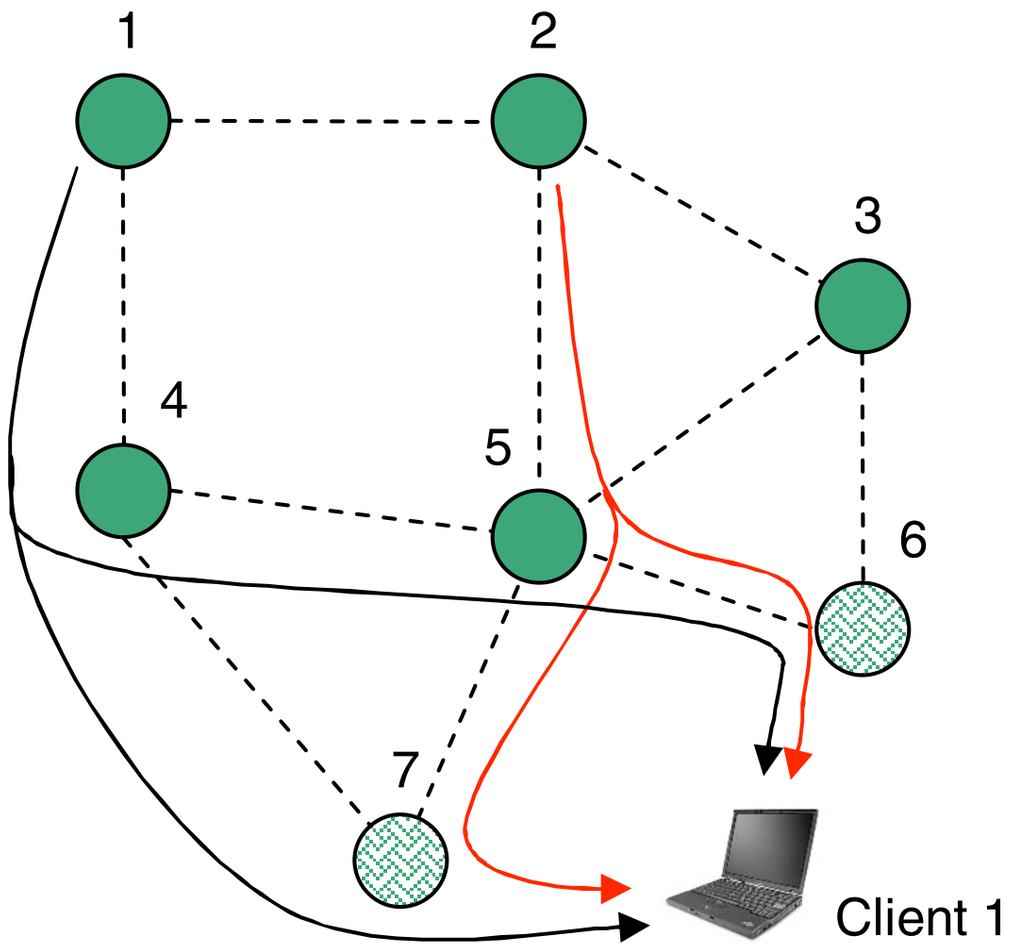
User space

Kernel space



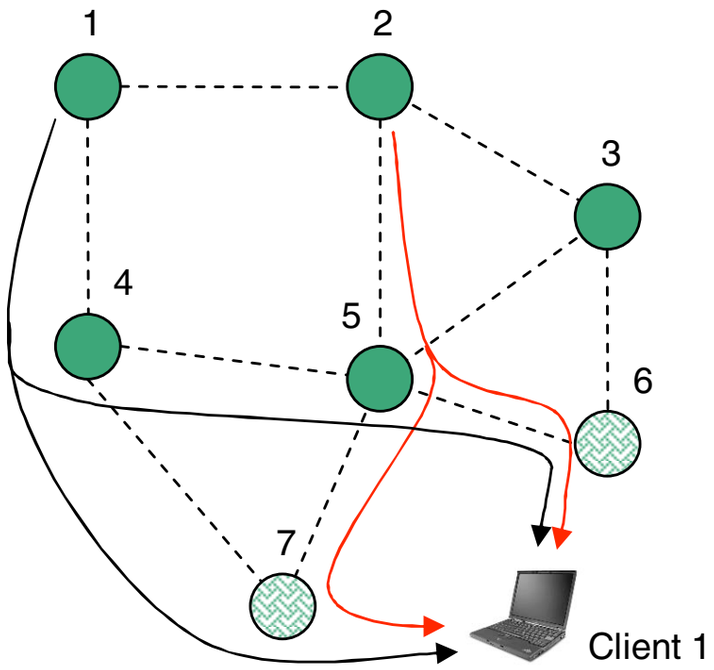
TCP Throughput (Mbps)



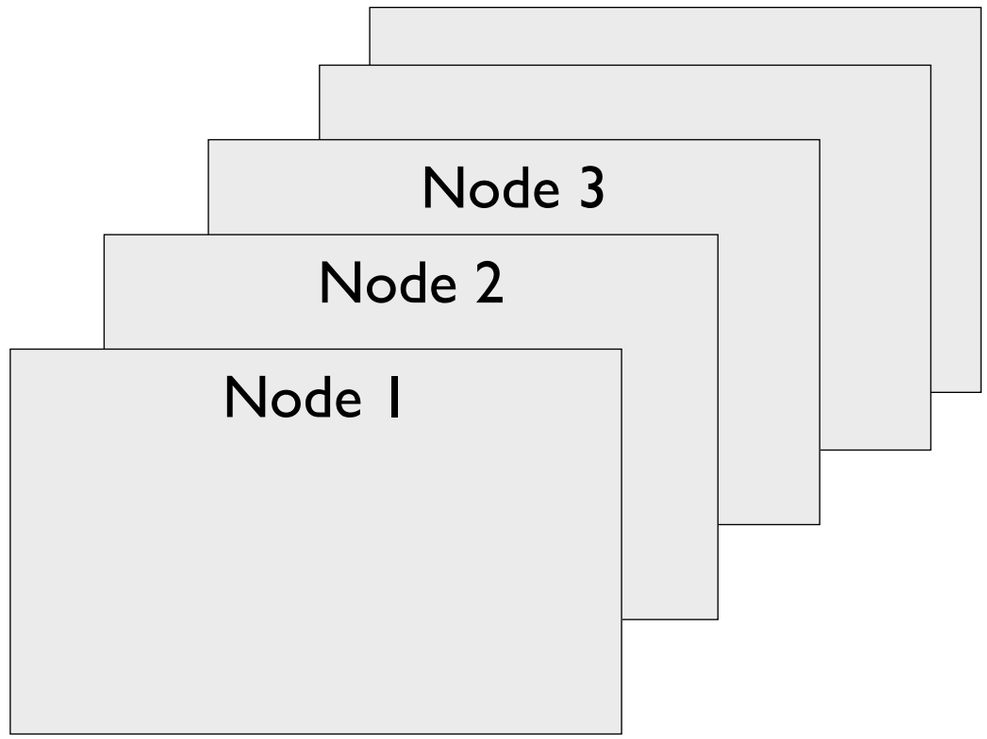


To route, use **source** based multicast trees.

Multipath routing is not supported by current operating systems.



