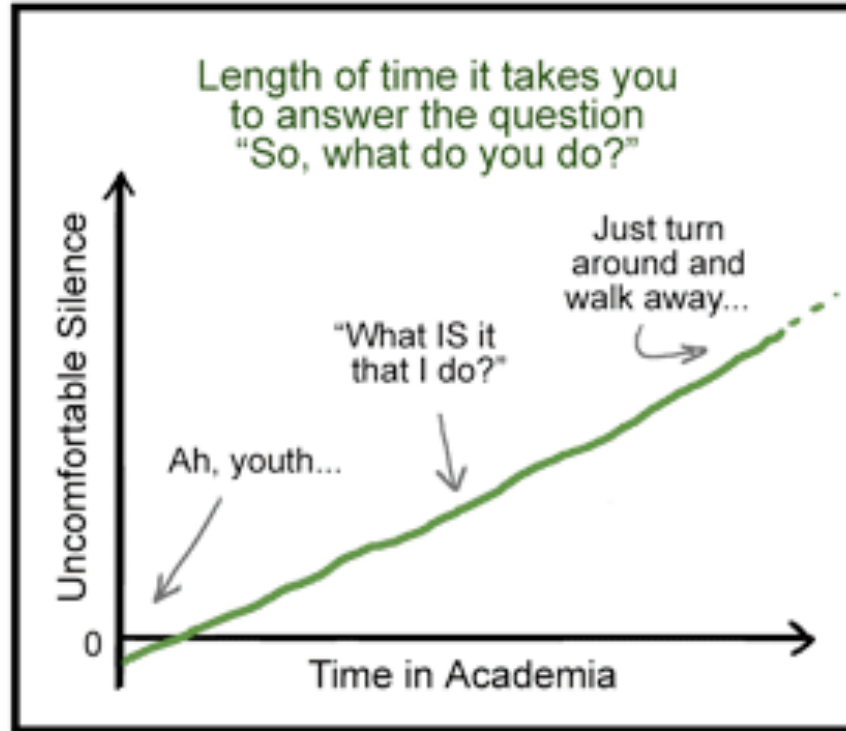


# Enabling the Next Frontier in Mobile Applications



**Earl Oliver**

**Networks and Distributed Systems Seminar, March 6, 2009**



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# Outline

The mobile application space

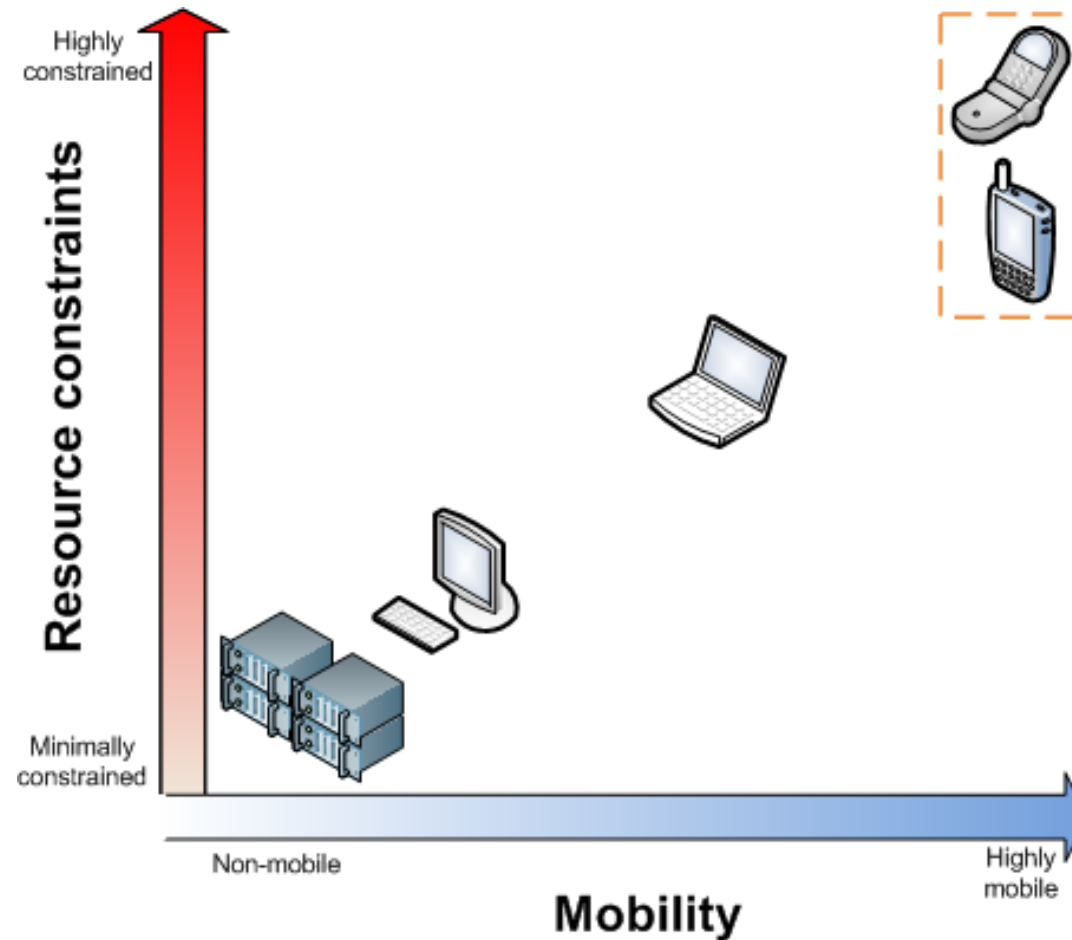
Mobile application middleware

Related work

Challenges

Open discussion

# The Mobility / Resource Constraint Continuum

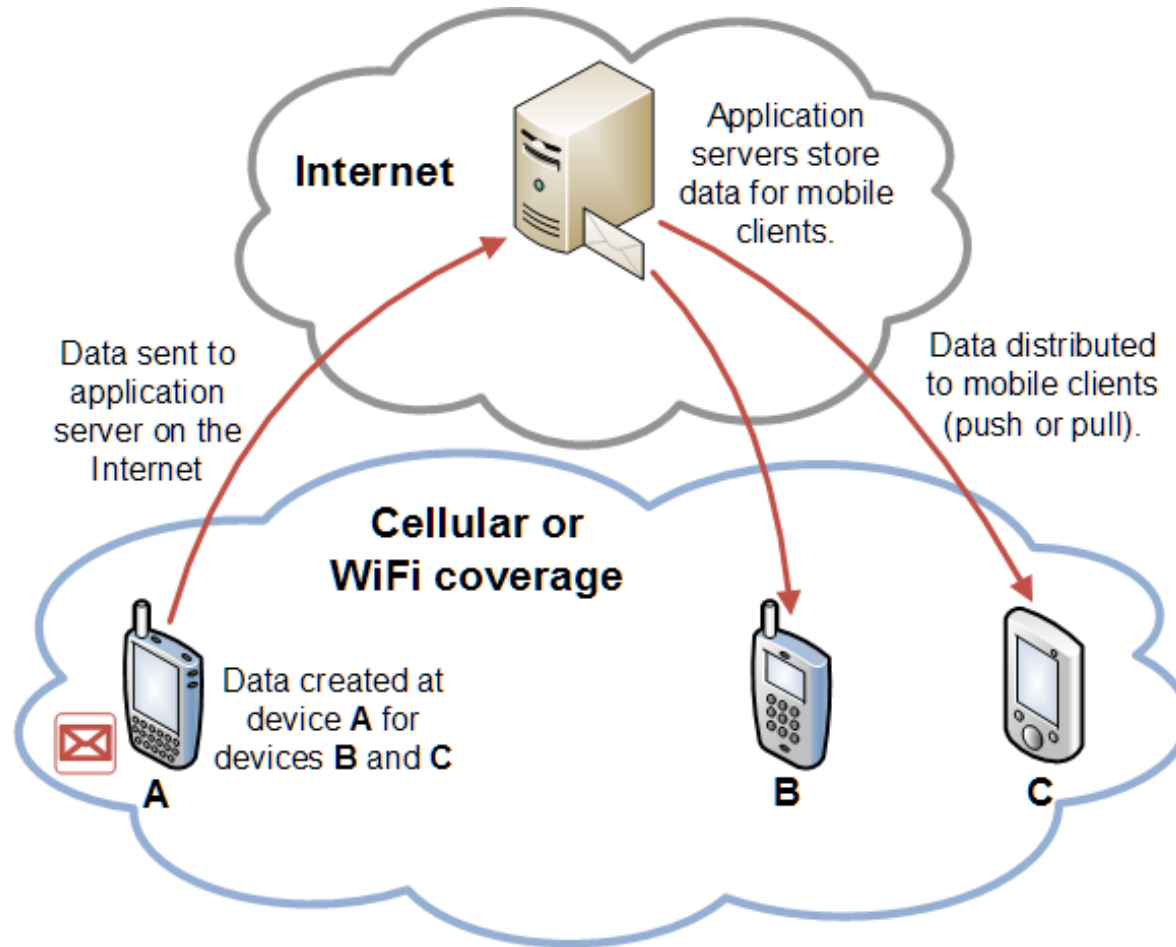


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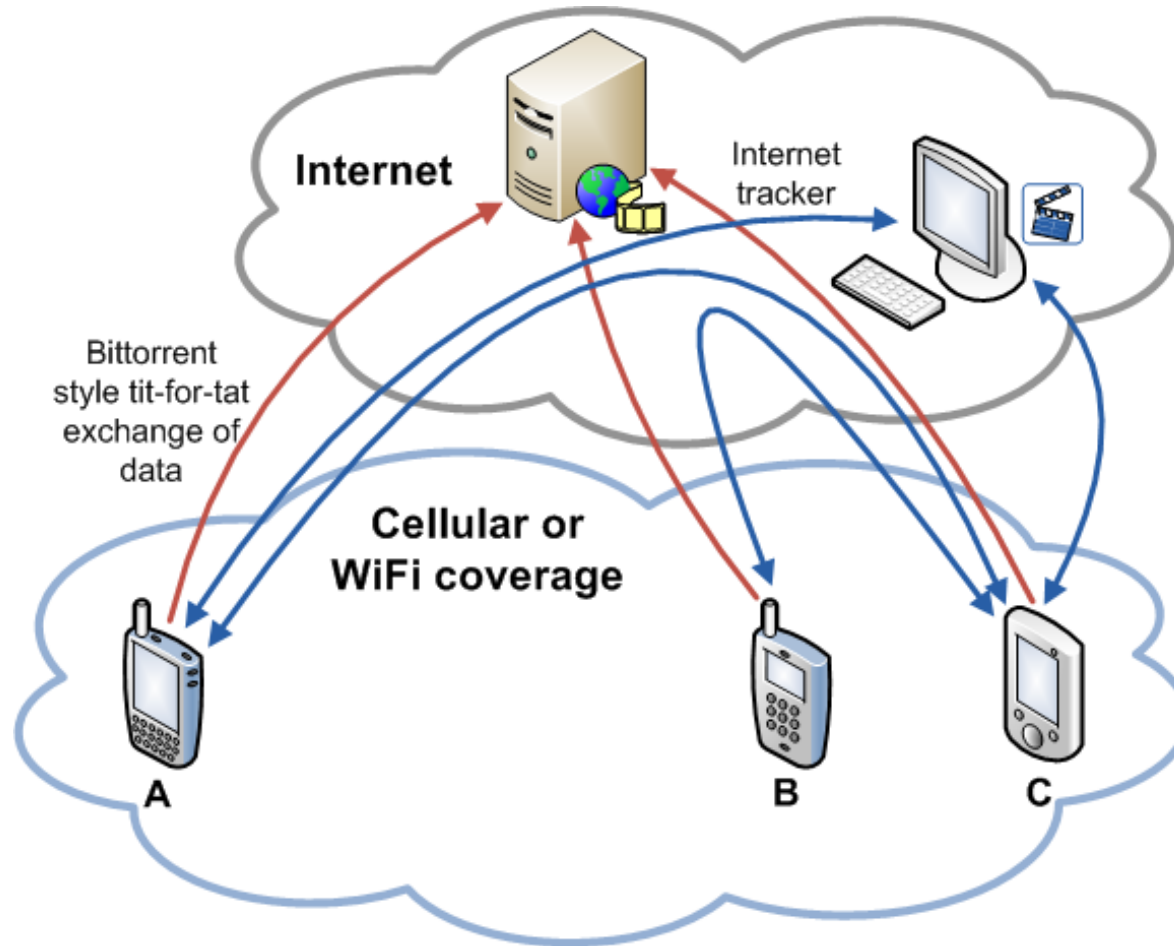
# The Mobile Application Space

- Existing application architectures:
  - Non-networked
  - Client-server
  - Peer-to-peer
  - Point-to-point
- Hybrid

# Client-Server

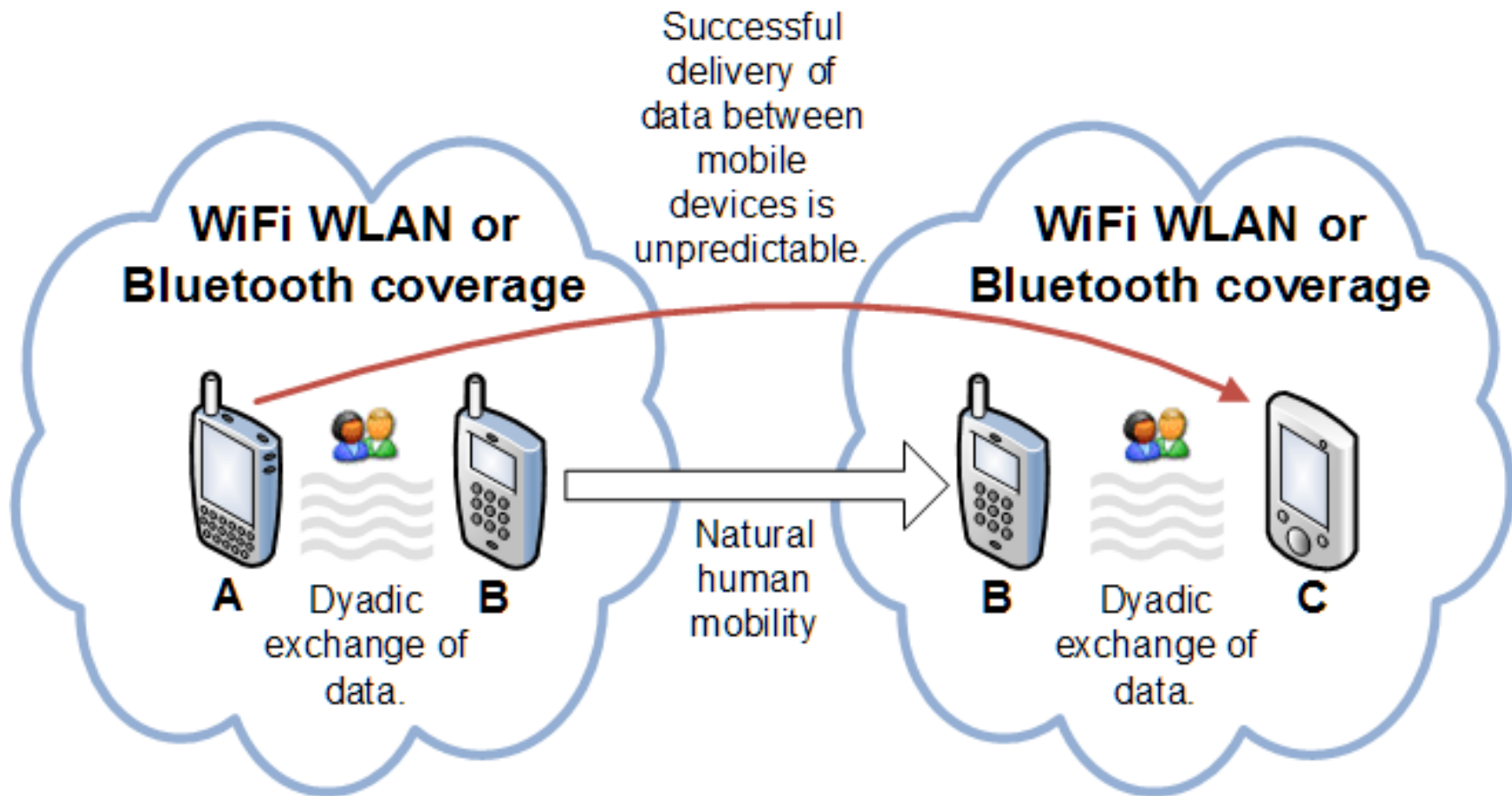


# Peer-to-peer



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# Point-to-point

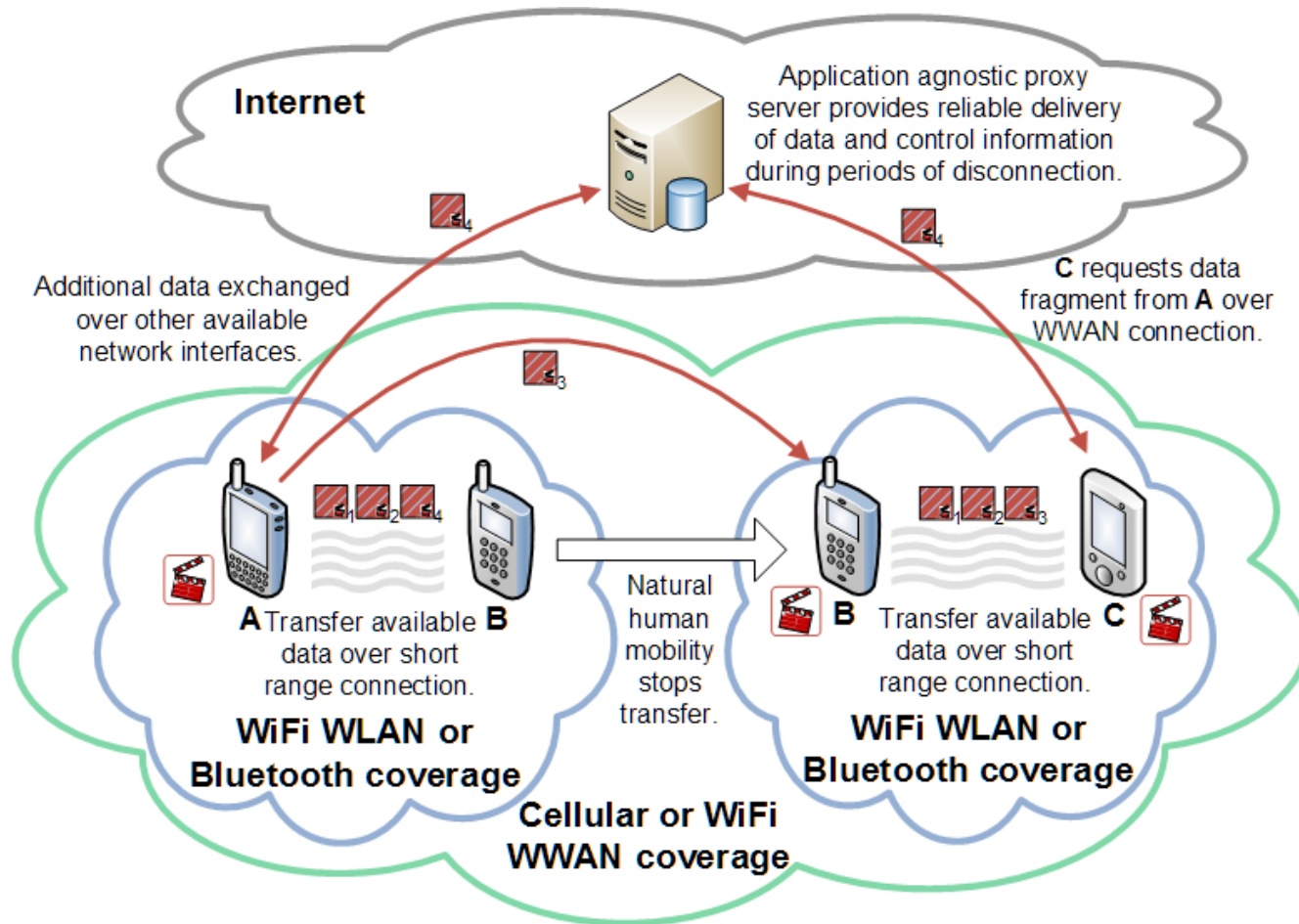


# The Next Frontier in Mobile Applications

- Data is stored, shared, and consumed solely on mobile devices.
- Applications exploit all forms of connectivity.
  - Short range ad hoc networks – long range cellular networks.
- Without the use of application specific servers on the Internet.



