Enabling the Next Frontier in Mobile Applications

Ph.D. Stage II Talk

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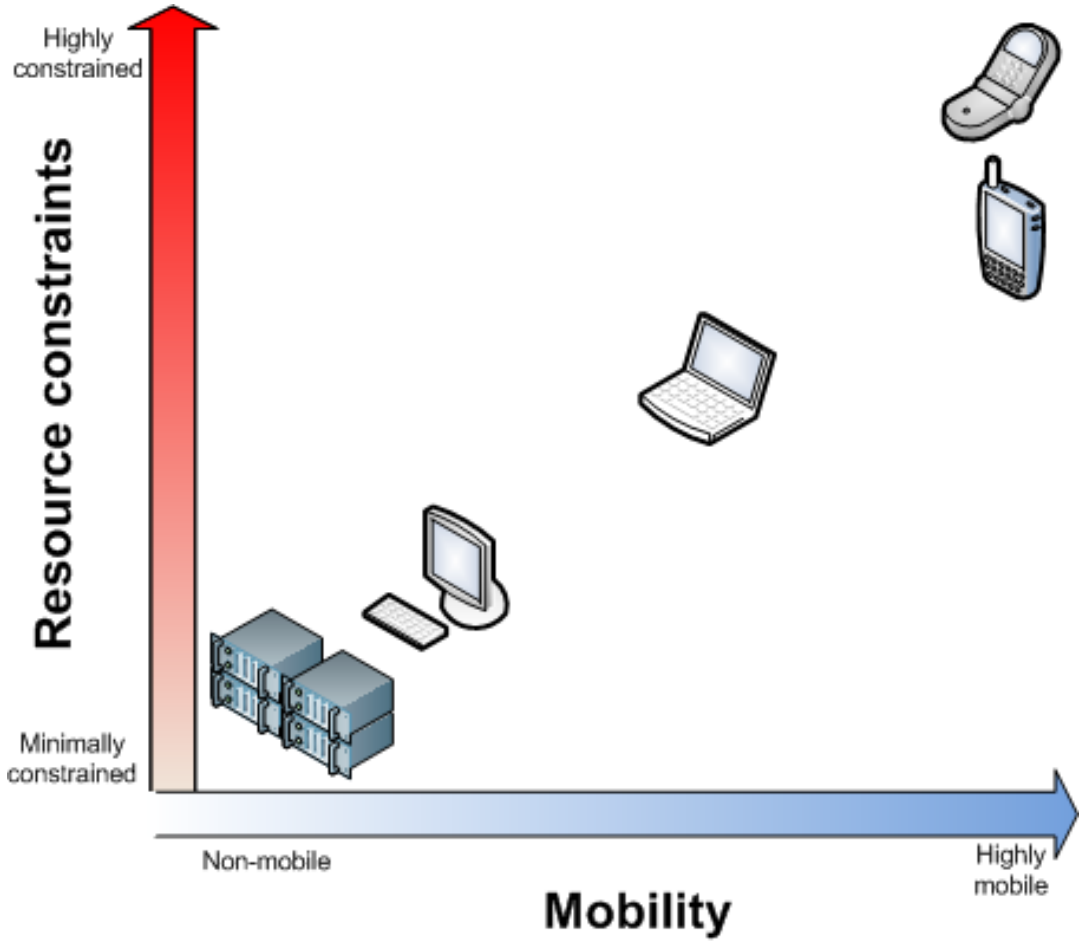
March 2, 2009

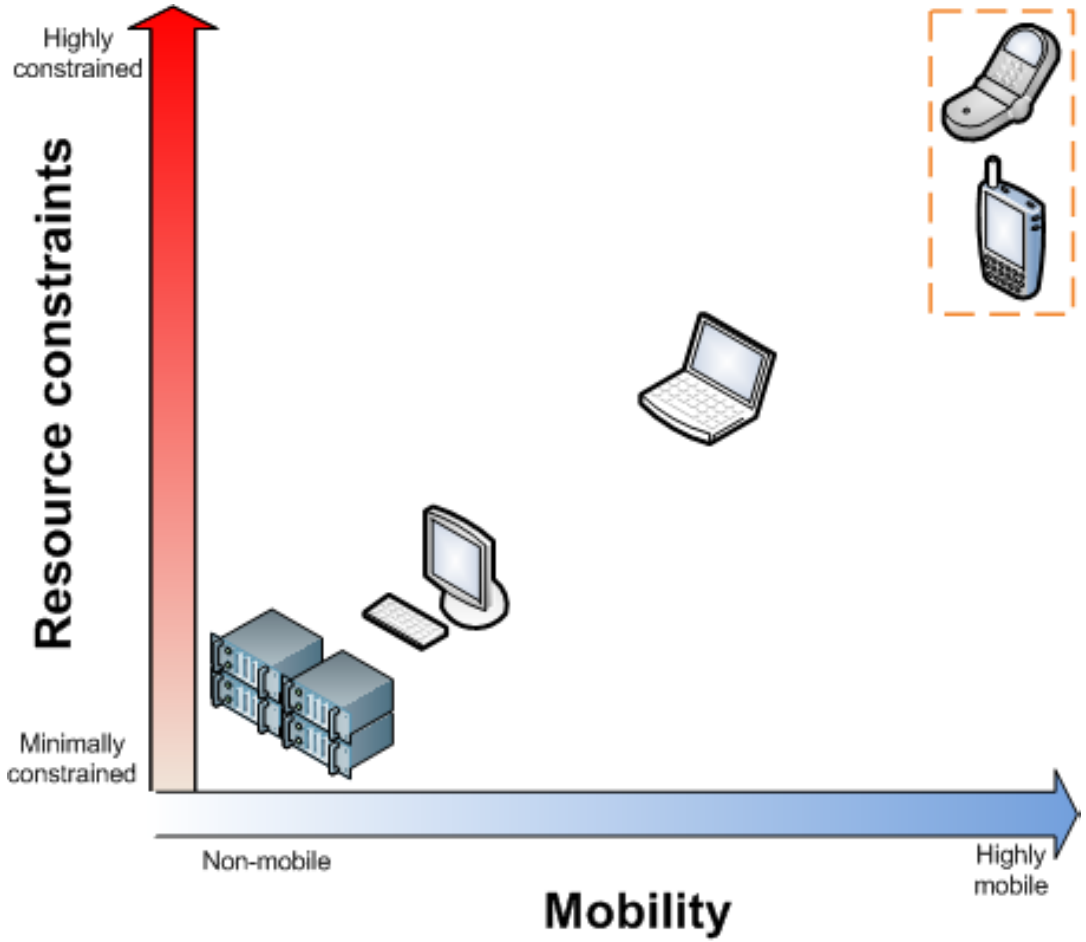
Outline

- The mobile application space
- Mobile application middleware
- Related work
- Challenges
  - Timeline

The Mobility / Resource Constraint Continuum



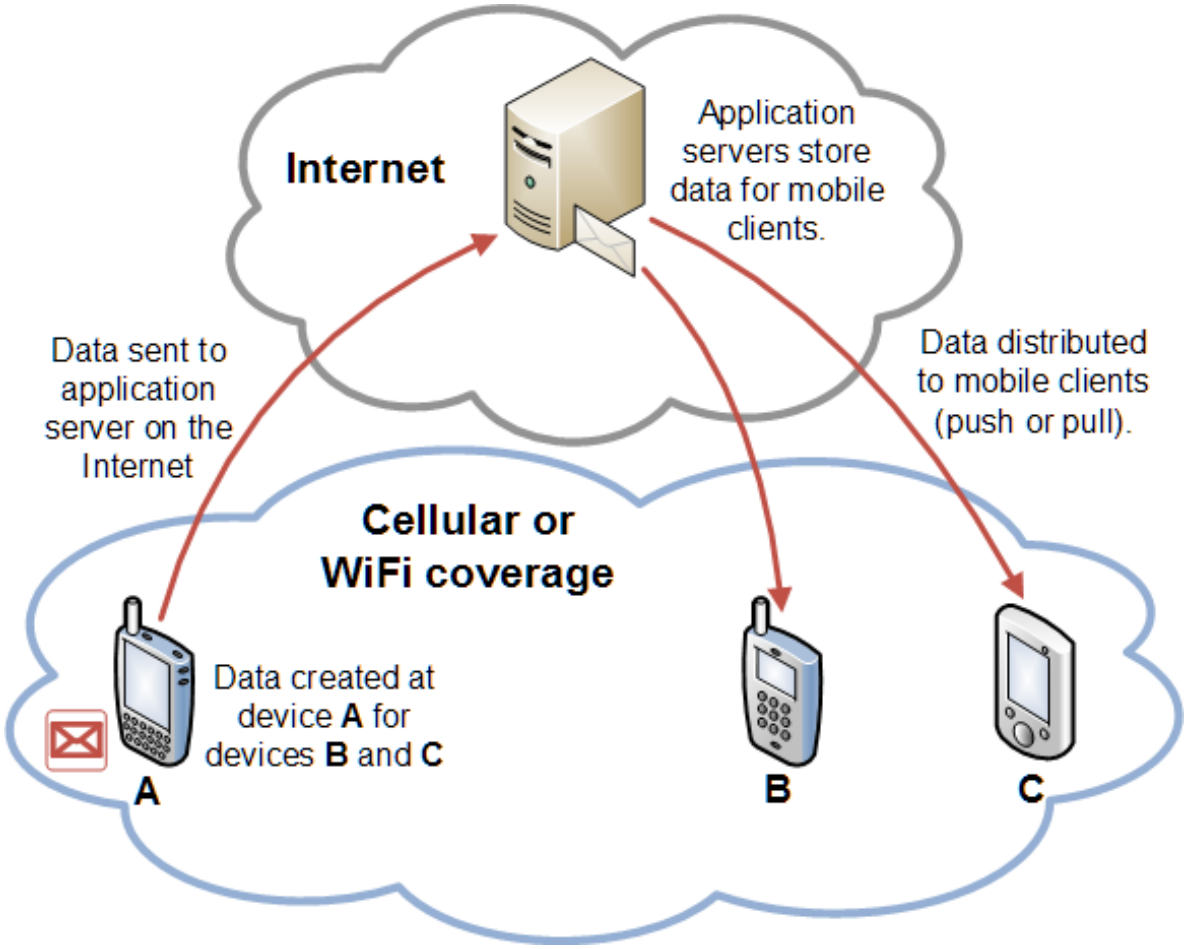
The Mobility / Resource Constraint Continuum



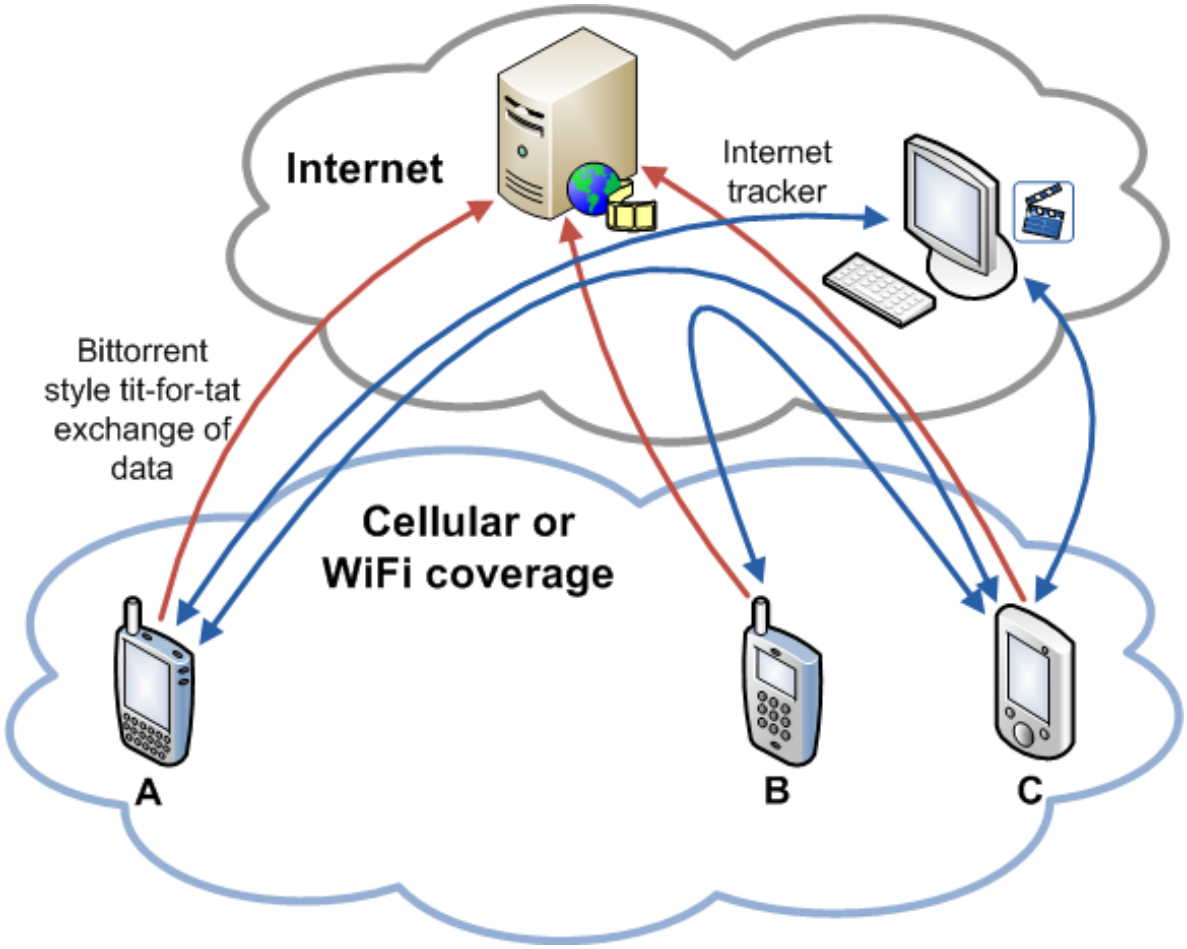
The Mobile Application Space

- Existing applications
  - Non-networked
  - Client-server
  - Peer-to-peer
  - Point-to-point
- Hybrid