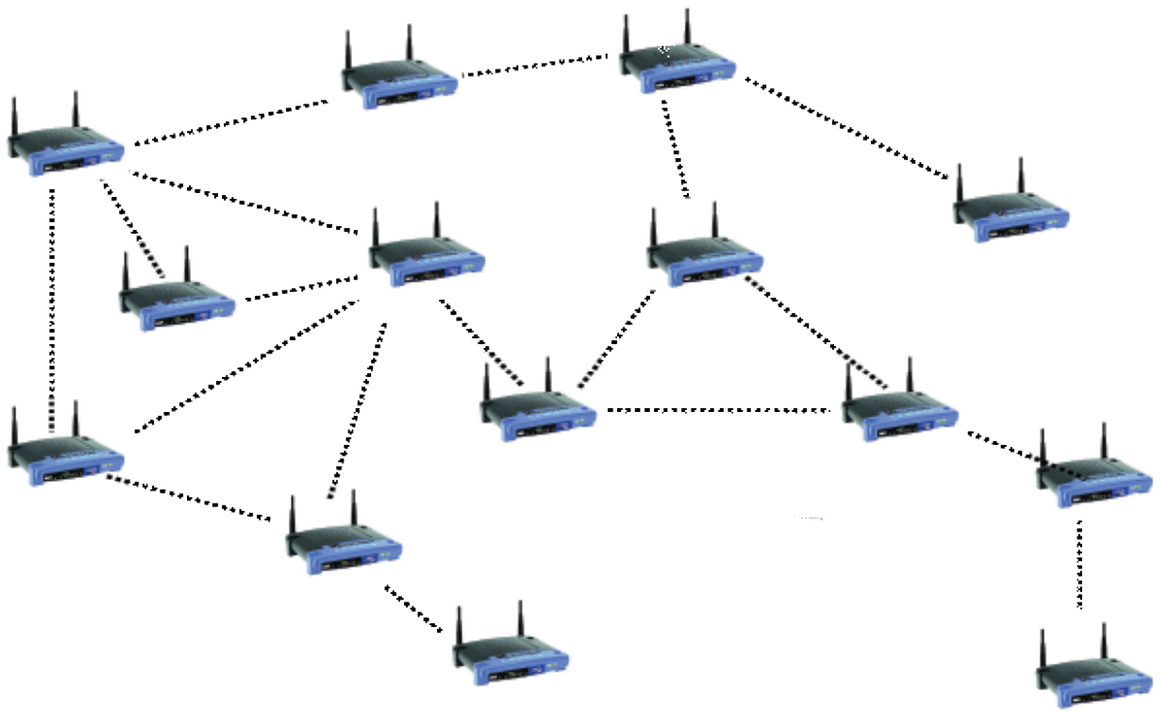
Node's 5 kernel routing tables:



Each node uses **multiple** kernel routing tables.

Each route may have **multiple next-hops**.

Nodes	17
Rate	24 Mbps
Transmission power	50 mW
Retransmission limit	7



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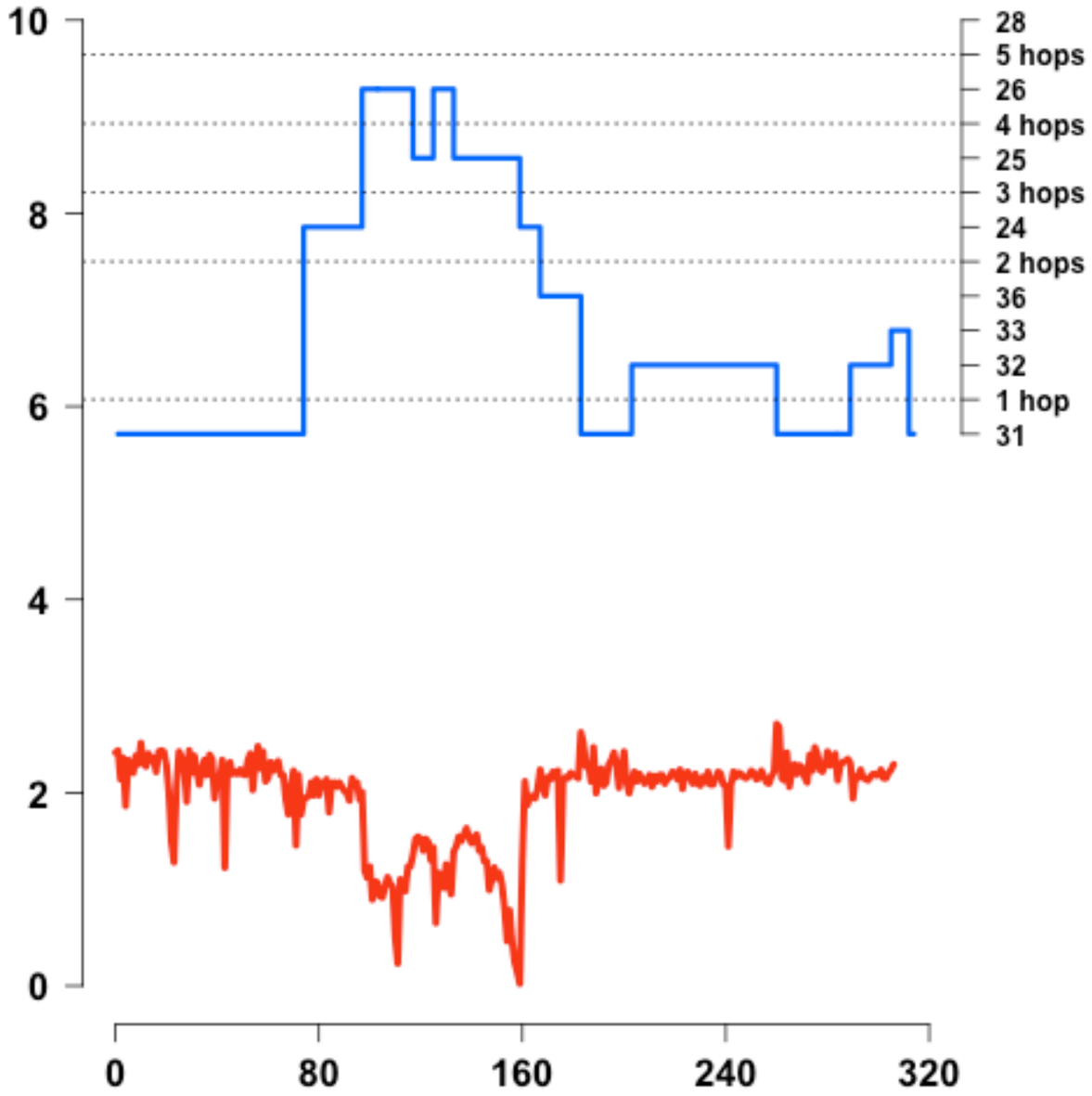
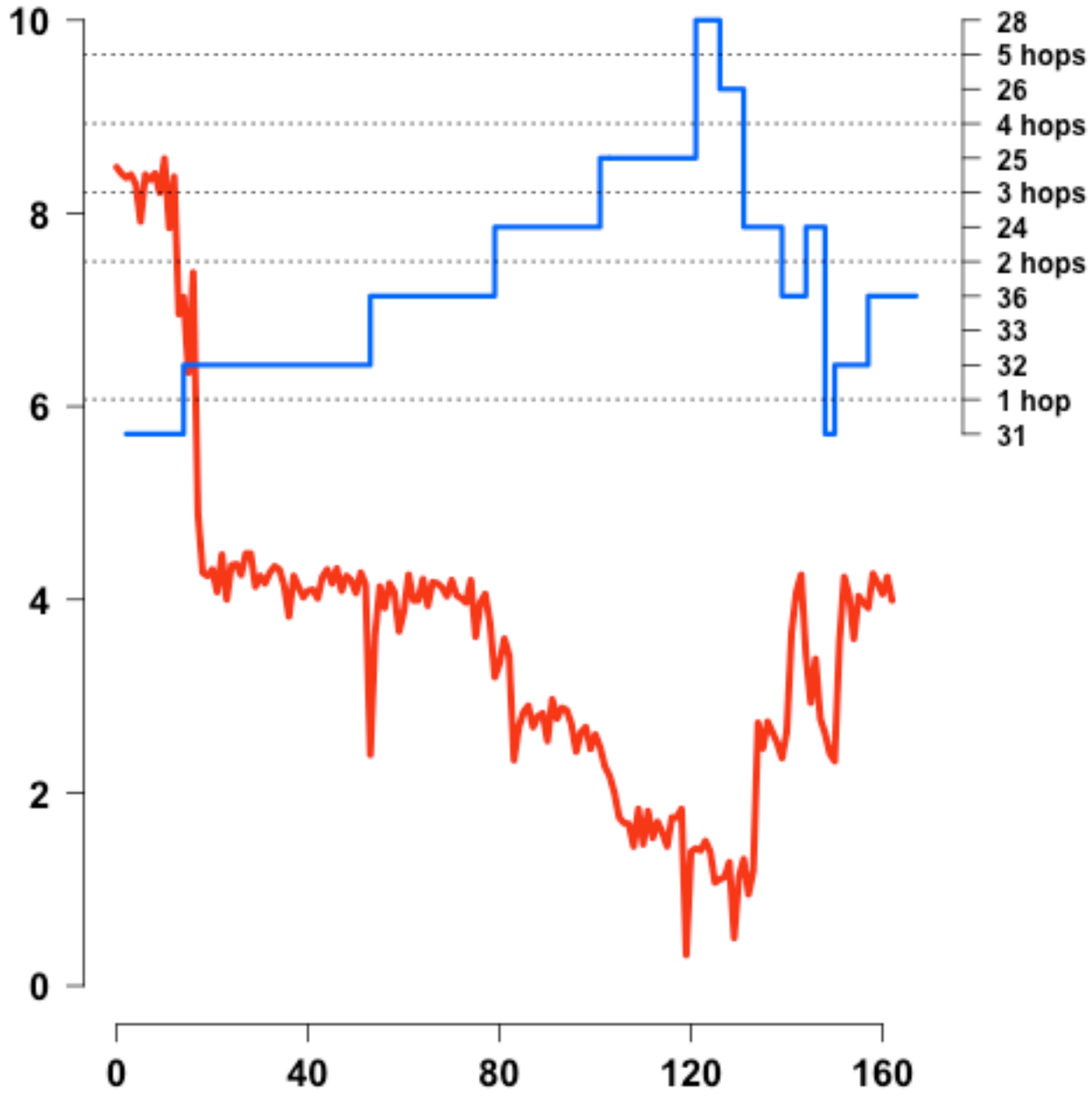


User-space overlay system



SMesh kernel routing

Application:

Push-to-Talk

System for First Responders

What is PTT?

