

# Achieving Reliable Communication in Dynamic Emergency Responses

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# State-of-the-practice exhibits

**TRIAGE TAG**

CONTAMINATED

CONTAMINATED

MORGUE

MORGUE



14-11111  
21  
IMMEDIATE  
21  
IMMEDIATE  
21  
IMMEDIATE  
21  
IMMEDIATE

MEDICAL COORDINATOR

PATIENT #	STATUS	ELABORATE	UNIT #	DISTRIBUTION	ETA
36	2			Kellogg	
5	2			Baltes	
18	2			Pelmer	
3	2			Pelmer	
5	2			Murray	
10	2			Sharp	
9	2			Sharp	
11	2			Kaiser	
21	2			Kaiser	
12	2			Kaiser	
22	2			Sharp	
20	2	Delayed		Ballbank	

MEDCOM - paper 21 Aug

Triage tag

Example Coordination

Medcom

- **Communications using radios & paper**
  - Error-prone and labor-intensive
  - Slow dissemination of information
- **Electronic data may address these limitations**





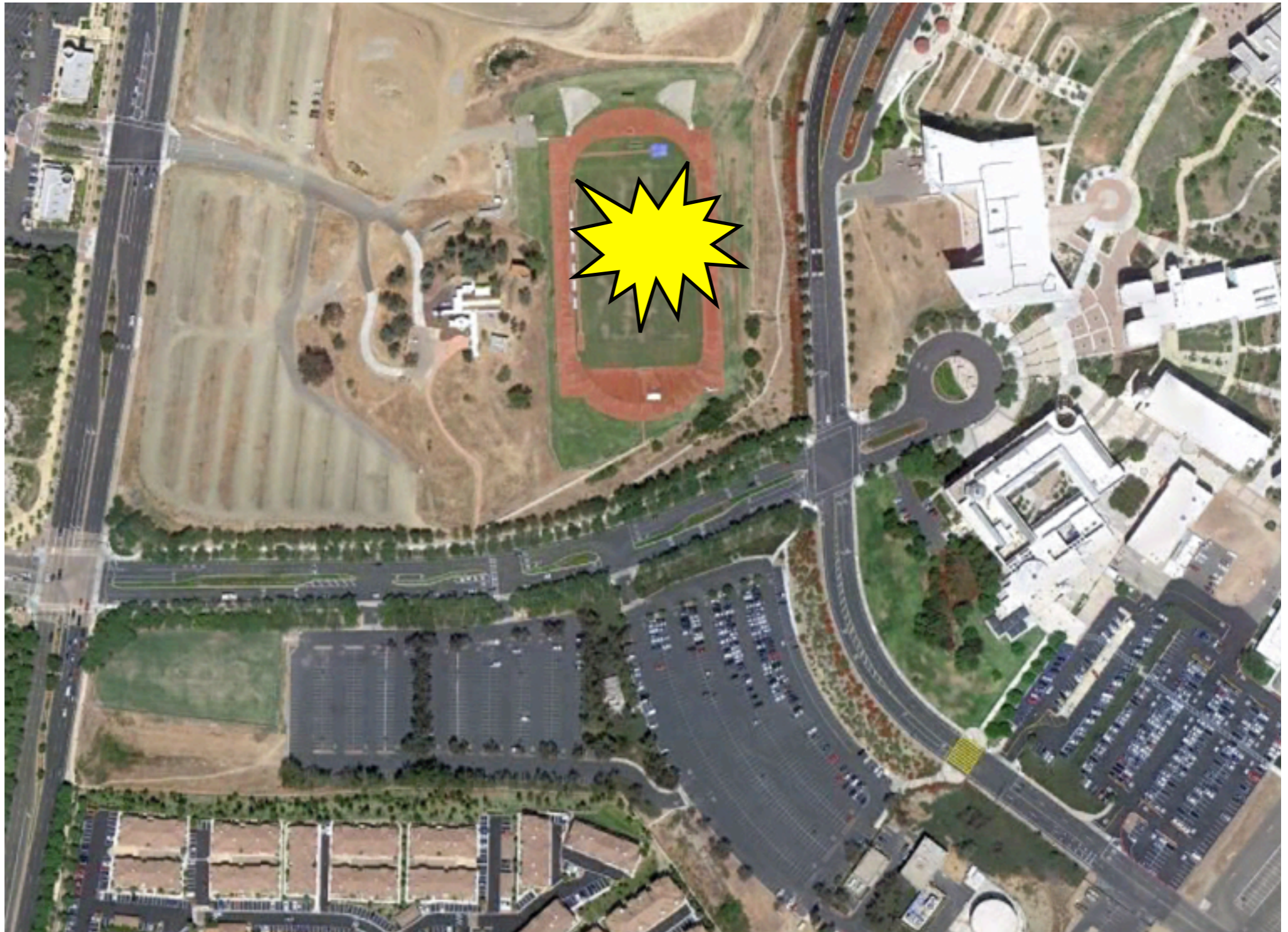
# “Typical” disaster scenario



Golden Guardian drill, April 2010



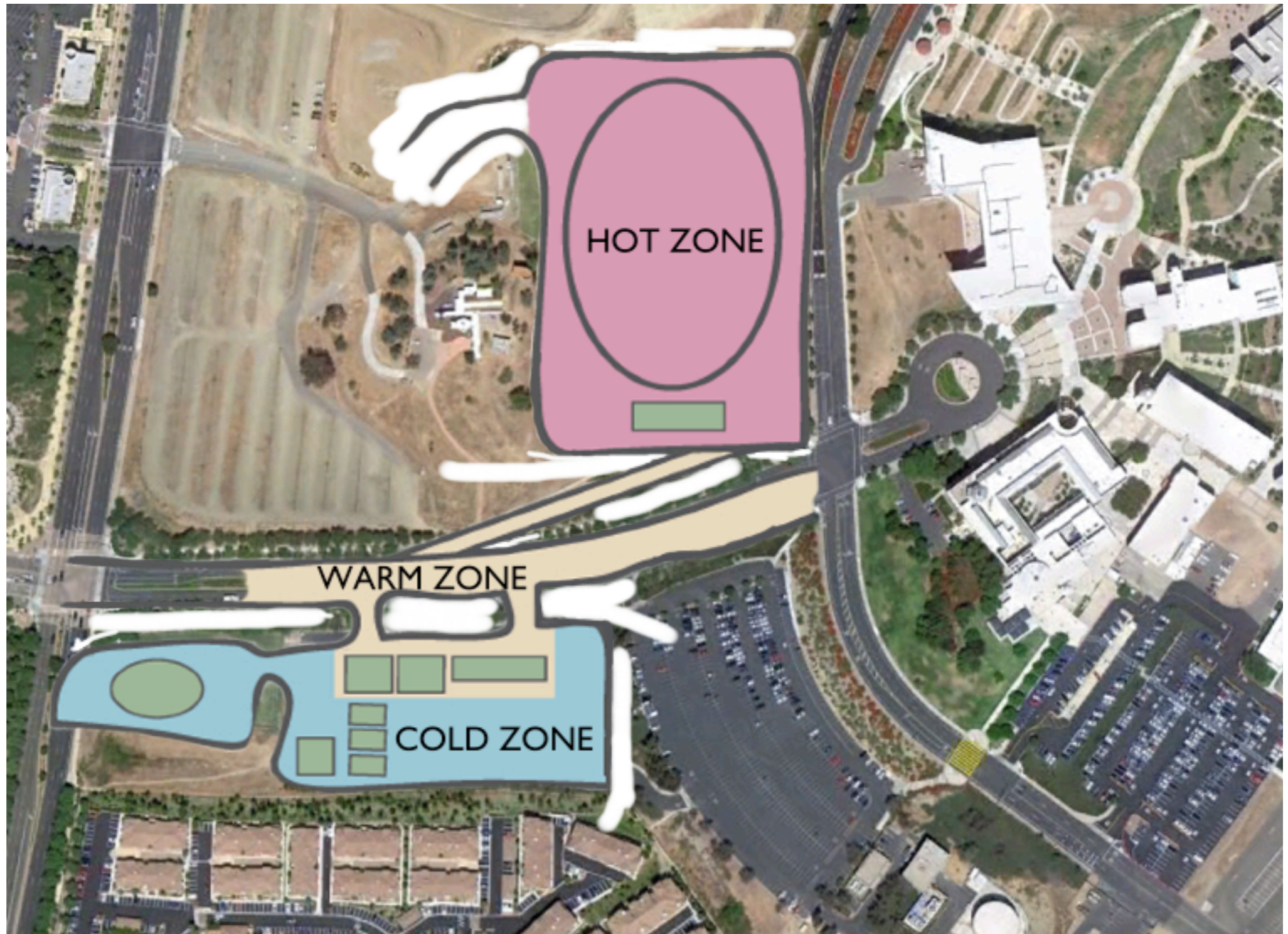
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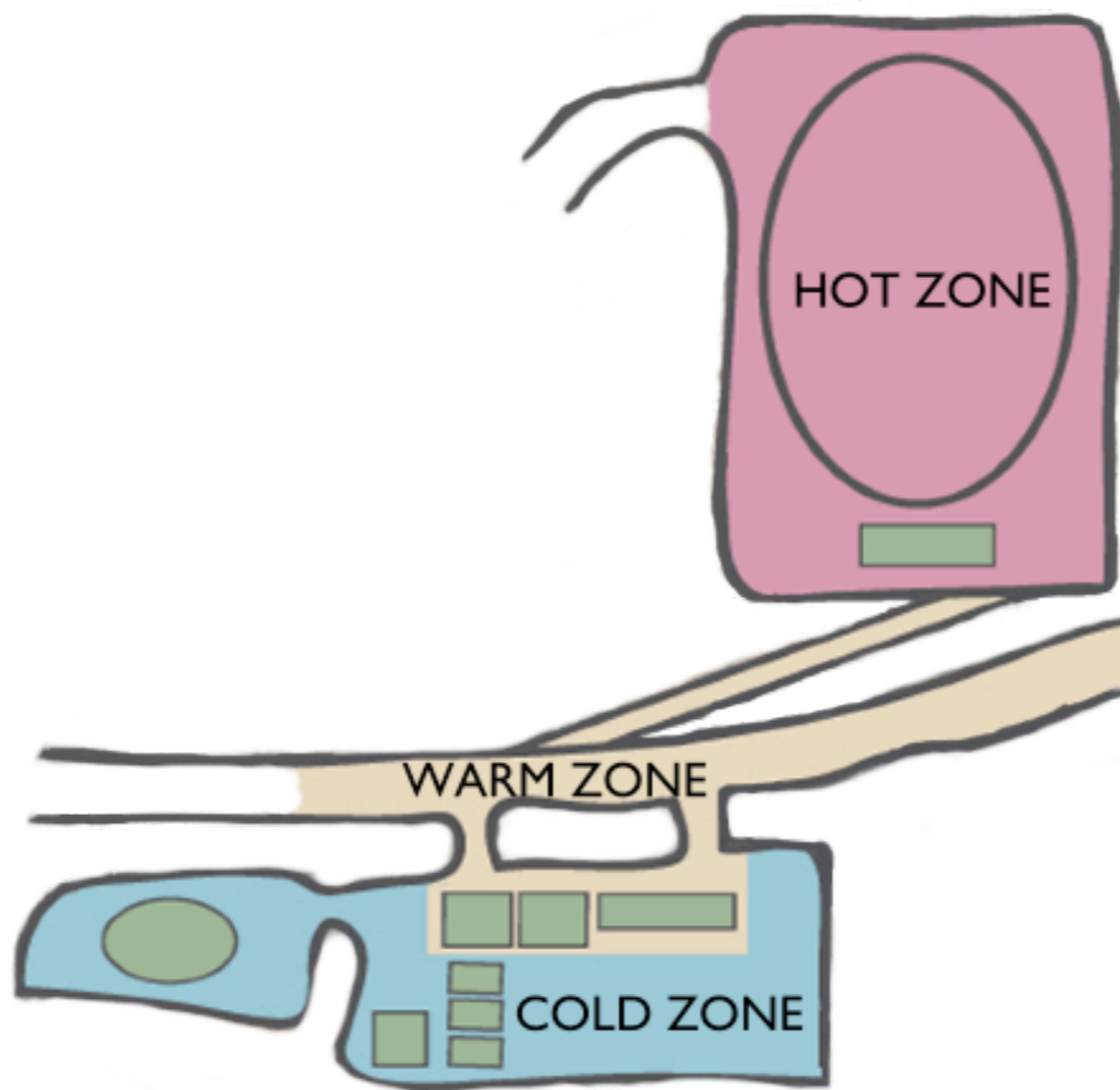
Golden Guardian drill, April 2010