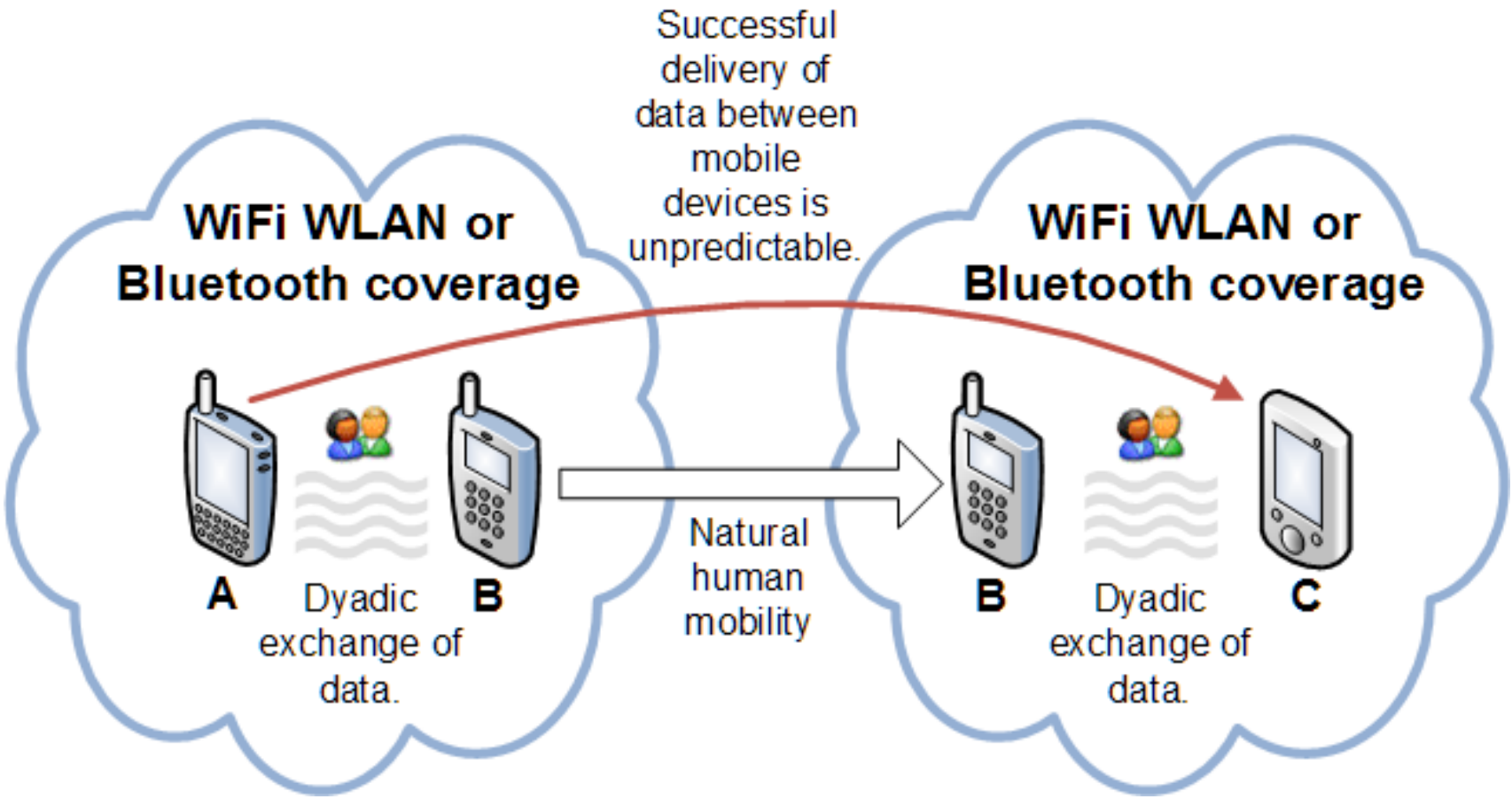
Client-Server



Peer-to-peer


Internet
Internet tracker
Bittorrent style tit-for-tat exchange of data
Cellular or WiFi coverage
A
B
C

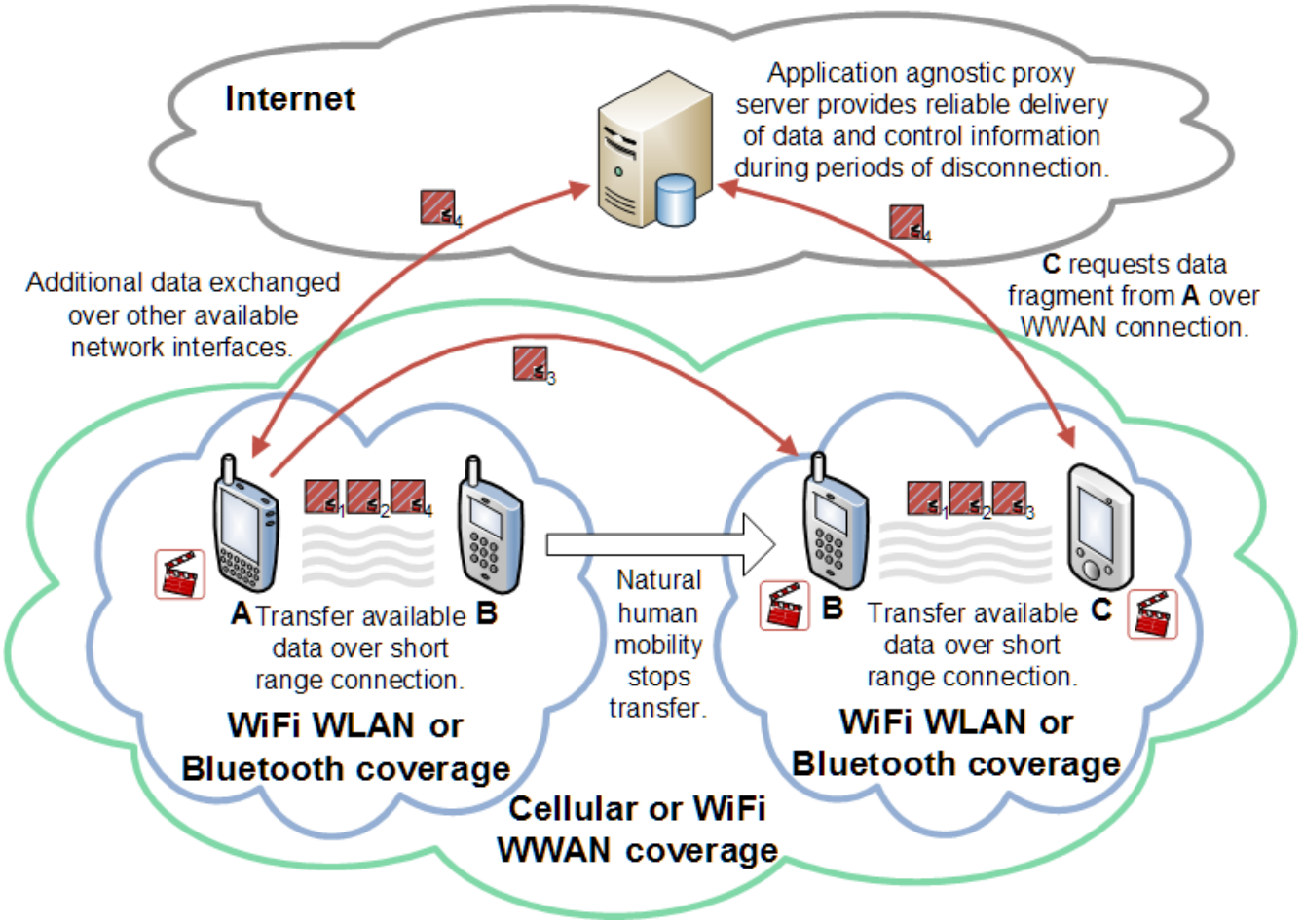
Point-to-point



The Next Frontier

- 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.

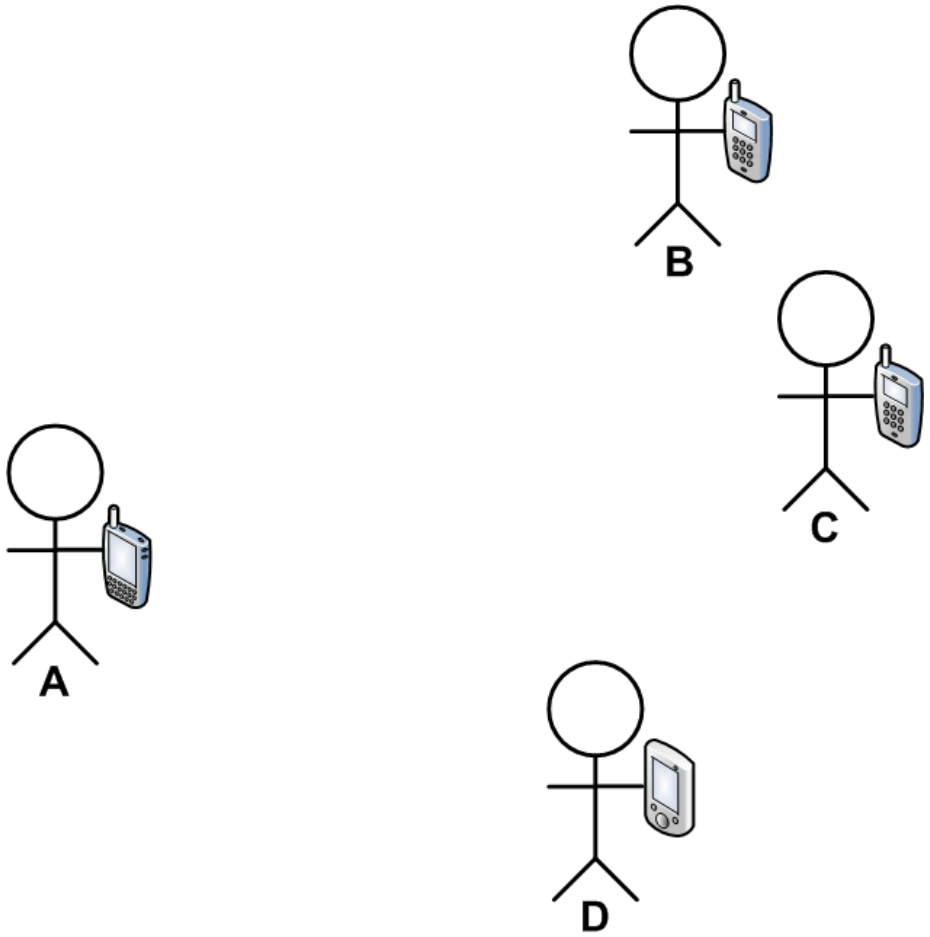
The Next Frontier (overview)