Half-duplex
communication system.

While **one** person
speaks, the others listen.

Challenges we face:

Network partitions and merges

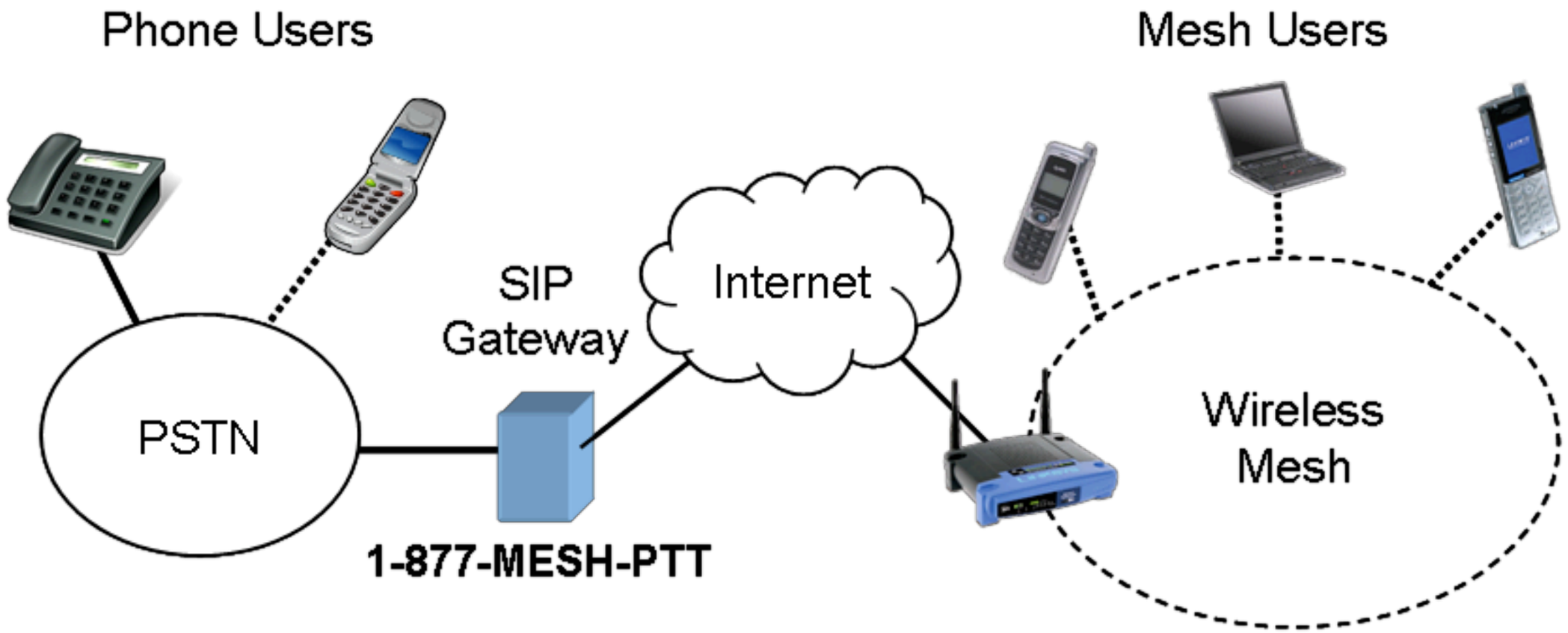
Node crashes

Users join and leave

Low transfer times

Also interesting:

Allow regular phone users to join a PTT session.



System overview

Interface with Mobile Client

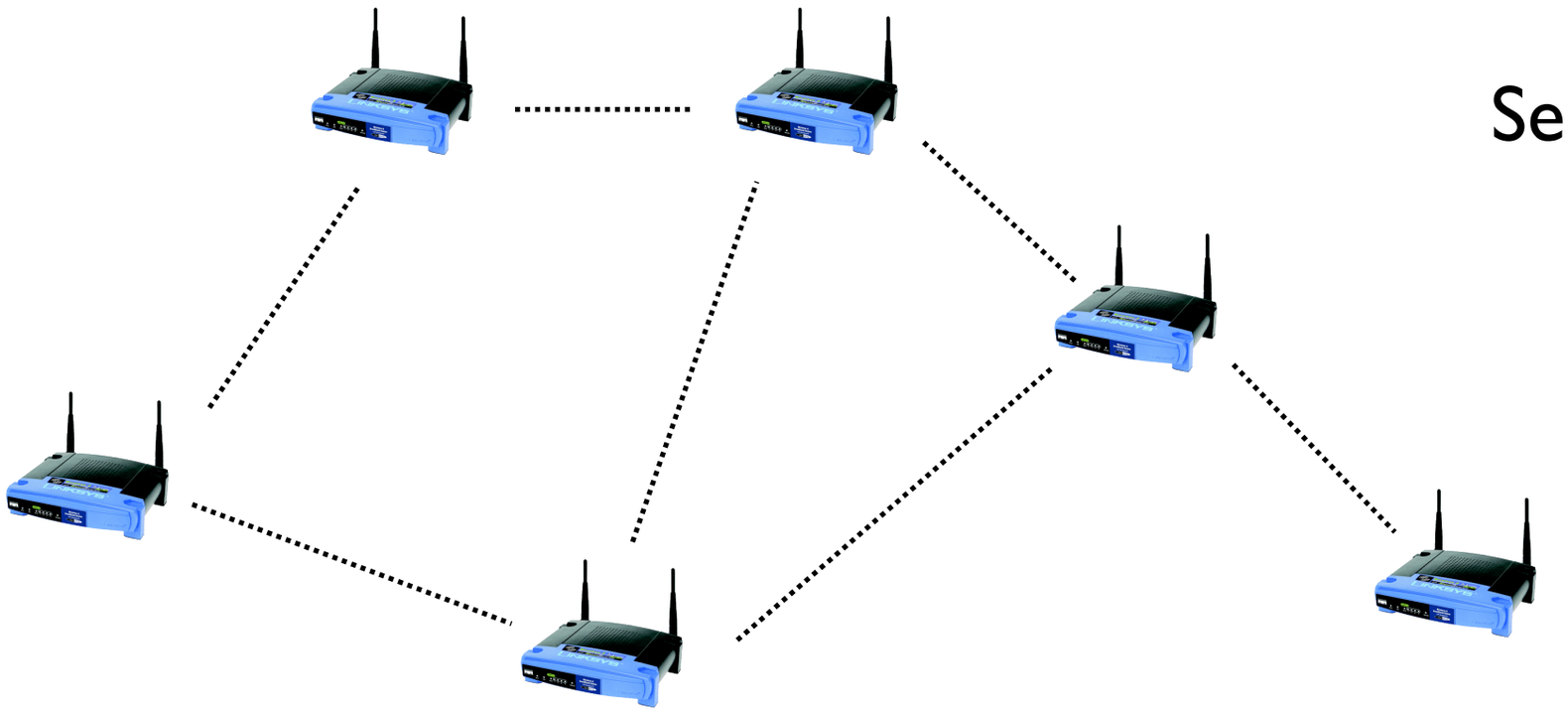
Session Initiation Protocol (SIP)

Third Party Call Control Server (3pcc)

The entire mesh behaves like a **single** 3pcc server.