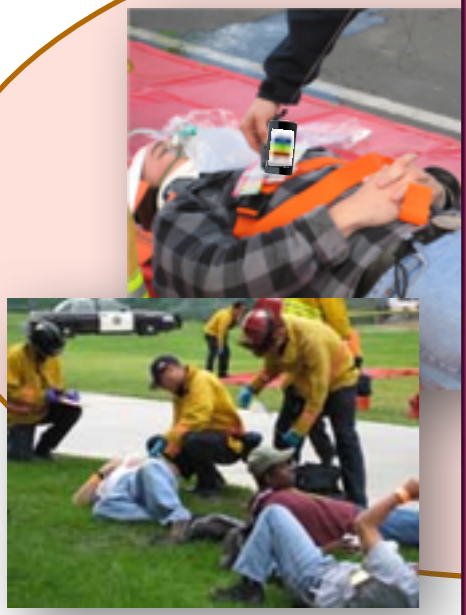
# “Typical” disaster scenario



Golden Guardian drill, April 2010







**Personal Property Receipt** Evidence Tag  
**TRIAL TAG**

**CONTAMINATED** **CONTAMINATED**

**EVIDENCE** **EVIDENCE**

**MORGUE** **MORGUE**

**IMMEDIATE** **IMMEDIATE**  
 Life-Threatening Injury

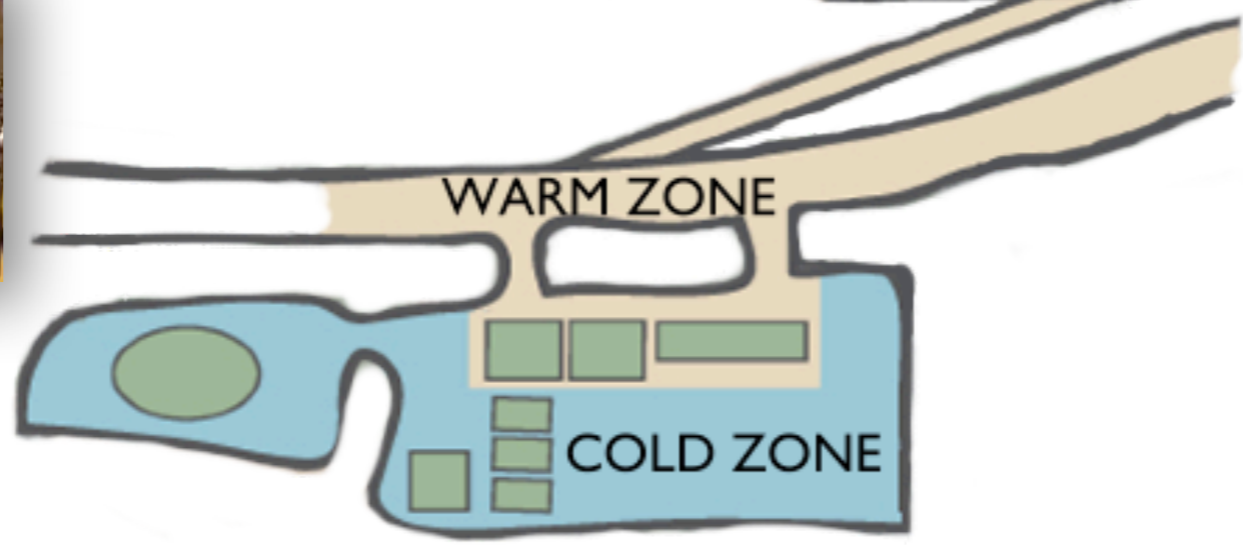
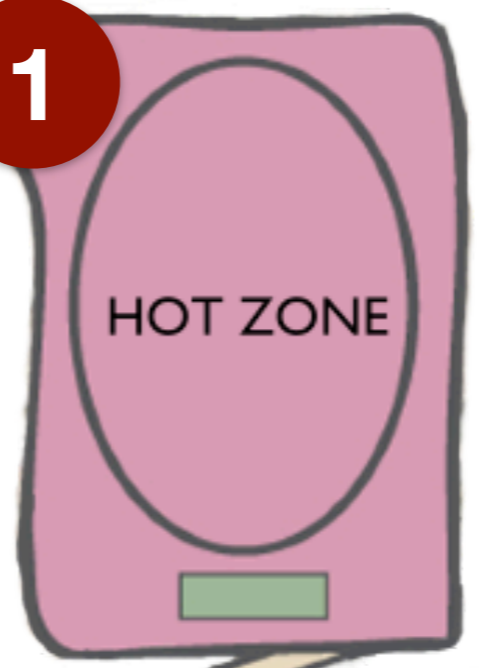
**DELAYED** **DELAYED**  
 Serious Non-Life-Threatening Injury

**MINOR** **MINOR**  
 Walking Wounded

**CONTAMINATED** **CONTAMINATED**



1





**PERSONAL PROPERTY RECEIPT**

**EVIDENCE TAG**

**TRIAGE TAG**

**CONTAMINATED**

**EVIDENCE**

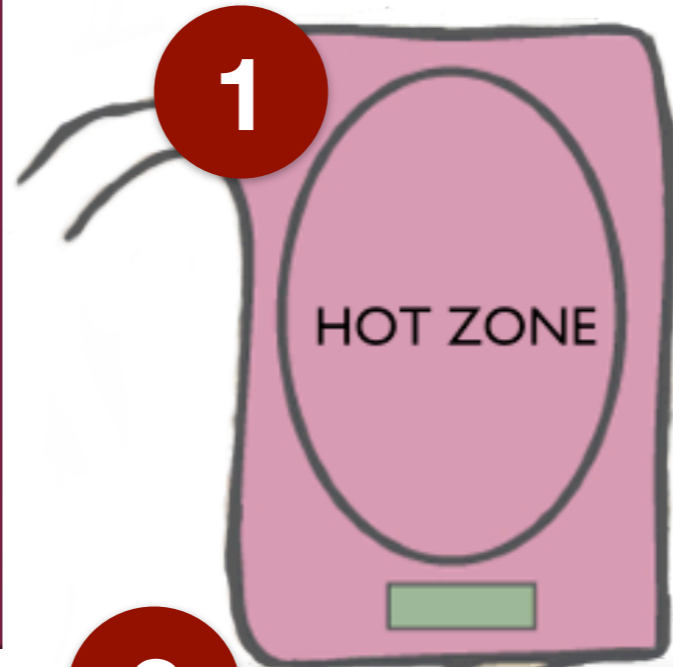
**MORGUE**

**CONTAMINATED**

**EVIDENCE**

**MORGUE**

IMMEDIATE	IMMEDIATE	IMMEDIATE	IMMEDIATE
DELAYED	DELAYED	DELAYED	DELAYED
MINOR	MINOR	MINOR	MINOR



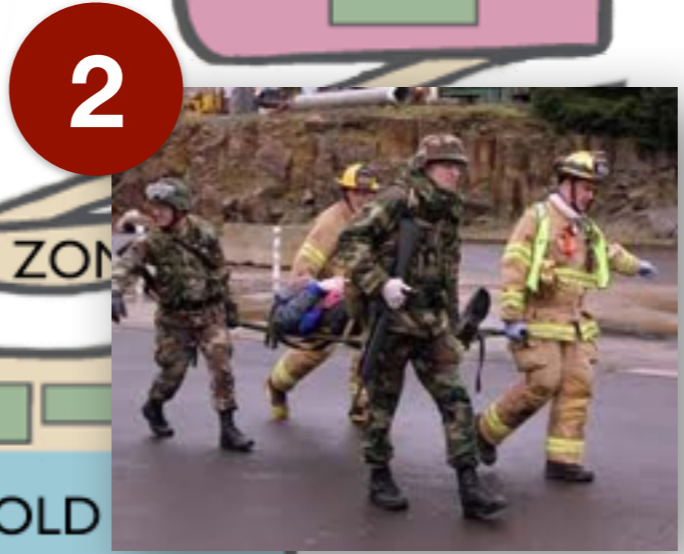
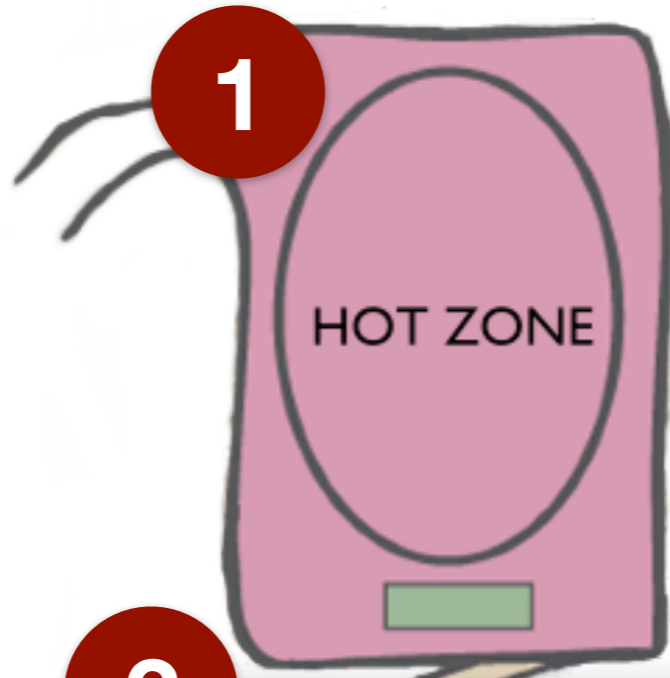
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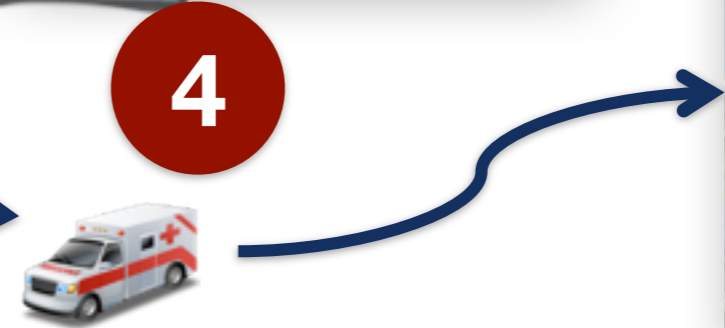
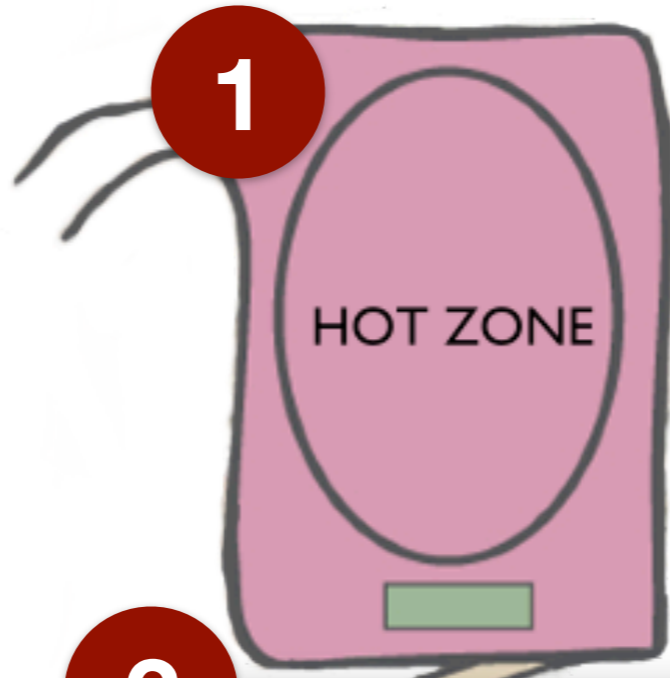
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<b>CONTAMINATED</b> EVIDENCE <b>MORGUE</b> IMMEDIATE DELAYED MINOR MORGUE	<b>CONTAMINATED</b> EVIDENCE <b>MORGUE</b> IMMEDIATE DELAYED MINOR MORGUE







<p>Personal Property Receipt: [Barcode]</p> <p>Evidence Tag: [Barcode]</p> <p>Incident: [Barcode]</p> <p>No. [Barcode]</p> <p><b>TRIAGE TAG</b></p> <p>APPS: [Barcode]</p>		<p>Personal Information</p> <p>Patient's Name: _____</p> <p>REGISTRATION: <input type="radio"/> R <input type="radio"/> P <input type="radio"/> M</p> <p>WOUND STATUS: _____</p>	
<p>CONTAMINATED</p> <p>CONTAMINATED</p>		<p>CONTAMINATED</p> <p>CONTAMINATED</p>	
<p>IMMEDIATE</p> <p>DELATED</p> <p>MINOR</p>		<p>IMMEDIATE</p> <p>DELATED</p> <p>MINOR</p>	
<p>MORGUE</p>		<p>MORGUE</p>	





# Reliable communication is a key challenge

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- **Responders and commanders must communicate reliably**
- **Challenges:**
  - limited infrastructure → **existence of network partitions**
    - cannot rely on existing infrastructure
    - limited opportunities to deploy infrastructure during emergencies
  - dynamic radio environment → **continuously changing topology**
    - heavy equipment attenuates radio signals
    - external interference (e.g., video broadcasts)
    - mobile users