# The Next Frontier (overview)



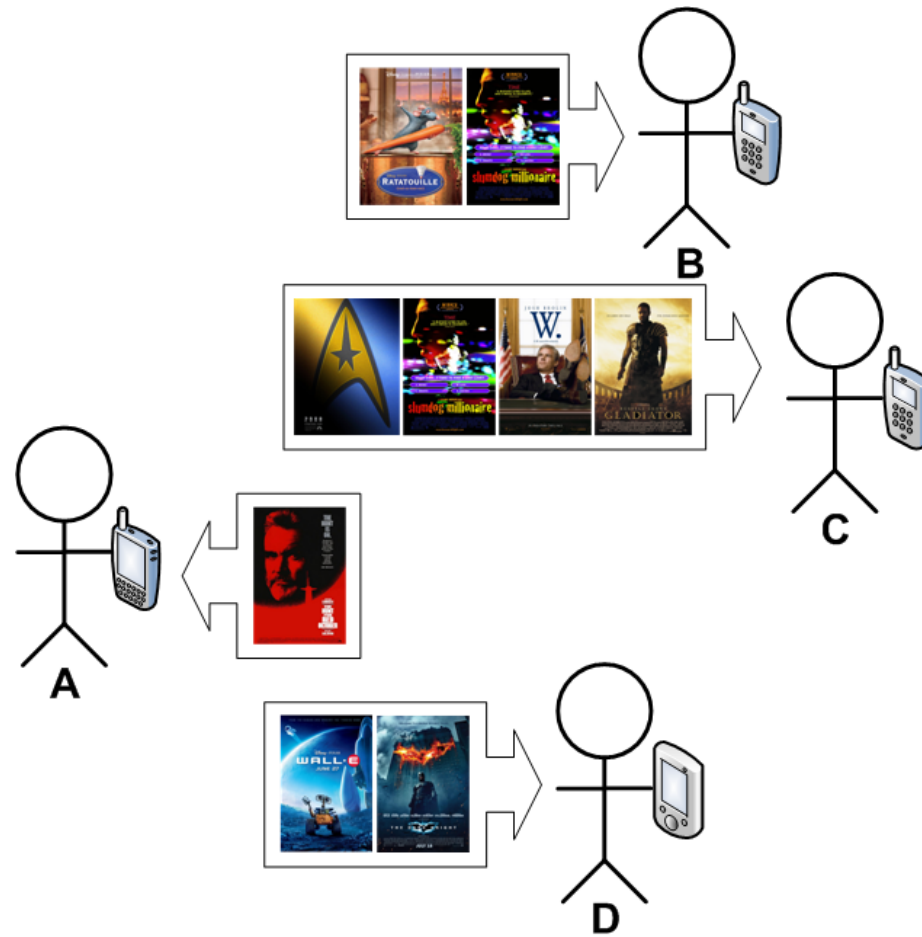
# Example applications

- **MyTube** – decentralized file sharing system
- **PocketBay** – rural classifieds system
- **PocketBook** – decentralized social networking

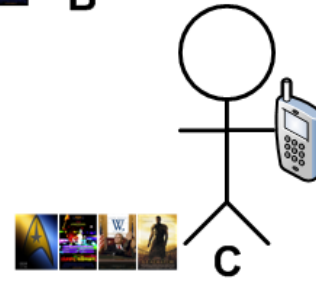
# MyTube



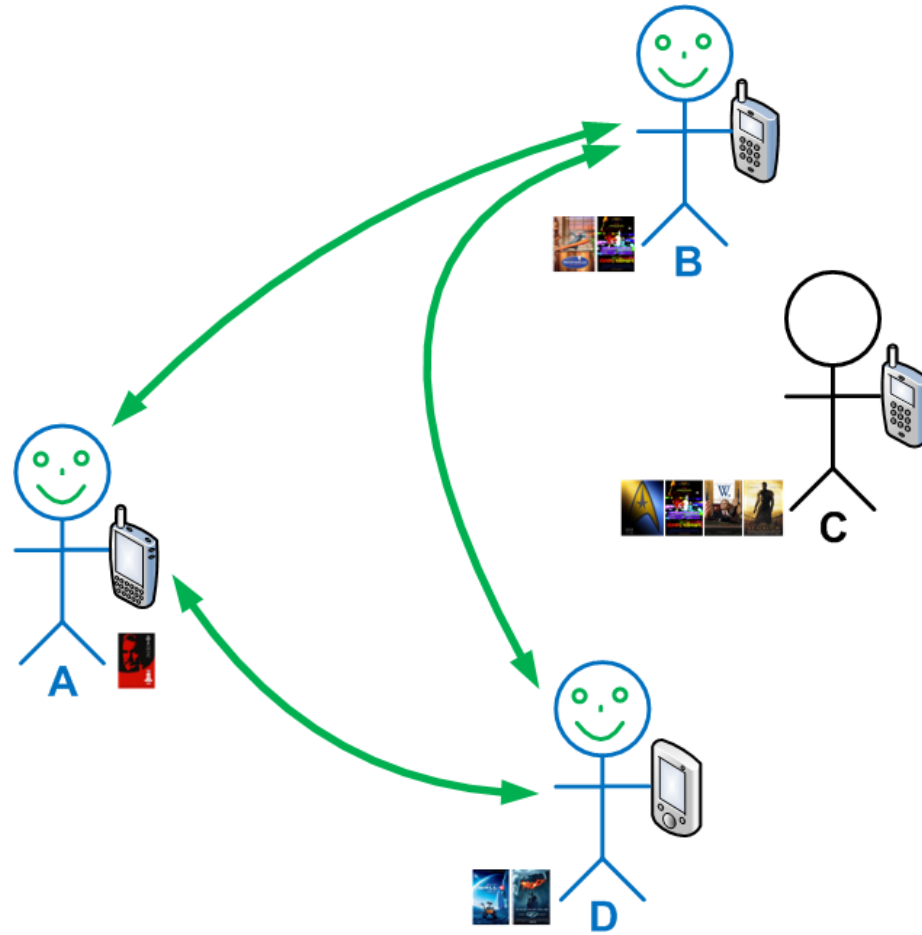
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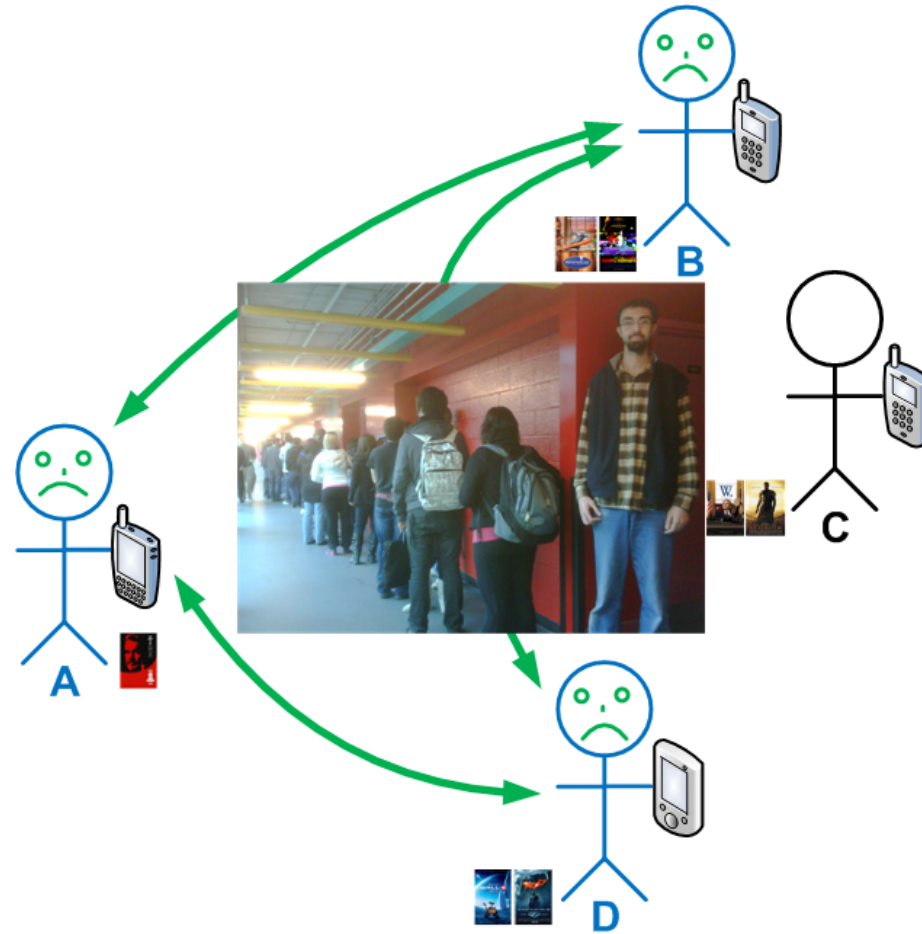
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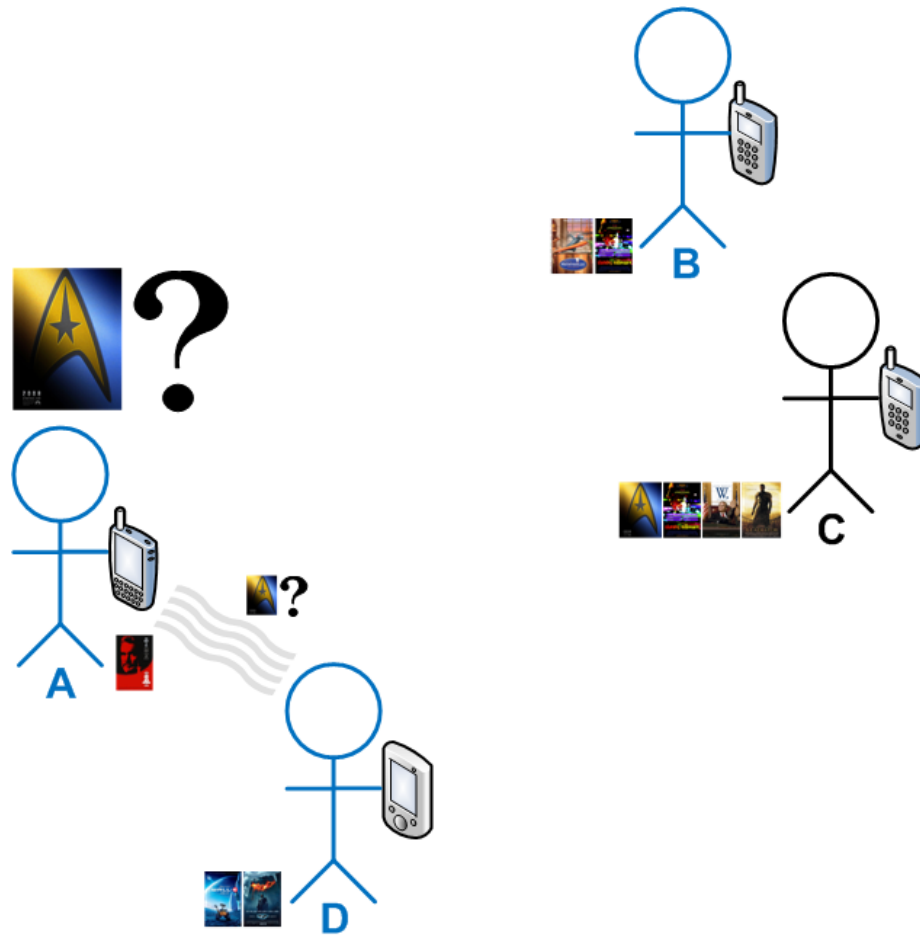


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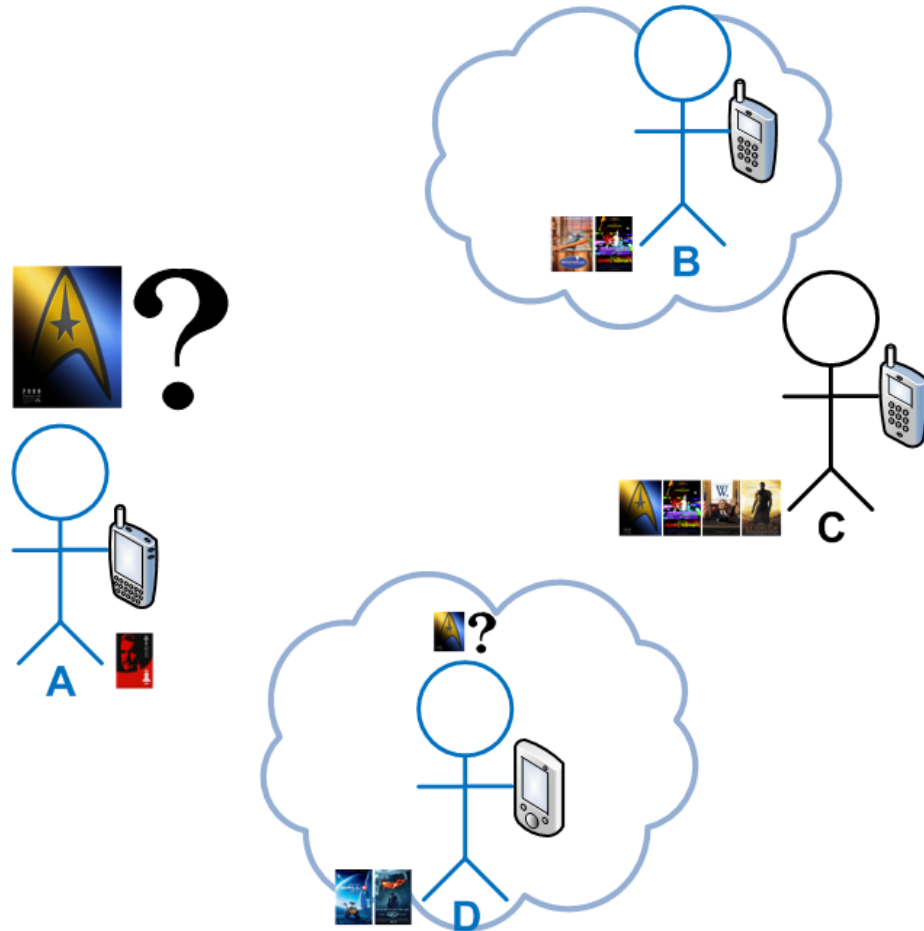
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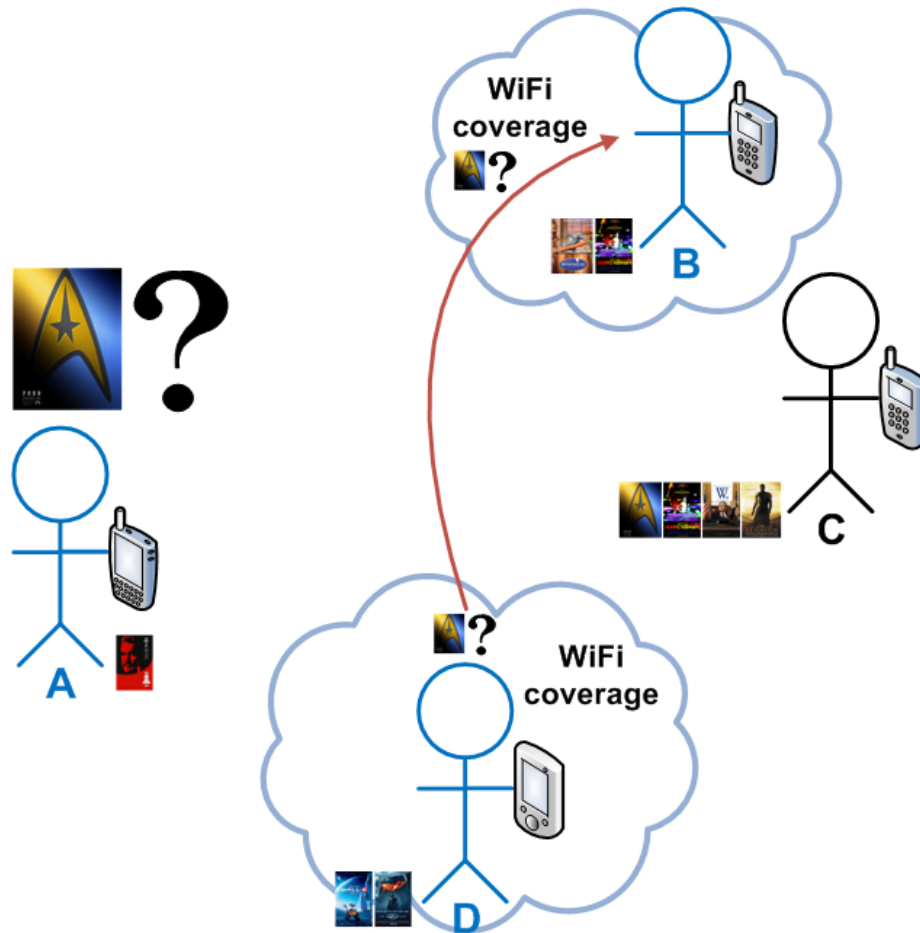
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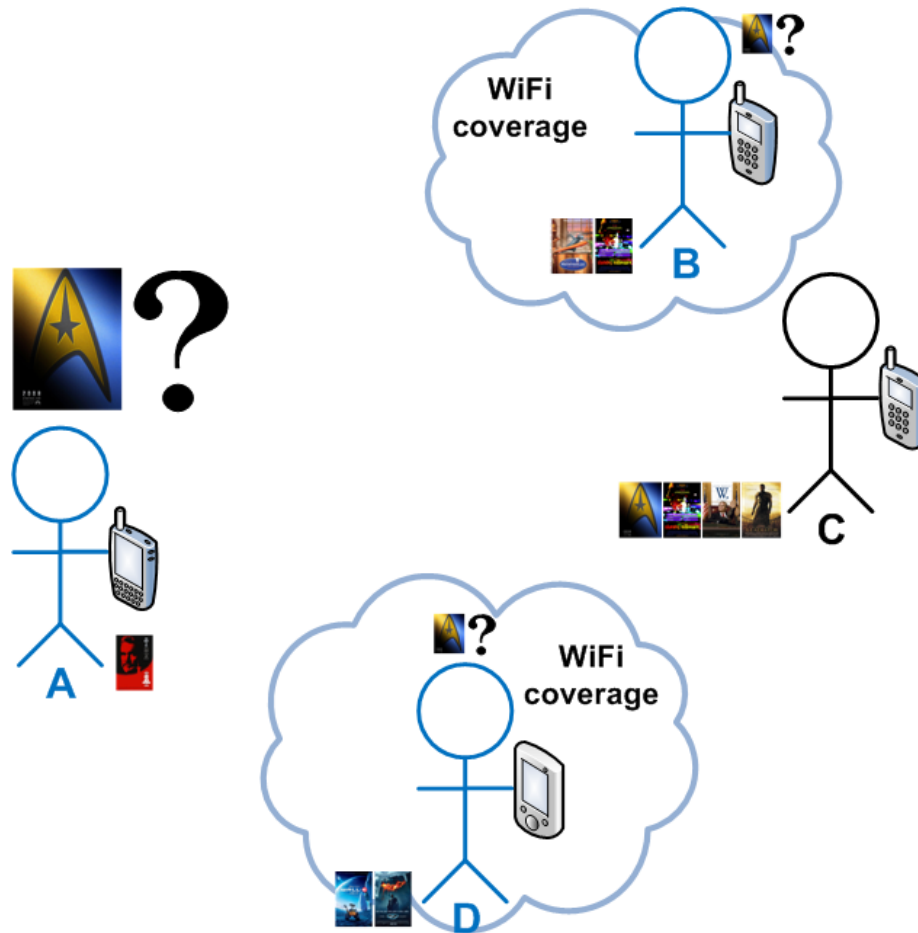
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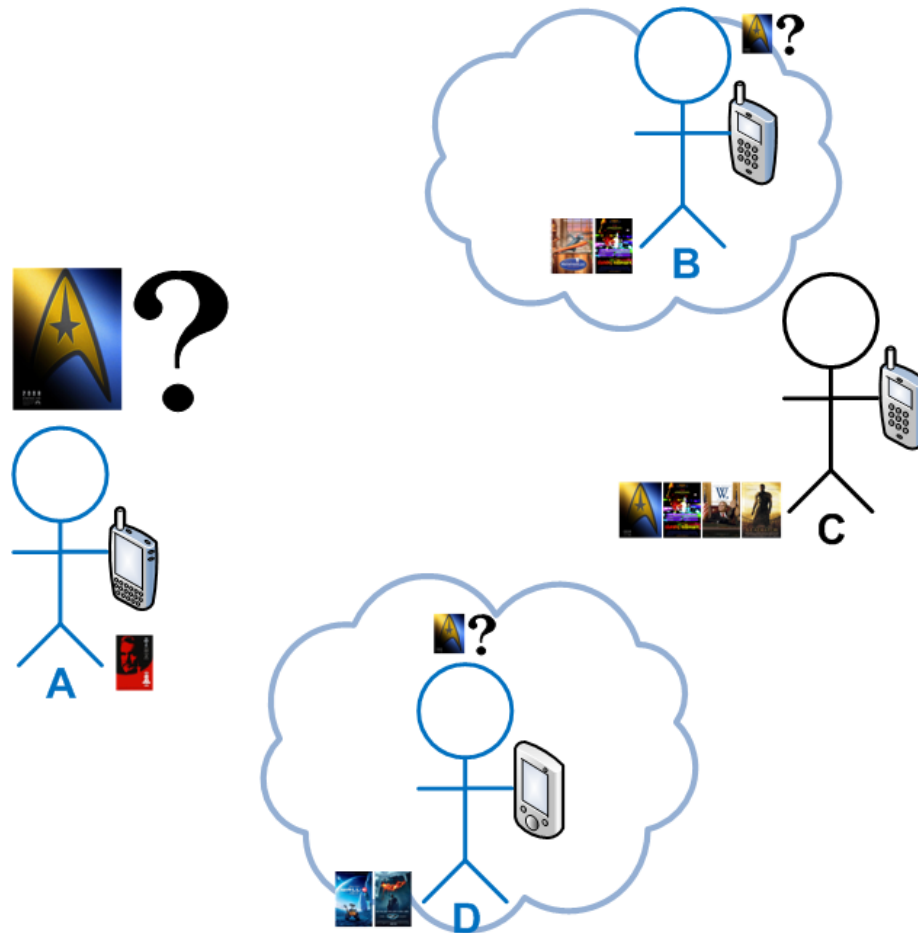
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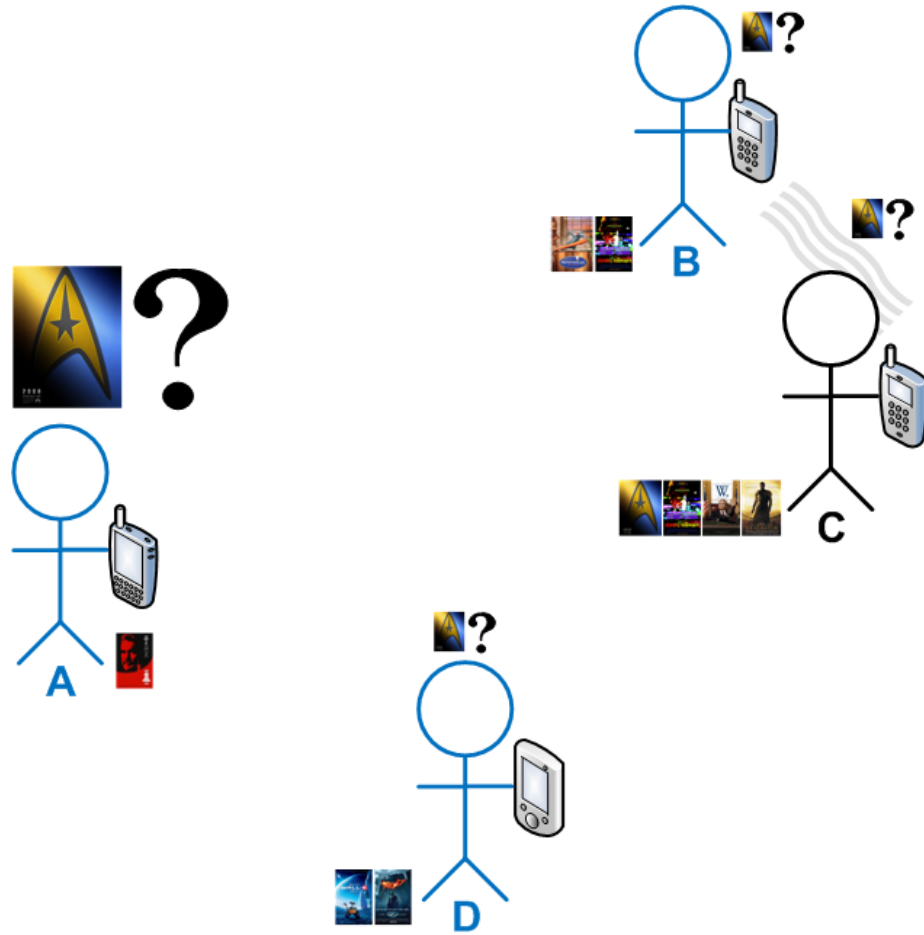