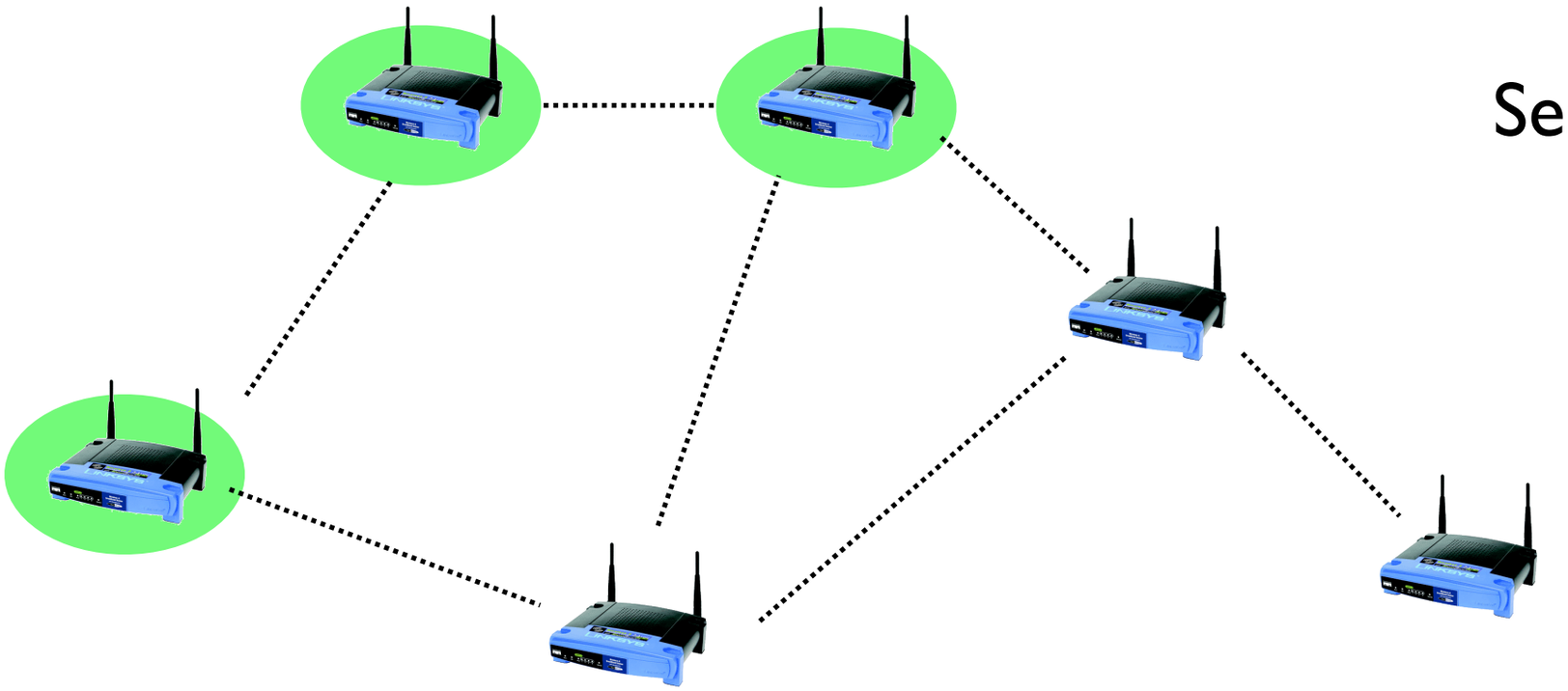
Client management

Session management



Client management

Control Group



Session management

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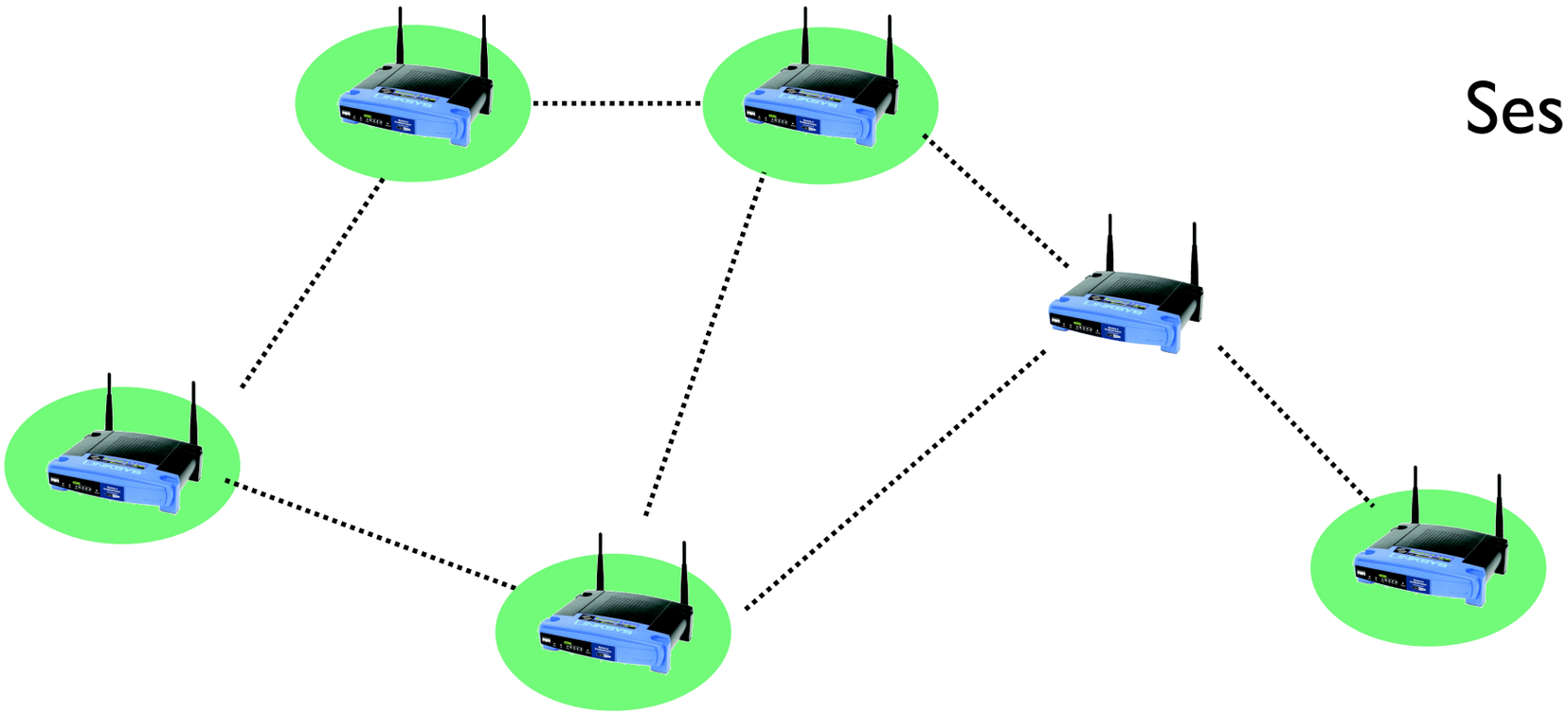