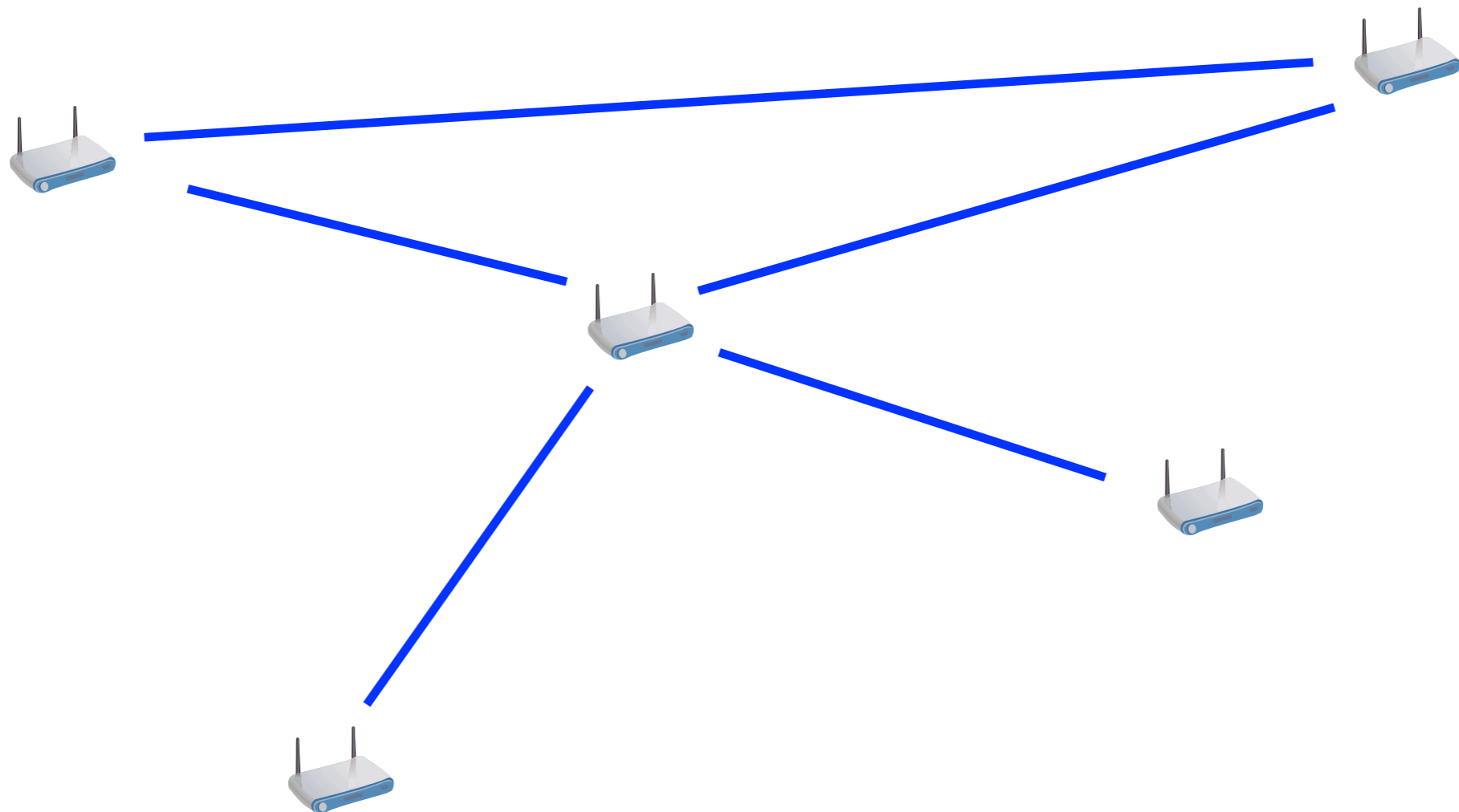


# Initial approach: Client-server + Adhoc routing

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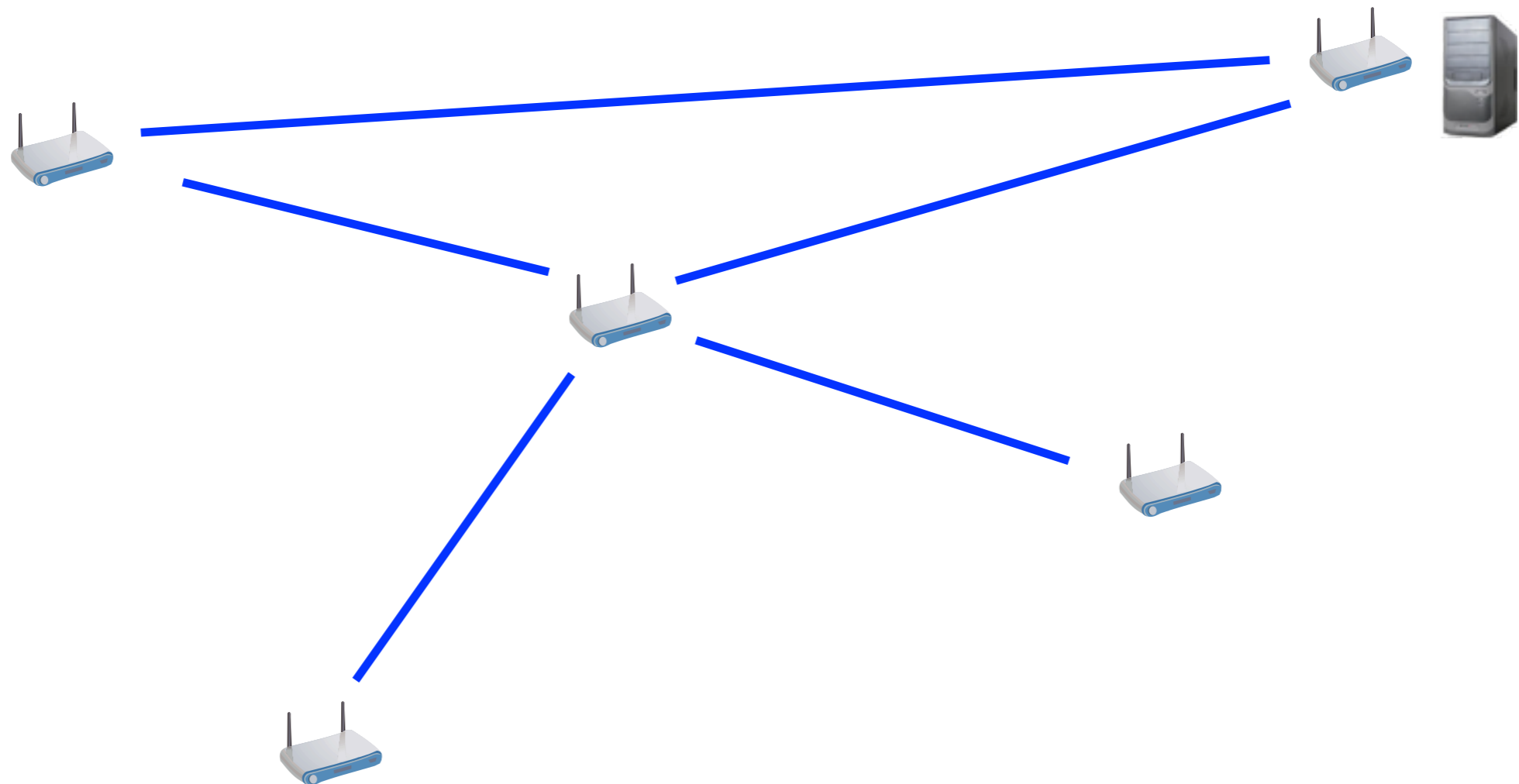
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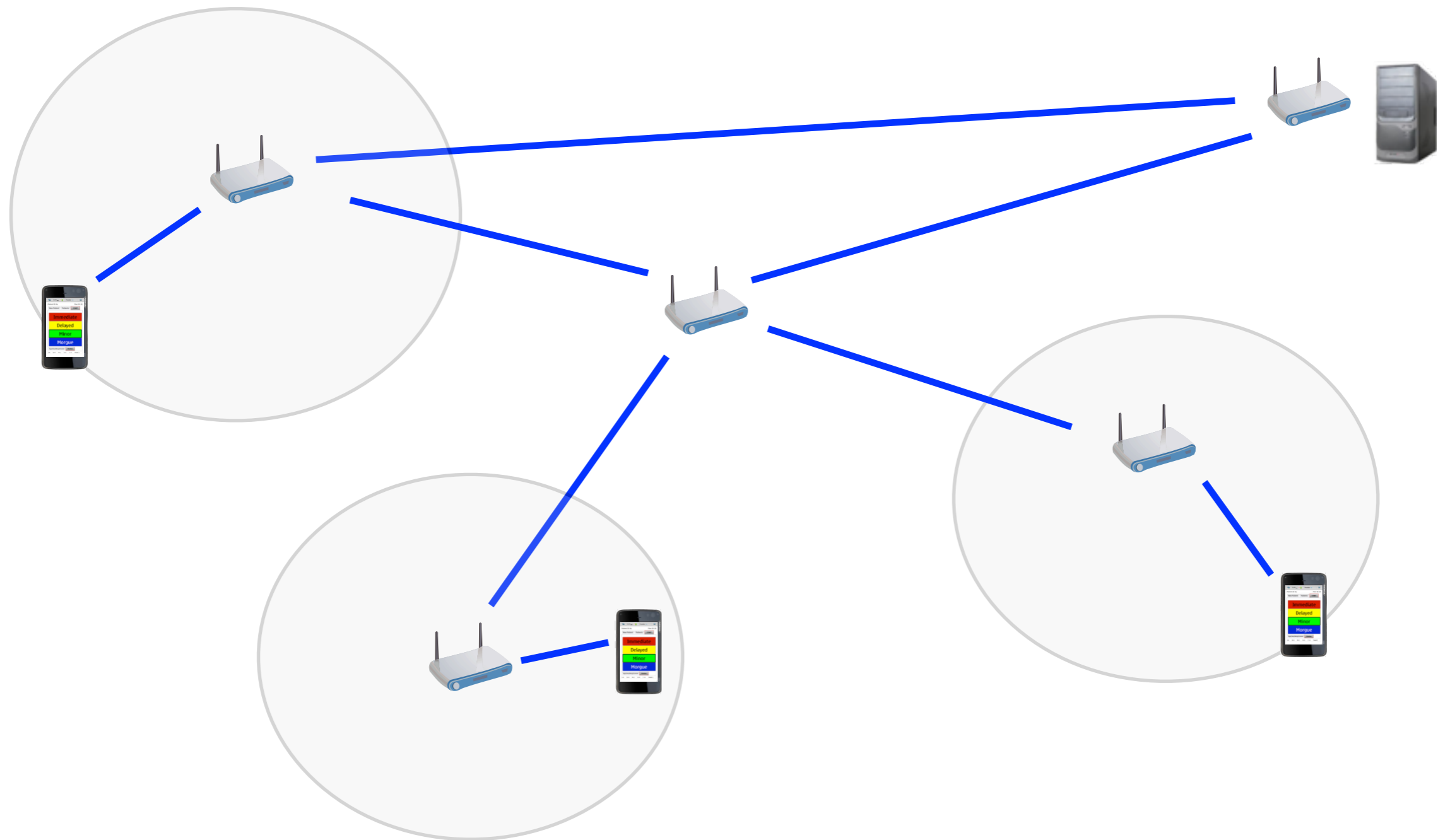
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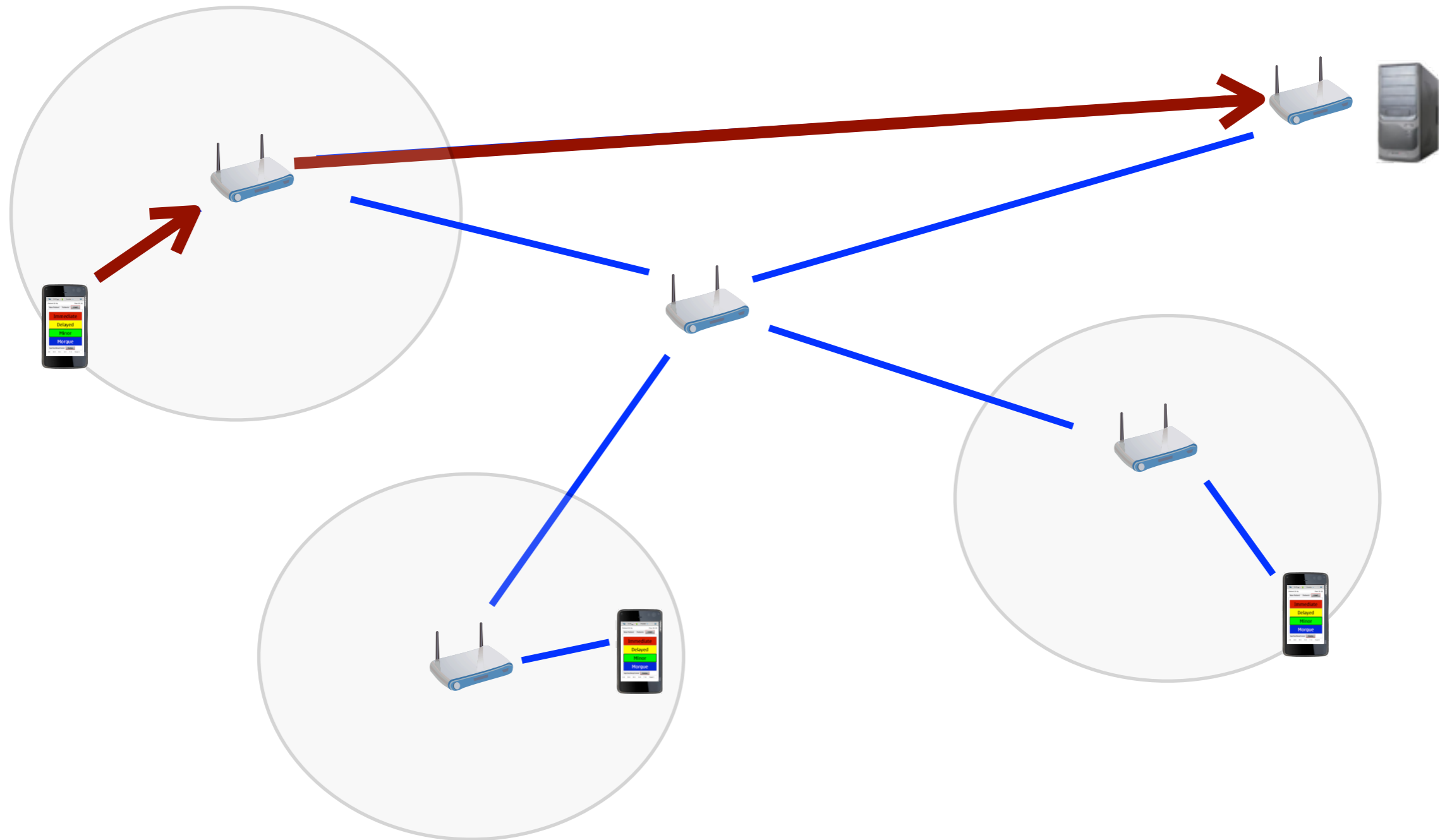