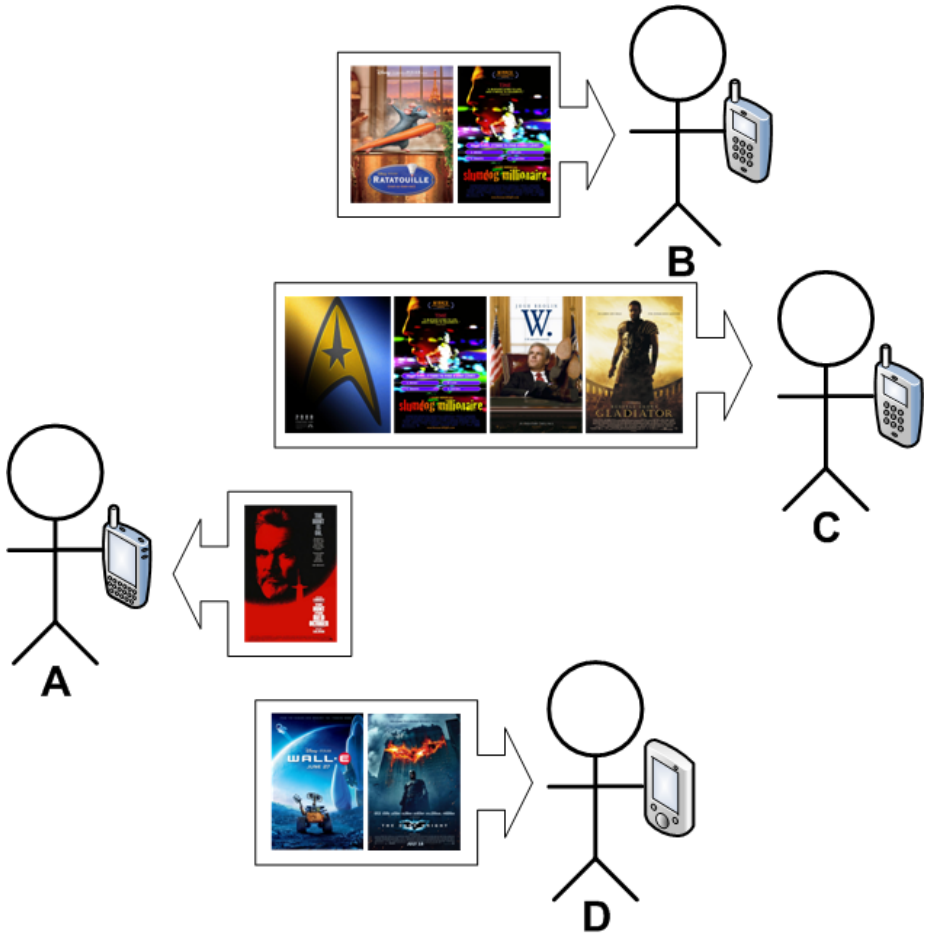


Example applications

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

MyTube

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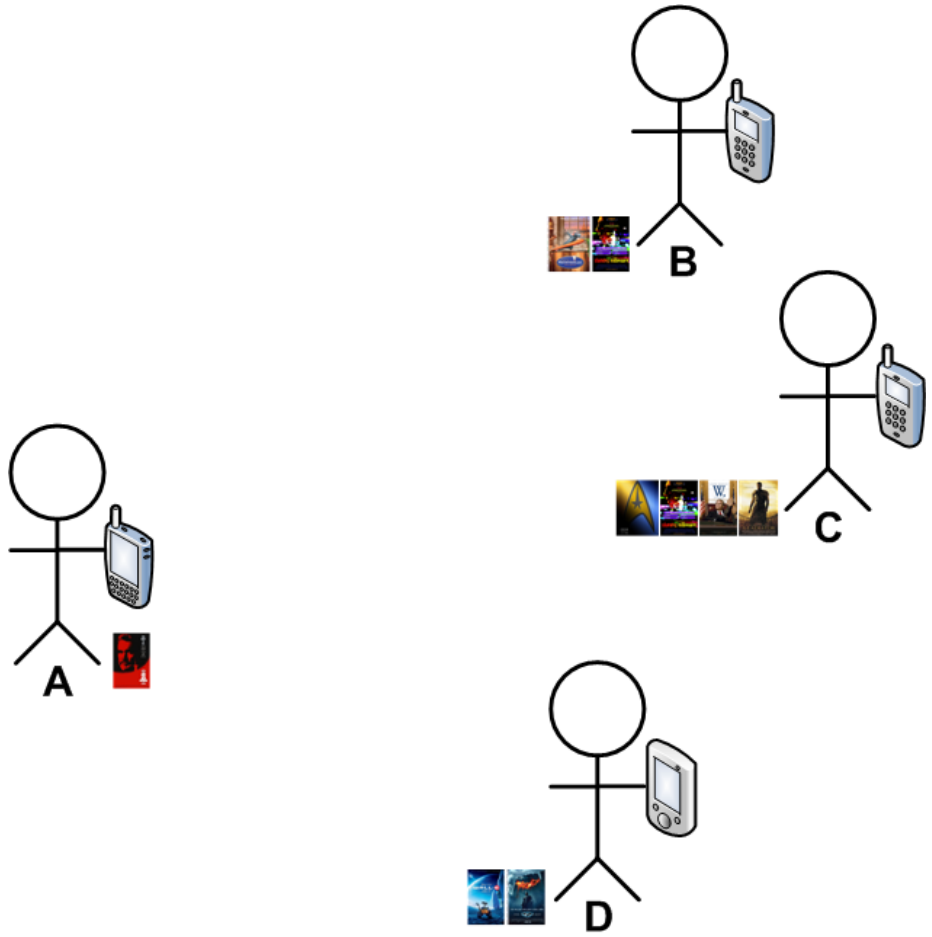
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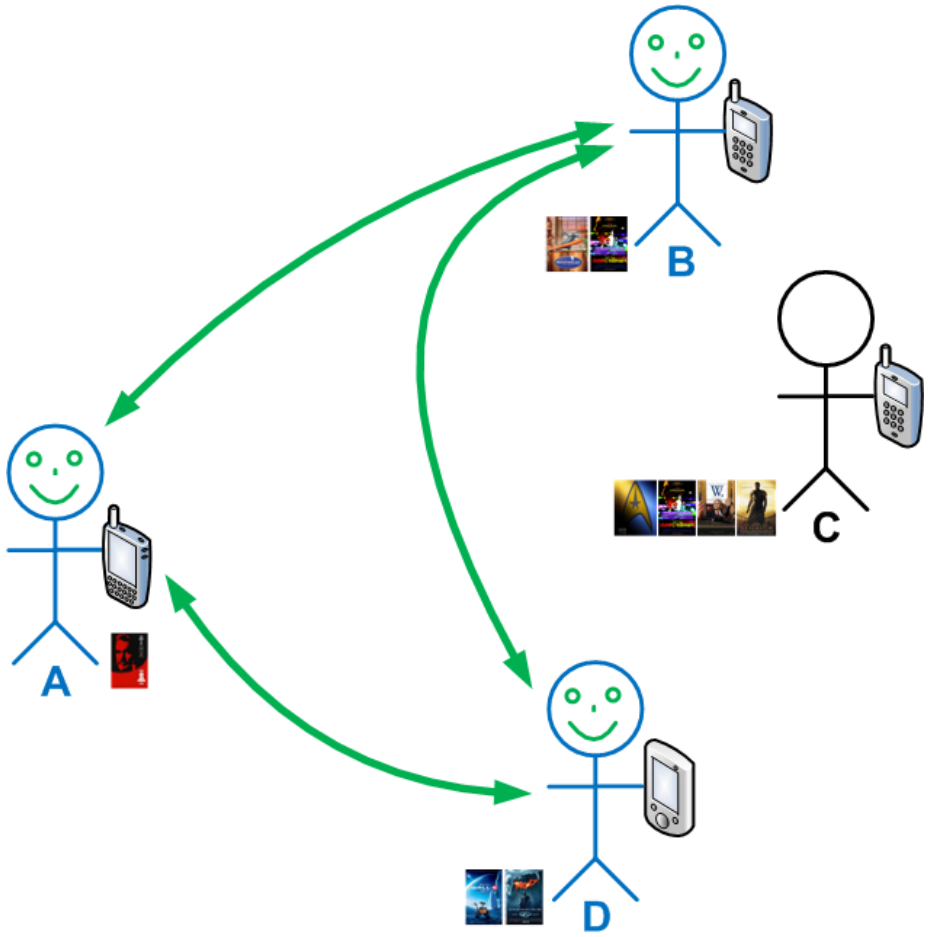
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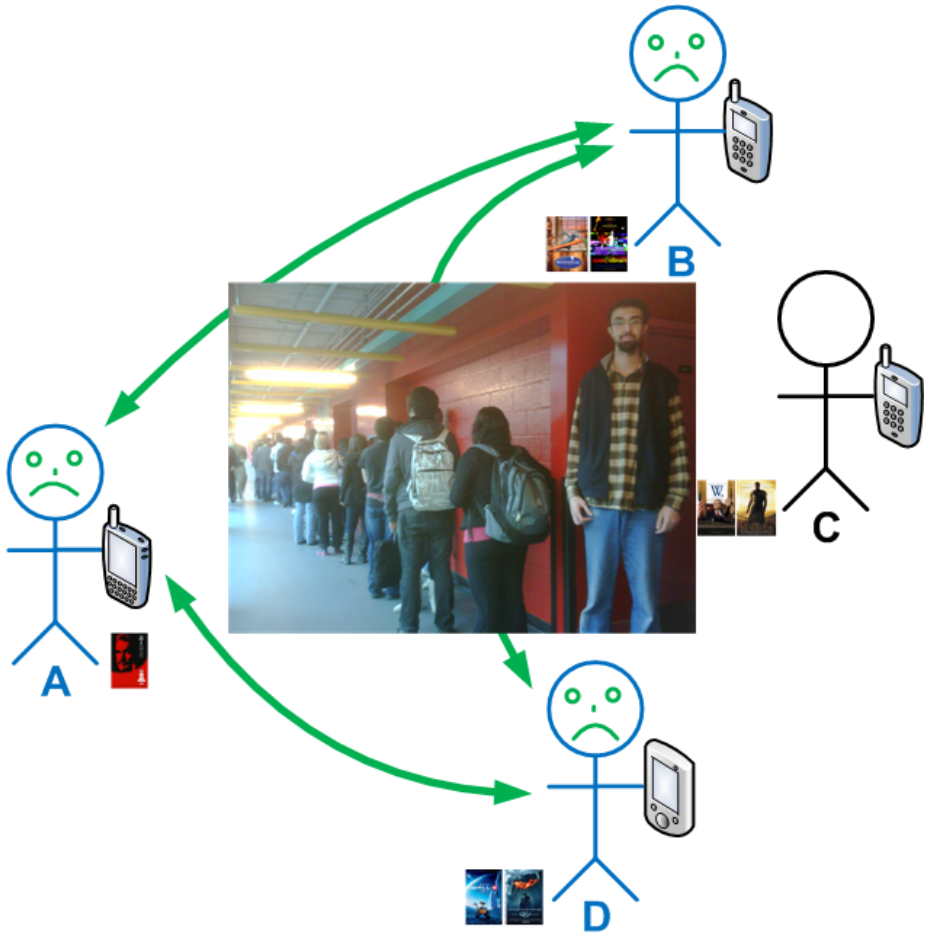