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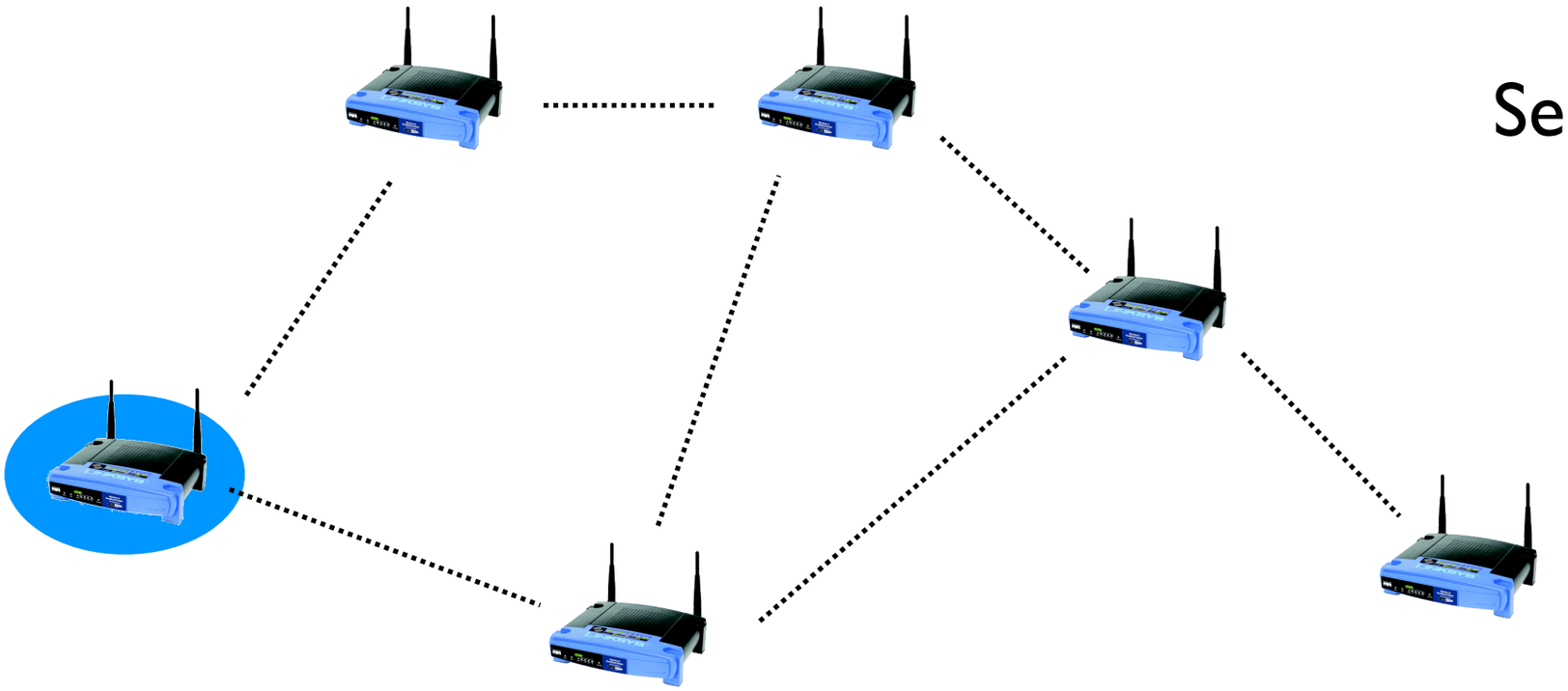
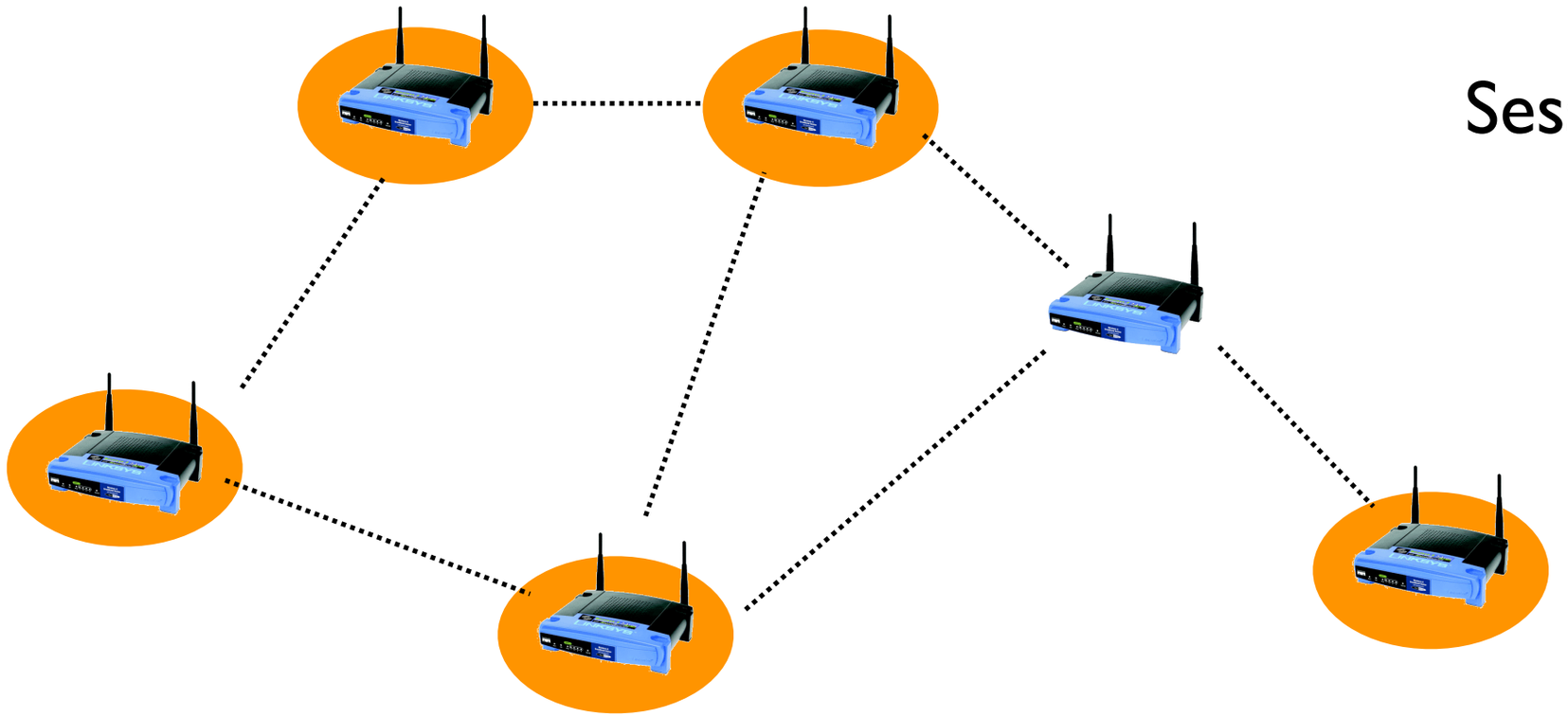