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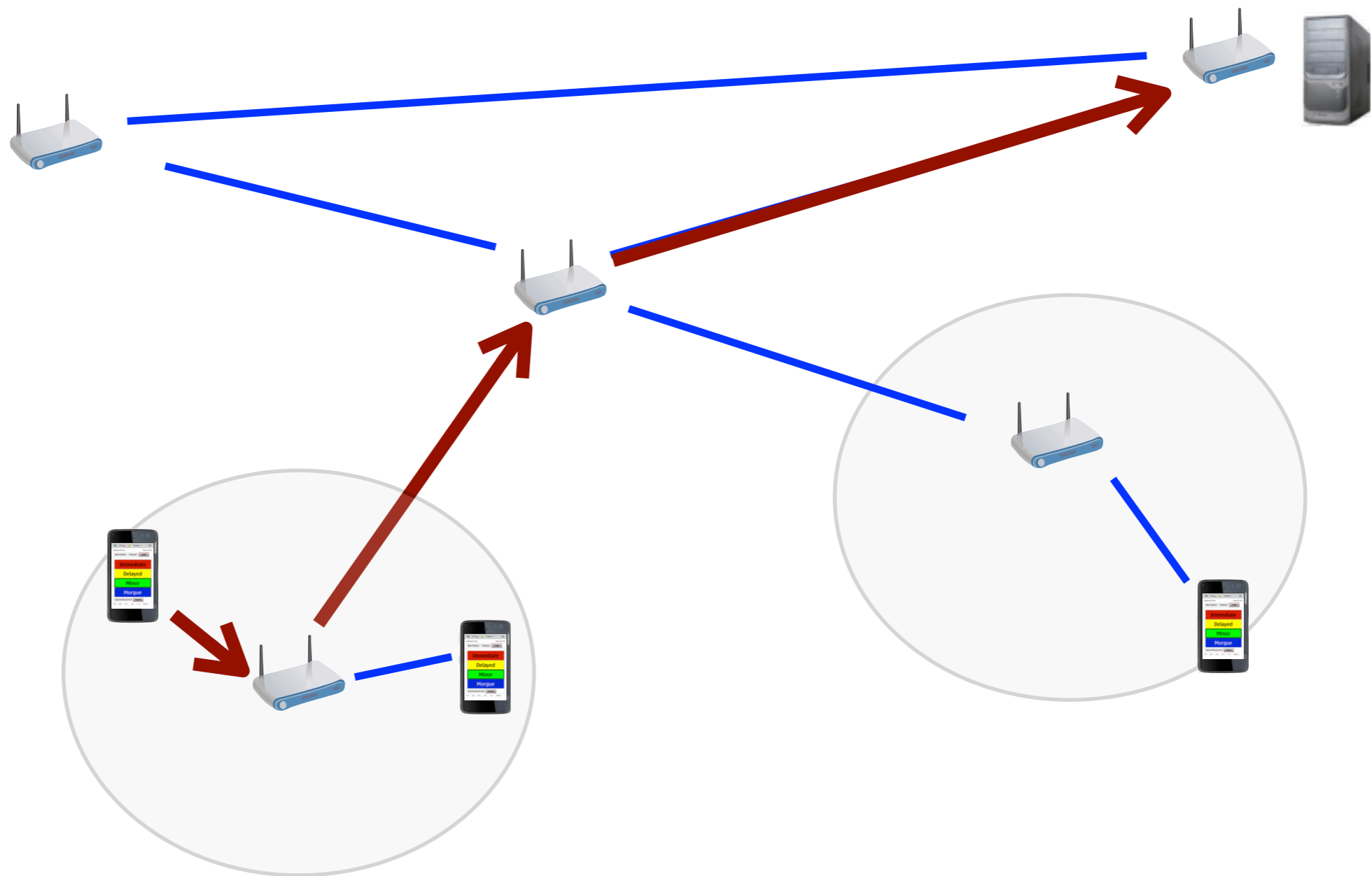
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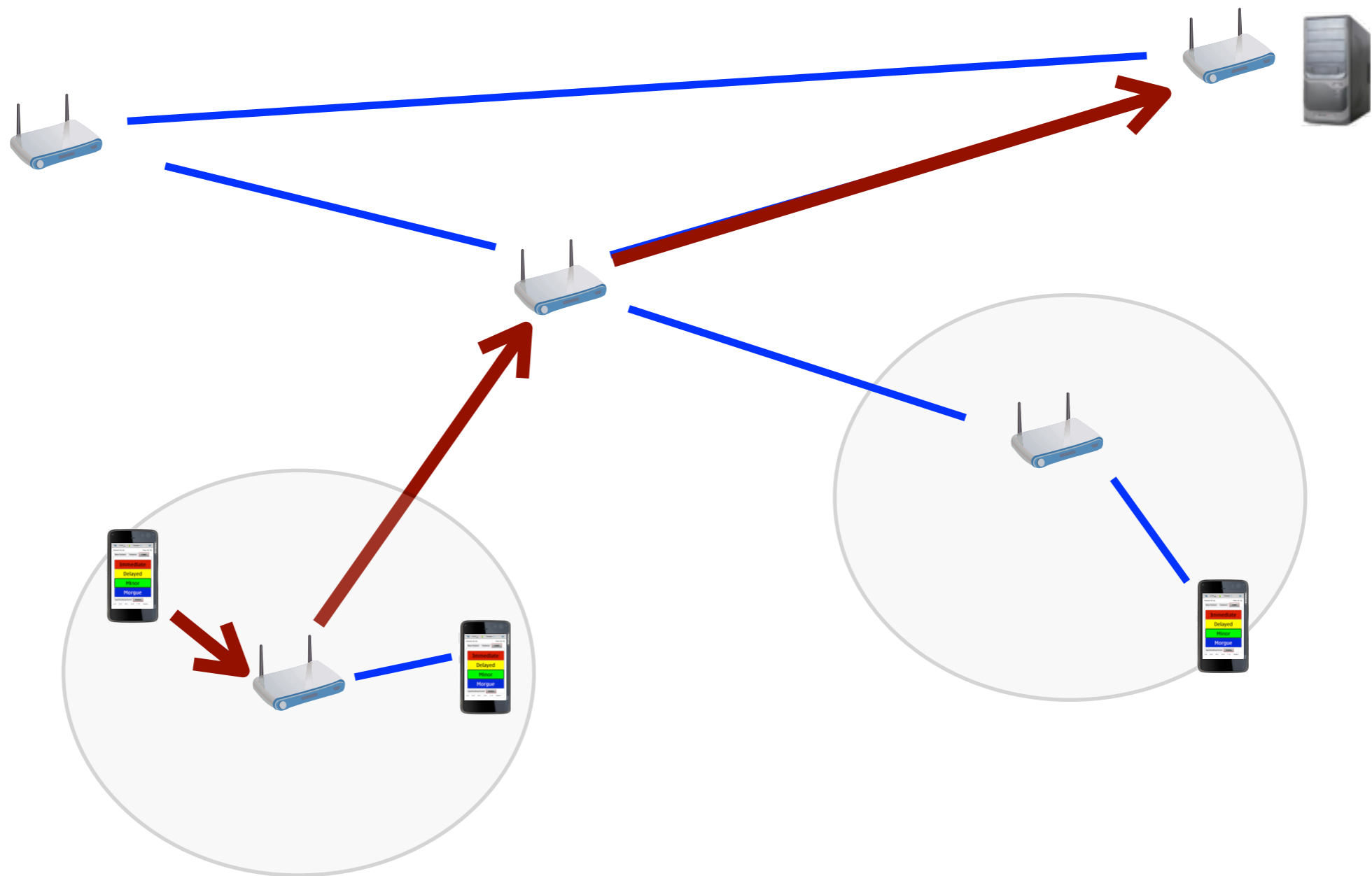
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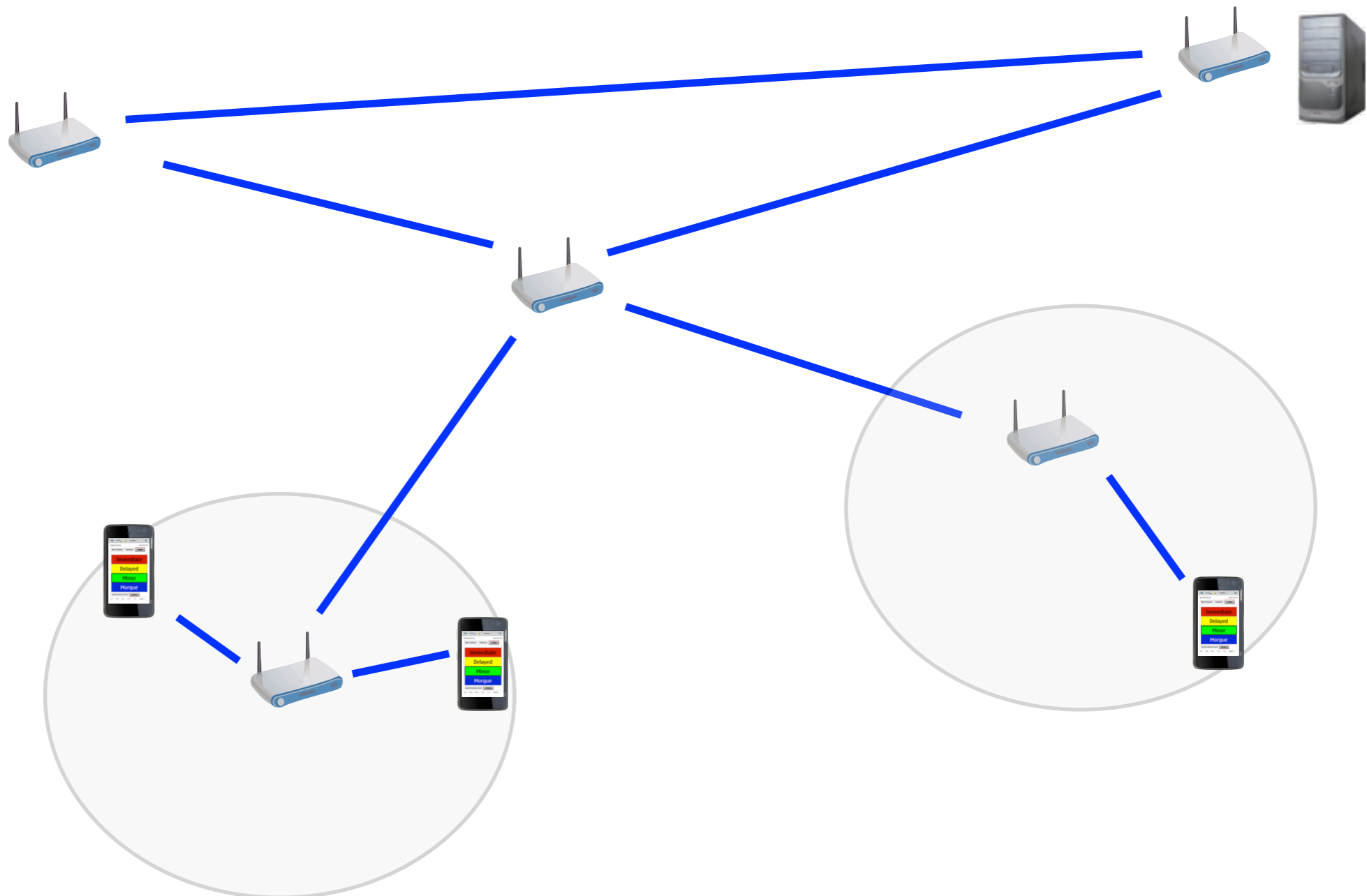
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Failure to update end-to-end paths  $\Rightarrow$  low reliability