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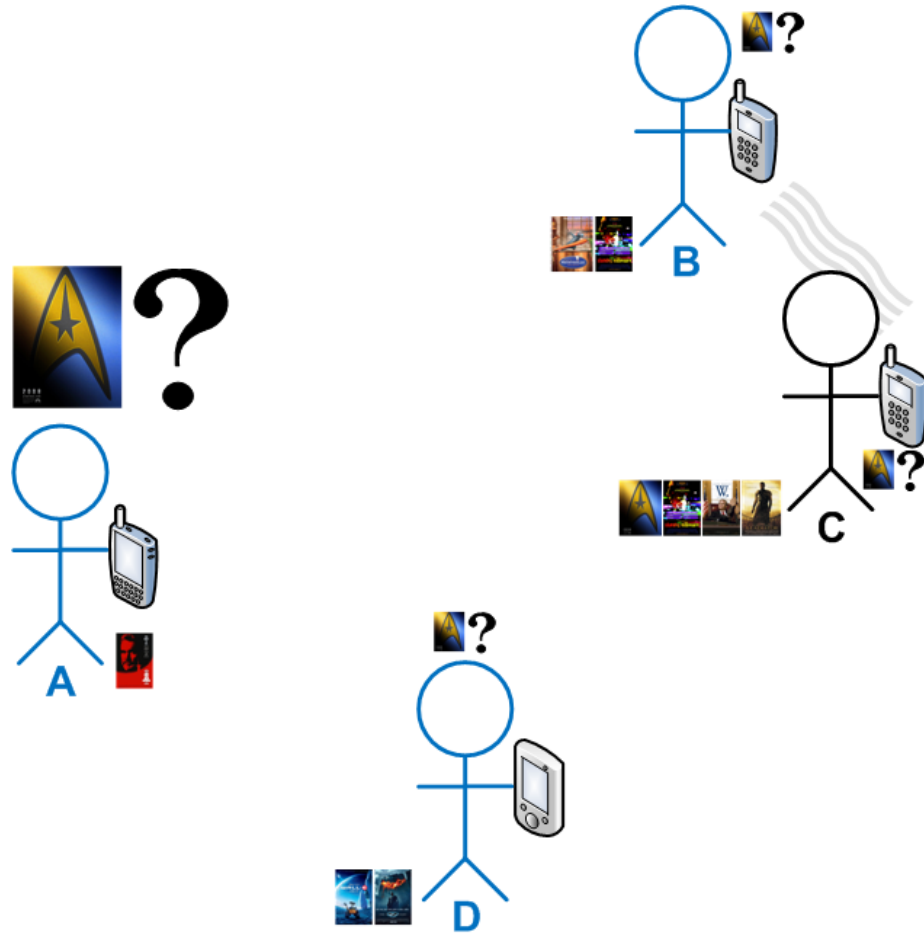


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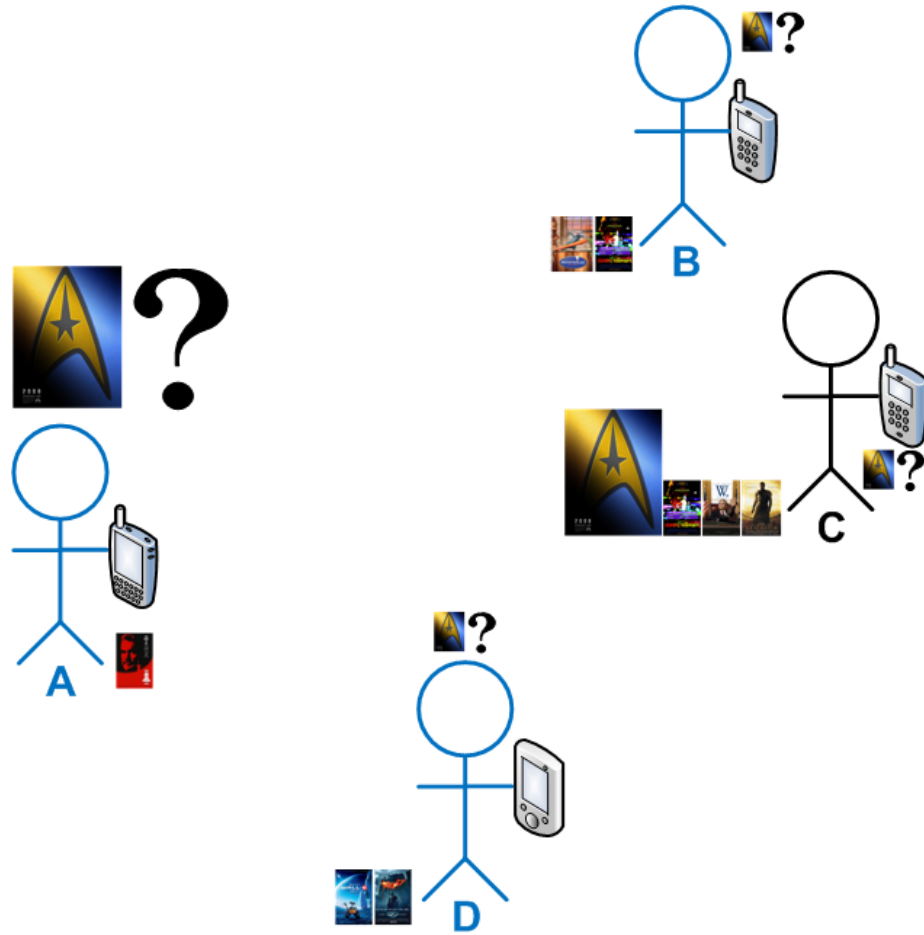




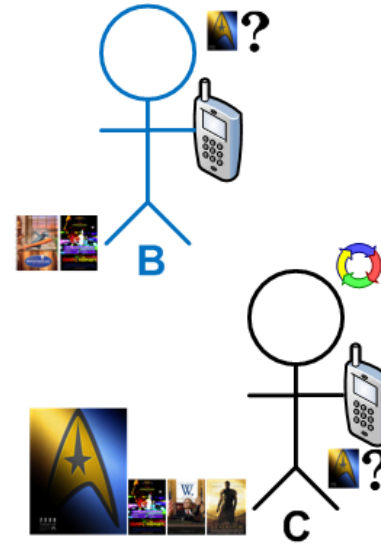
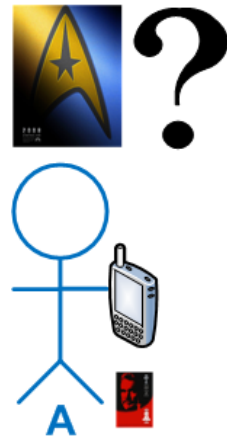
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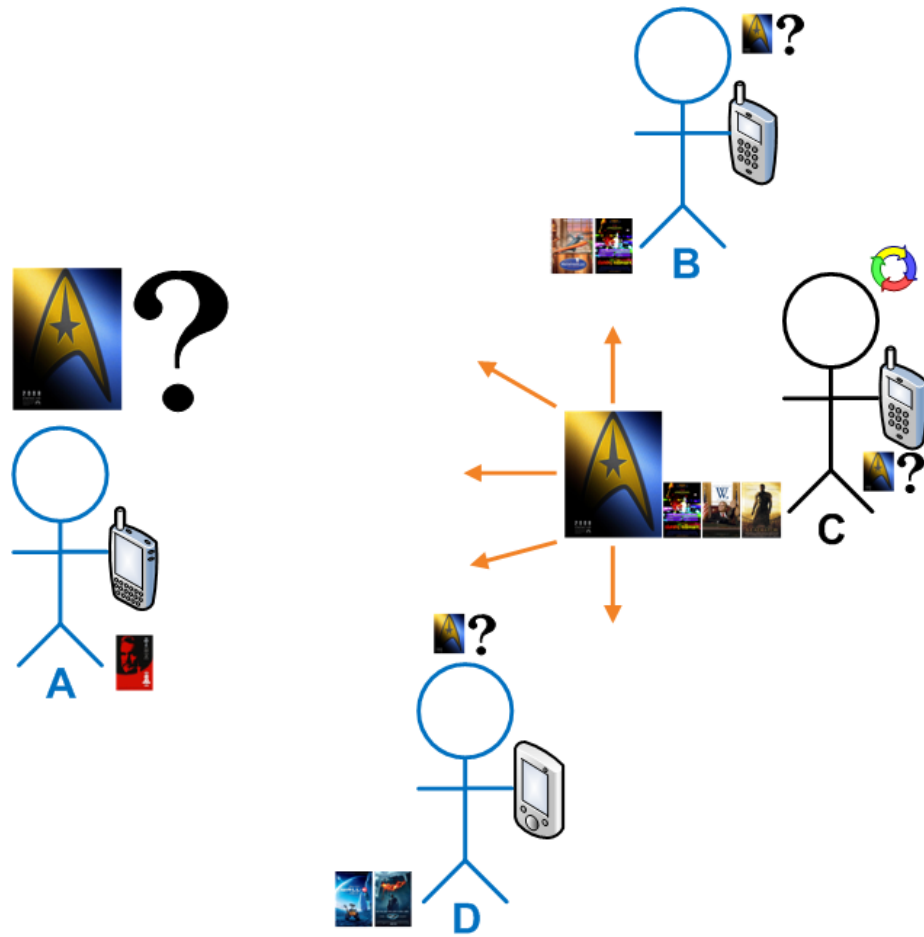
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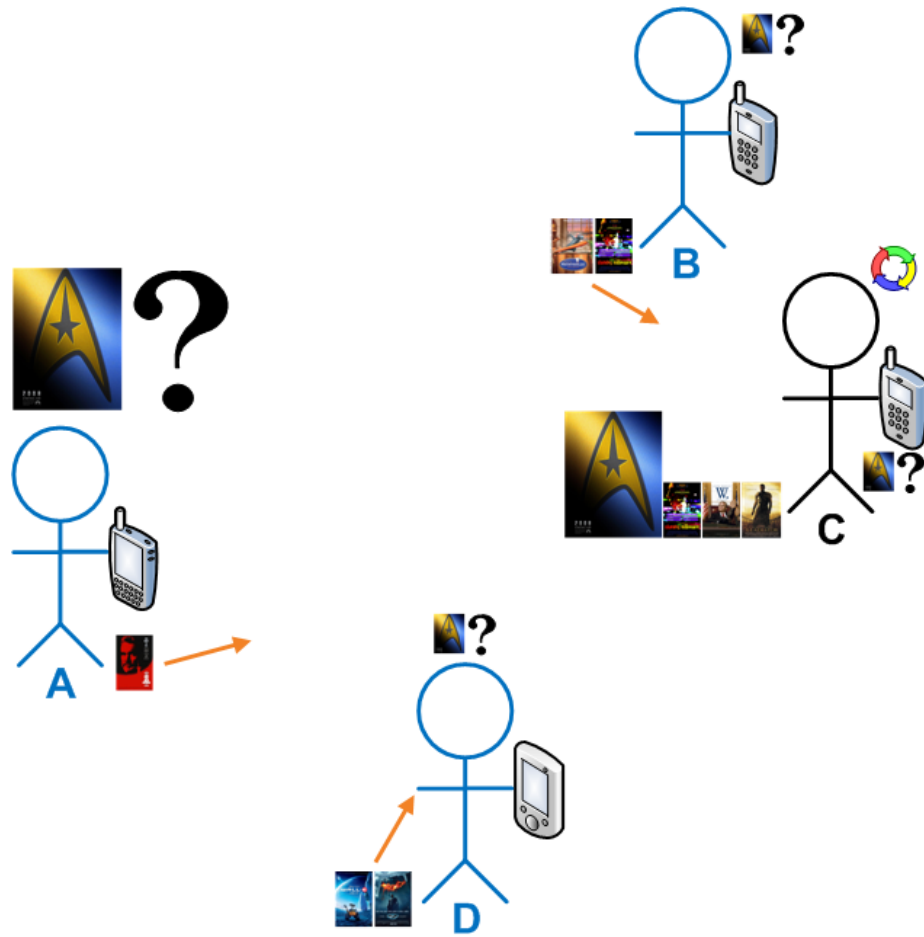
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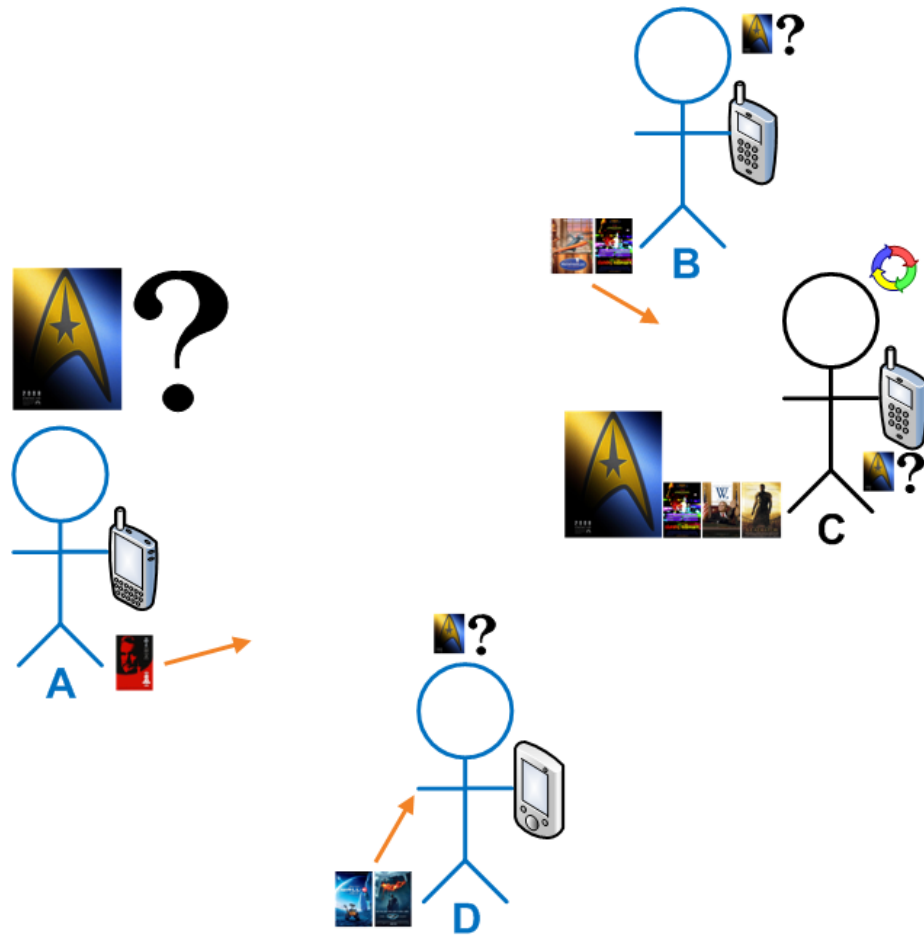
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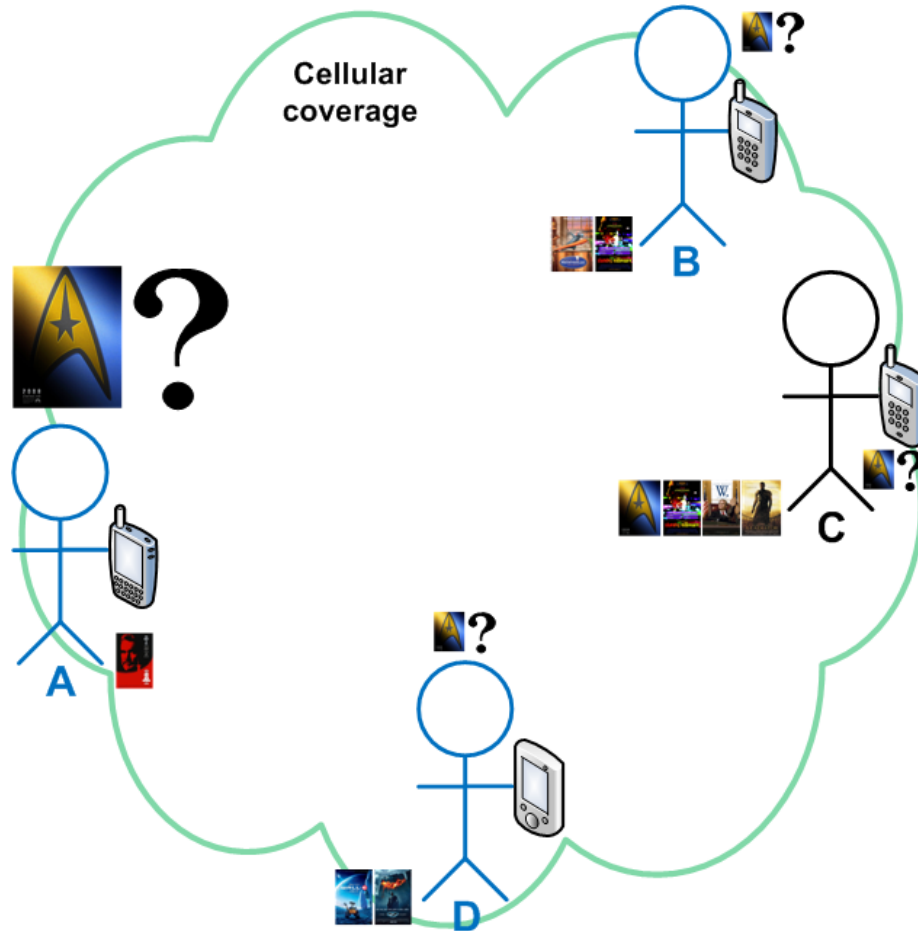
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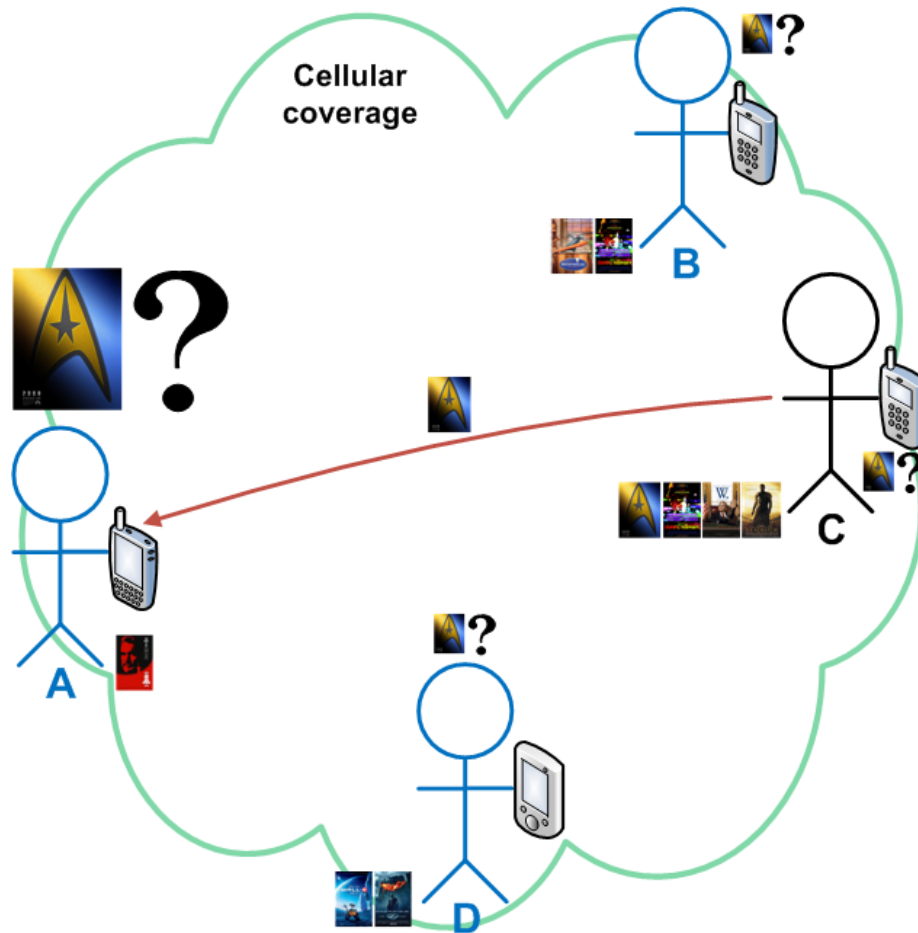