Session management

Controller Group

Client management

Control Group



Session management

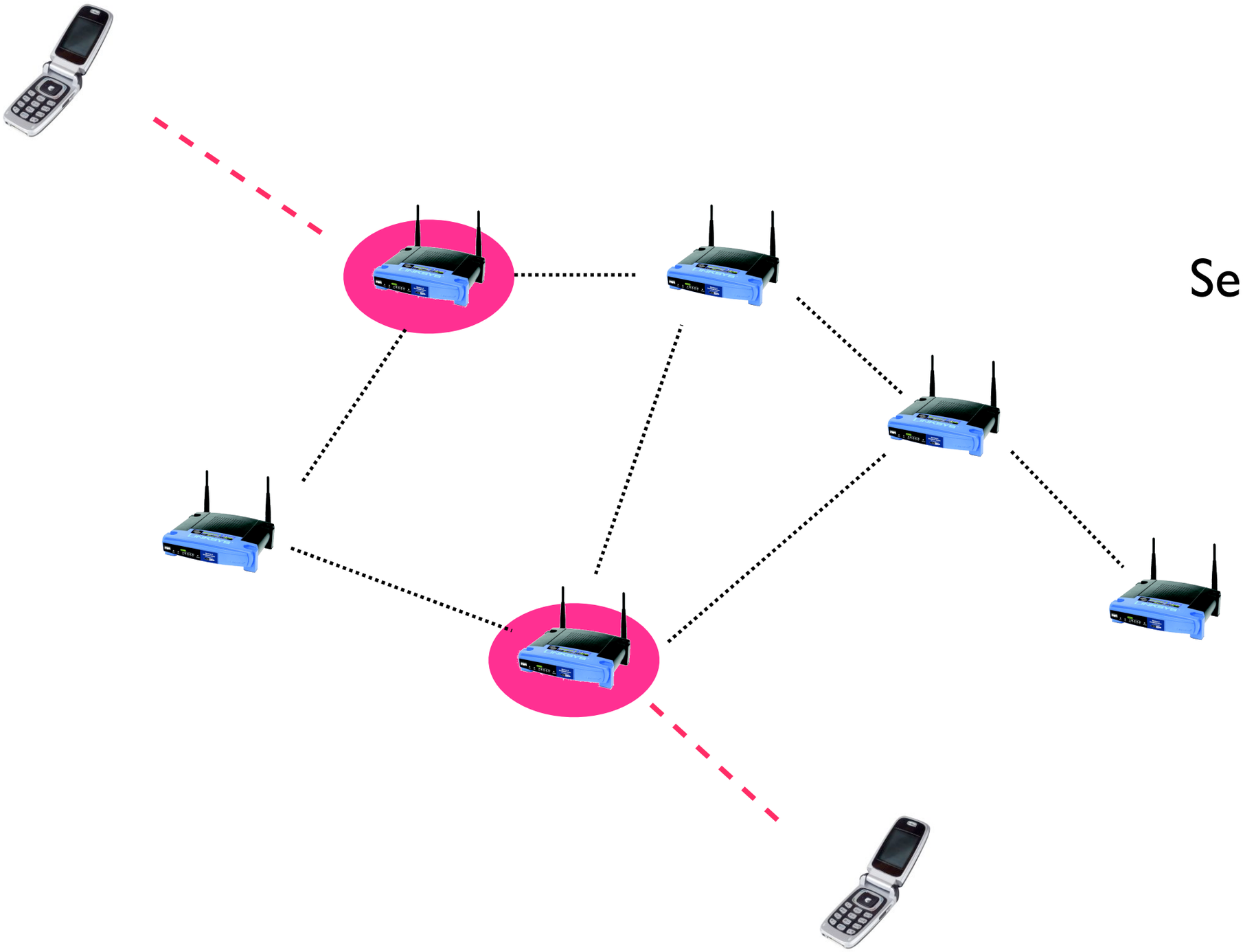
Controller Group

Monitoring Group

Client management

Control Group

Session management



Controller Group

Monitoring Group

Data Group

Floor Arbitration

Sending client

Mesh node

Controller

Sending client

Mesh node

Controller

Request to speak

Sending client

Mesh node

Controller

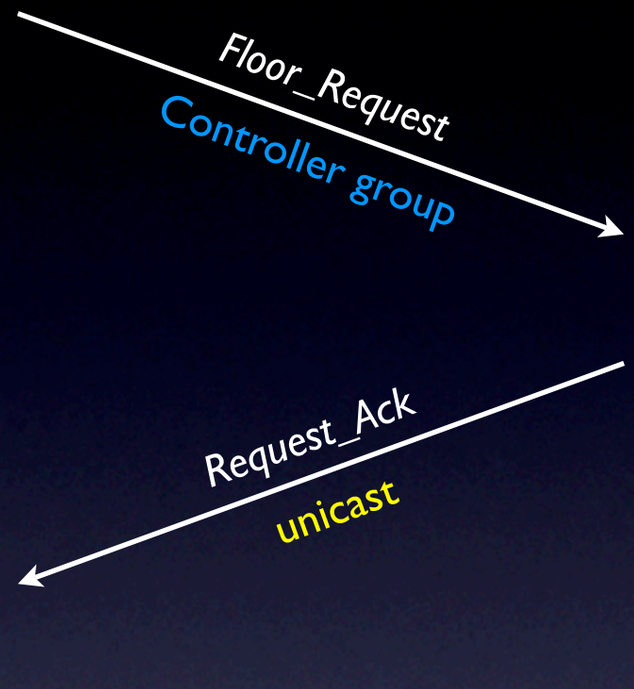
Request to speak

Sending client

Mesh node

Controller

Request to speak



Sending client

Mesh node

Controller

Request to speak

Floor_Request

Controller group

Request_Ack

unicast

Permission_to_Speak

Client Control group

Permission granted

Mesh node

Sending client

Mesh node

Controller

Request to speak

Floor_Request

Controller group

Request_Ack

unicast

Permission granted

Mesh node

Permission_to_Speak

Client Control group

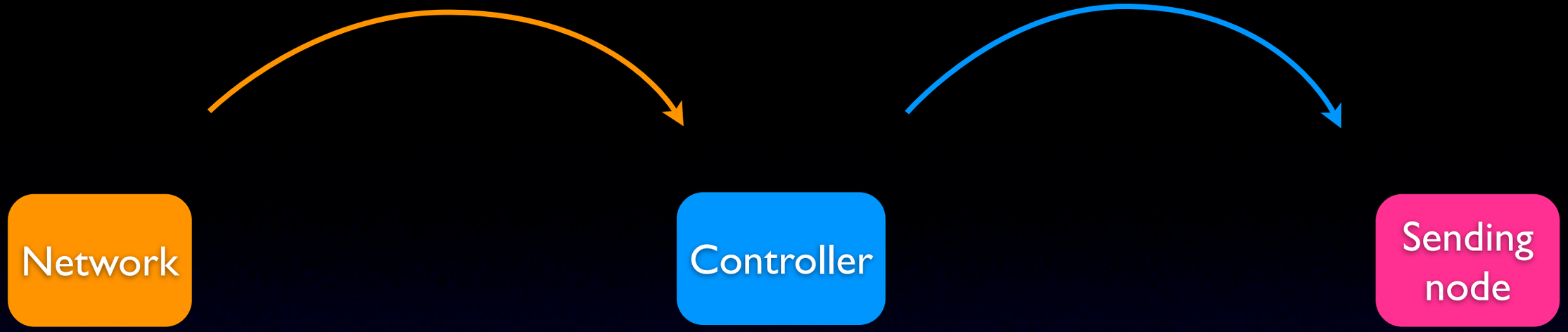
PTS_Ack

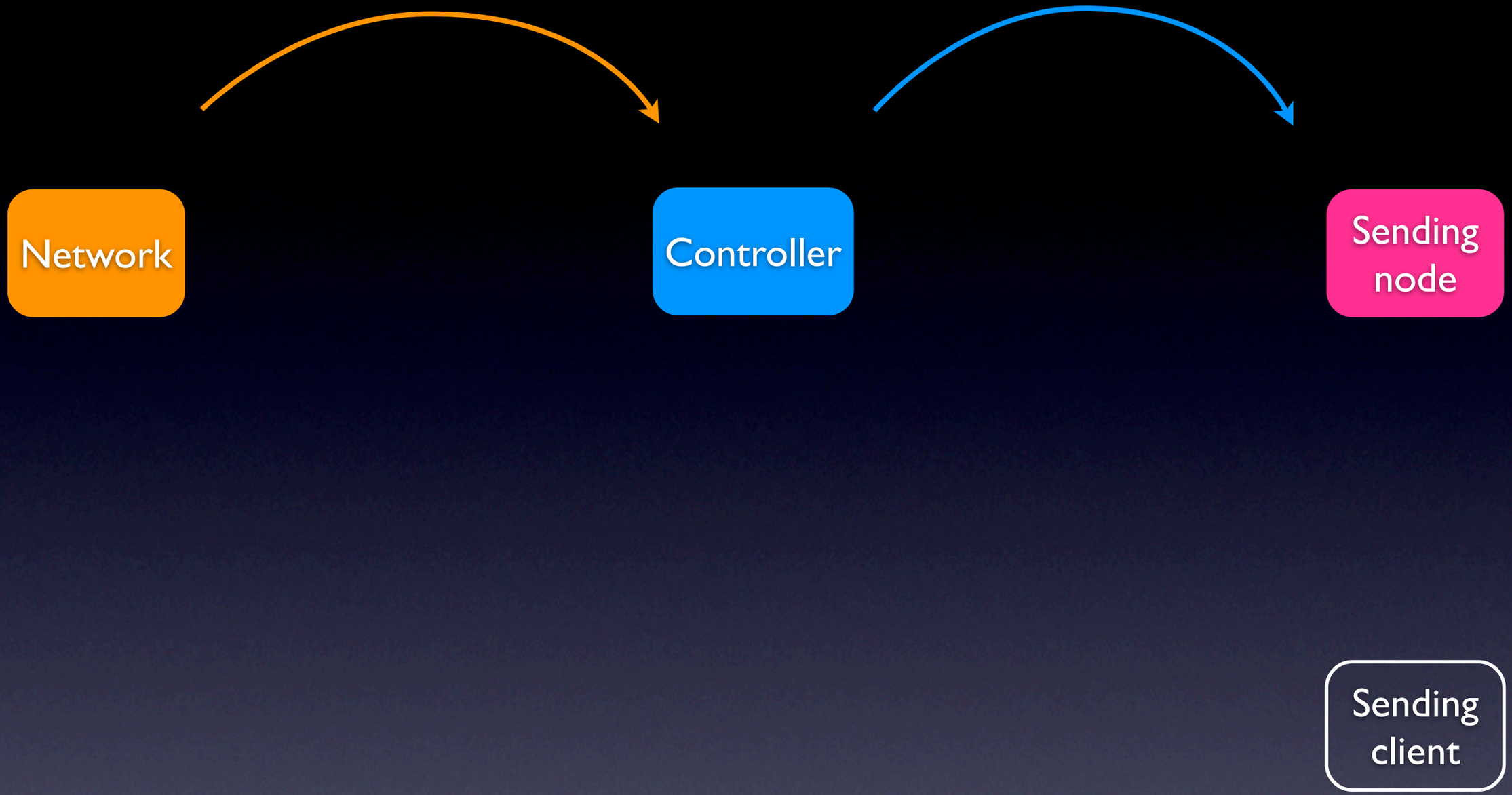
unicast

Protocol Robustness

Network


Network
Controller


Network
Controller
Sending node


Network
Controller
Sending node
Sending client

On timeout: Controller is lost

Join Controller group (if lowest IP).
Start handling requests.