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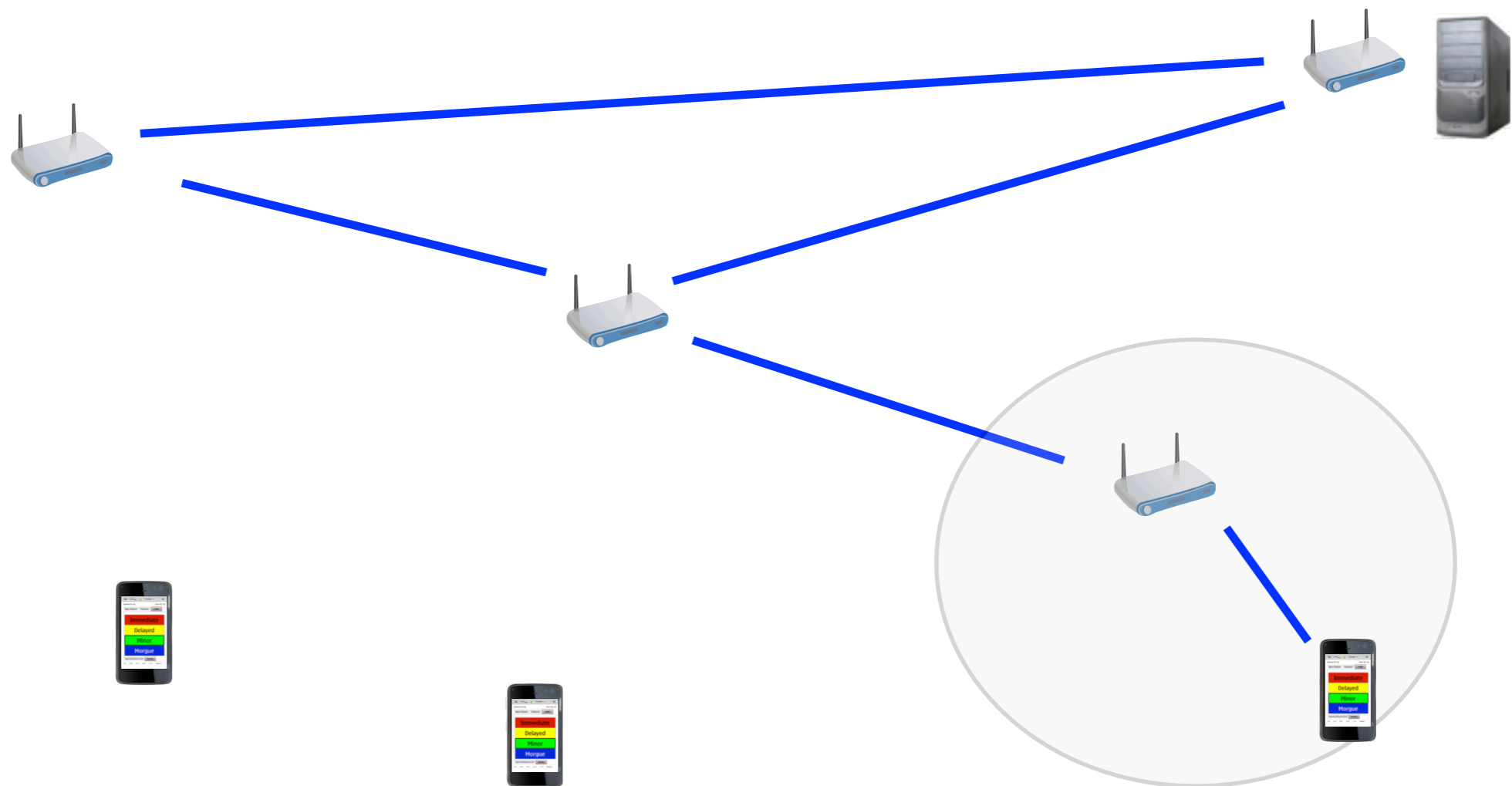
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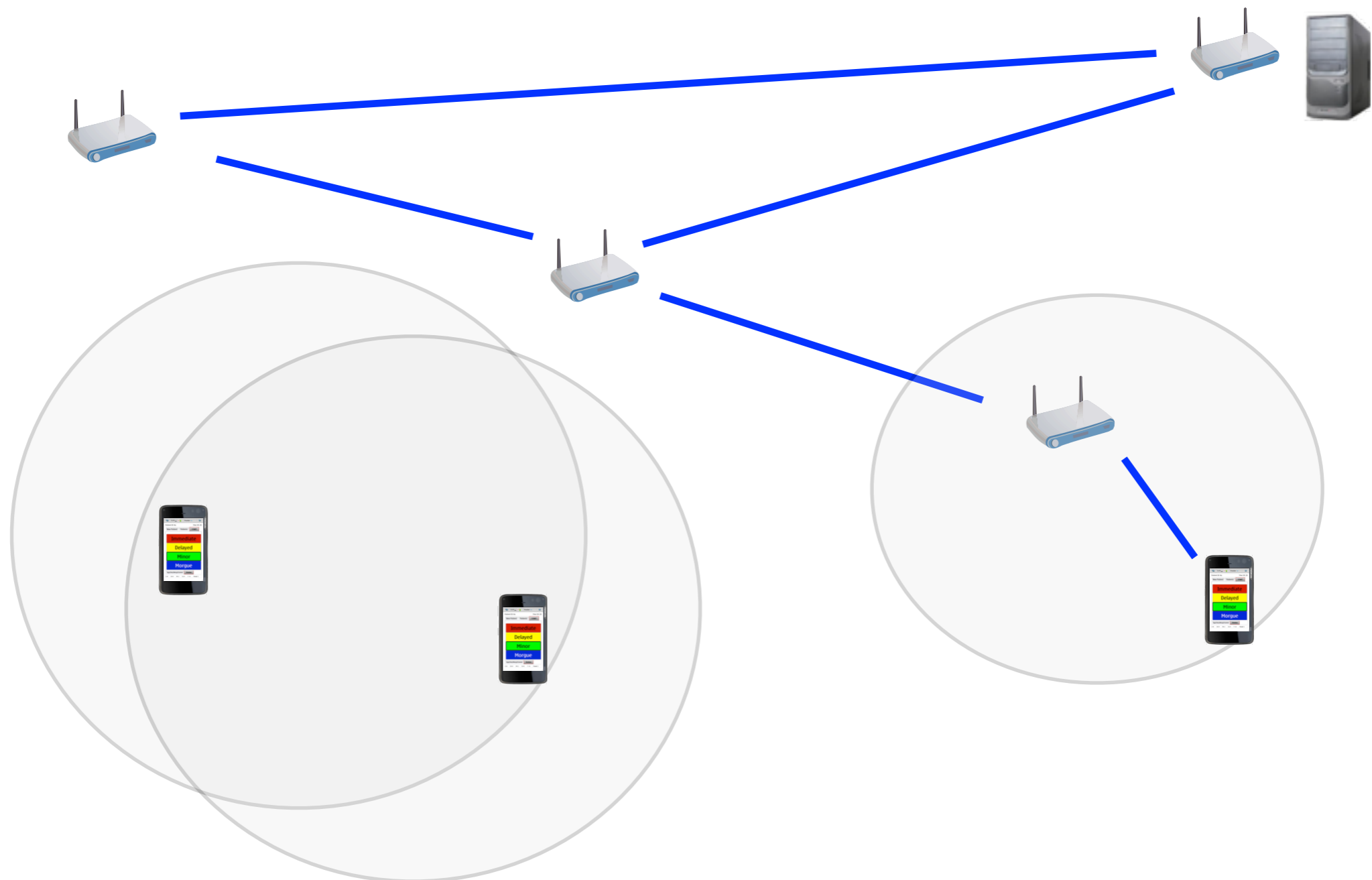
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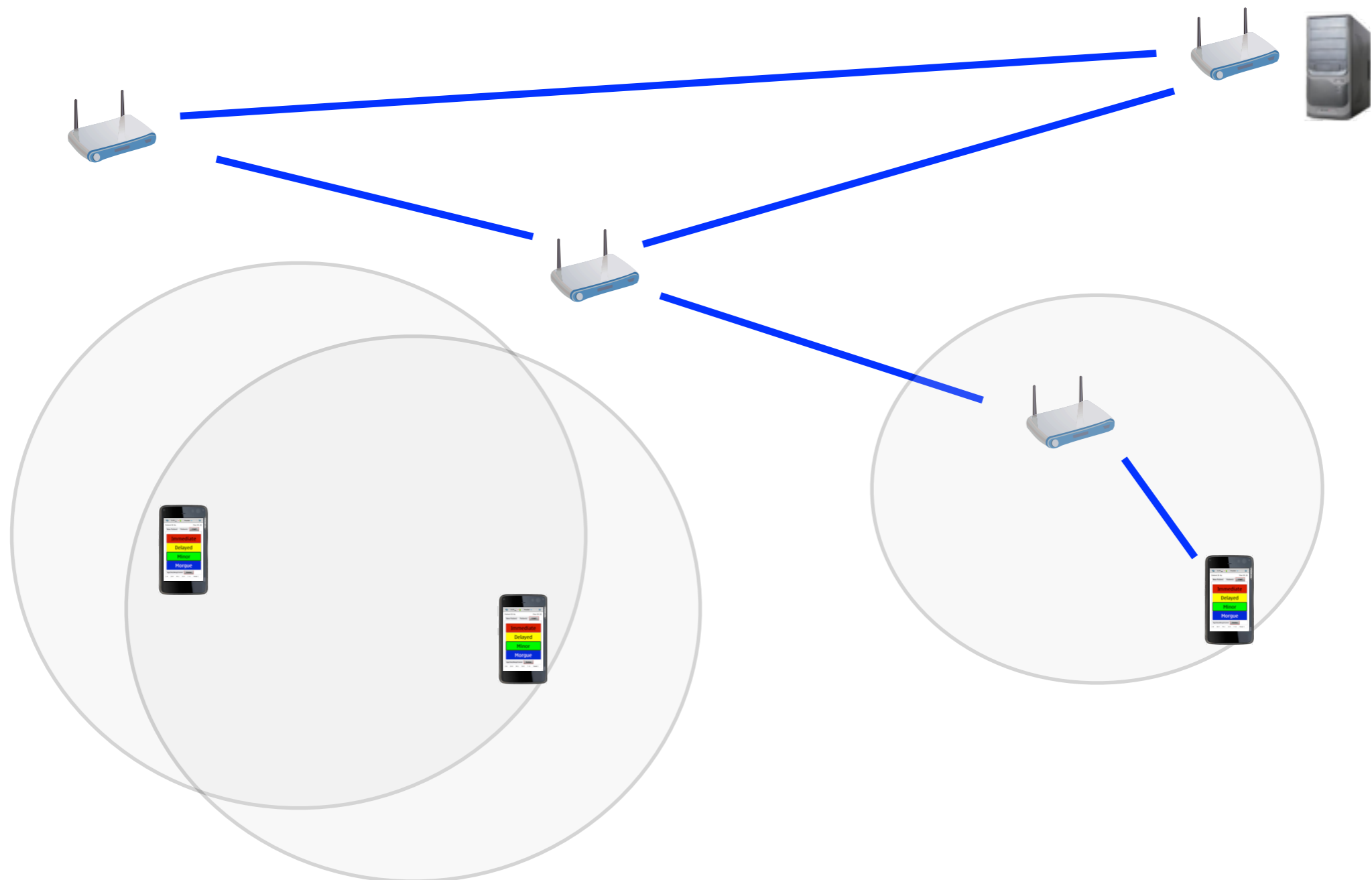
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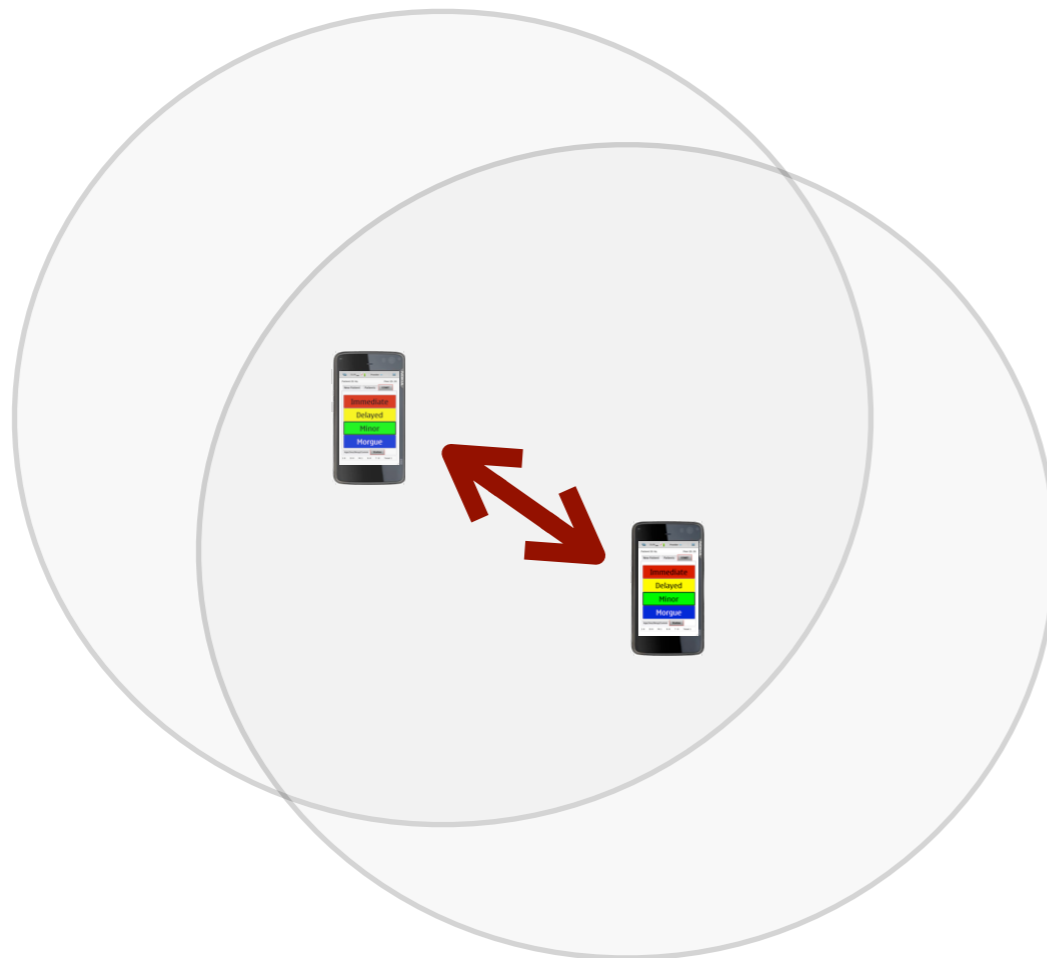
Network partitions  $\Rightarrow$  prevent clients from communicating