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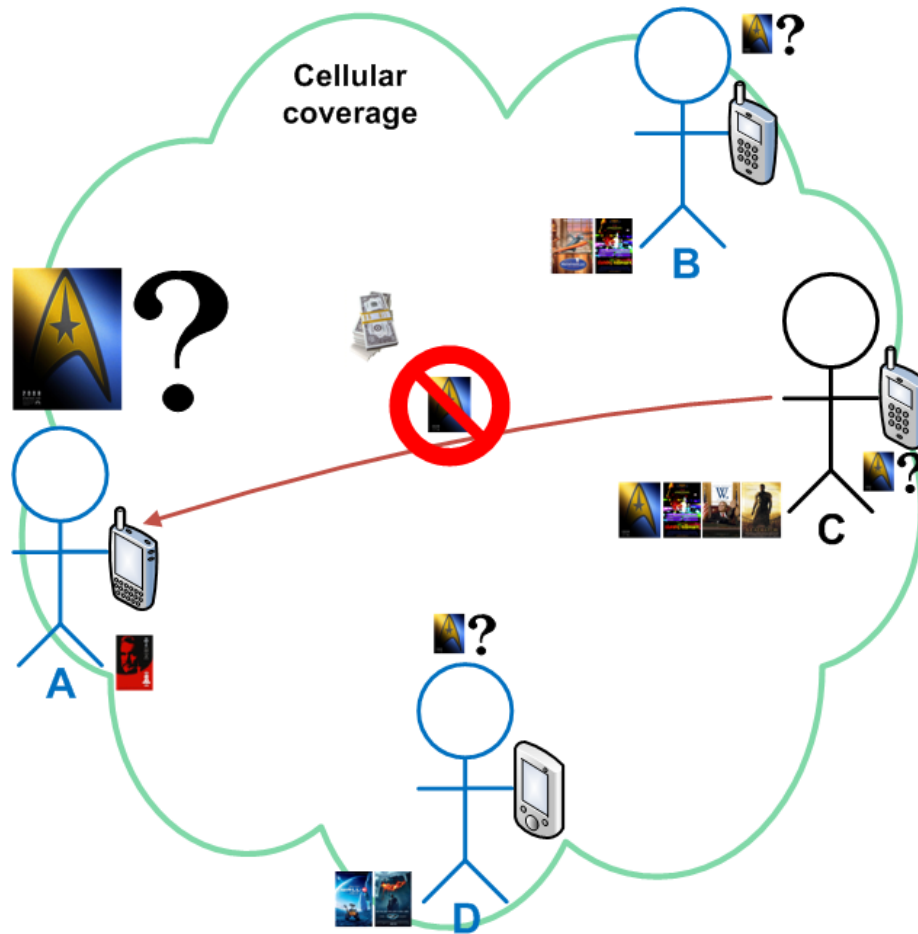


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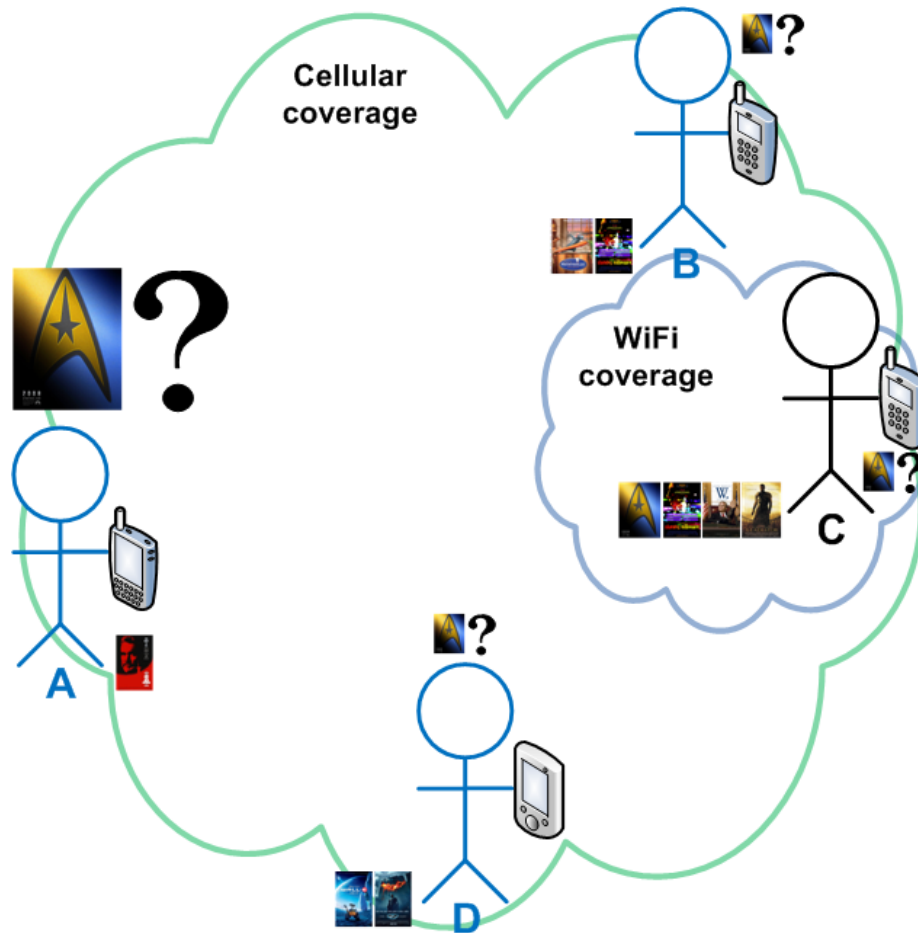




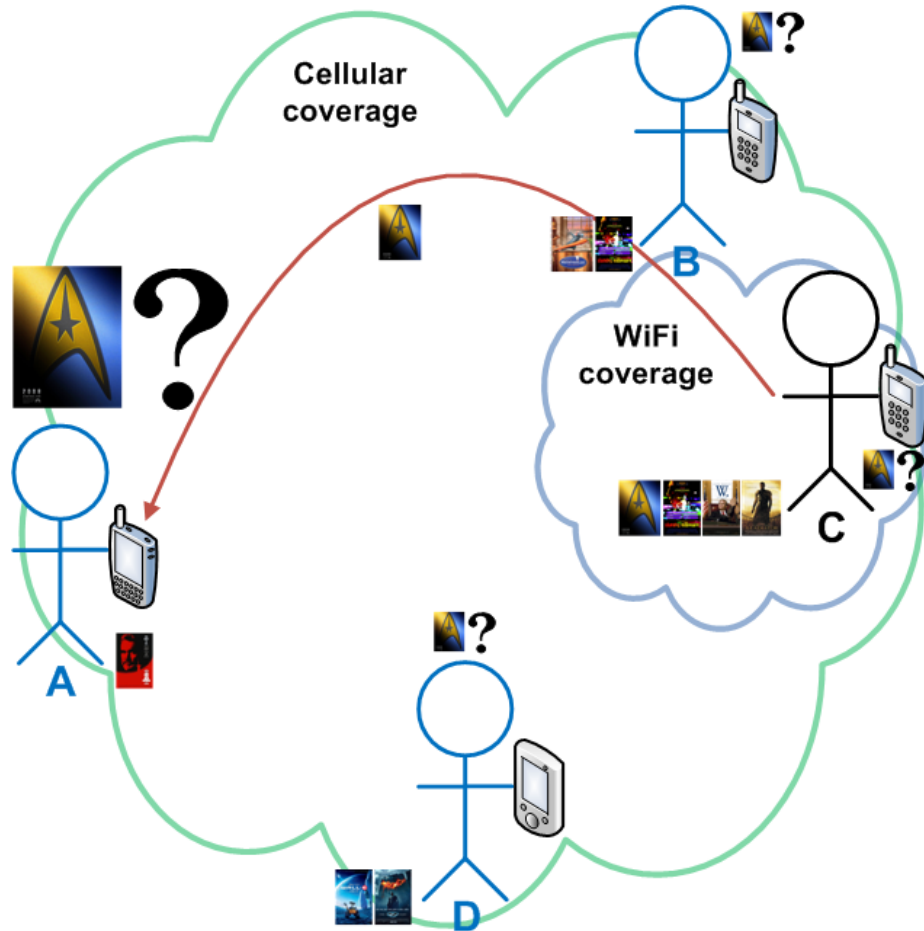
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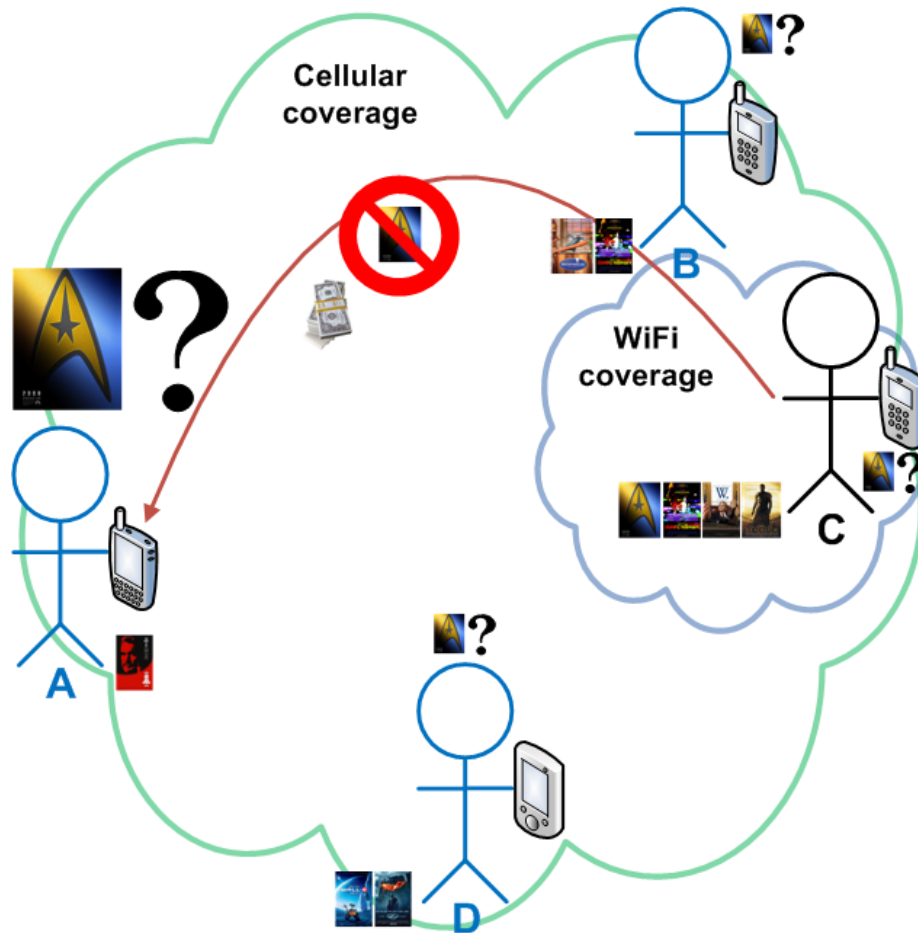
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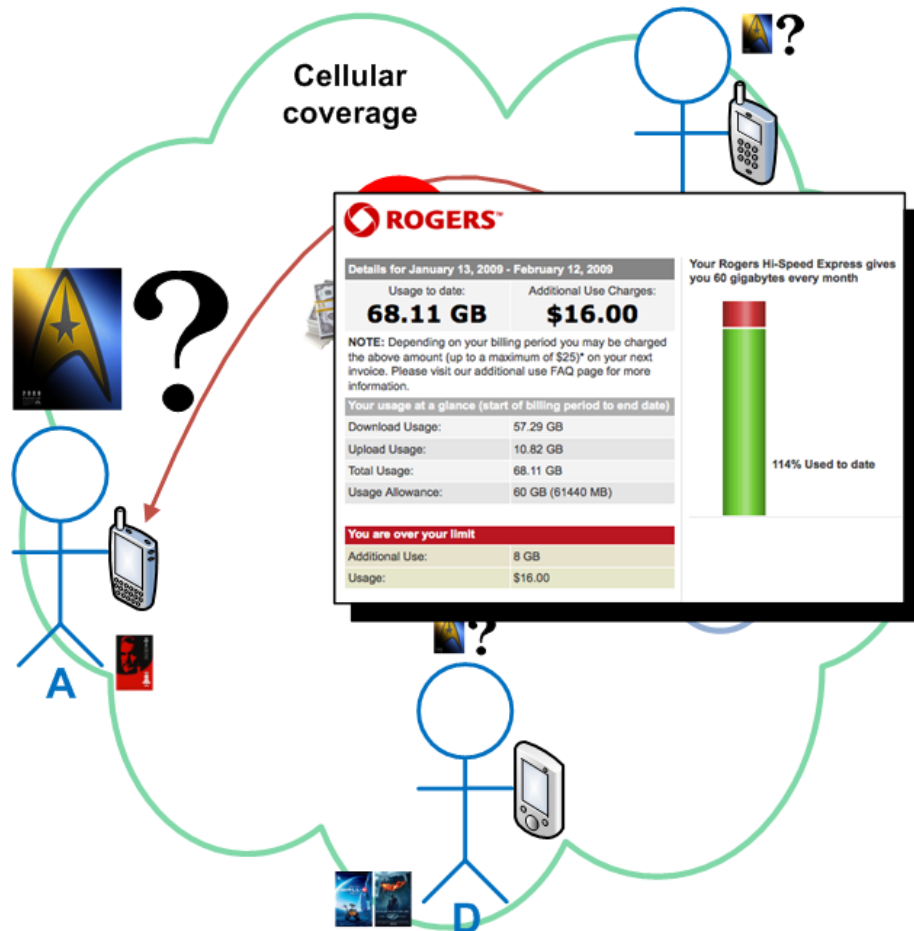
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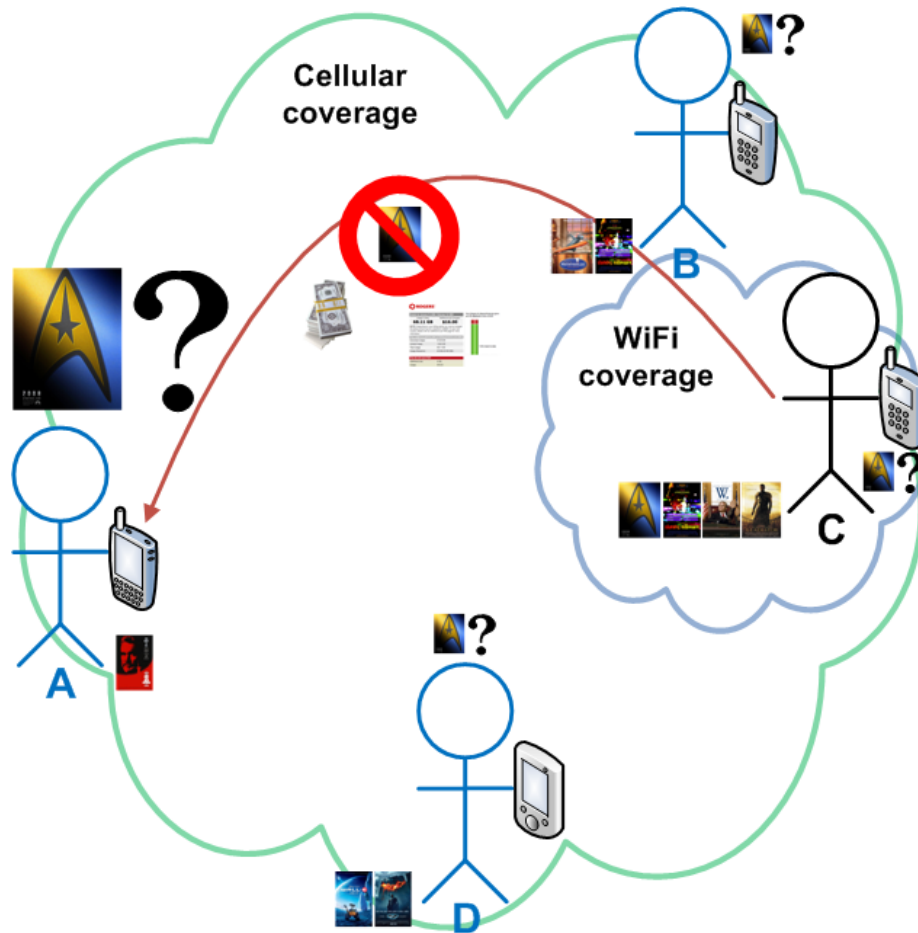
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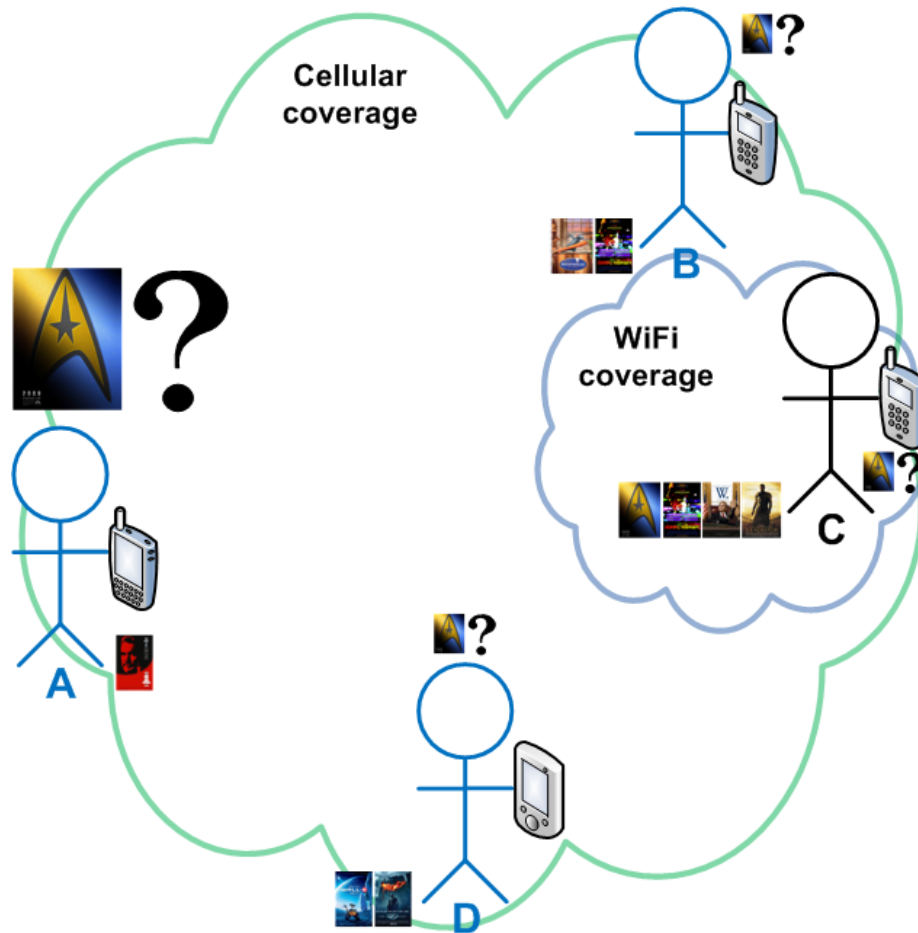
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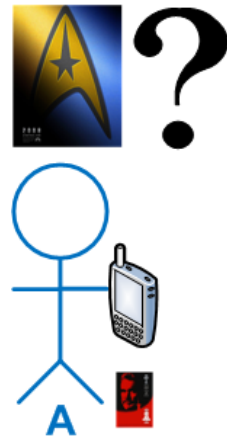


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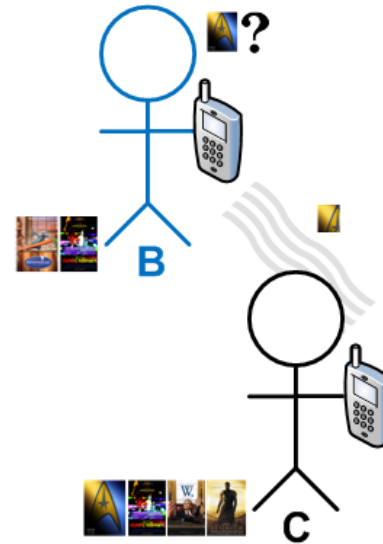


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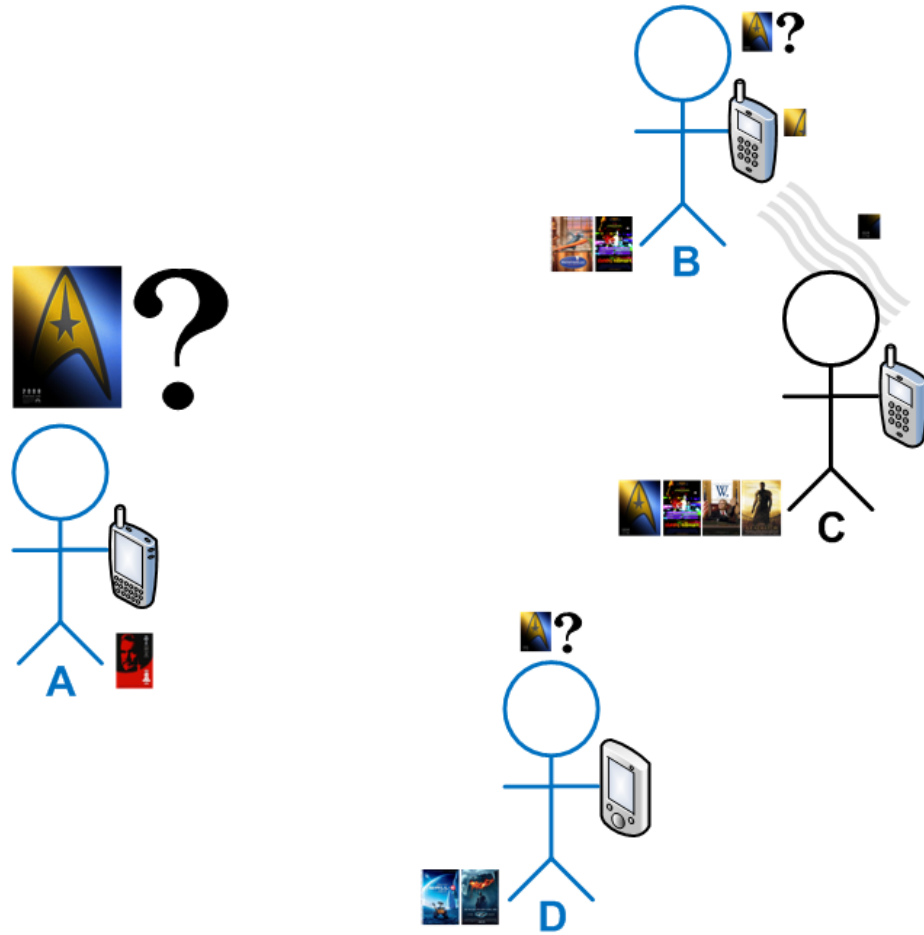