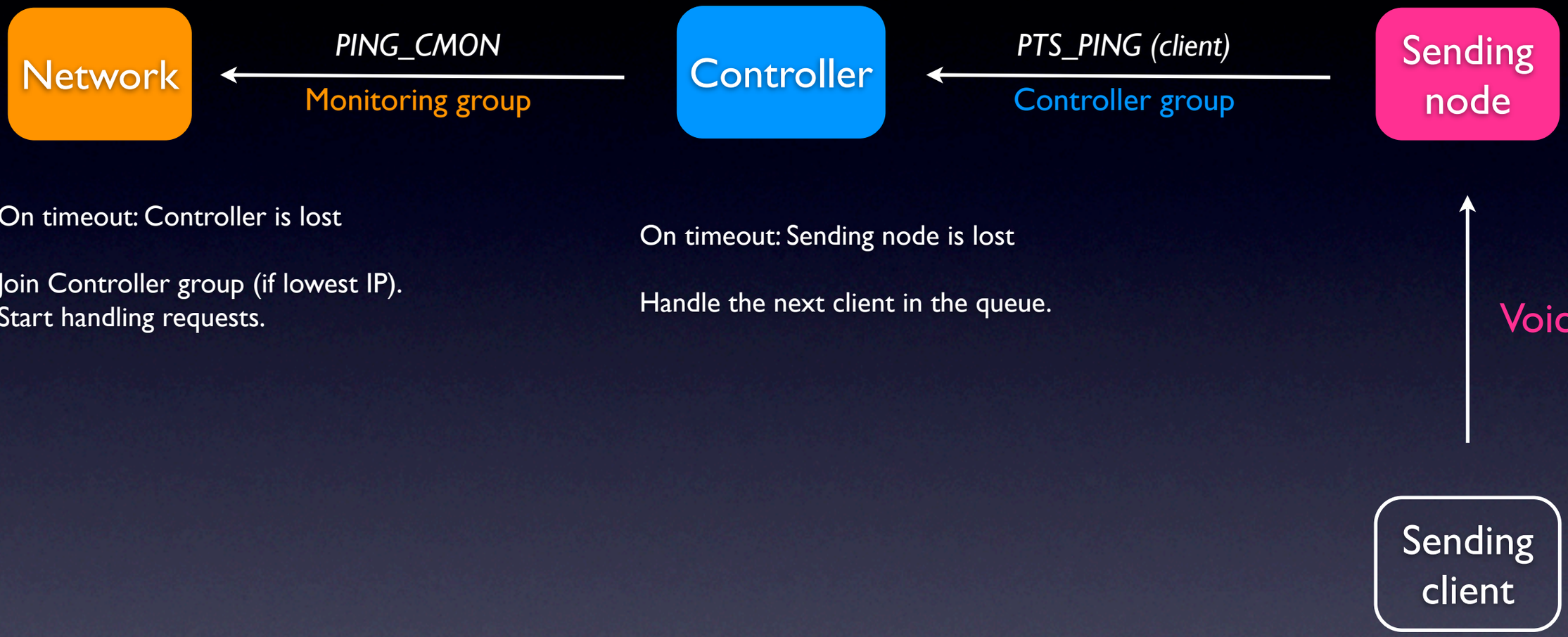
On timeout: Controller is lost

Join Controller group (if lowest IP).
Start handling requests.

On timeout: Sending node is lost

Handle the next client in the queue.

Sending client

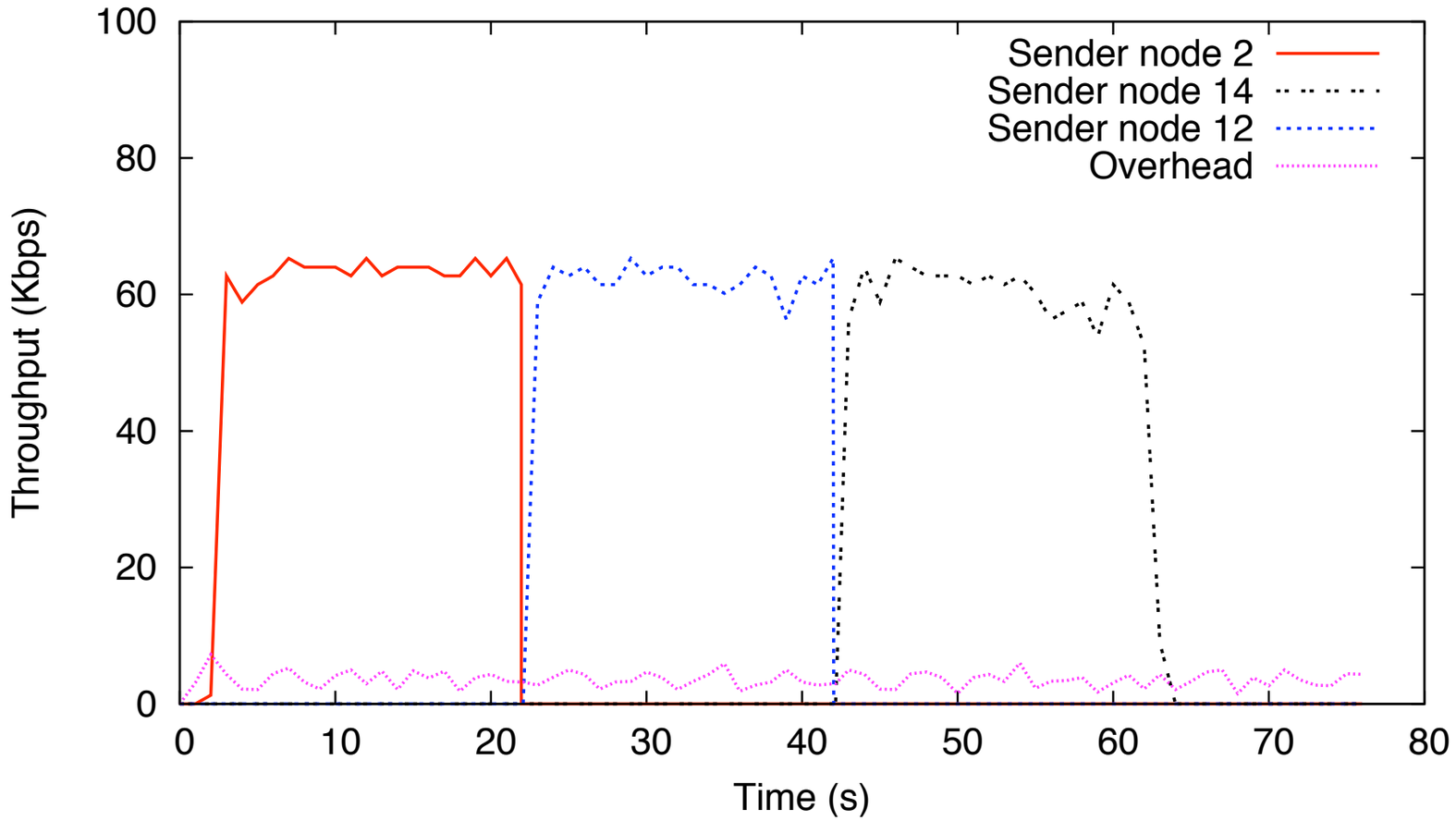

Network
PING_CMON
Monitoring group
Controller
PTS_PING (client)
Controller group
Sending node
On timeout: Controller is lost
Join Controller group (if lowest IP).
Start handling requests.
On timeout: Sending node is lost
Handle the next client in the queue.
Voice
Sending client

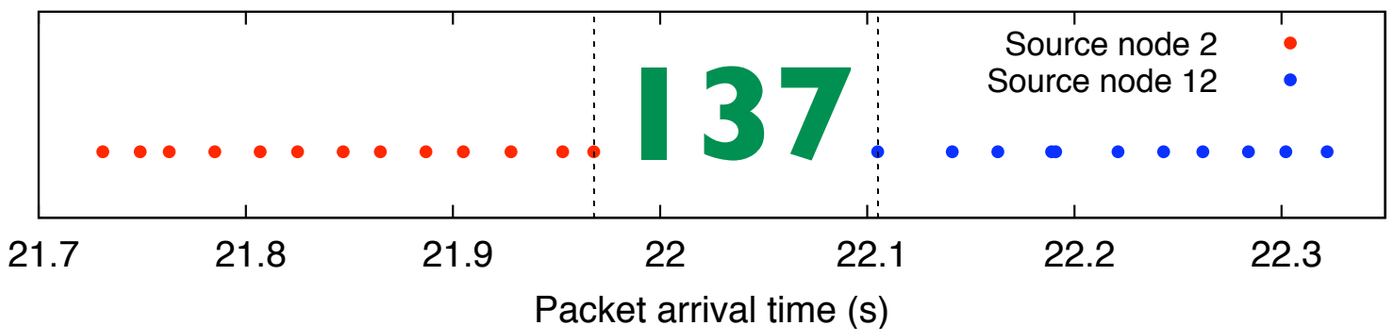
Experimental Results

Nodes	14
Rate	18 Mbps
Transmission power	50 mW
Retransmission limit	7
VoIP stream	64 Kbps
Speak duration	20 sec