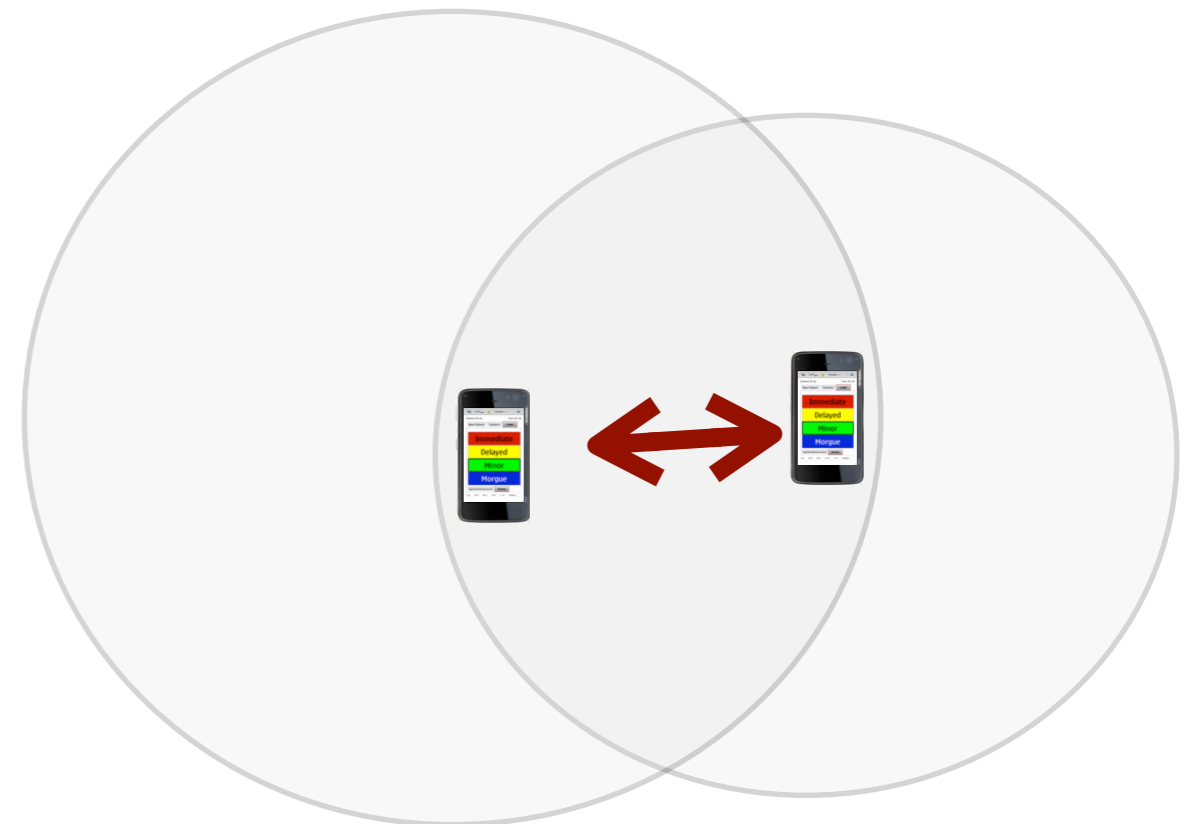
# Peer-to-peer + Gossip

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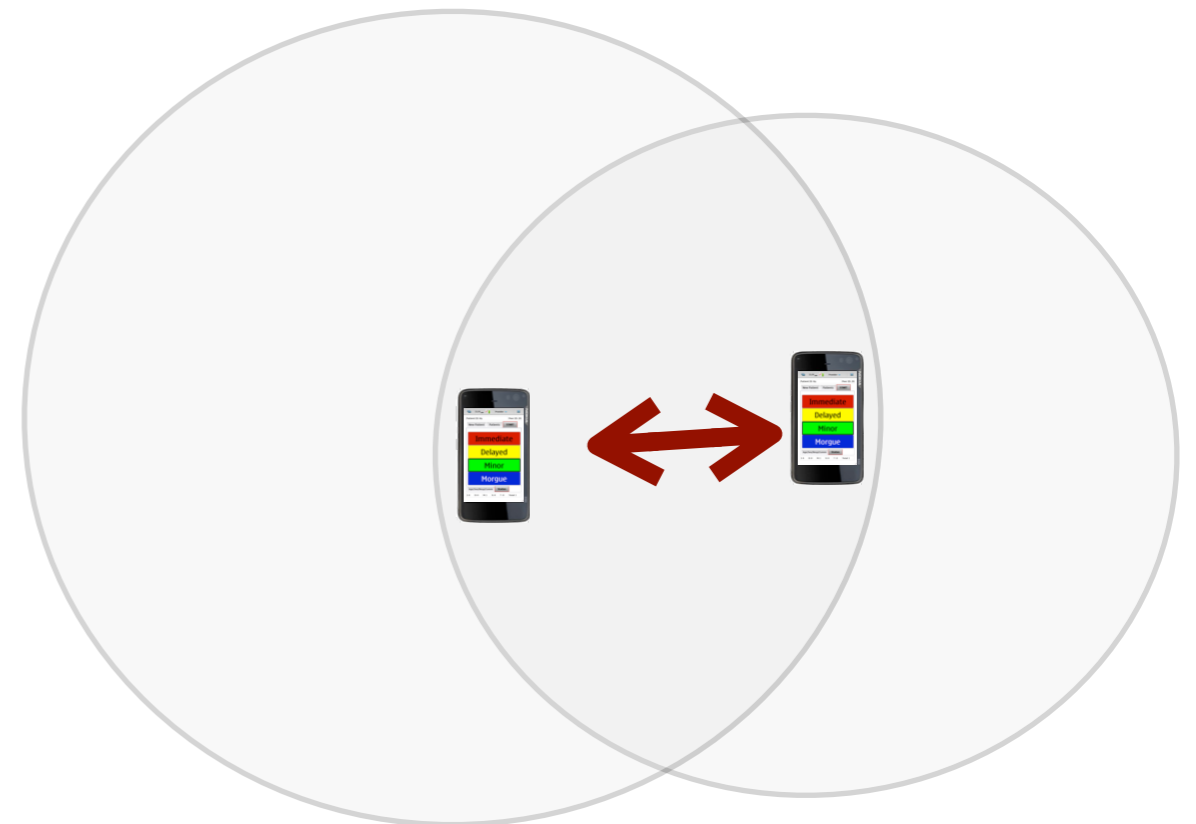
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# Peer-to-peer + Gossip

Peers communicate locally  $\Rightarrow$  tolerates topology changes

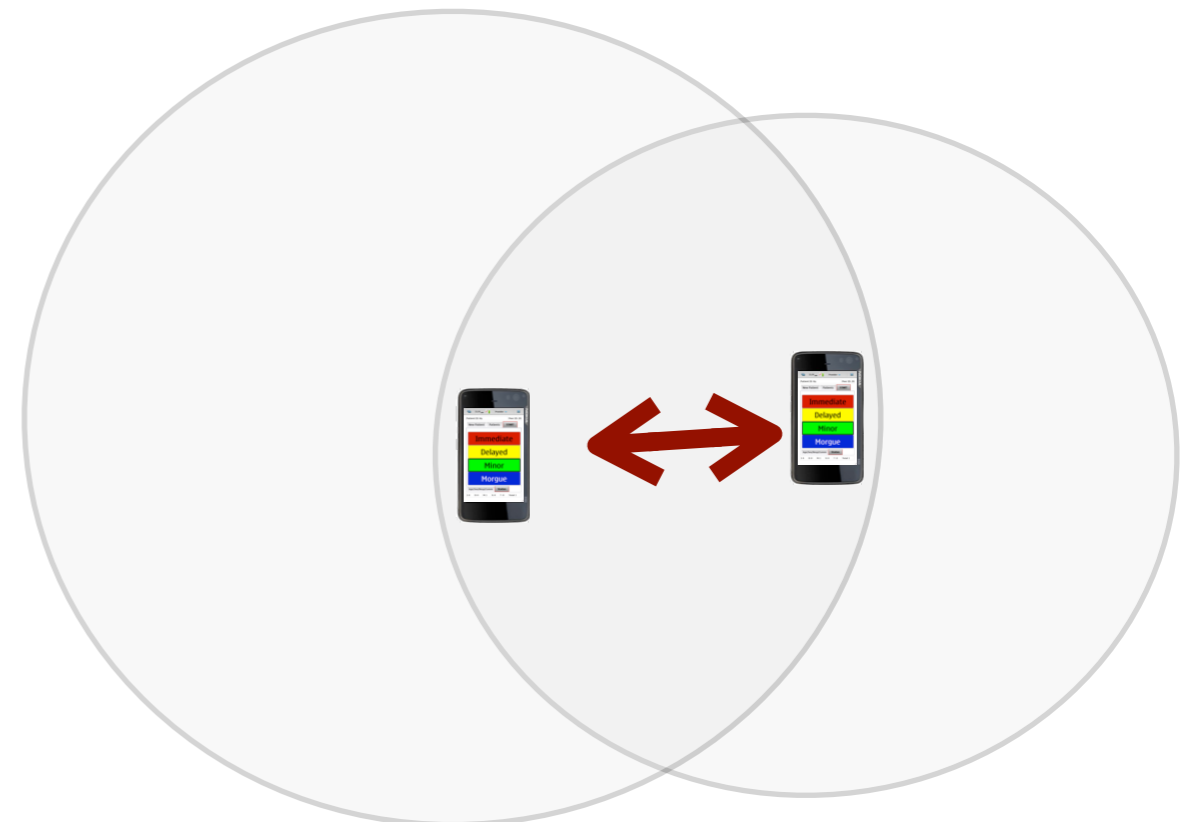




# Peer-to-peer + Gossip

Peers communicate locally  $\Rightarrow$  tolerates topology changes

Mobility  $\Rightarrow$  bridges network partitions

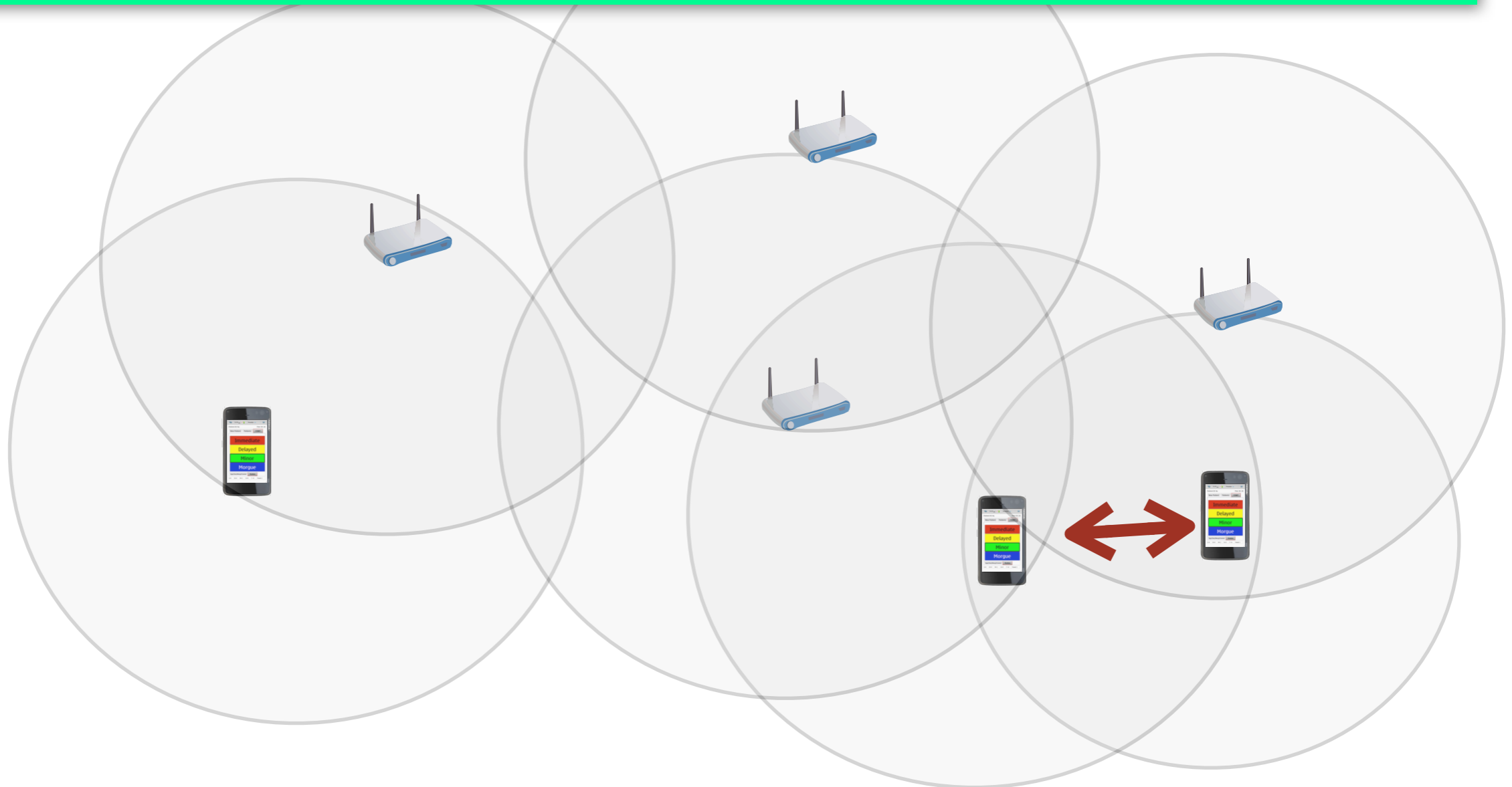


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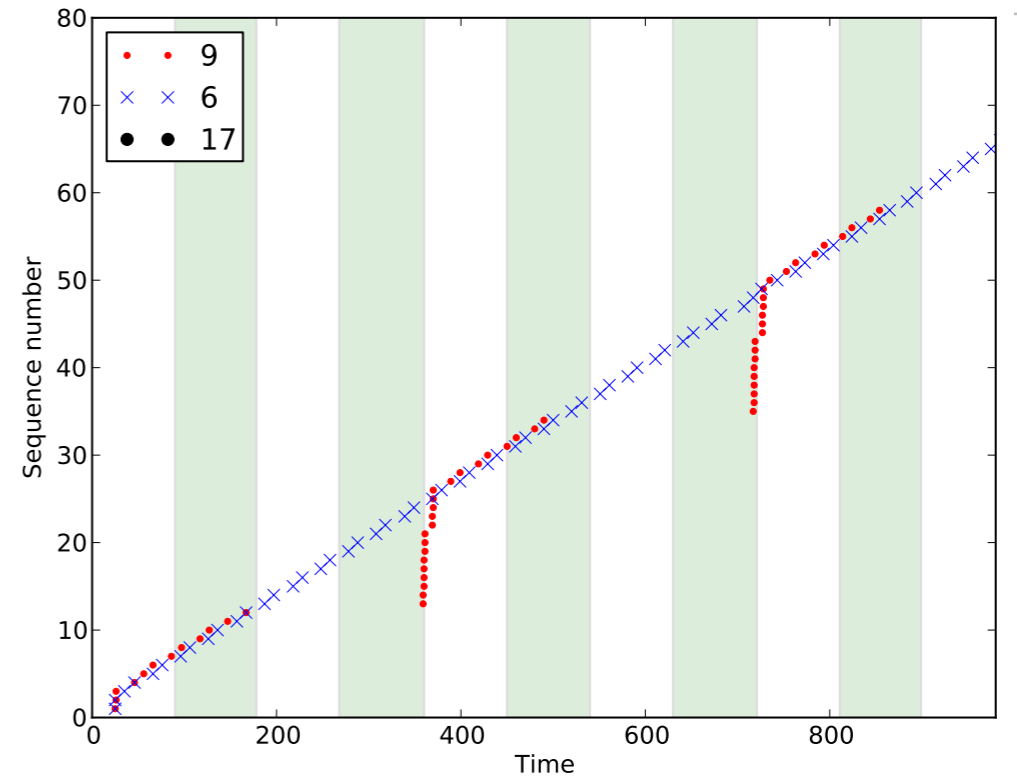
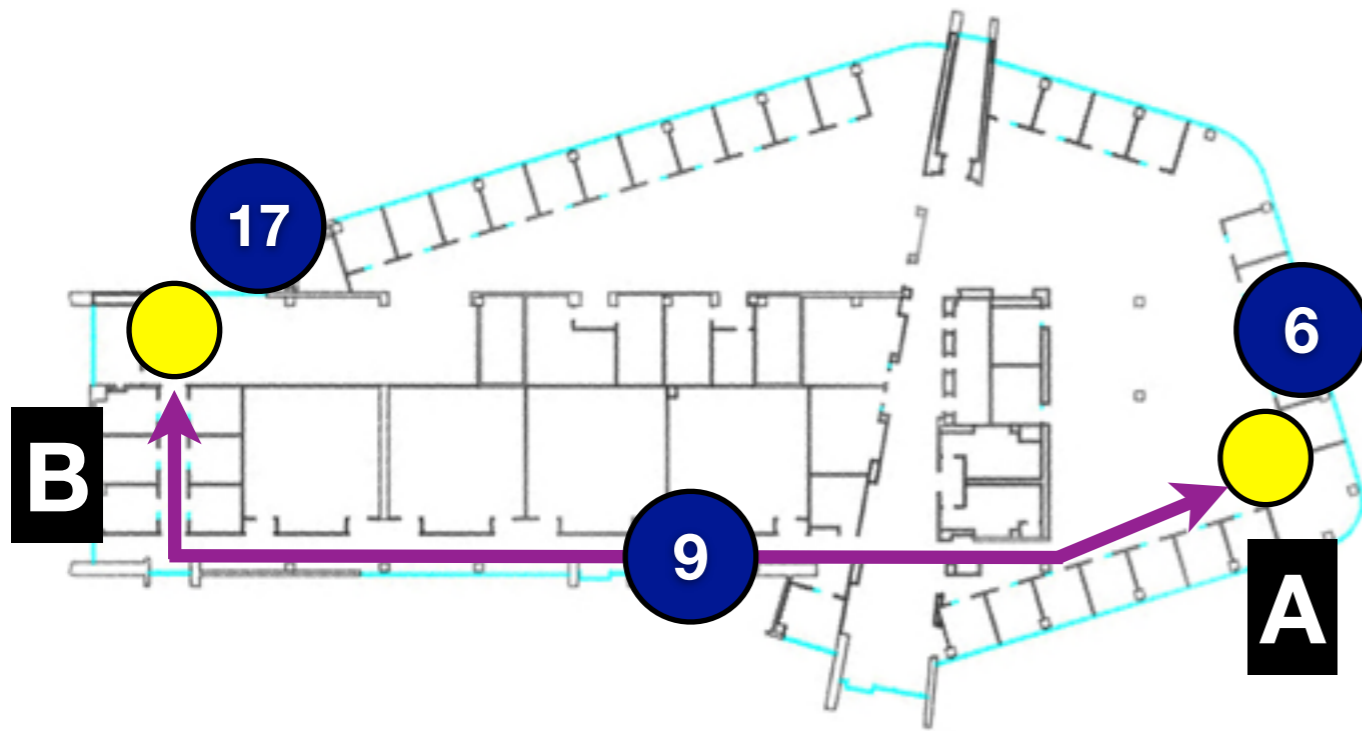
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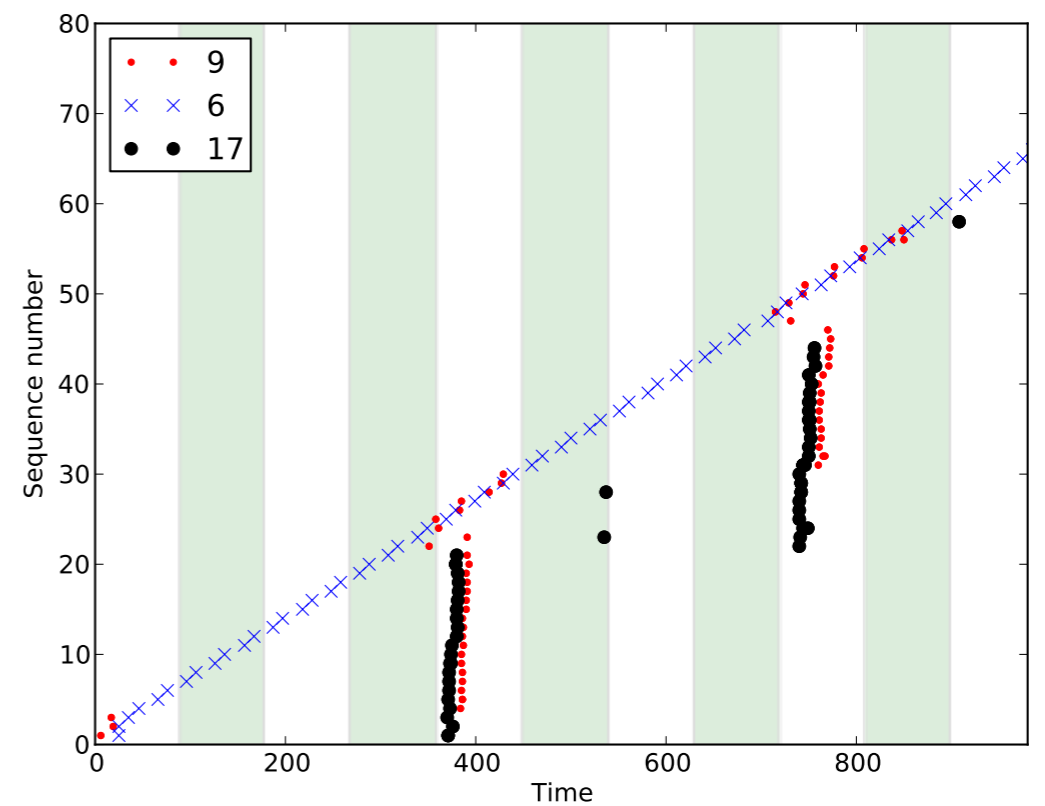
Infrastructure peers  $\Rightarrow$  augments communication