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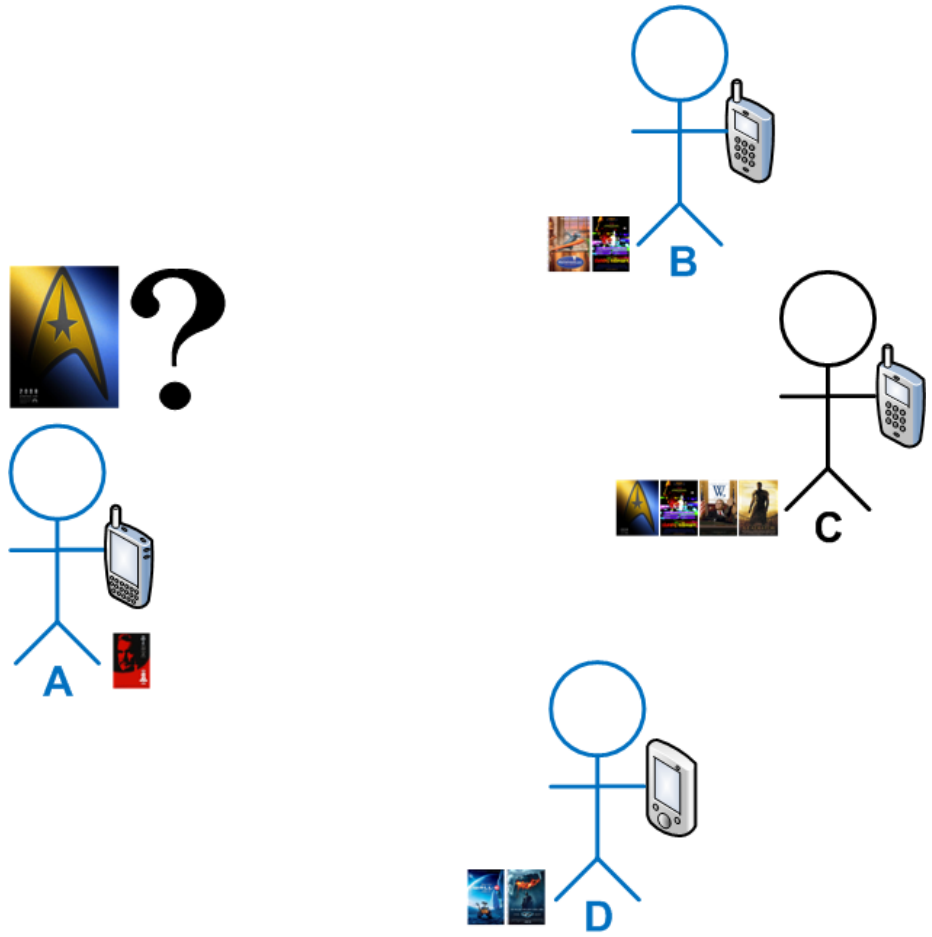
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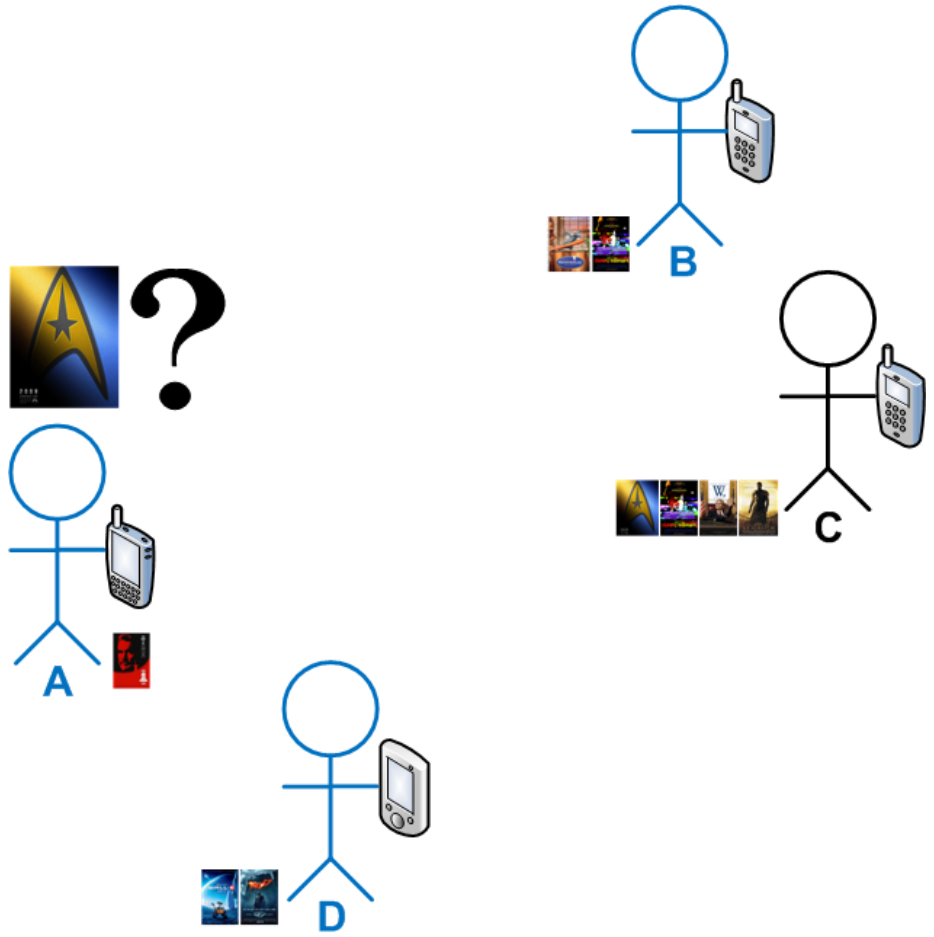
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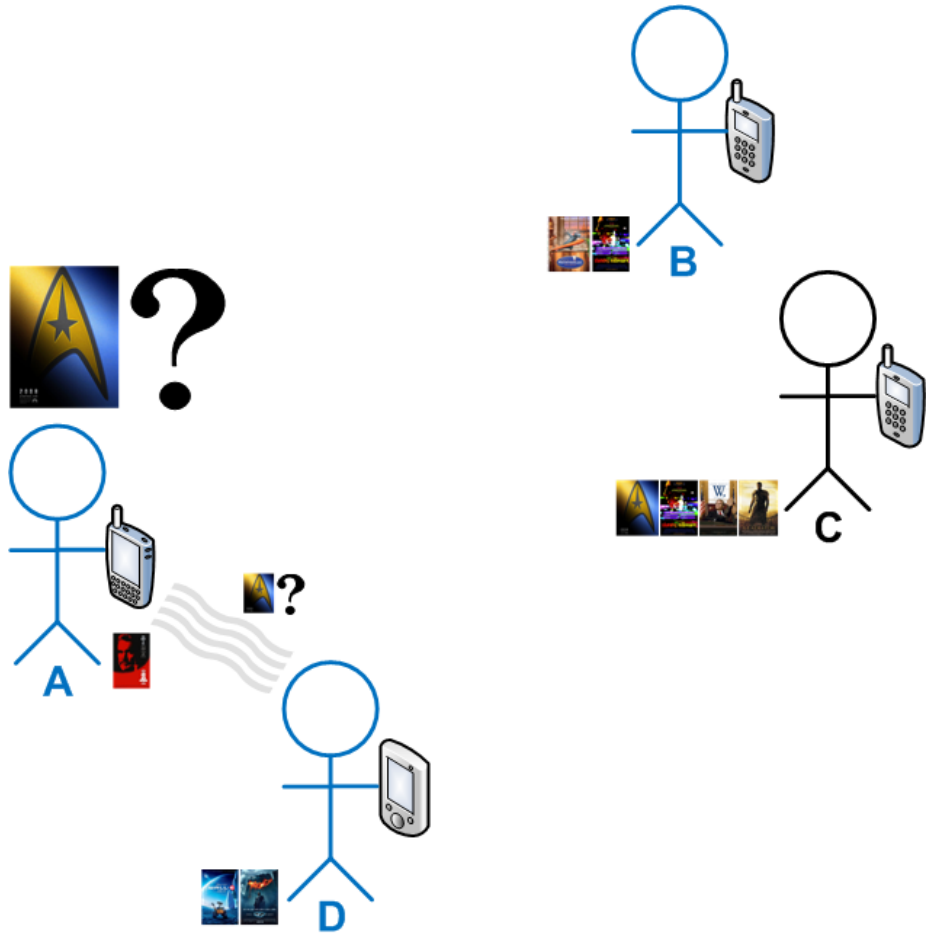
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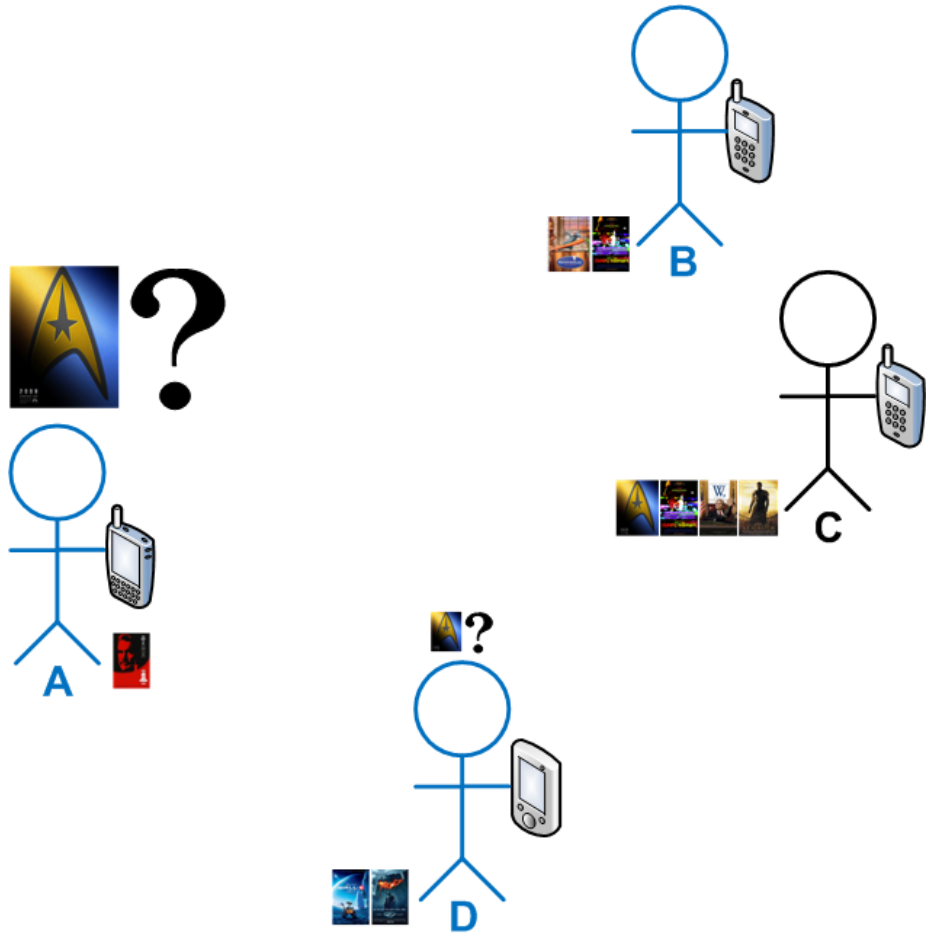
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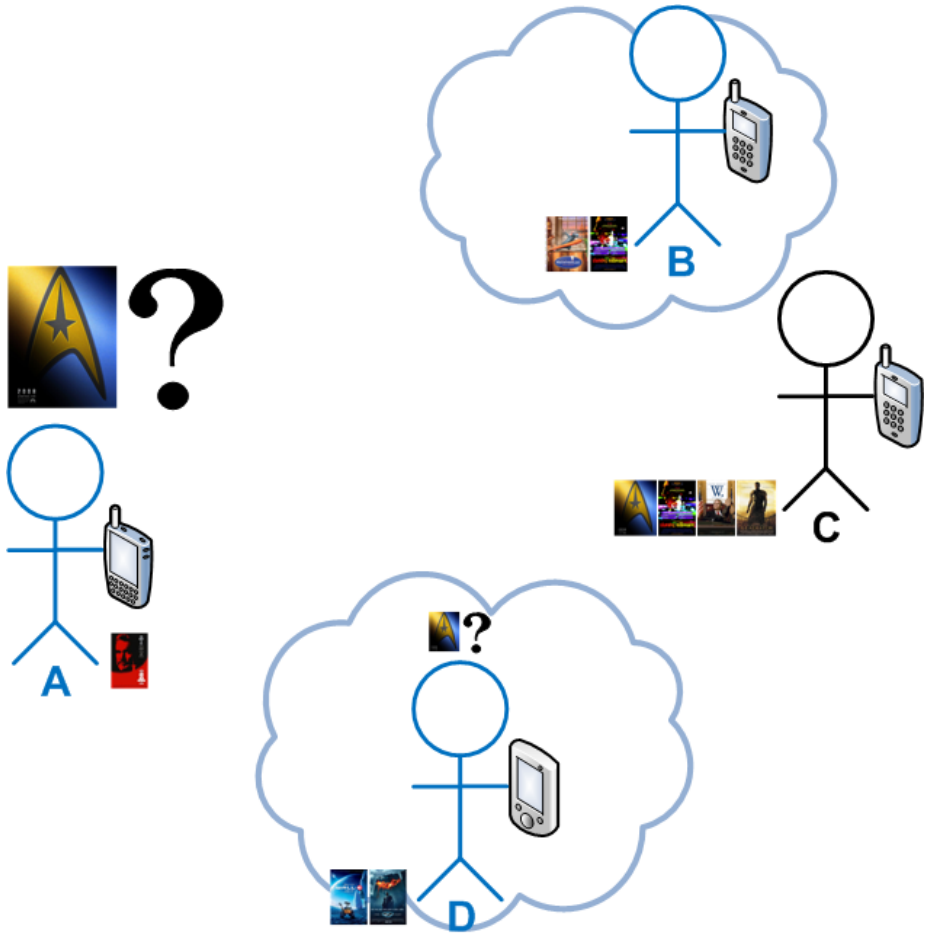