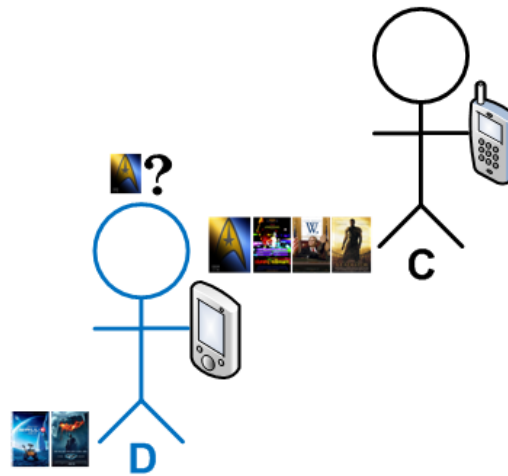
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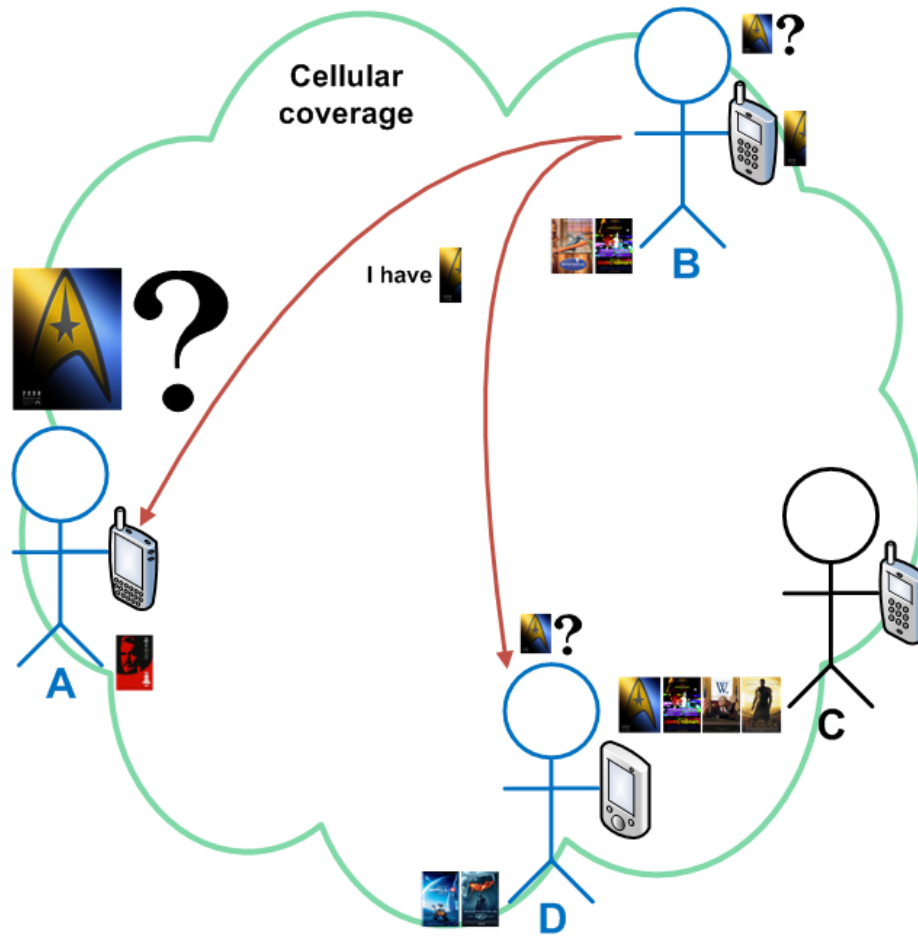
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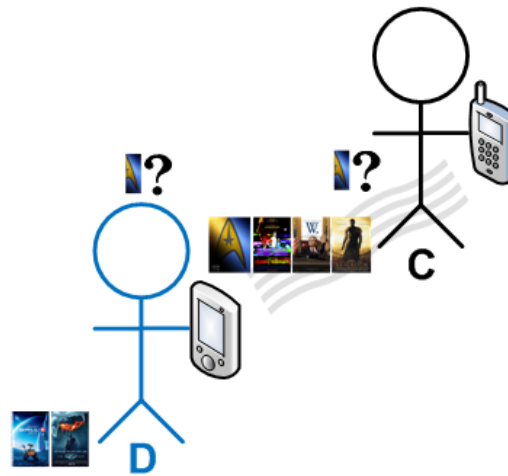
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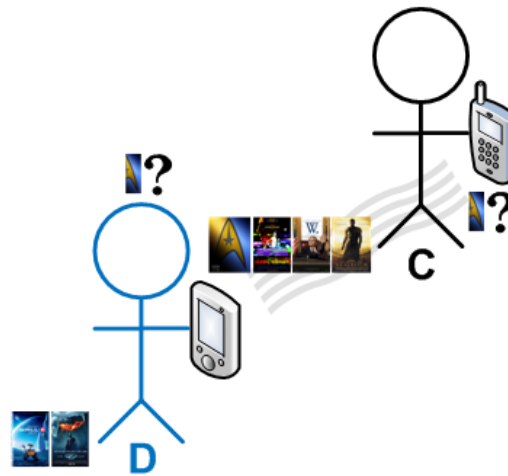
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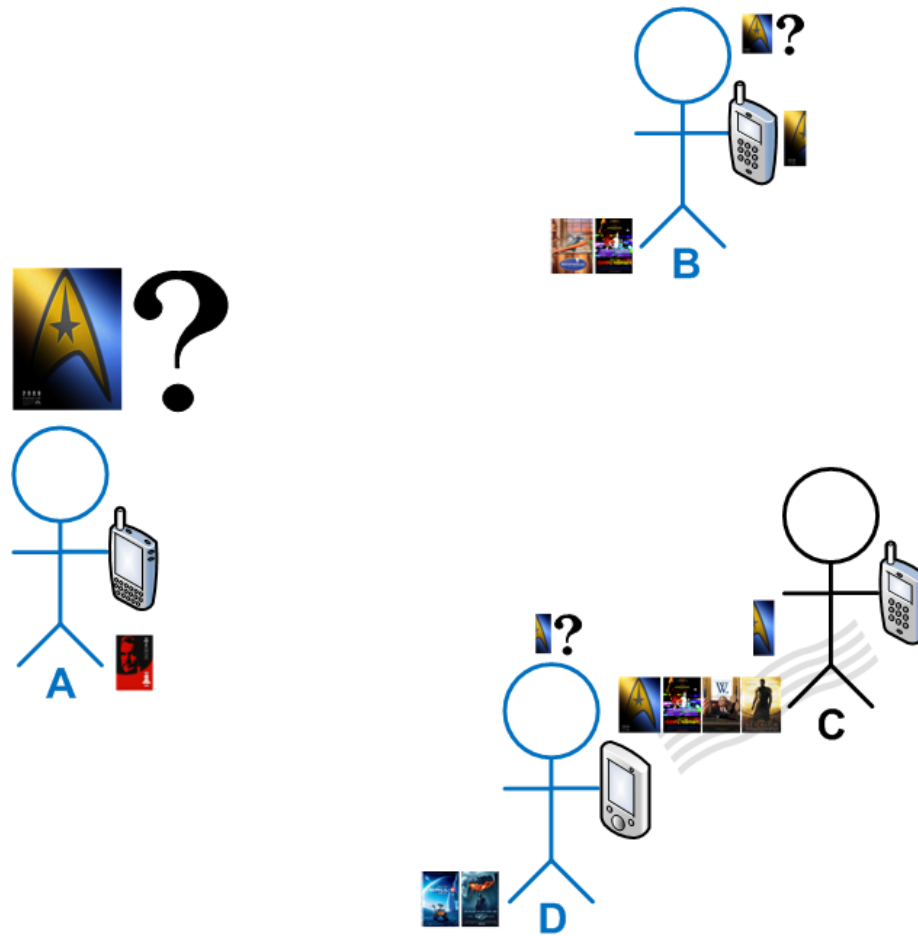
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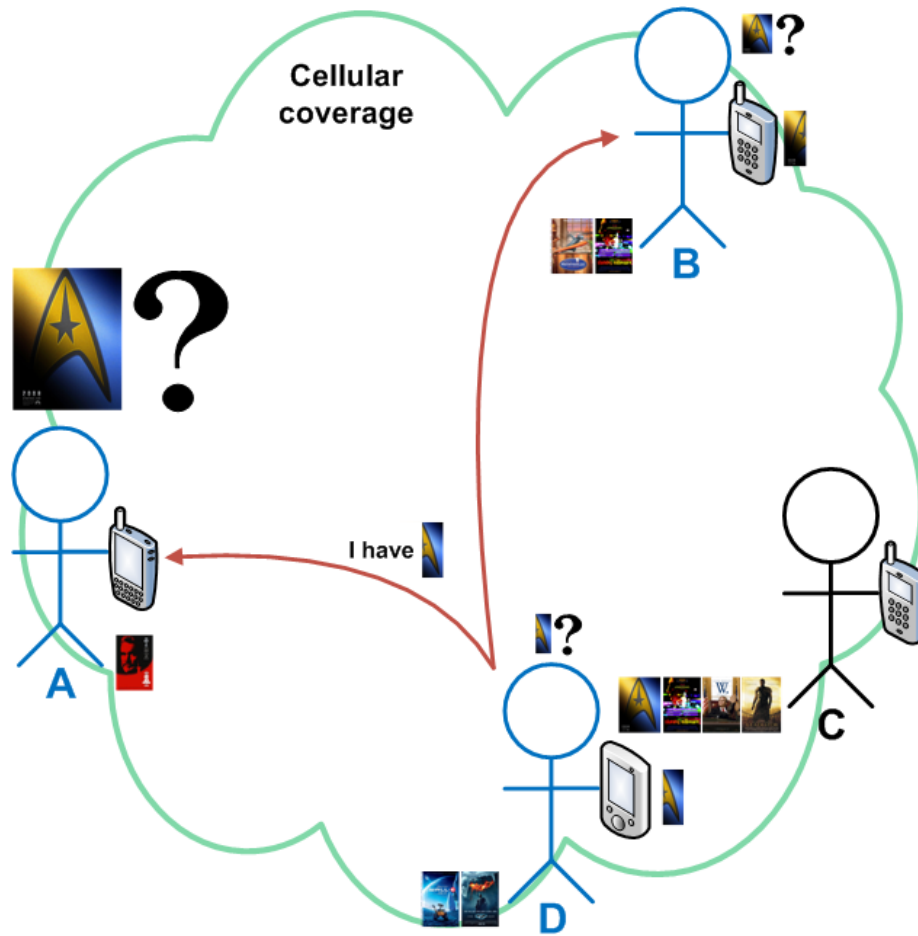


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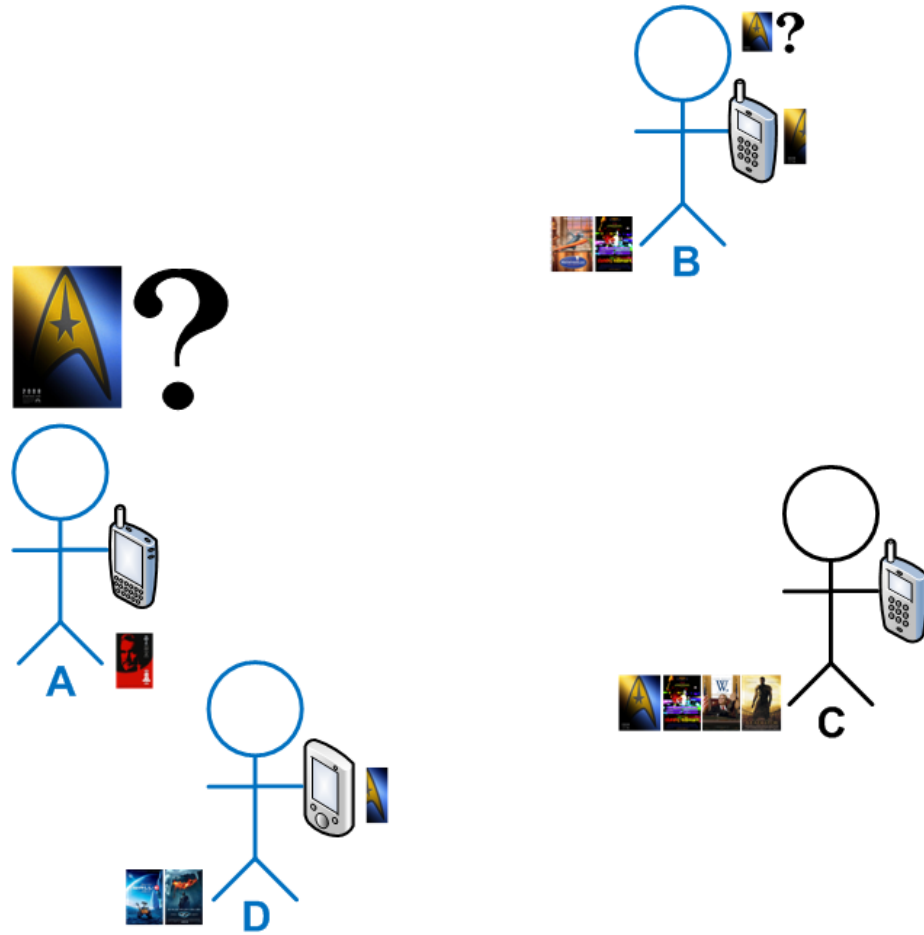


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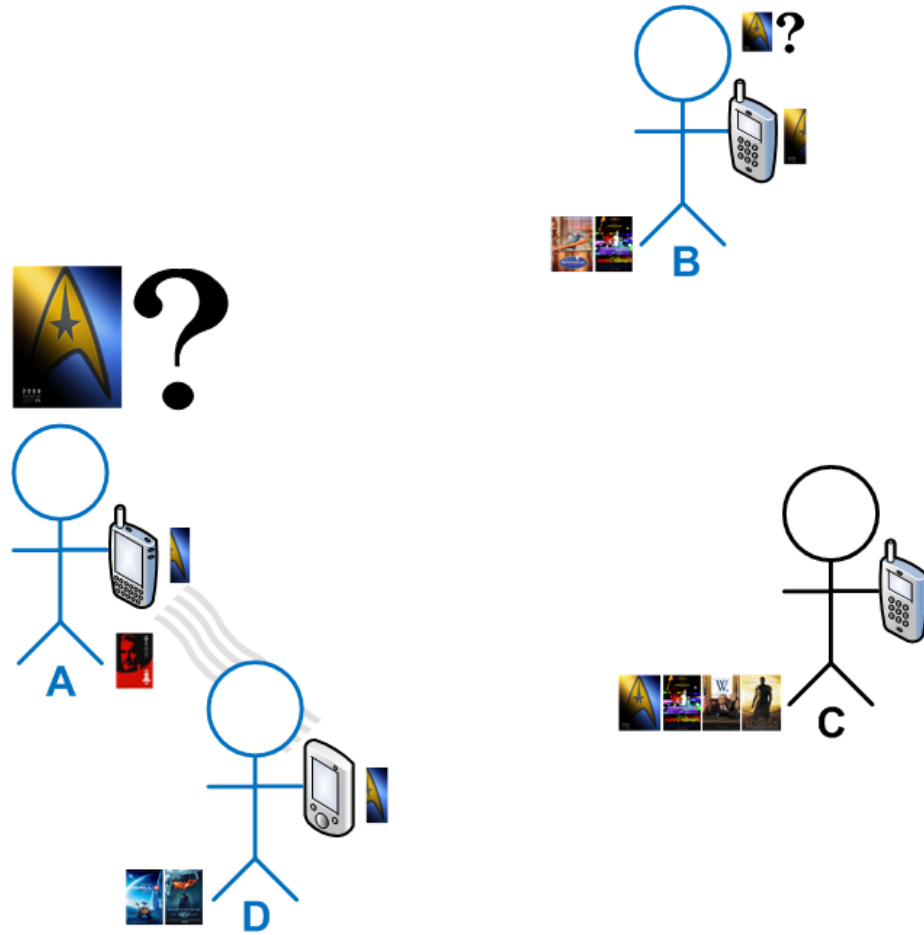