# Impact of network partitions



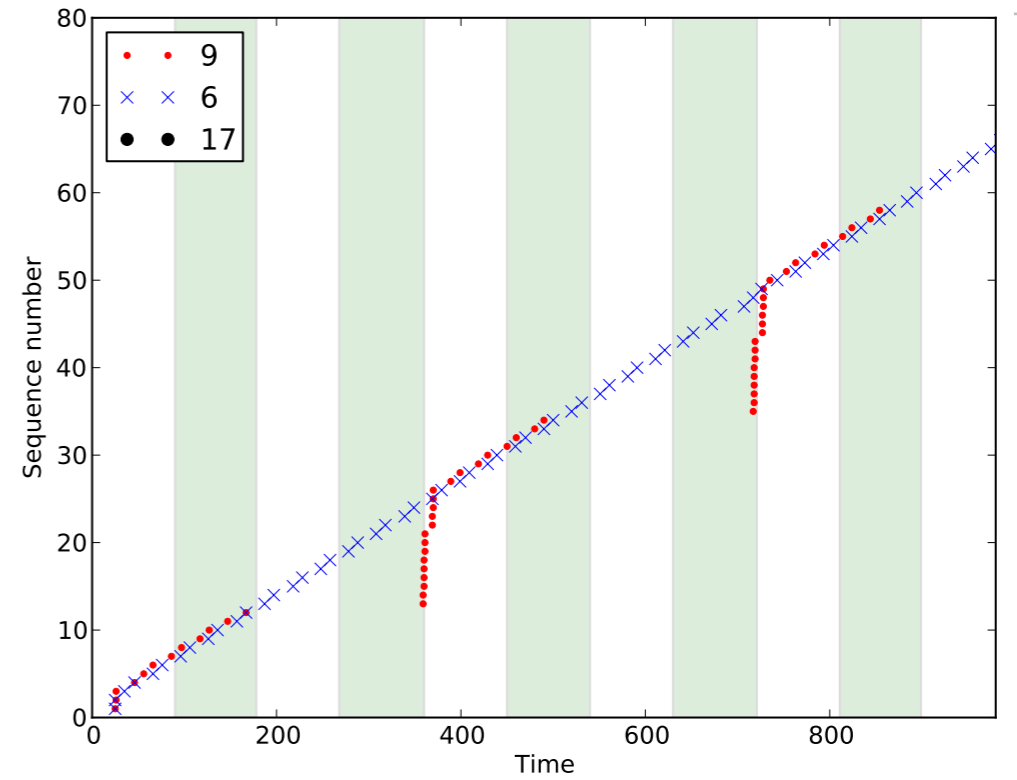
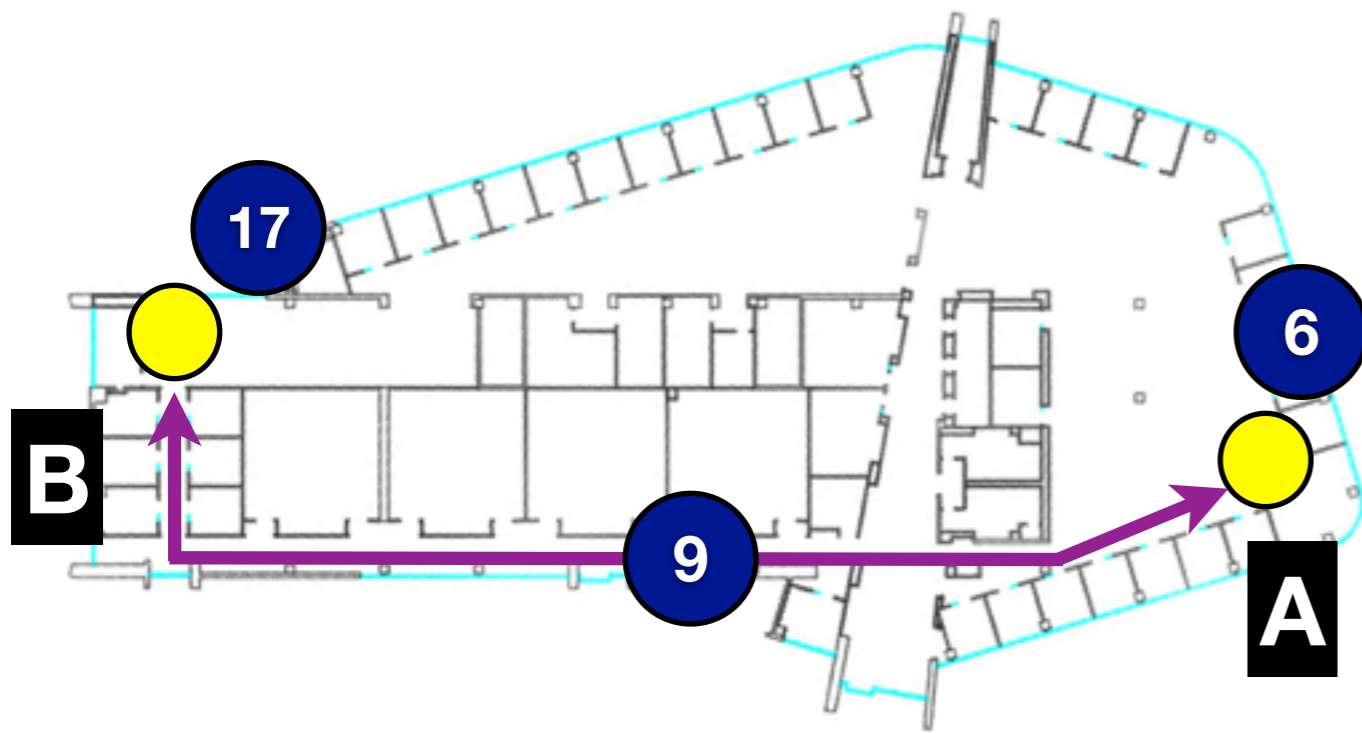
client server