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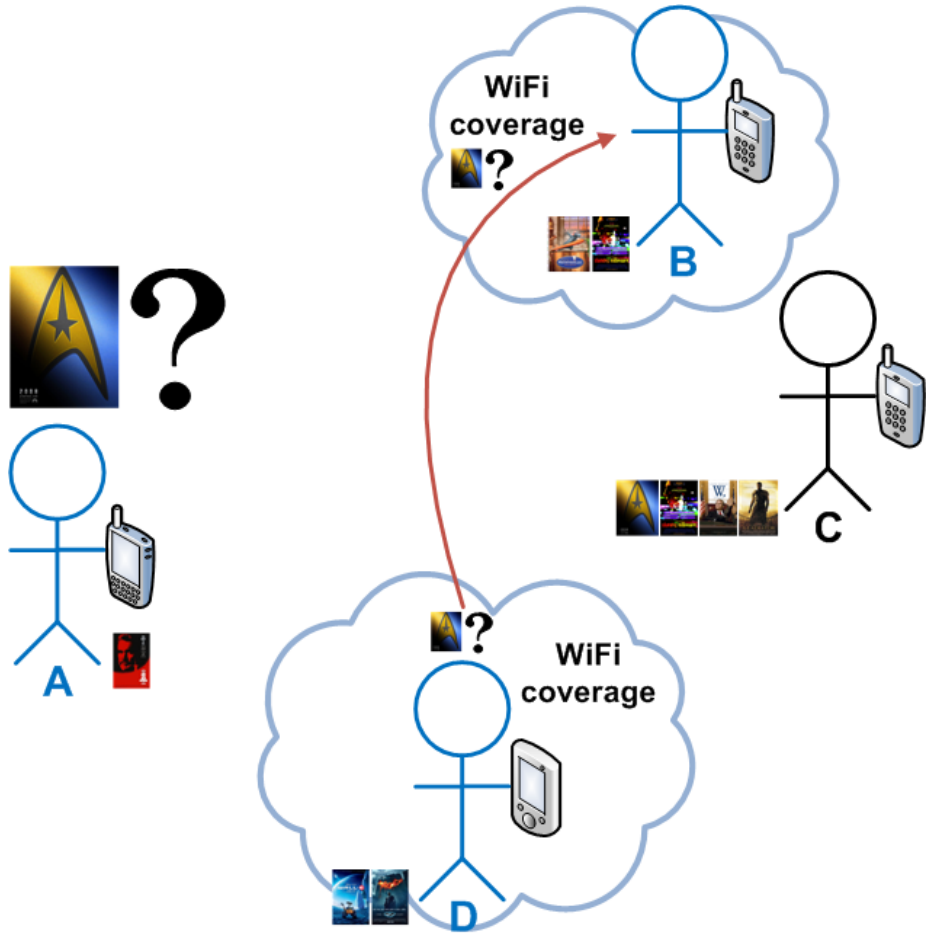
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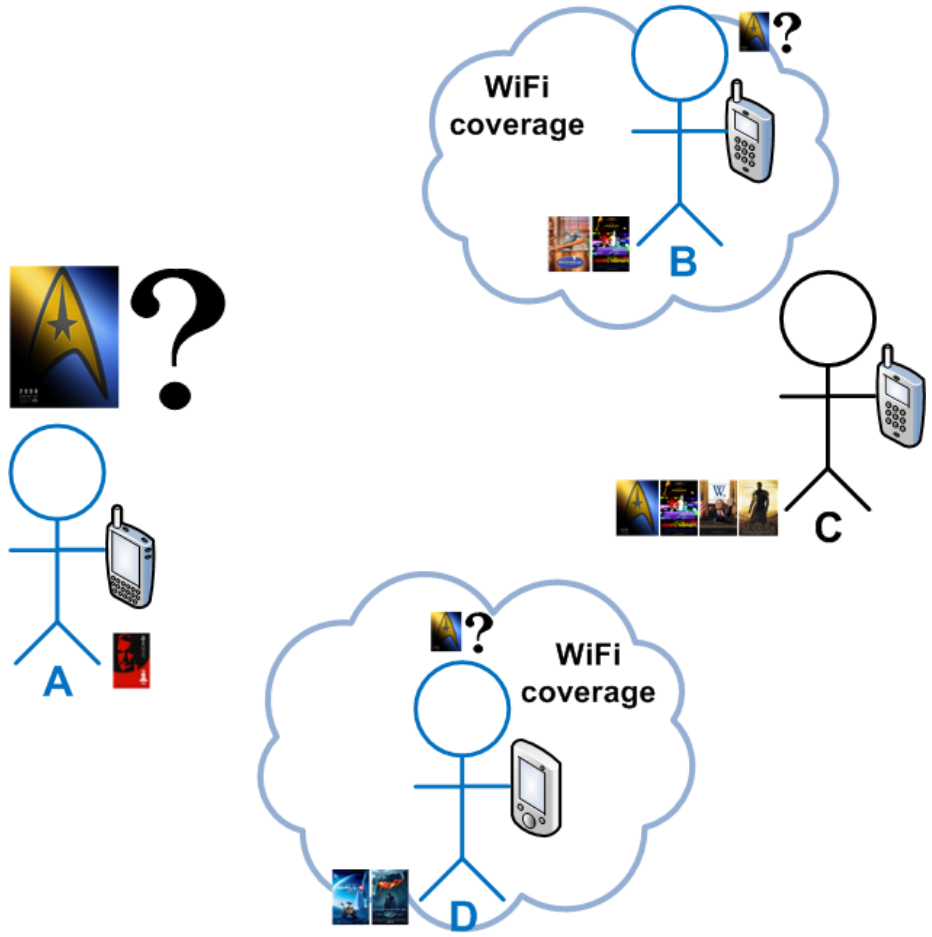
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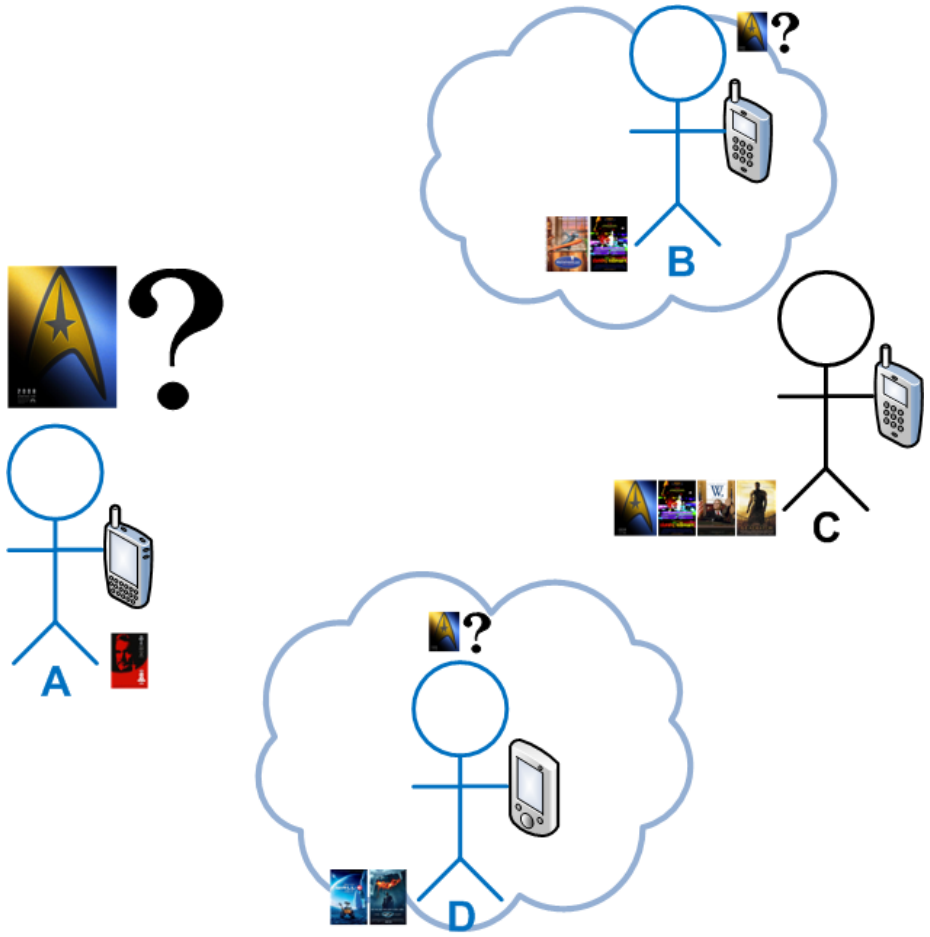
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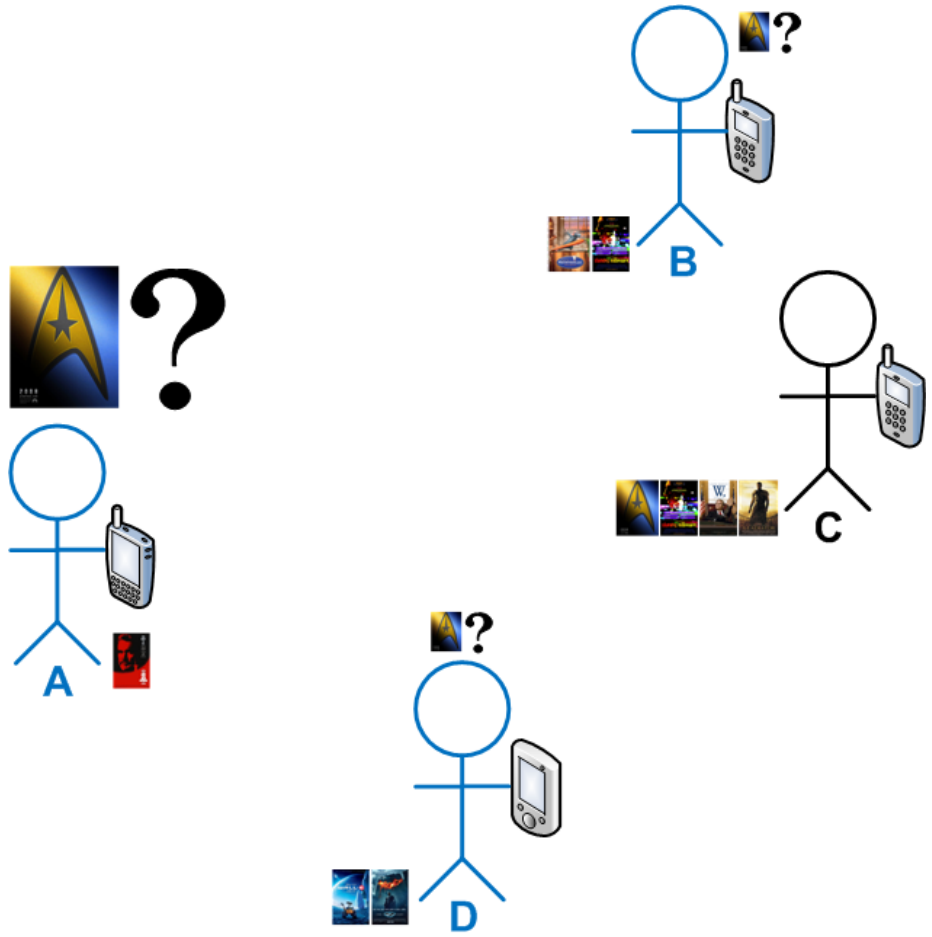