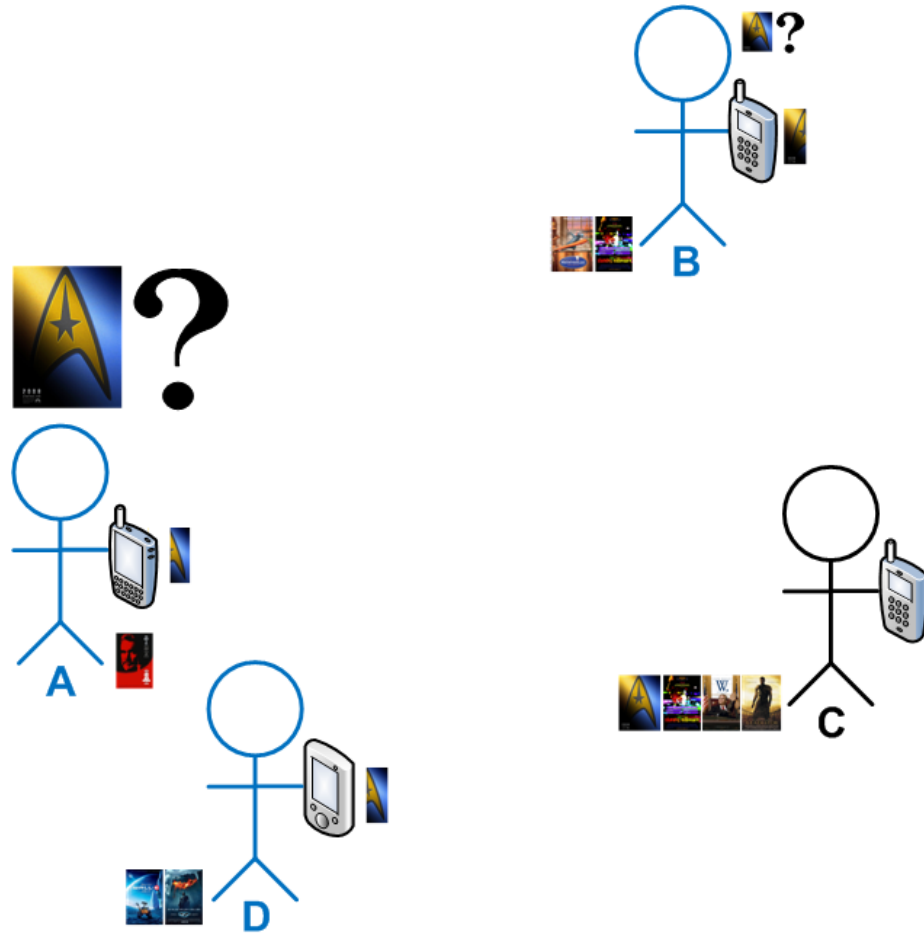
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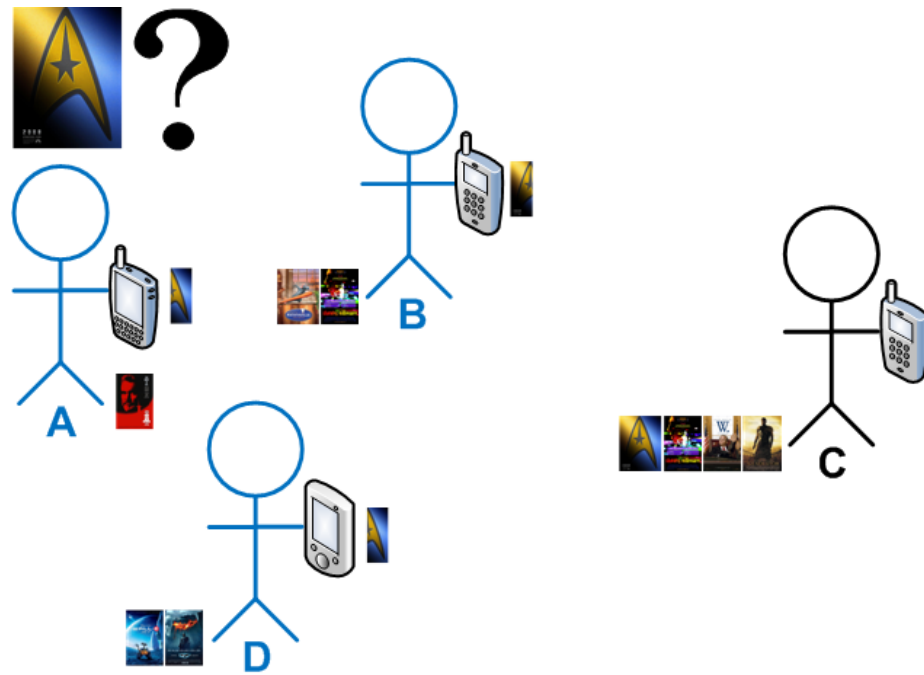
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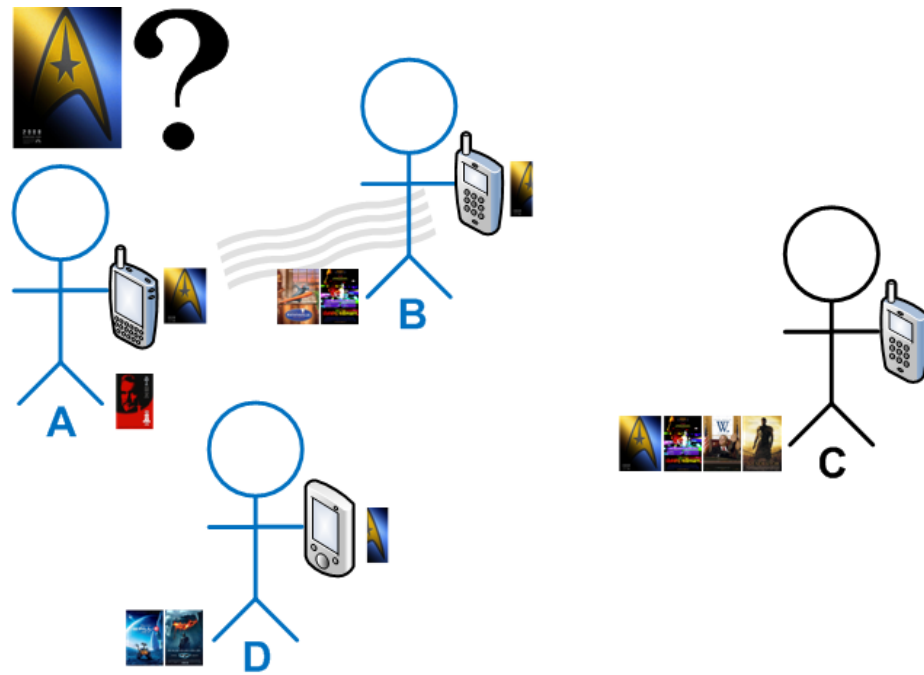
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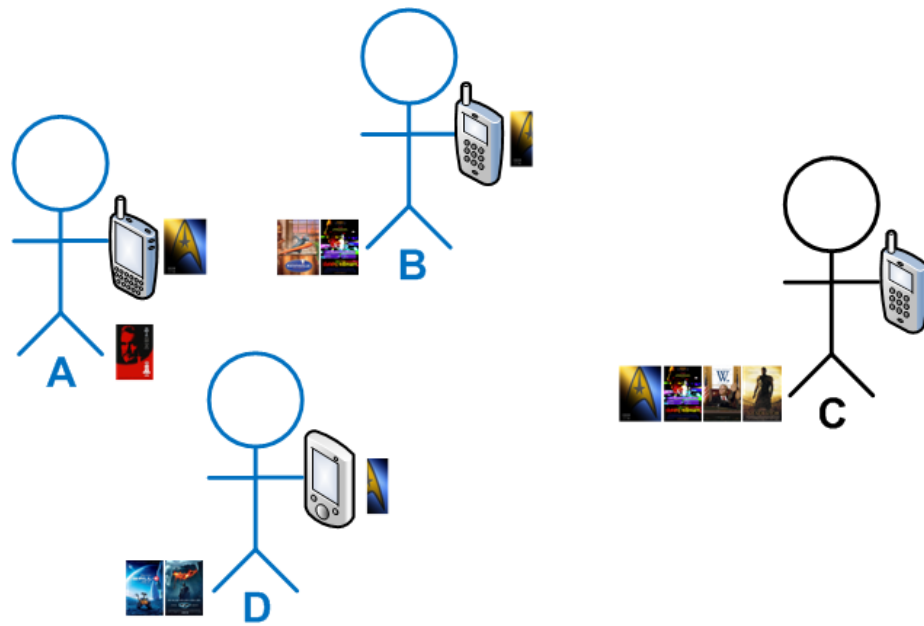
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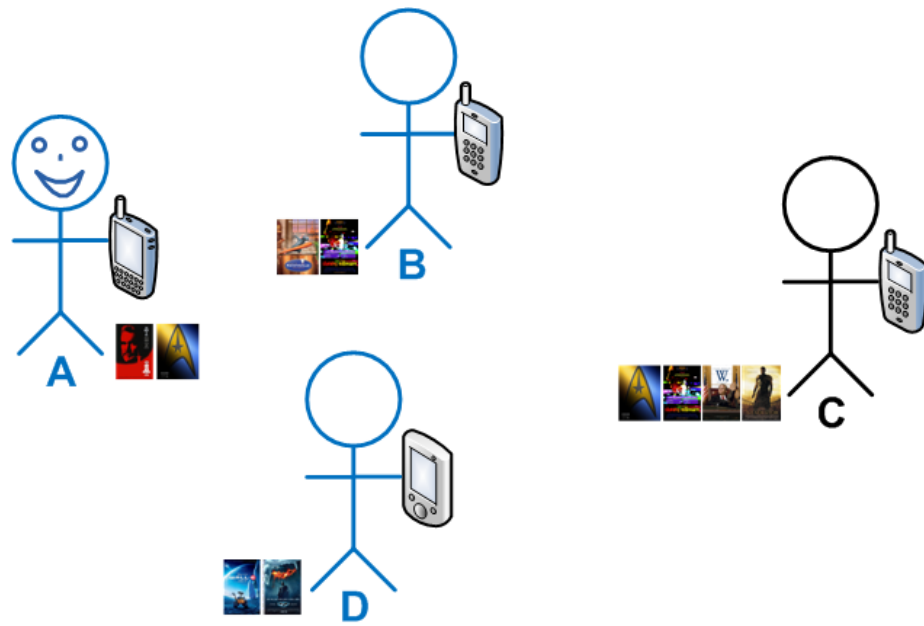
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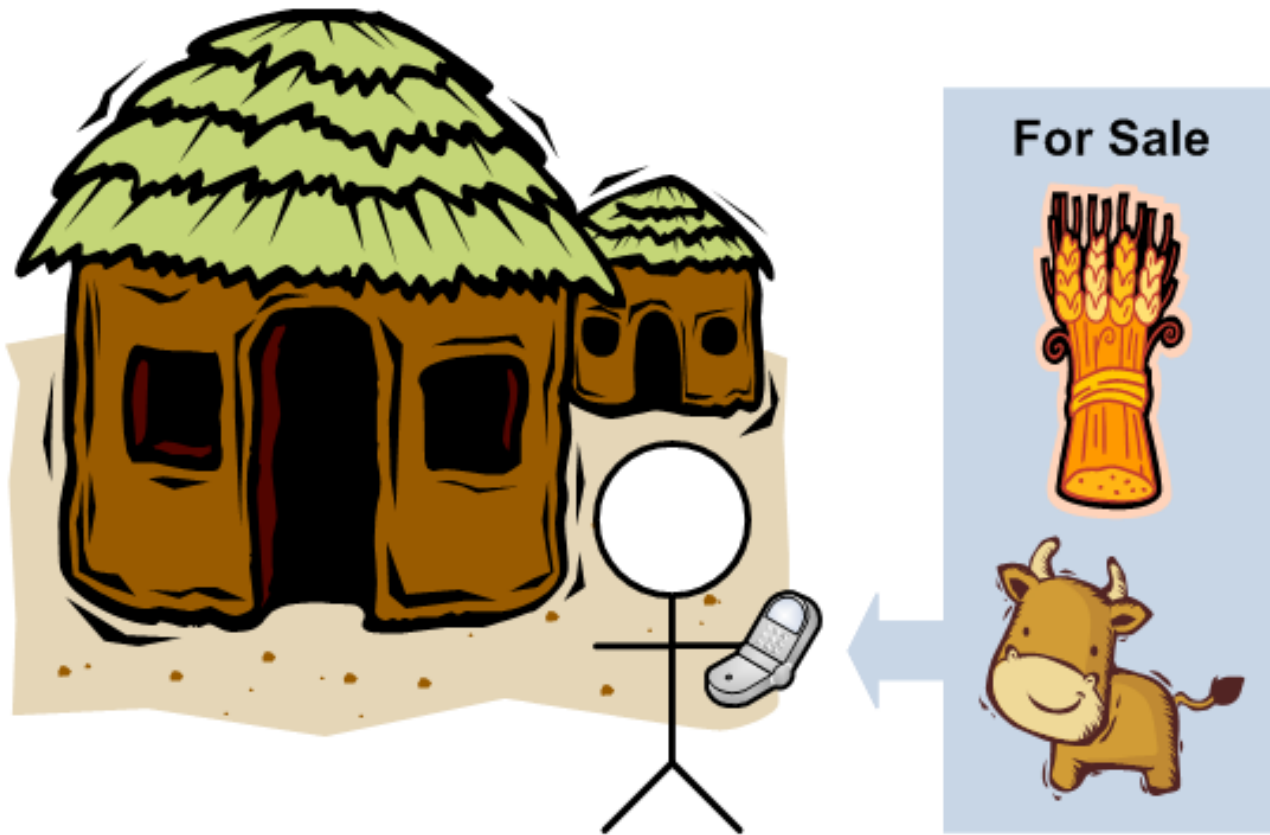
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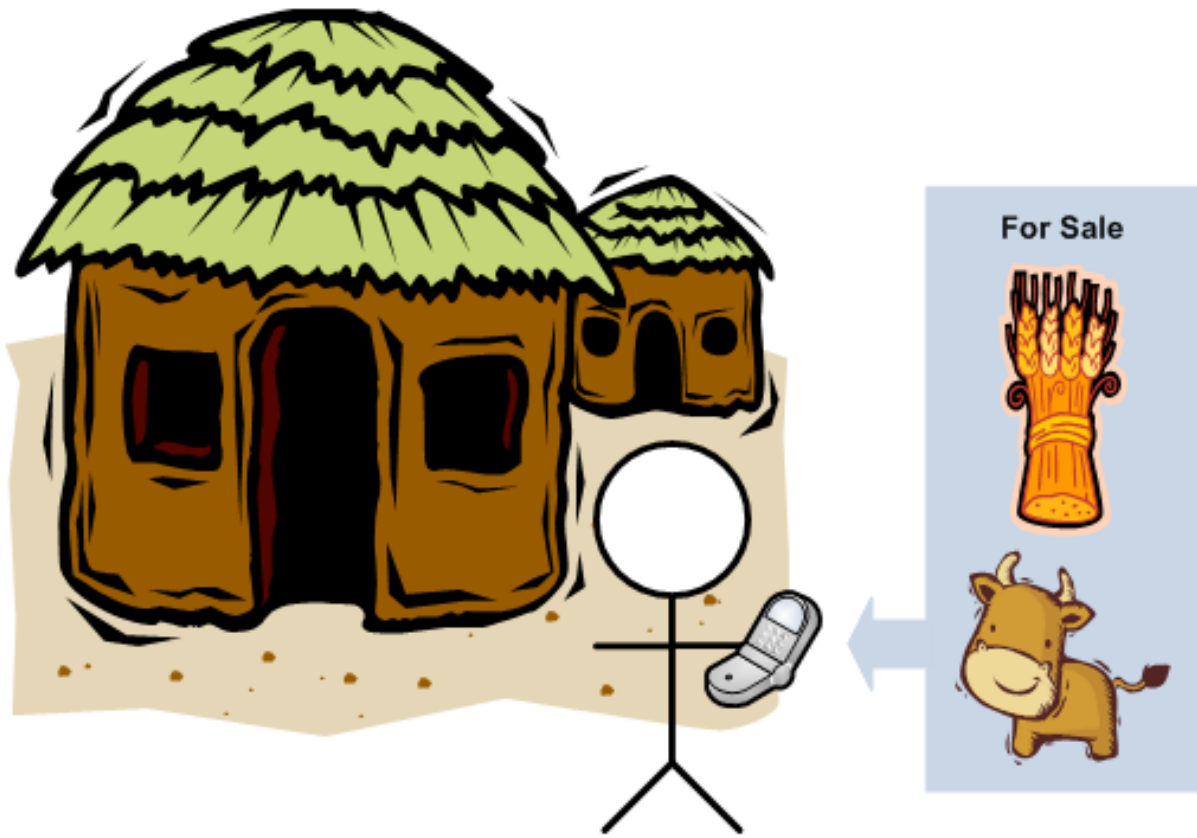
# PocketBay



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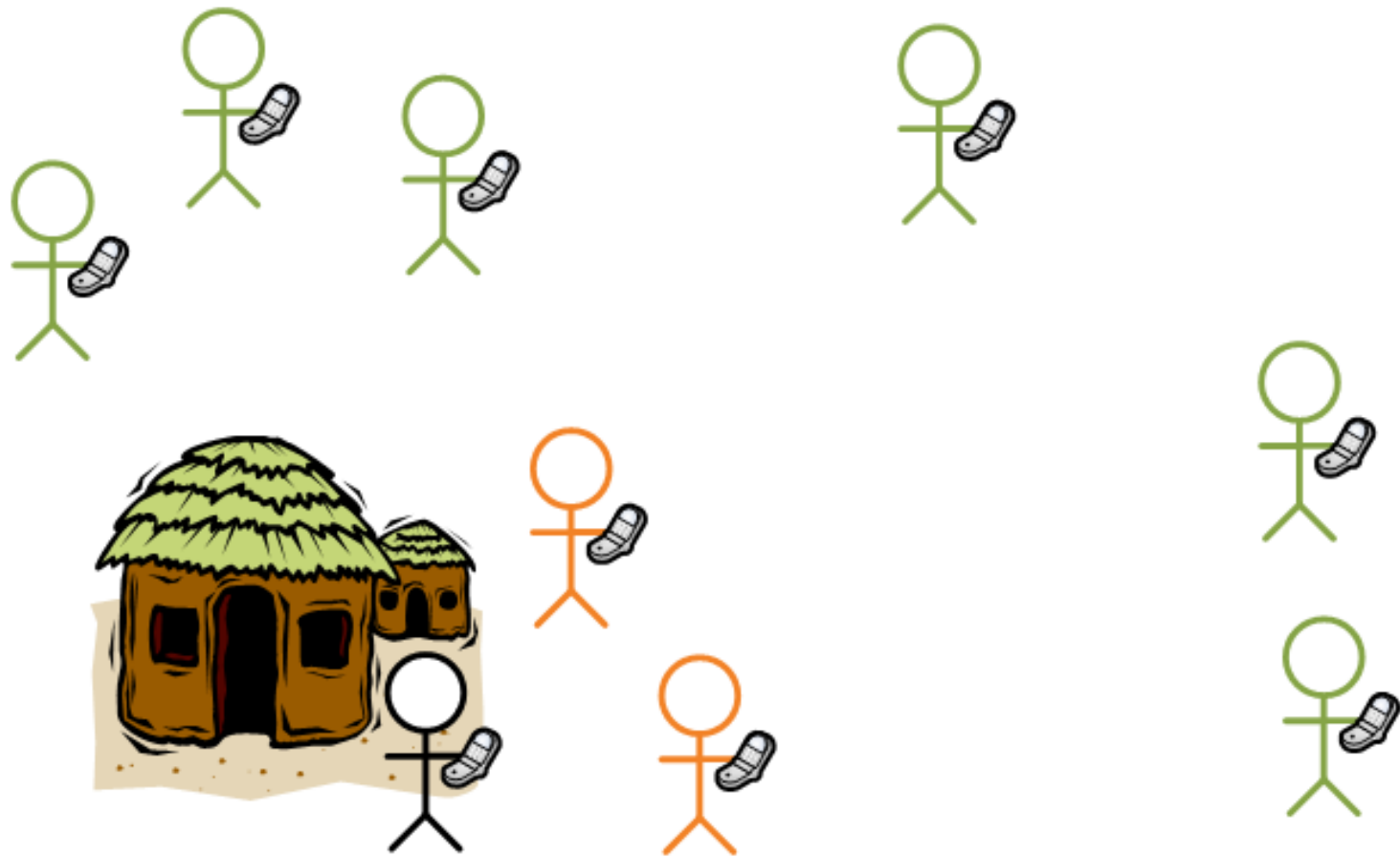
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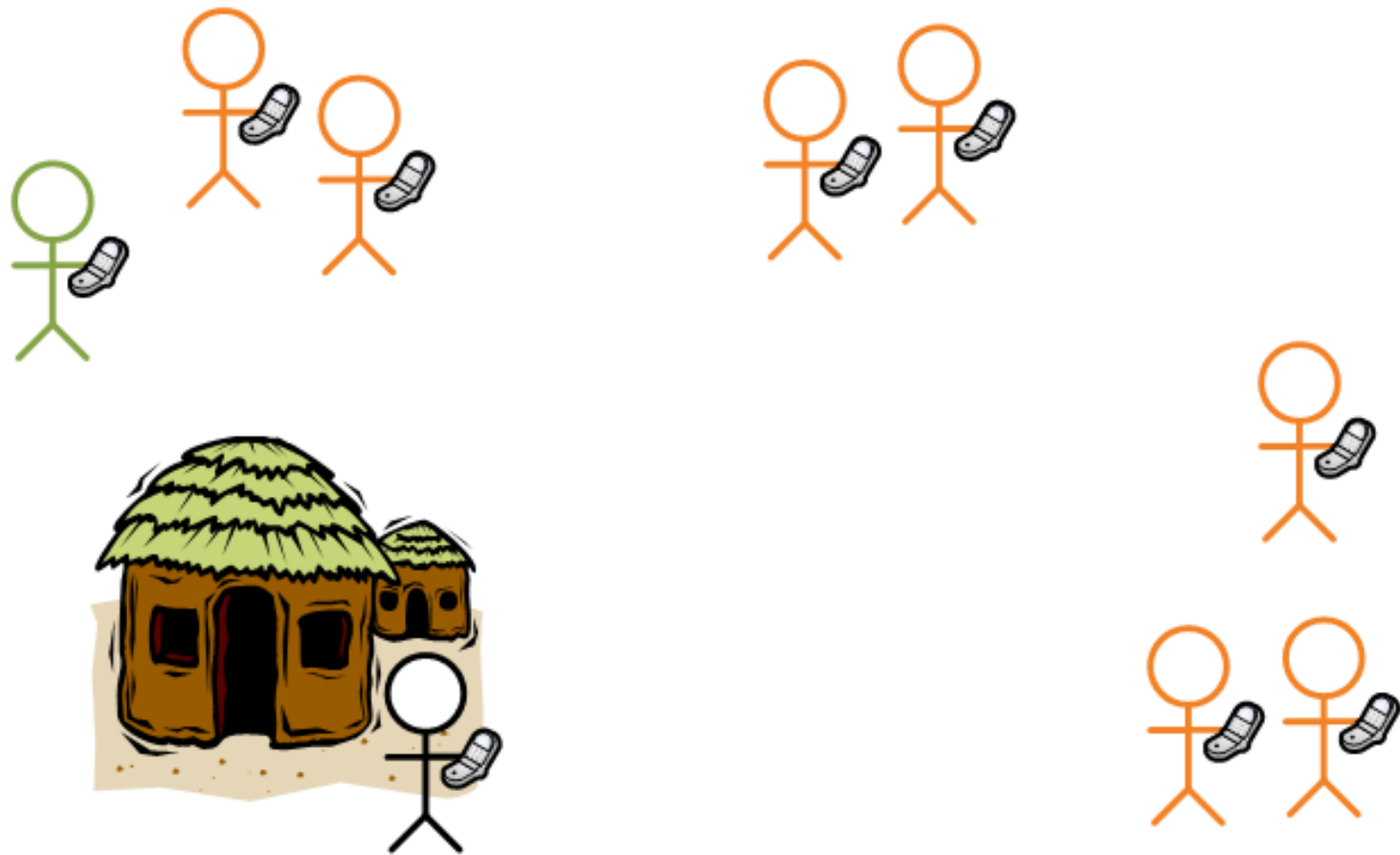