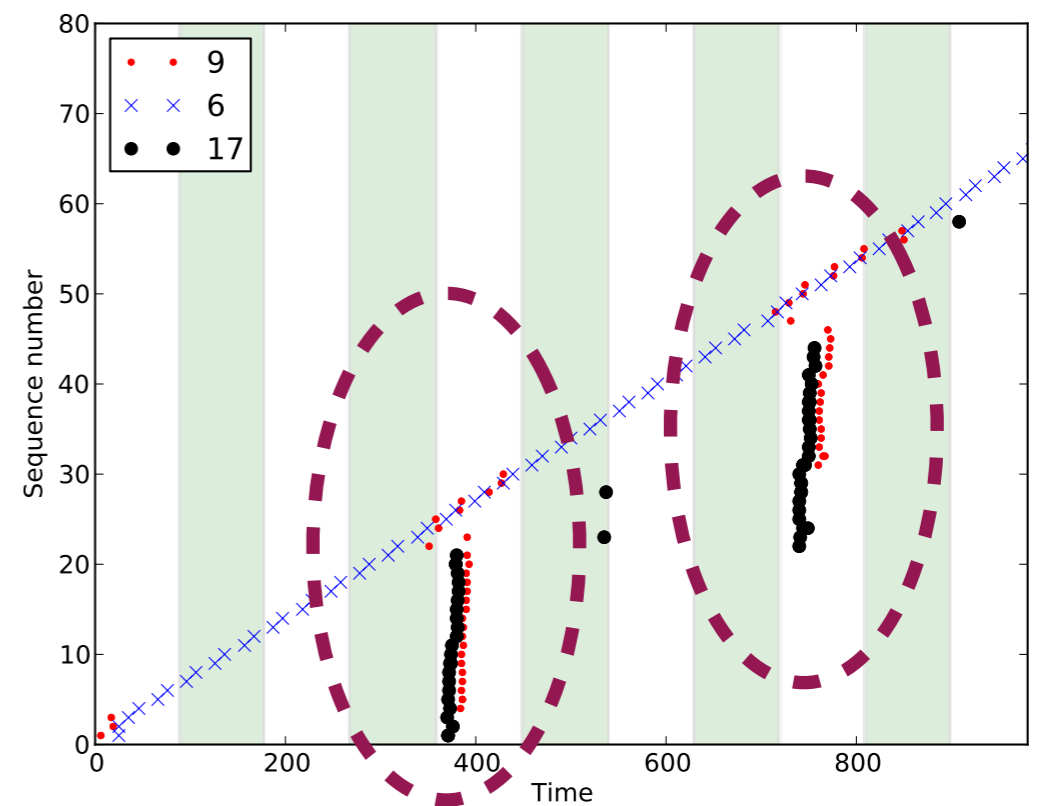
peer-to-peer



# Impact of network partitions

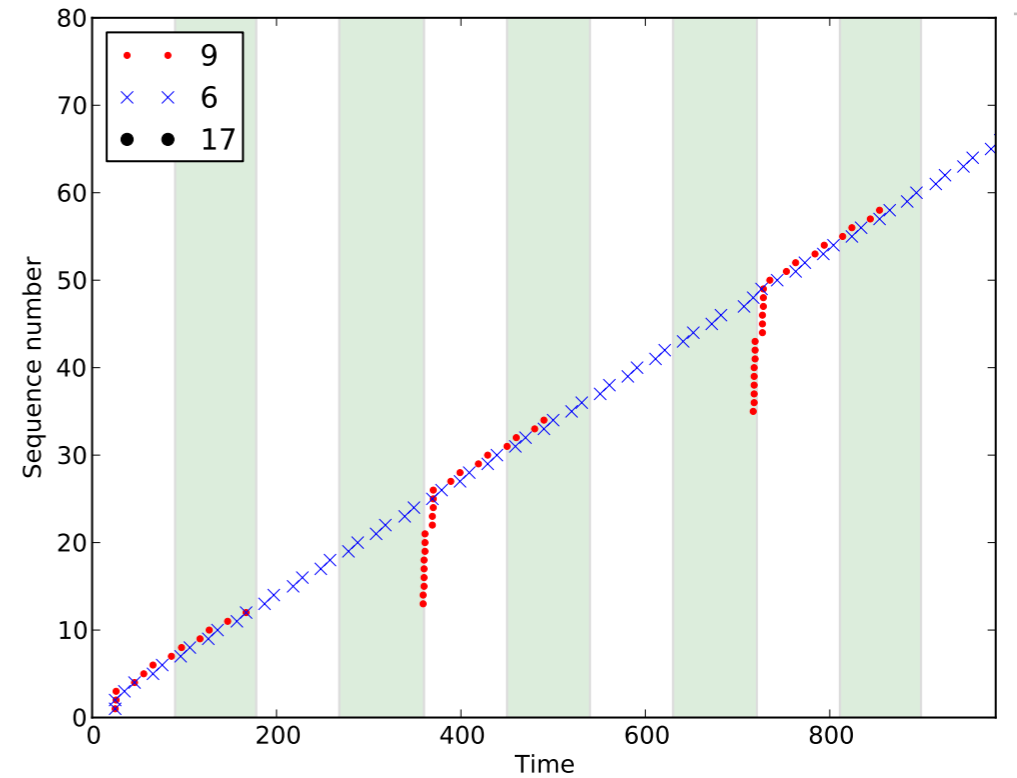
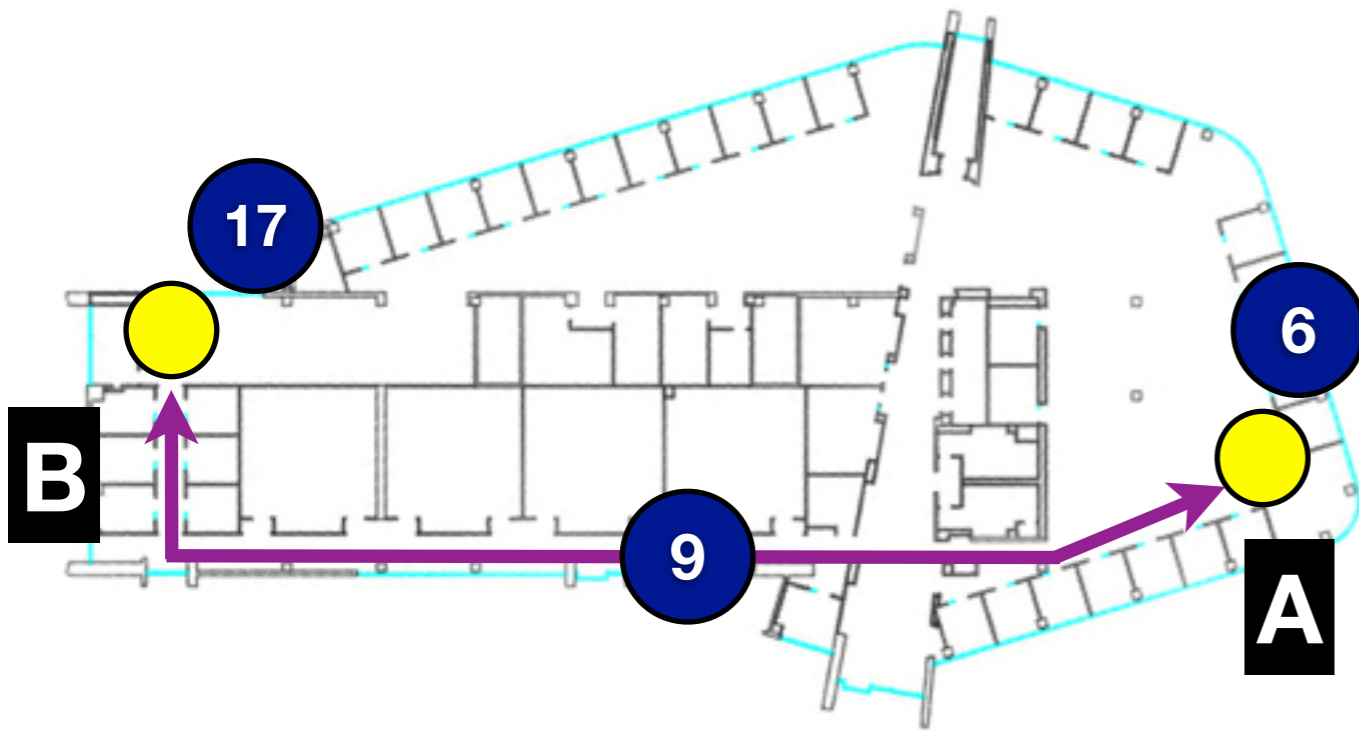


client server



peer-to-peer

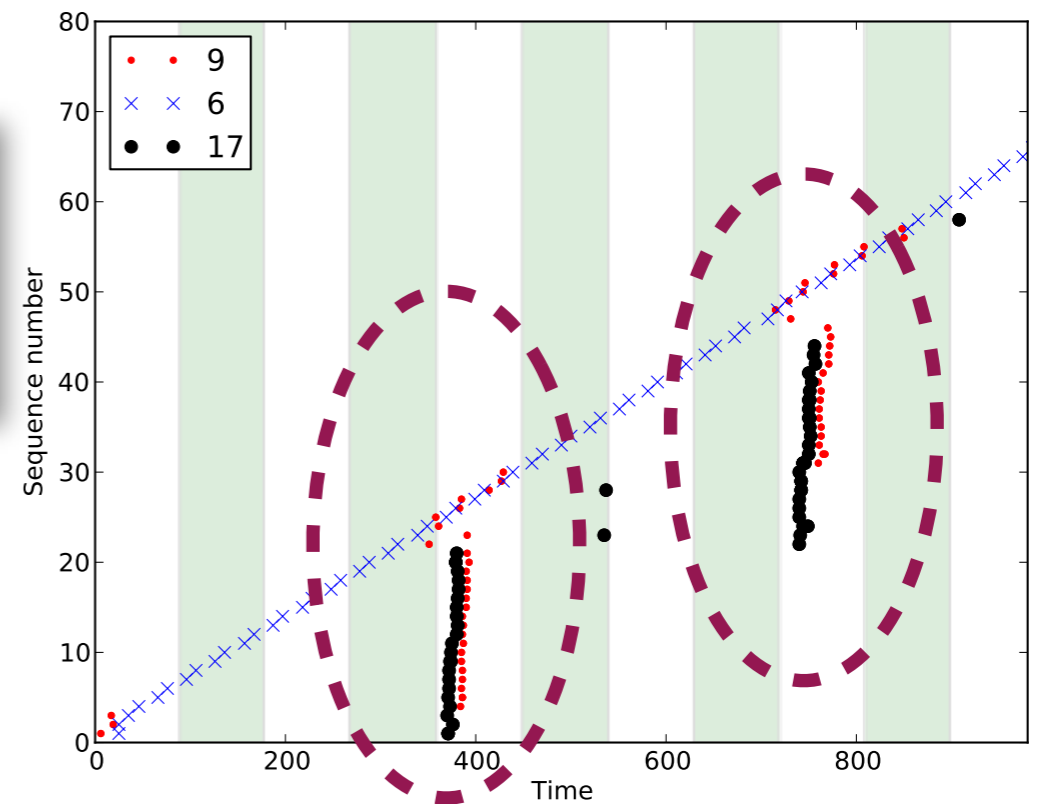
# Impact of network partitions



client server

Delivery from A to B without infrastructure

- client-server + routing: 0%
- peer-to-peer + gossip: 100%



peer-to-peer

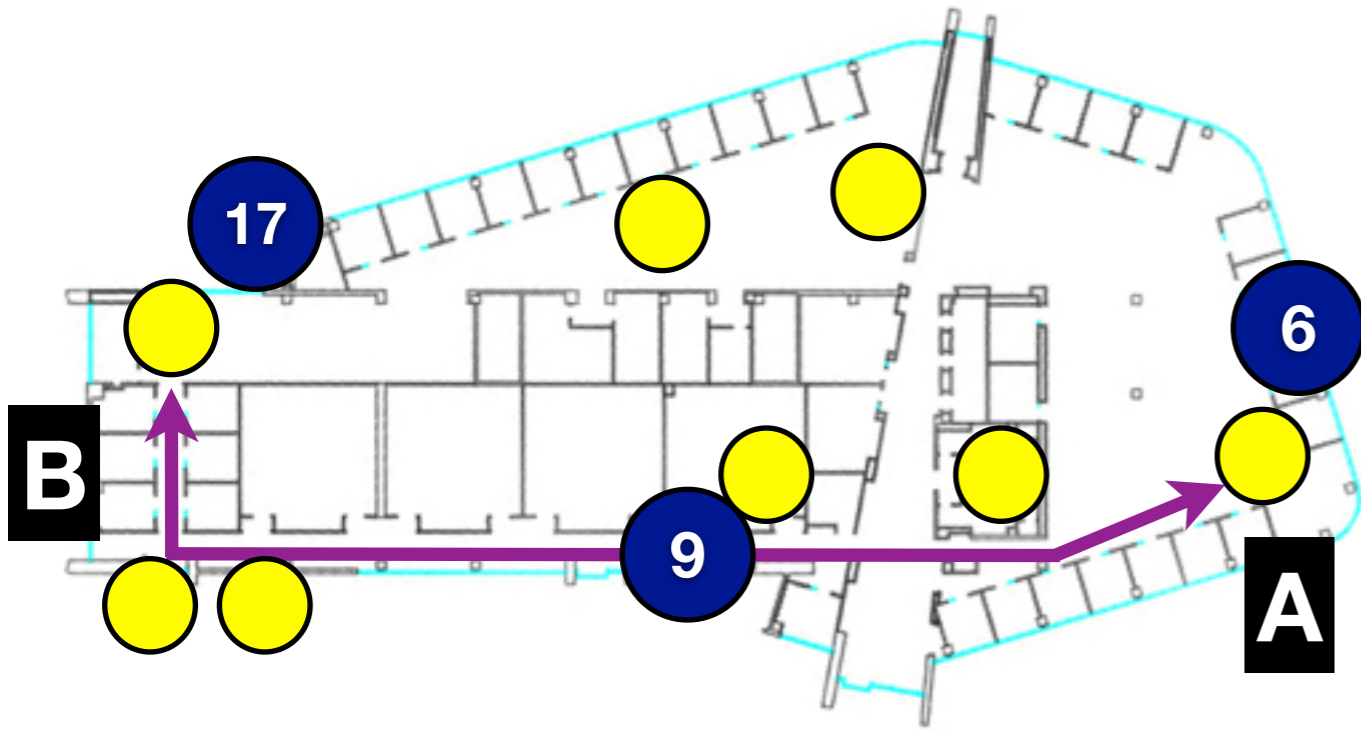
# Impact of mobility

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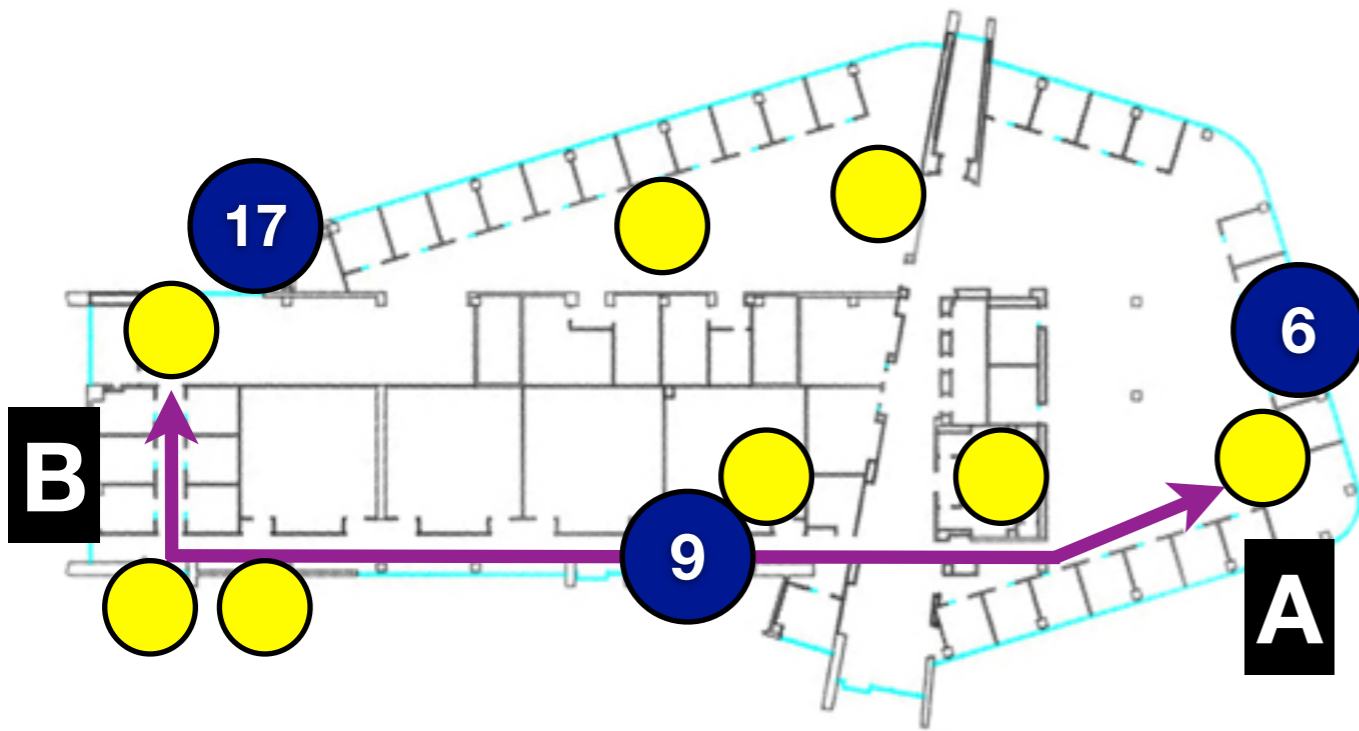
# Impact of mobility

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# Impact of mobility



Mobile node moving between A & B with infrastructure

- client-server + routing: 67.2%
- peer-to-peer + gossip: 100%

# Conclusions

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- **Medical response in disasters creates unique challenges for rapid, effective, affordable response**
  - IT solutions can help  $\Rightarrow$  robust communication a key challenge
- **Standard client-server + routing solutions has poor reliability**
  - difficult to maintain end-to-end routes in dynamic environments
  - network partitions prevent clients from communicating
- **Peer-to-peer + gossip significantly improves performance**
  - relies only on local information that is less susceptible to dynamics
  - tolerates network partitions