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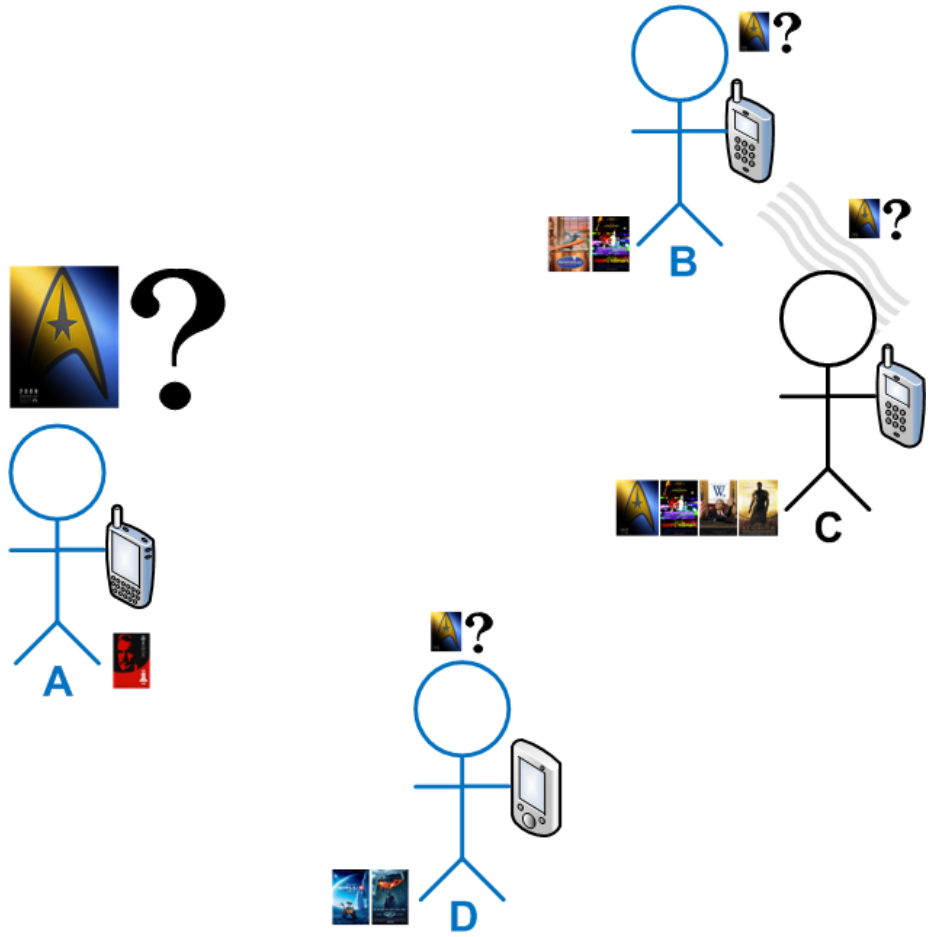
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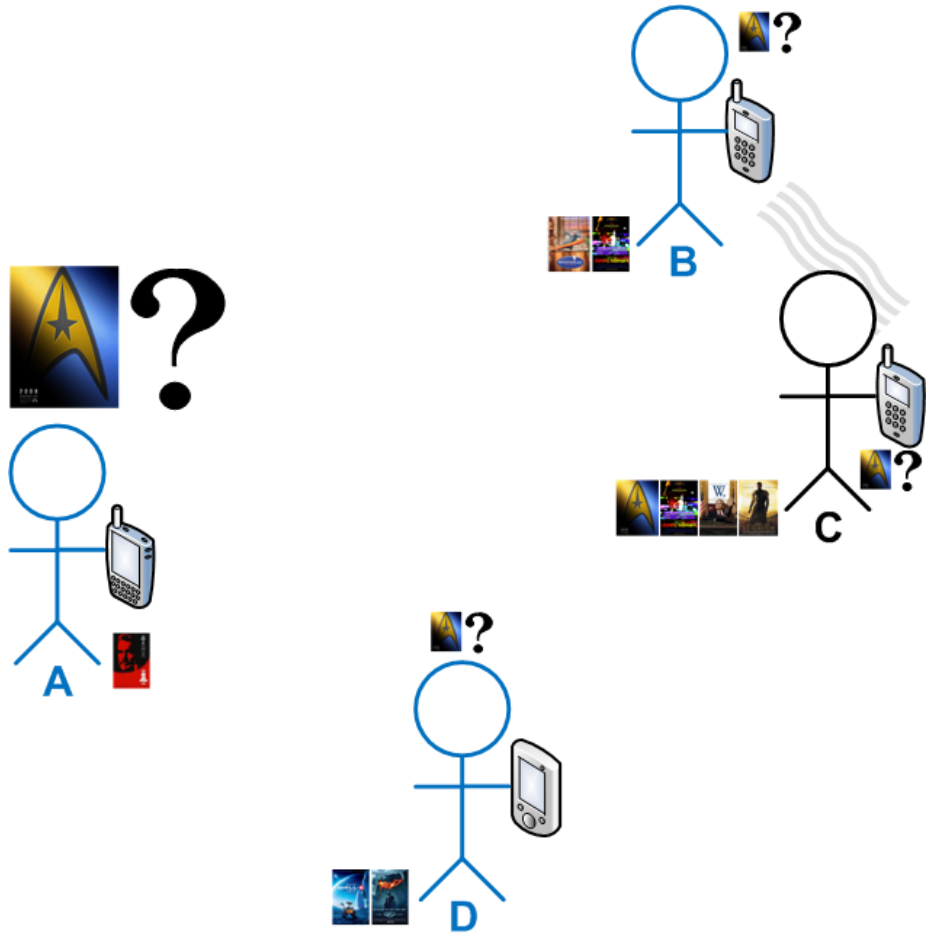
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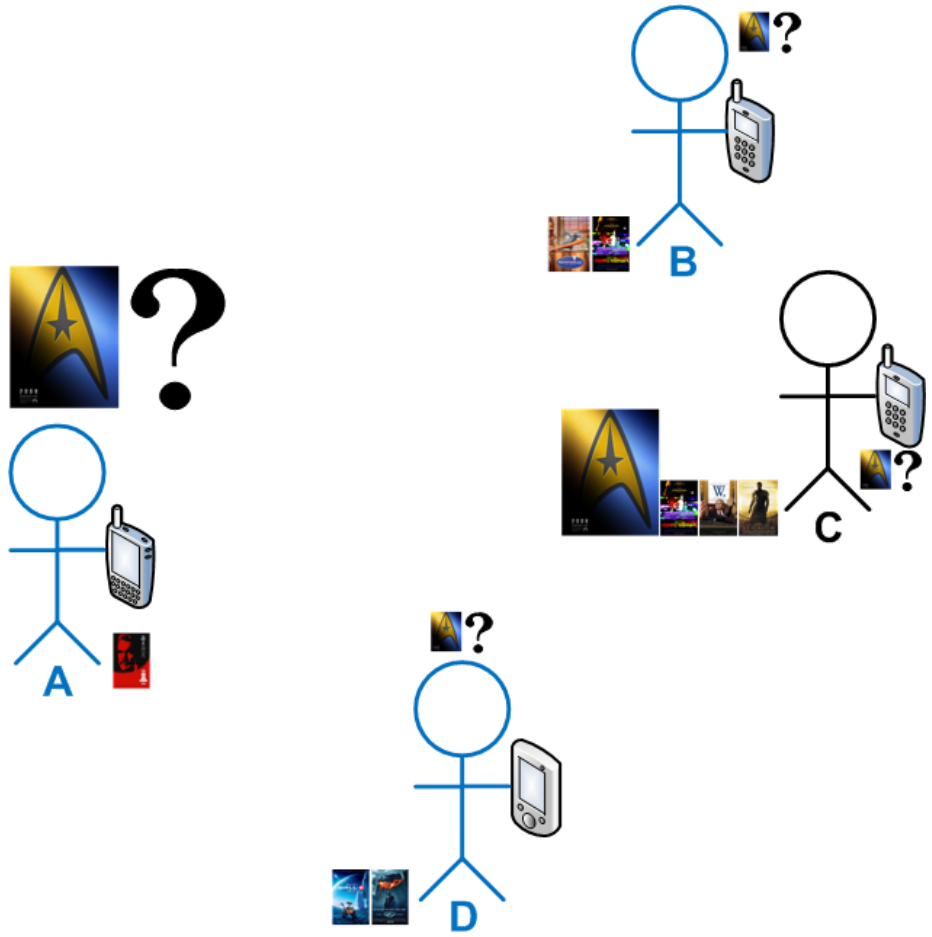
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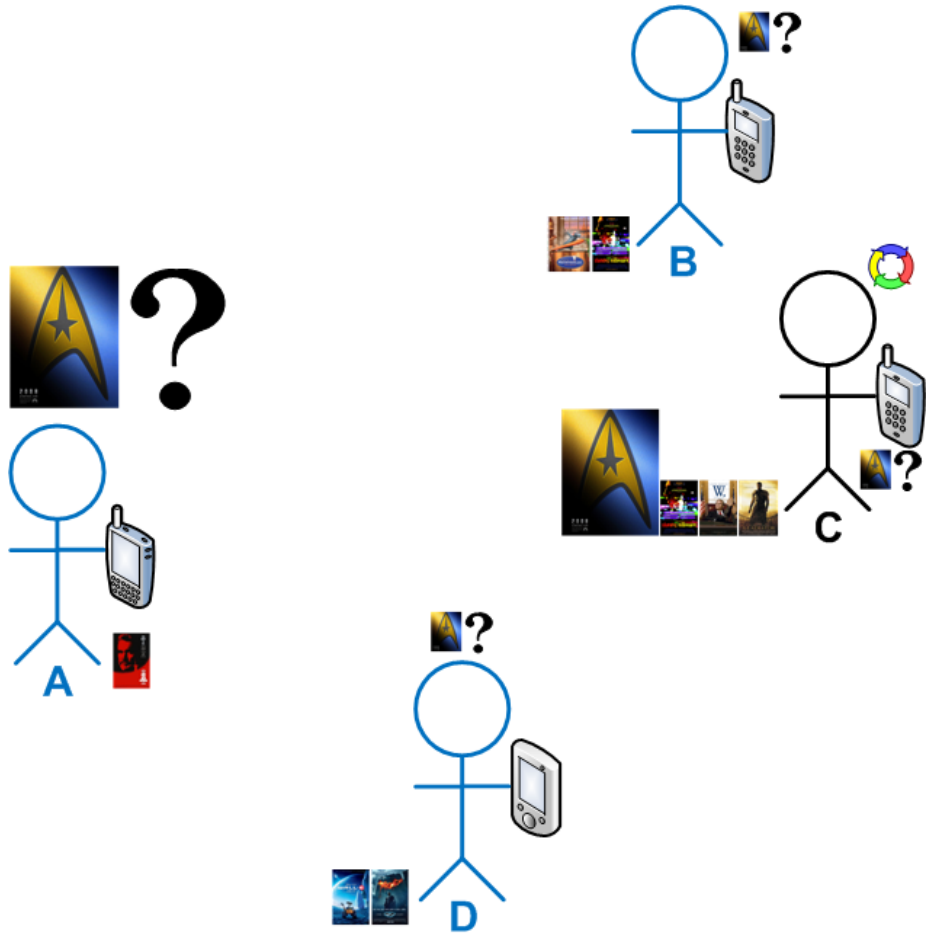
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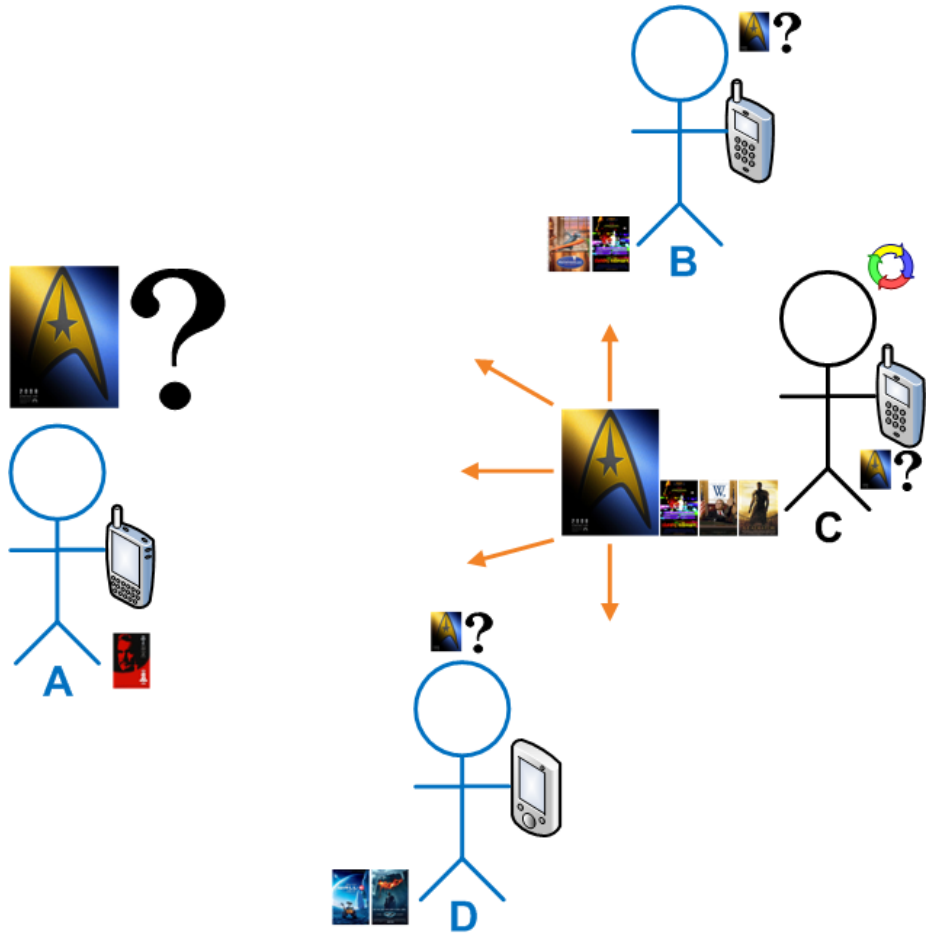