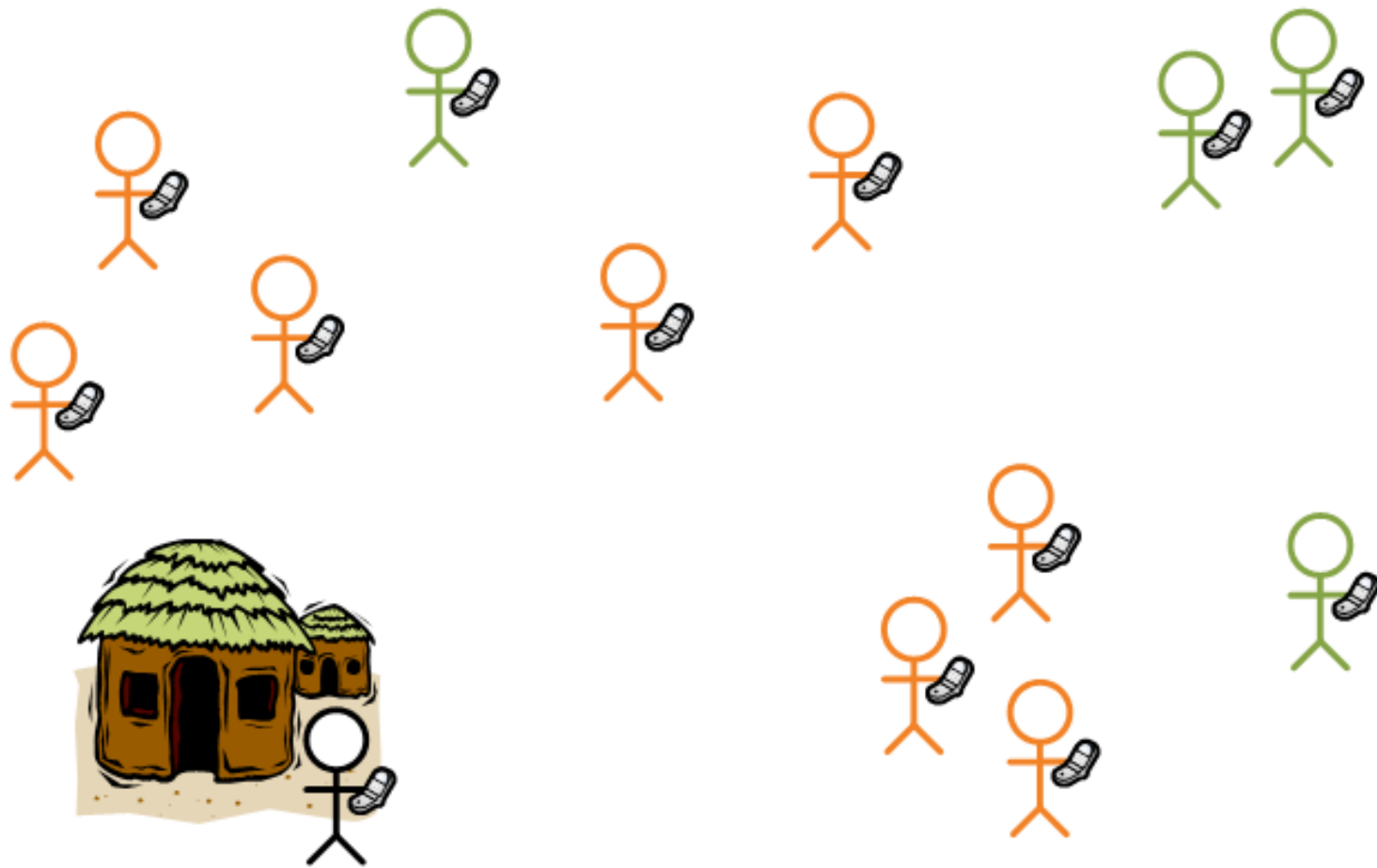
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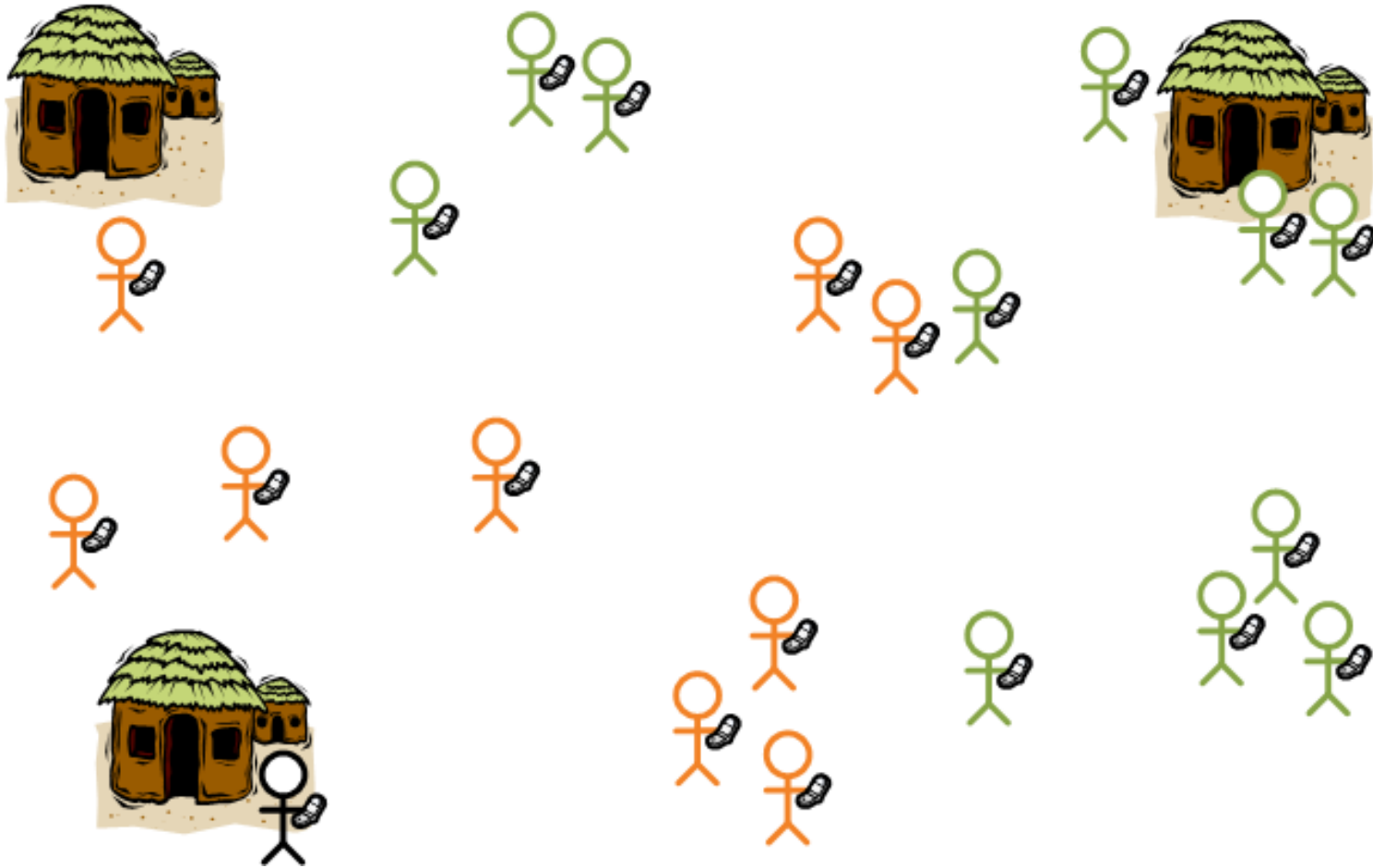
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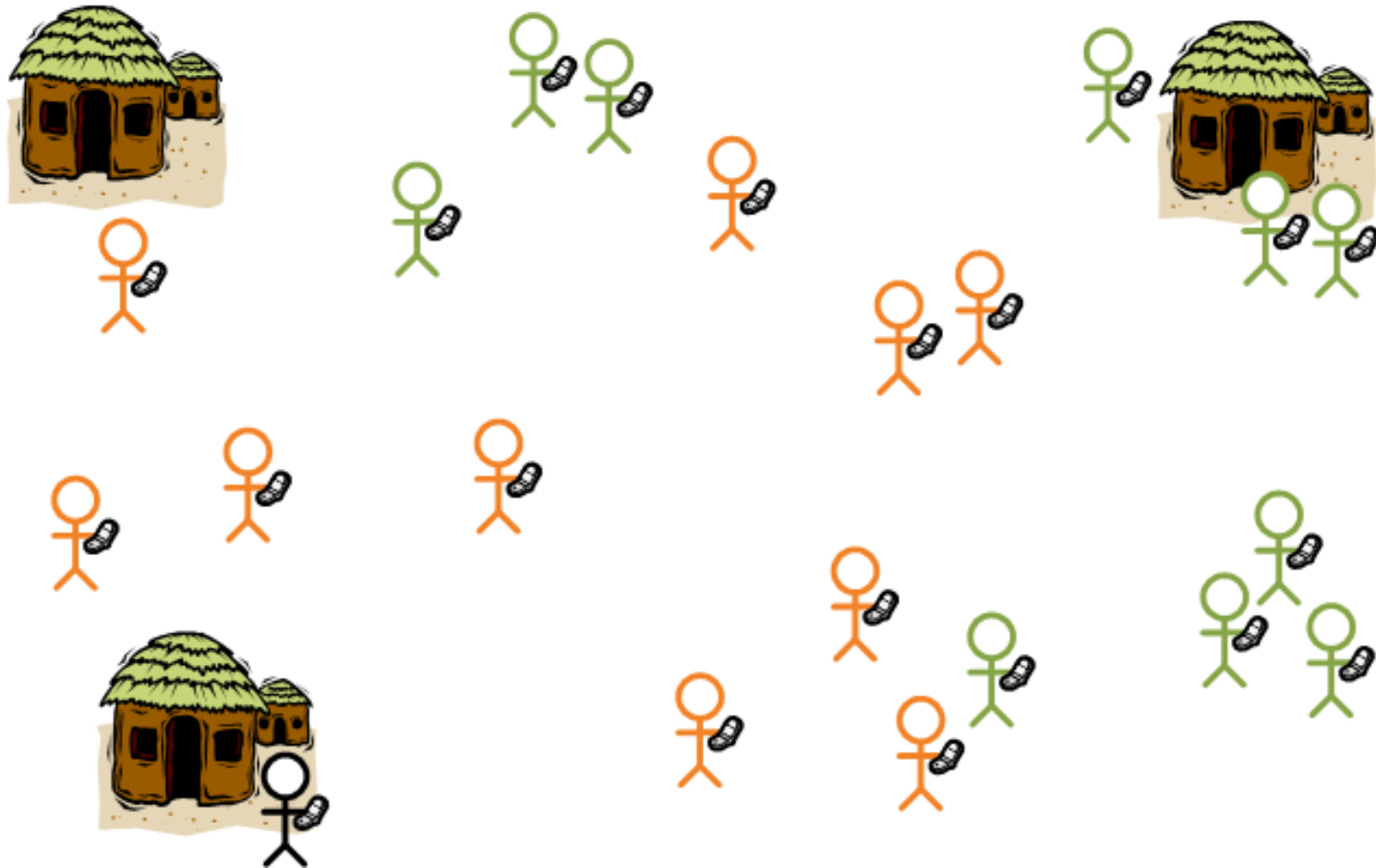
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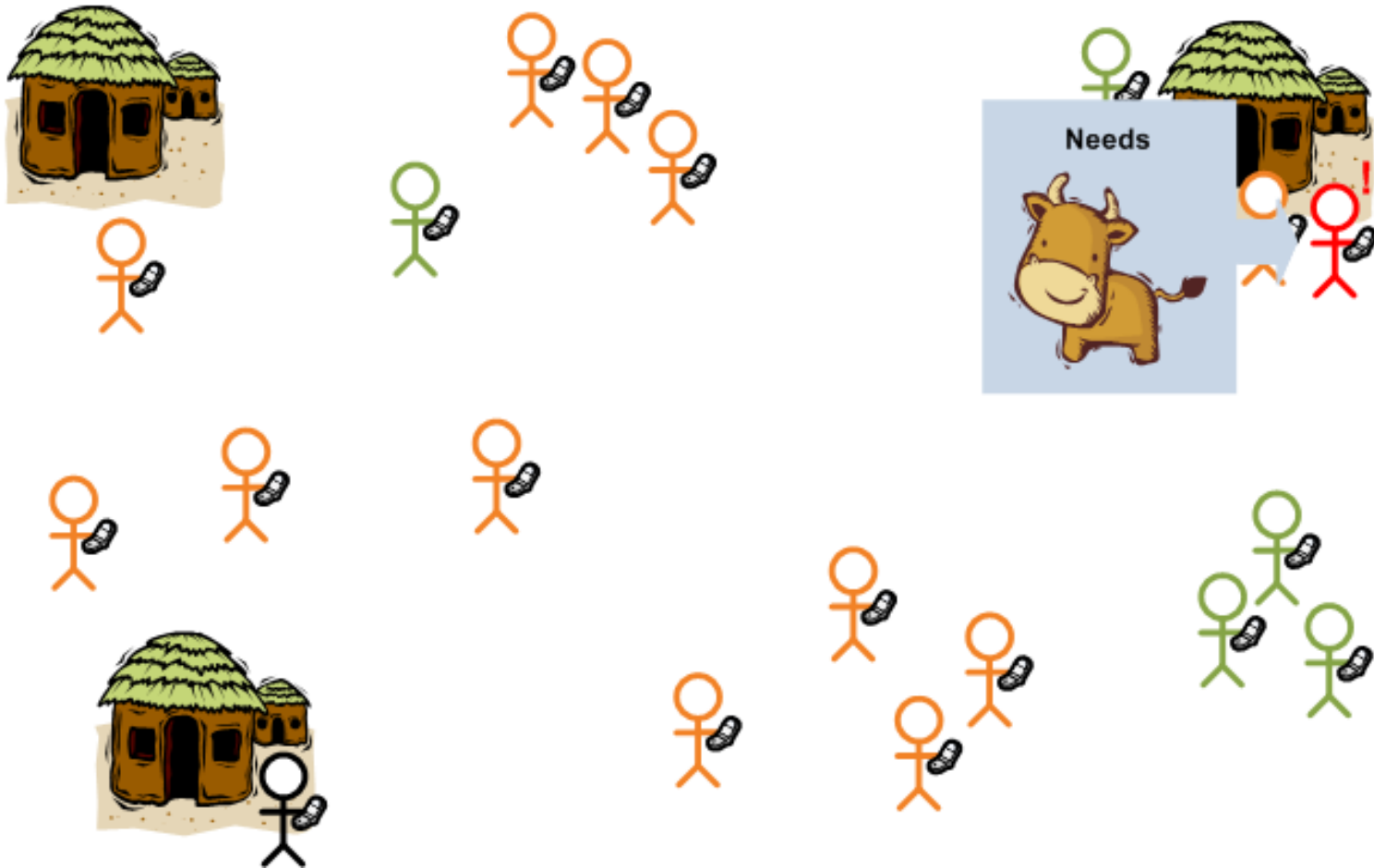


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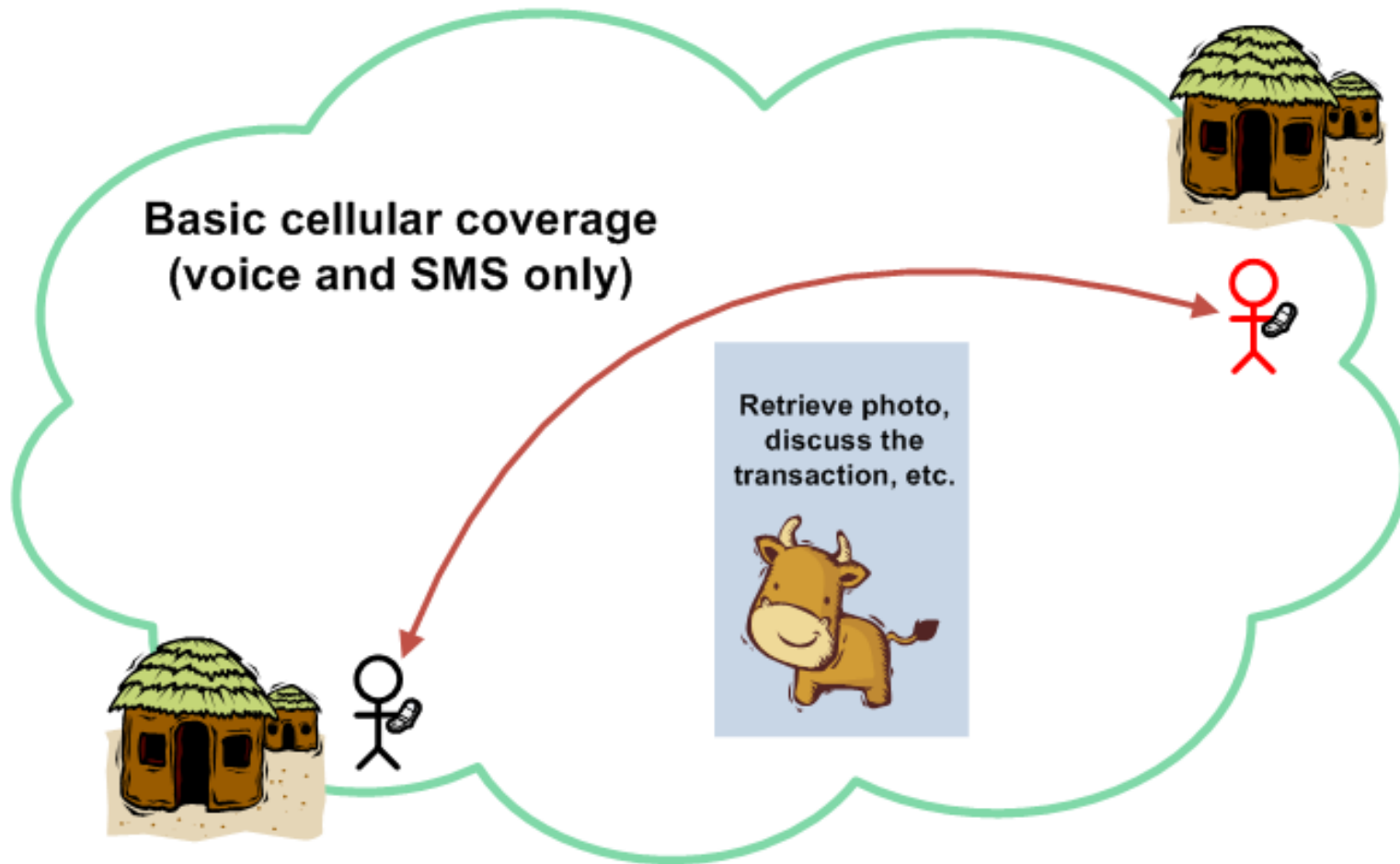


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**Basic cellular coverage  
(voice and SMS only)**



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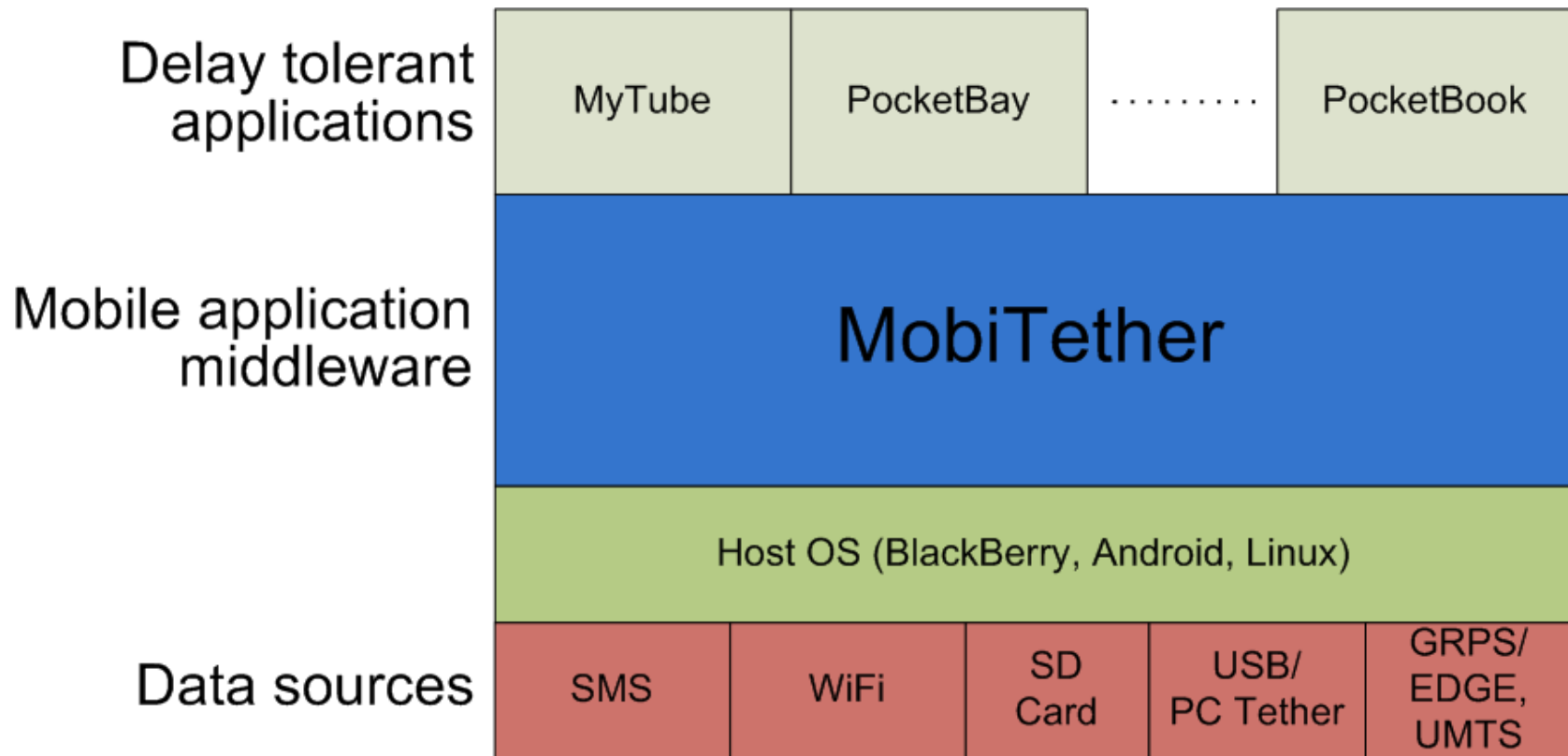
# PocketBook

- Facebook:
  - ‘We own your photos, conversation histories, personal data, ...’
    - Total privacy violation
  - Increasingly accessed by mobile devices.
- Decentralized social networking
  - Share personal information only with friends
  - Sample crawl of Facebook:
    - 169 “friends”, 48.8 photos each, 78.2 KB / photo
    - ~629 MB of storage

# Summary of applications

- Opportunistic communication between neighbouring devices
- Utilize multiple network interfaces
- Devices must store, carry, and forward data on behalf of others
- Varying quantities of data
- Isomorphic to other applications within this class.