Normal operation

137 milliseconds between the speakers

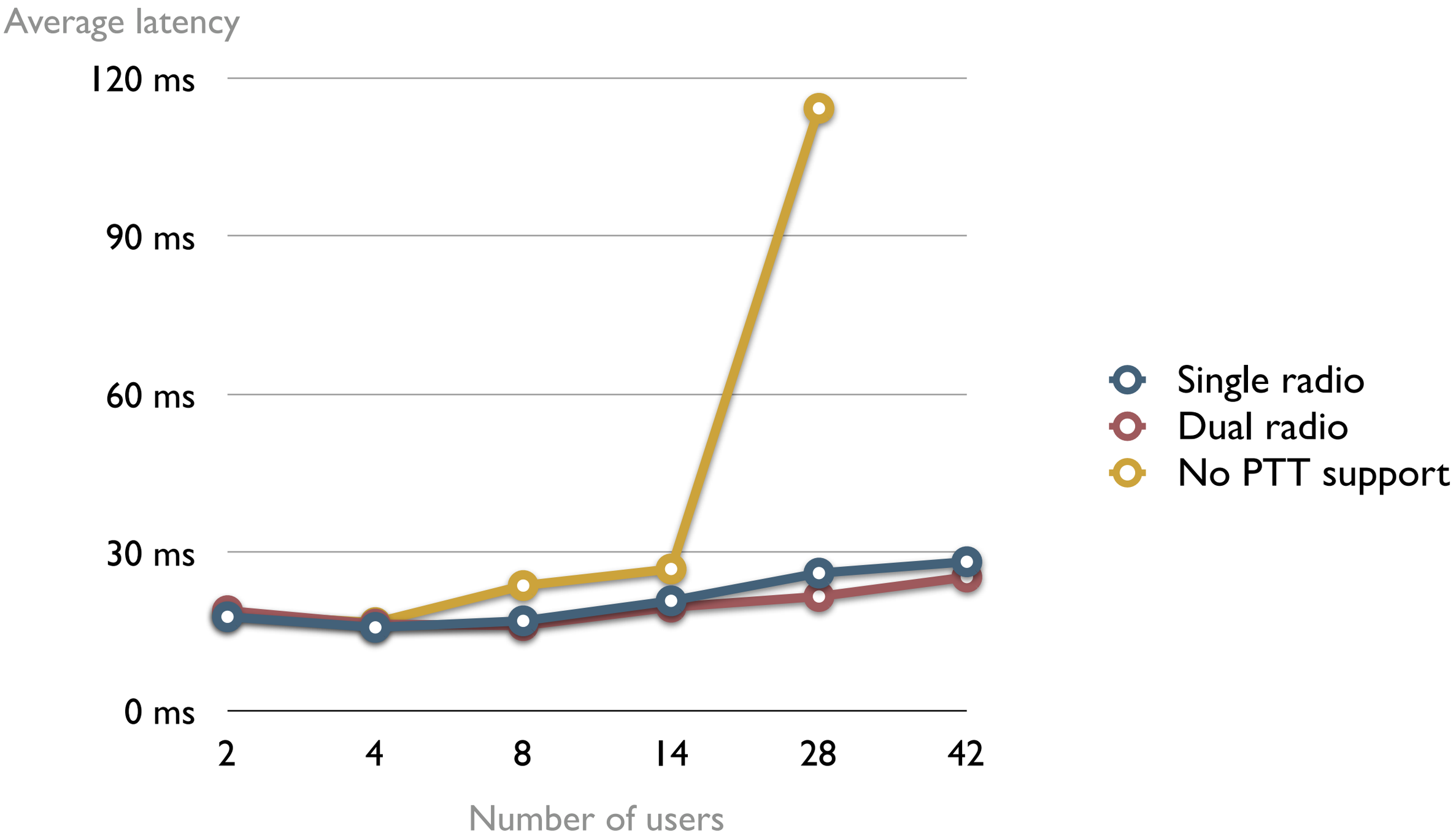




Does it scale?

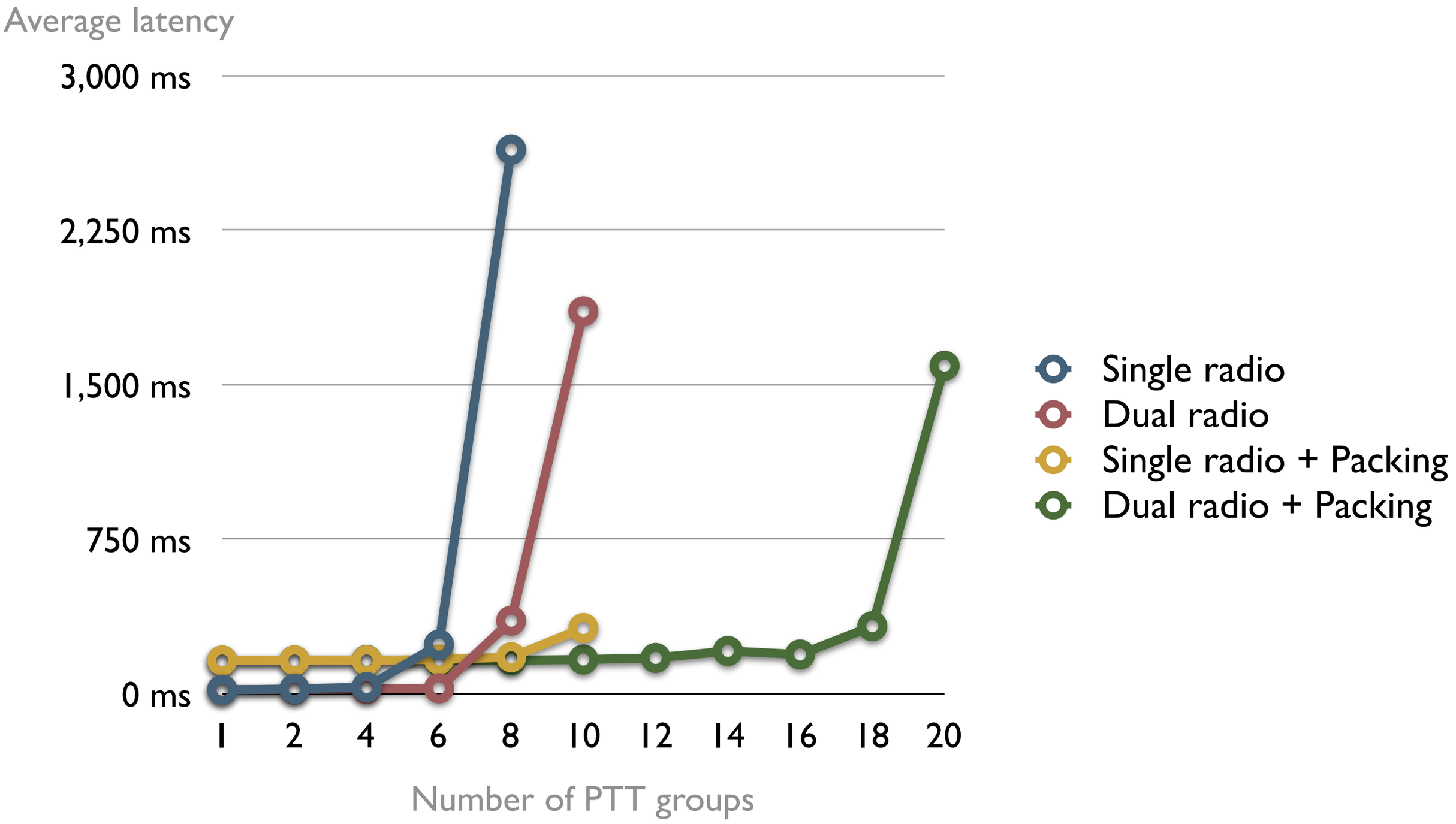
It scales to at least **42** users in a single PTT session,

in our testbed.



With packing and dual radios, it scales up to **18** sessions,

with 4 clients in a session.



SMesh is available as

open source

at smesh.org.