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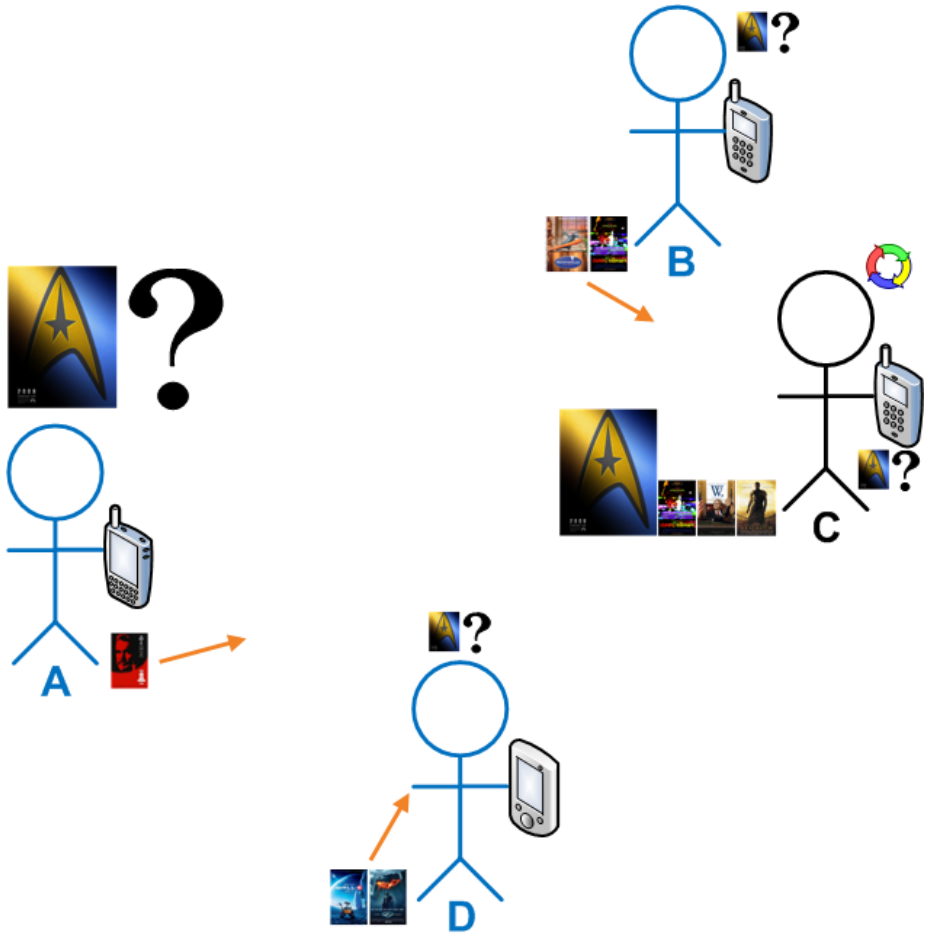
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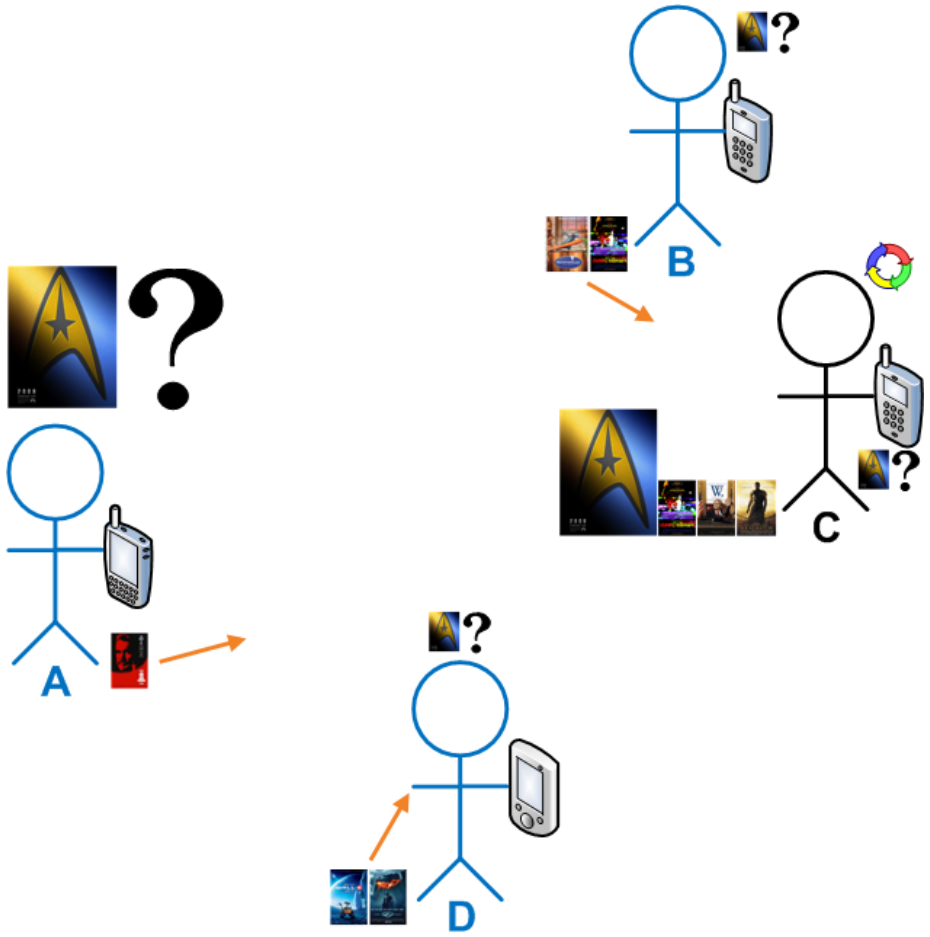
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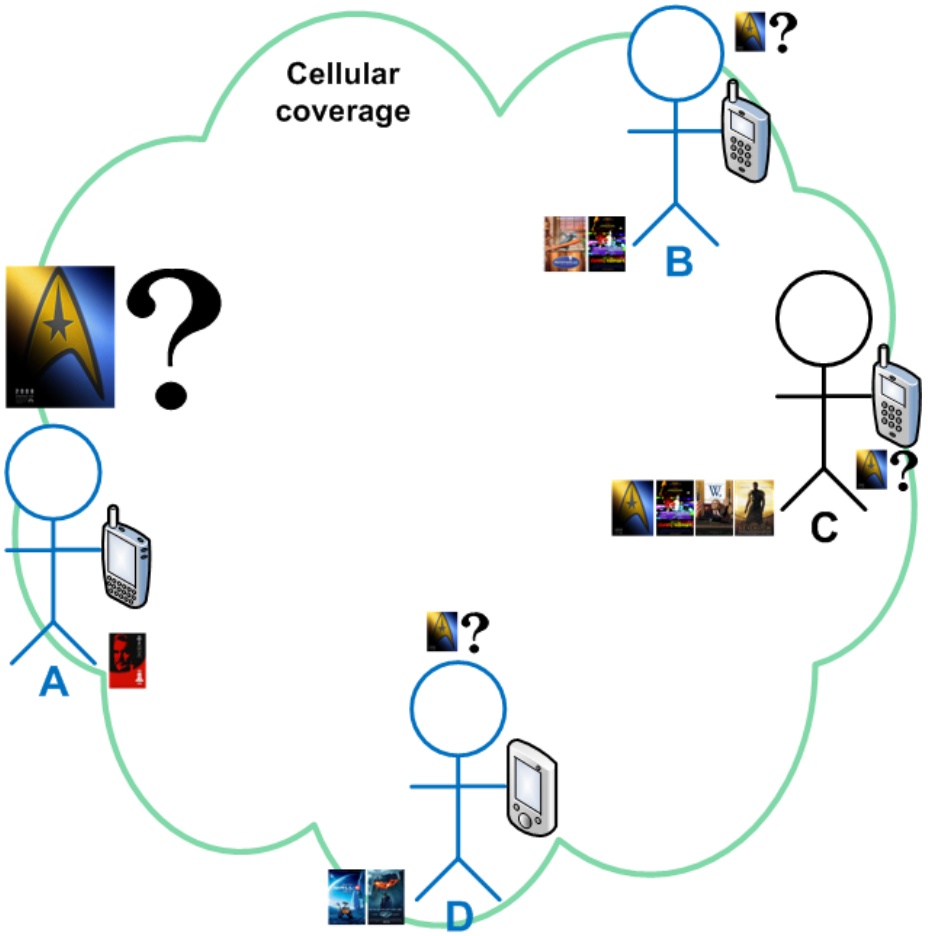
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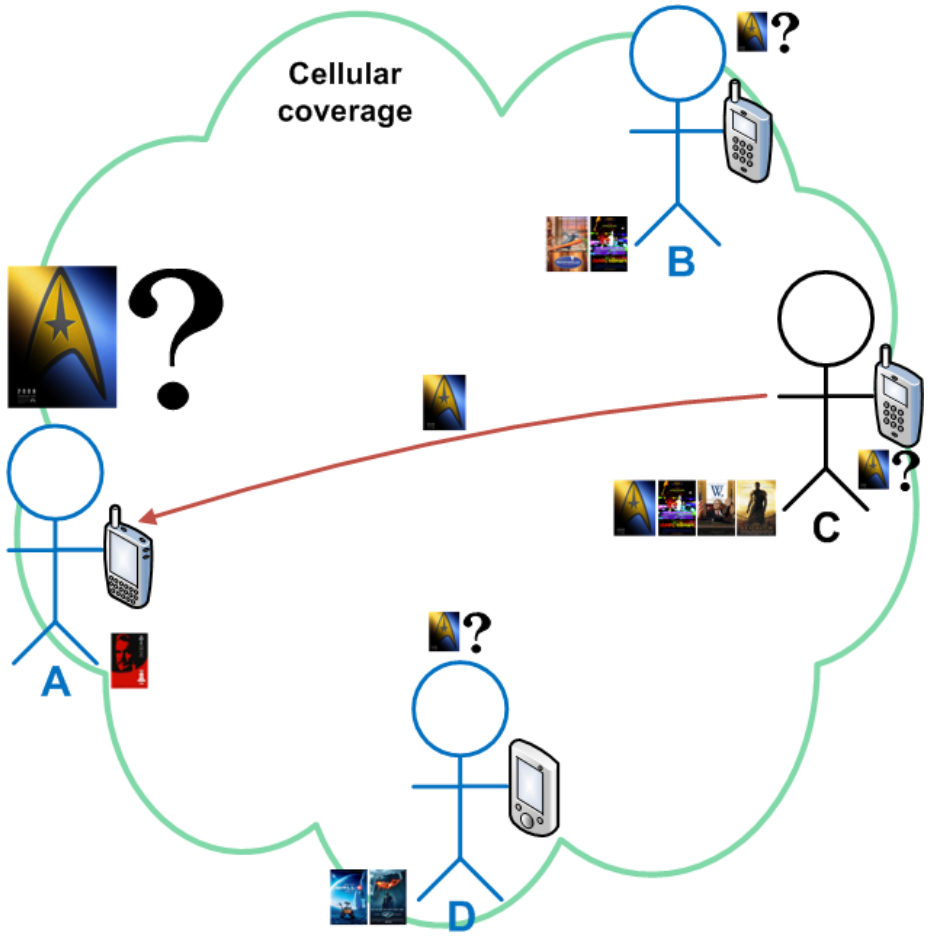