# Mobile Application Middleware





# Goals

- Support efficient communication over multiple network interfaces
  - Exploit all forms of network connectivity
    - Maximize battery life
    - or minimize delay
    - or minimize monetary cost

- Provide and enforce a system of participation incentives
  - Reward participants and inhibit free riders
  - Participation consumes
    - Energy
    - CPU cycles
    - Storage
    - Bandwidth

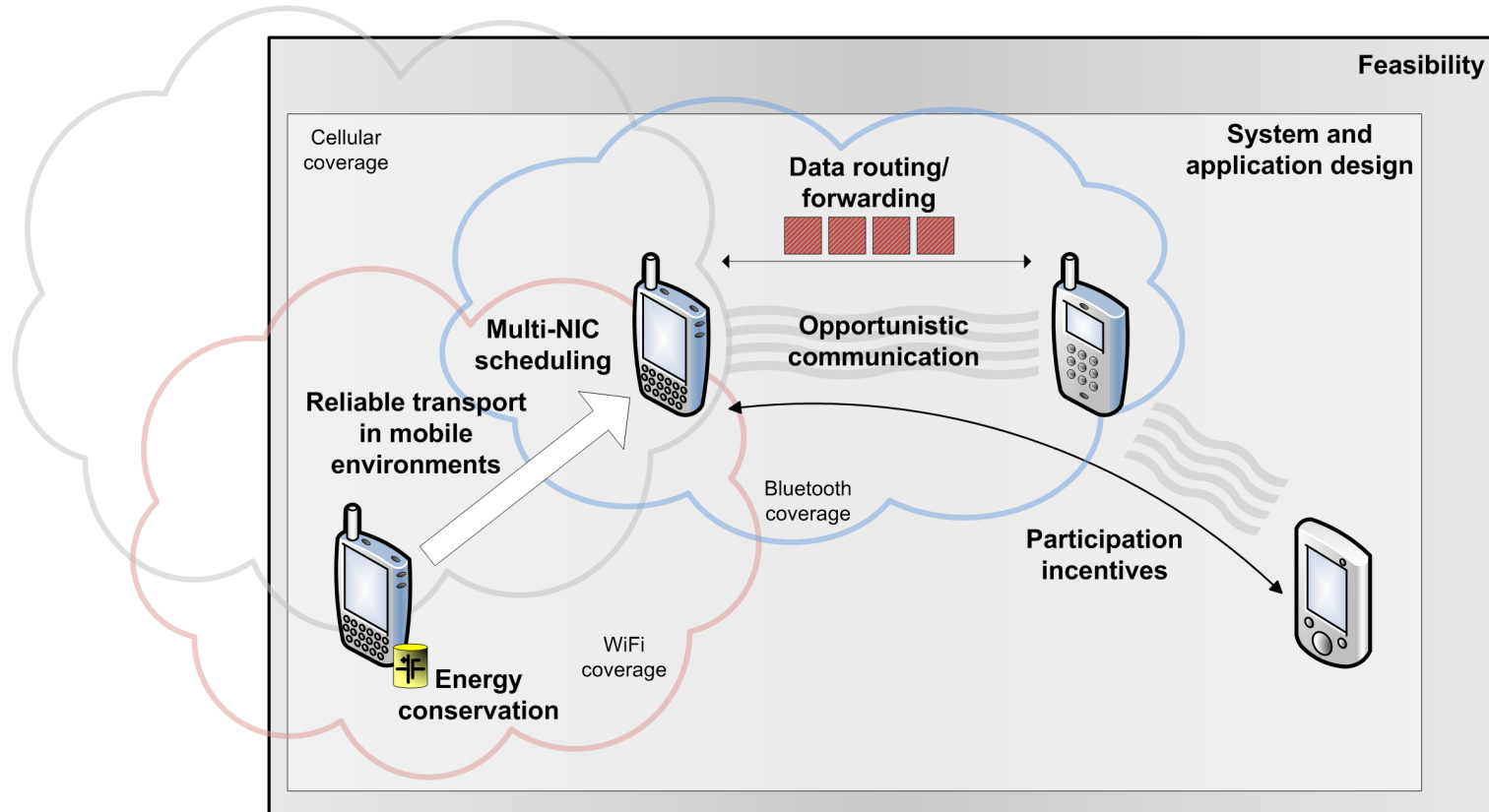
- Enable secure and reliable communication
  - Reliable transport under communication and power interruptions and unpredictable mobility.
    - Unicast, multicast, and broadcast addressing methods
  - Resistant to data tampering

- Protect the interests of the user
  - Resource interests
    - Persistent storage
    - Communication capacity
    - Energy
    - Computation
  - Monetary interests
    - Ex. rogue application sends MP3s over SMS
  - ‘Policy’ driven approach to application resource allocation.

- Provide feedback to the user
  - End-to-end paradigm engrained in mobile user's psyche.
    - Potential for high delay.
  - Uncertainty creates poor user experience
    - Inhibit adoption
  - Middleware must provide an intuitive global overview of system state.
    - Subject to the user's communication preferences.

- Facilitate easy deployment and high usability
  - Support incremental deployment by non-technical users
  - Simple mechanism to bootstrap identity and credentials
    - Portable across devices

# Related work



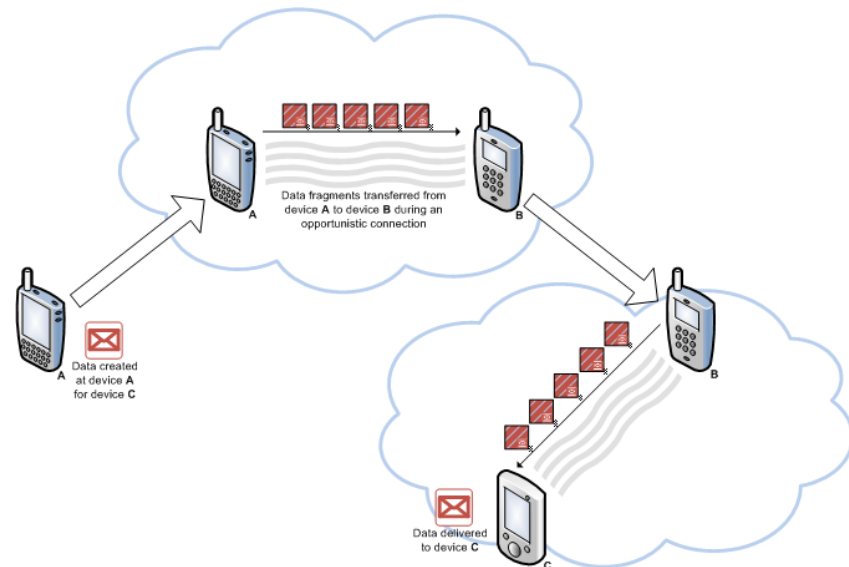
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- Most relevant related work:
  - Haggler
  - Opportunistic Connection Management Protocol



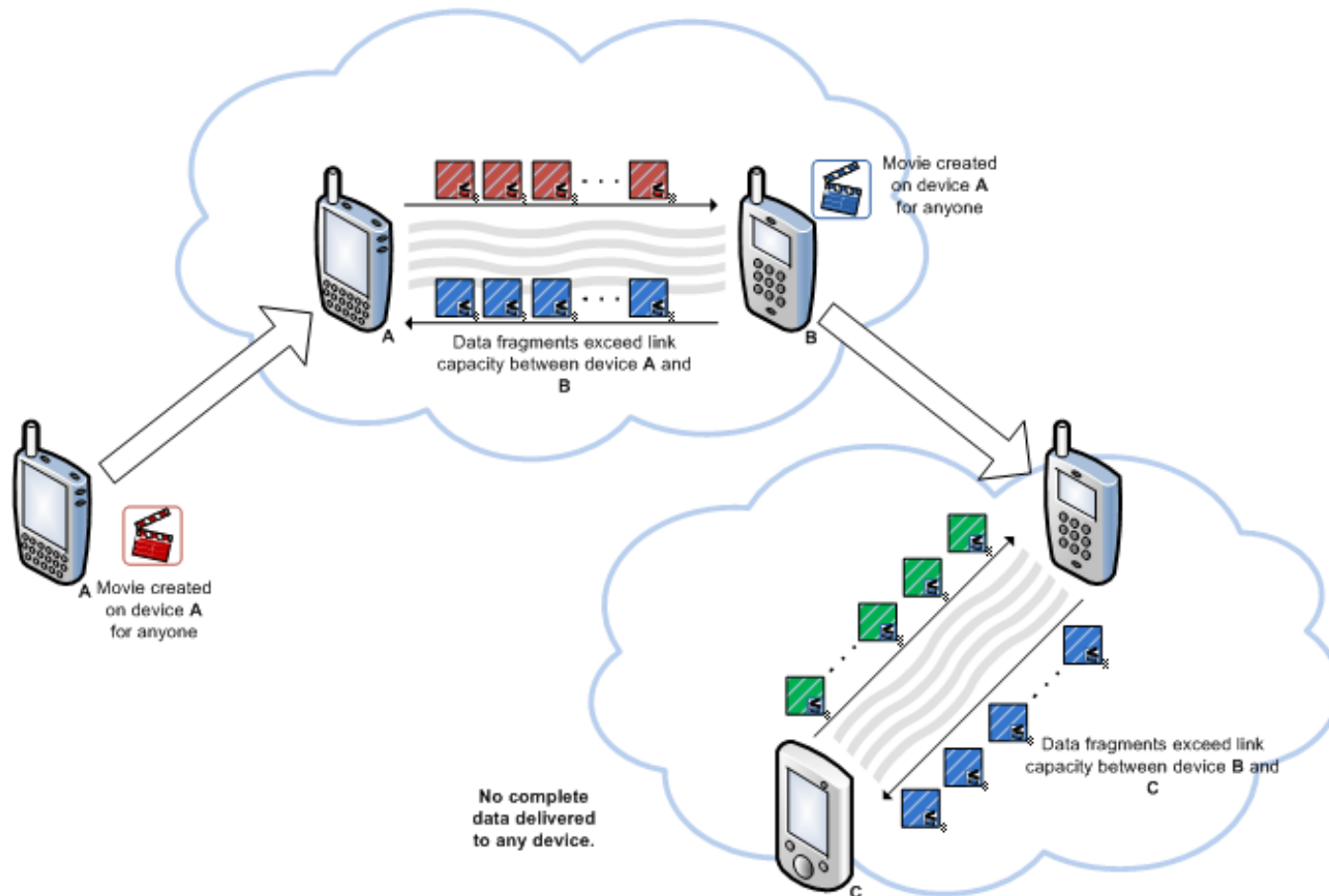
# Haggle

- Delay tolerant mobile application middleware
- Infrastructure-less\*
- Data disseminated between devices
- Platform for studying forwarding algorithms in disconnected environments.



# Problems with Hagggle

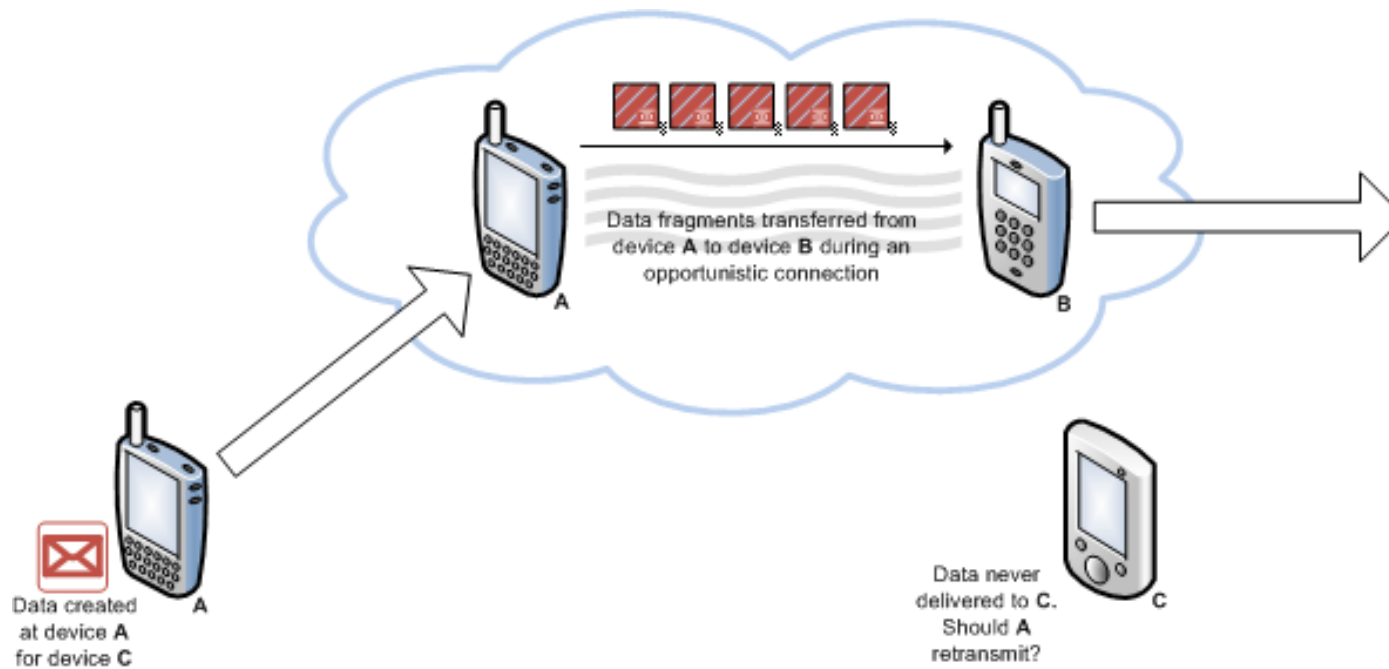
Scales poorly



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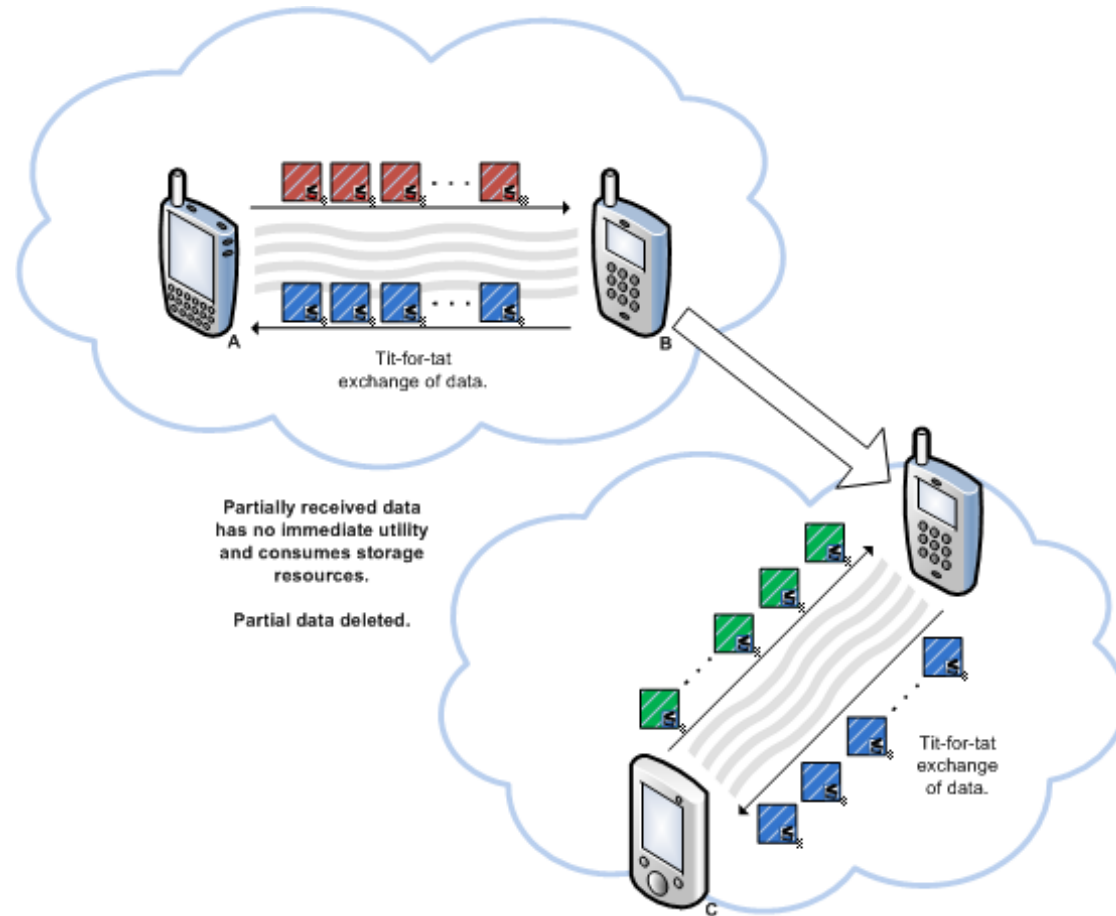
# Problems with Hagggle

## Unreliable data transport



# Problems with Haggle

## No participation incentives

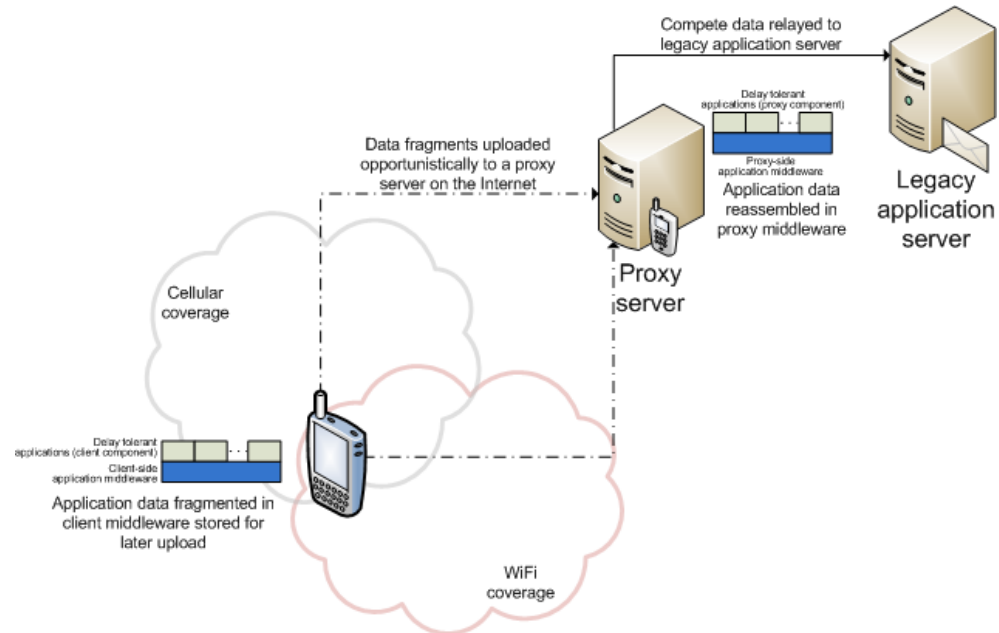


# Problems with Hagggle

- Only suitable for *simple* applications
  - Broadcast data
  - No fragmentation

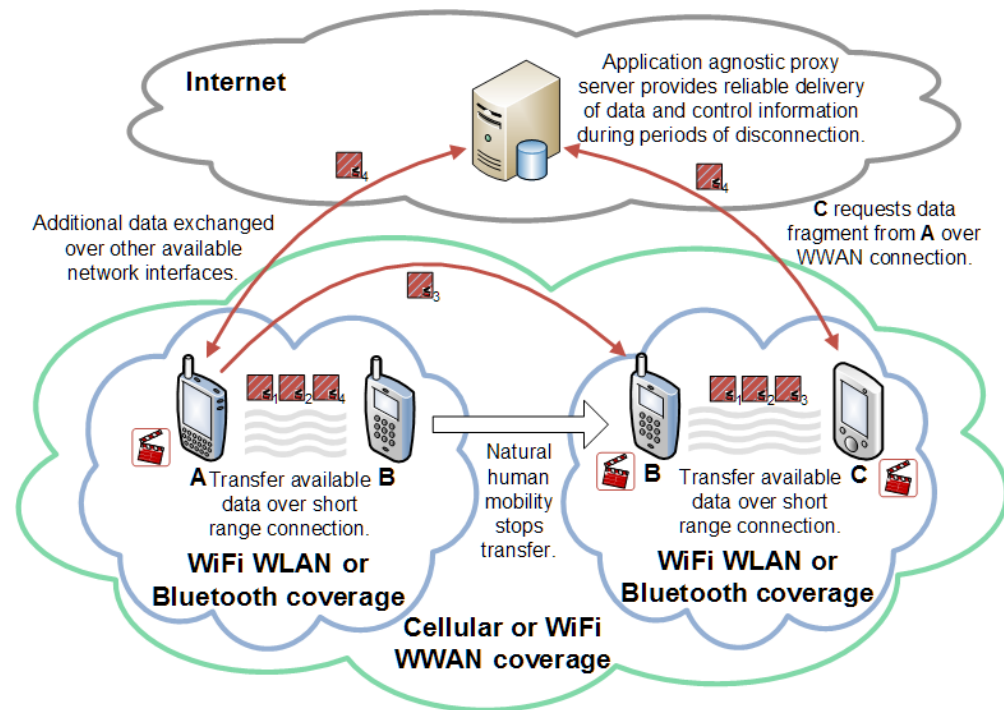
# Opportunistic Connection Management Protocol

- Client-server (proxy) architecture
- Delay tolerant application middleware
- Schedules data across multiple network interfaces
- Incrementally deployable



# Proposed Mobile Application Middleware

- Union (Haggle, OCMP)
  - Exploit untapped wireless capacity between devices
  - Application agnostic proxy server
    - Reliable communication
    - Maintain global 'view'



# Outline

- The mobile application space
  - Mobile application middleware
  - Related work
- Challenges
- Open discussion



# Research challenges

- System
- Communication
- Human computer interaction
- Deployment

# System Challenges

- *How do we design an efficient distributed application middleware on a resource constrained device?*

- *How do we create an enforce participation incentives in an (unmanaged) delay tolerant network?*
  - Reward participants and inhibit free riders
  - Participation consumes
    - Energy
    - CPU cycles
    - Storage
    - Bandwidth

# Communication Challenges

- *How can centralized coordination improve routing in a delay tolerant network?*

- *How do we exploit multiple network interfaces to provide efficient and reliable communication in a delay tolerant network?*
  - Exploit all forms of network connectivity
    - Maximize battery life
    - or minimize delay
    - or minimize monetary cost

- *How do can we exploit SMS has a control channel in delay tolerant networks?*
  - Easy use:
    - SMS-based transport protocol
    - <http://blizzard.cs.uwaterloo.ca/eaoliver/sms.html>

# Human Computer Interaction Challenges

- How do we design intuitive delay tolerant applications?
- How should users control the behaviour of a mobile application middleware?
  - Protect resource and monetary interests
    - Persistent storage
    - Communication capacity
    - Energy
    - Computation

# Deployment Challenges

- How do we engineer simplicity into a large scale distributed mobile system?
  - Support incremental deployment by non-technical users
  - Simple mechanism to bootstrap identity and credentials
    - Portable across devices



# Summary

- New mobile application vision
- Positioned work in existing\* delay tolerant networking middleware
- Identified research challenges to enable this new class of mobile applications



# Questions / Wild opinions / Discussion

Earl Oliver, NDS Seminar,  
University of Waterloo