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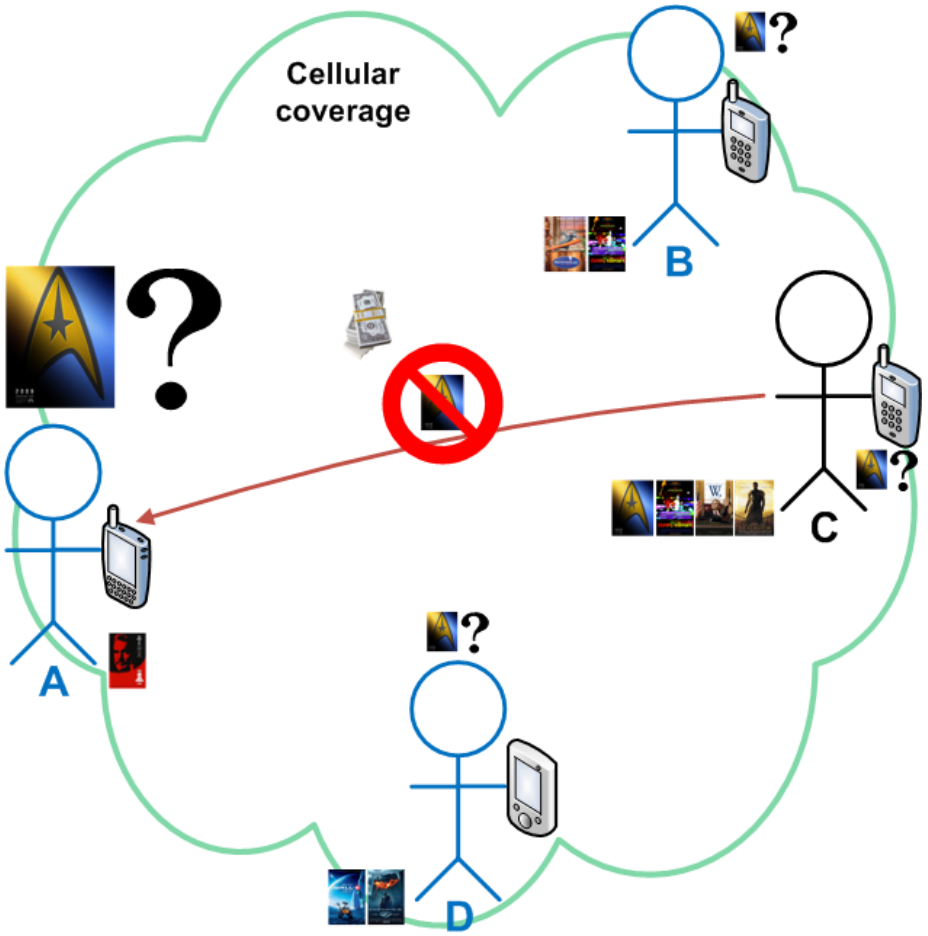
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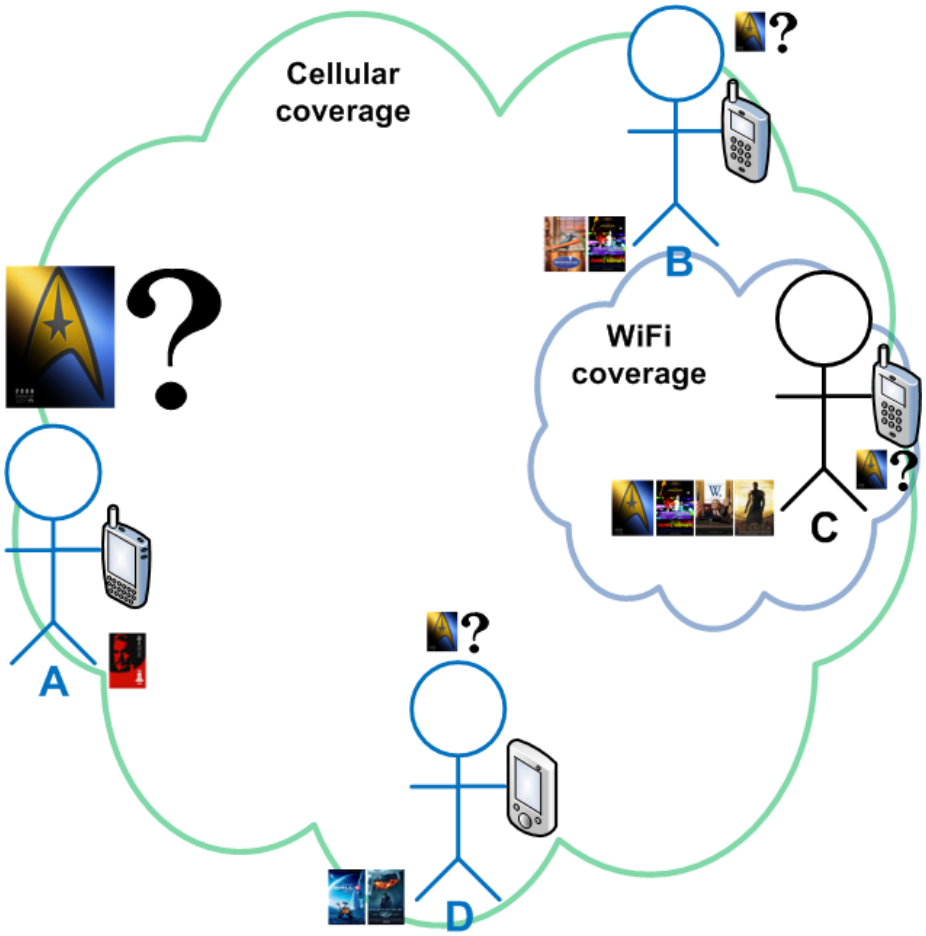
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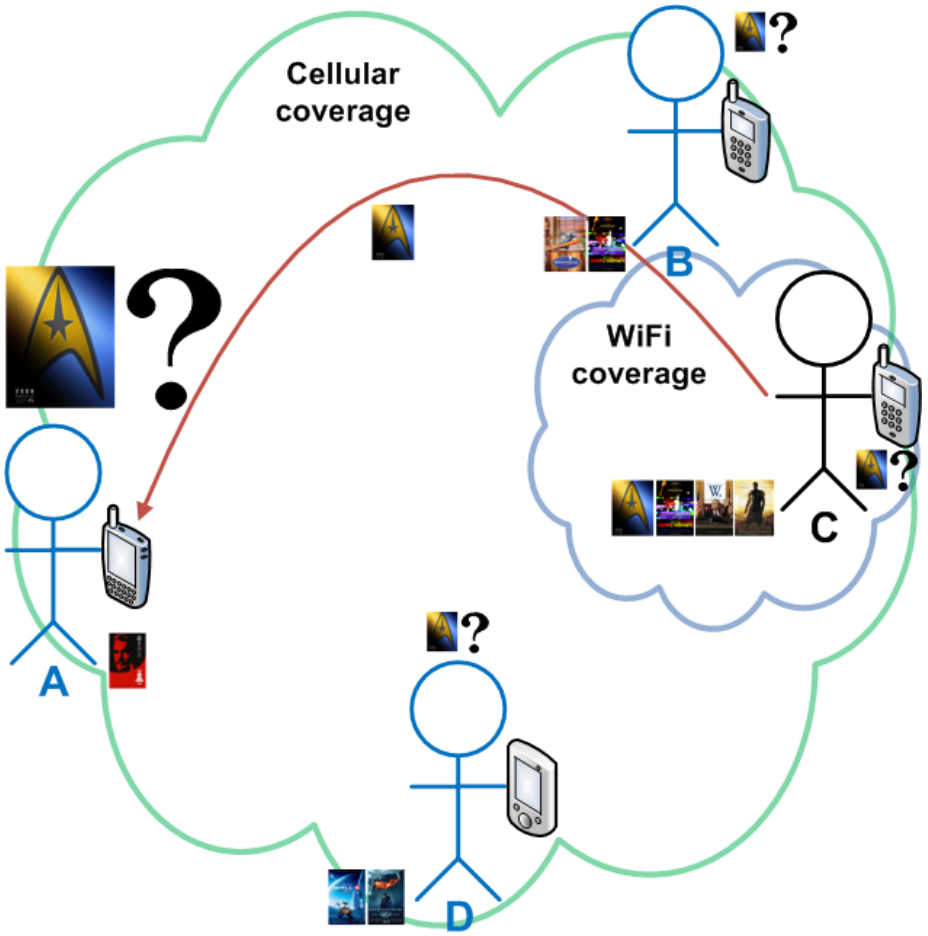
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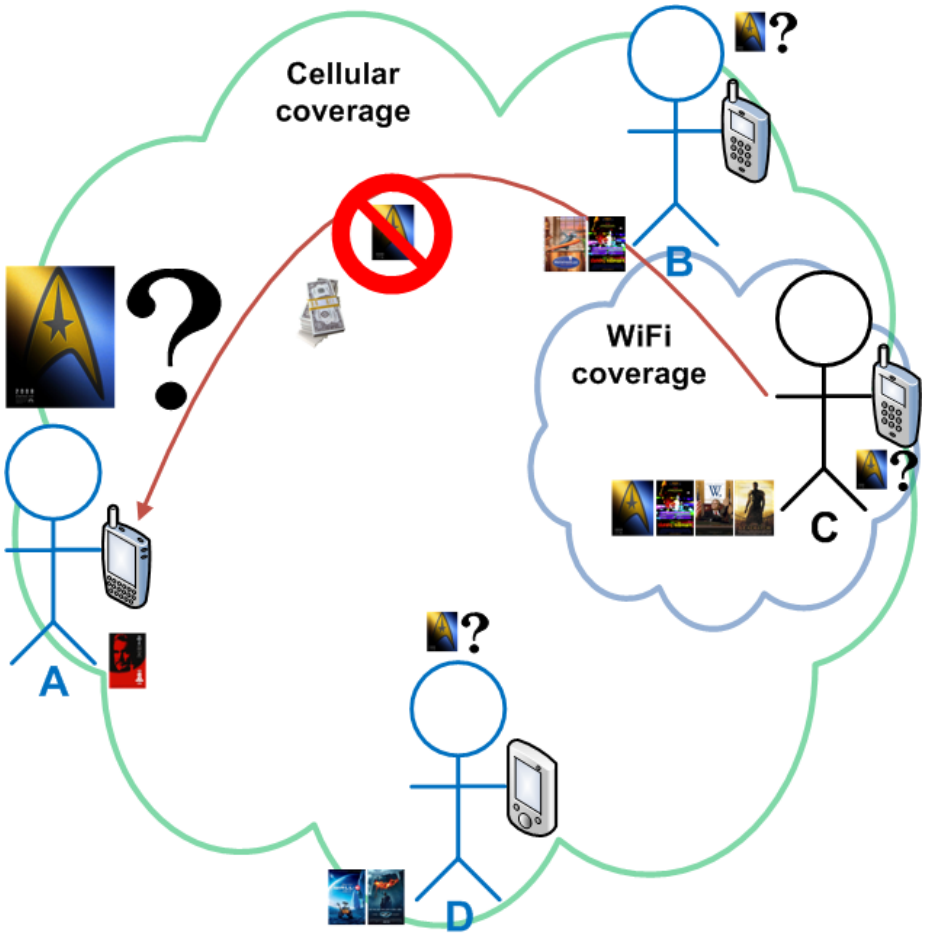
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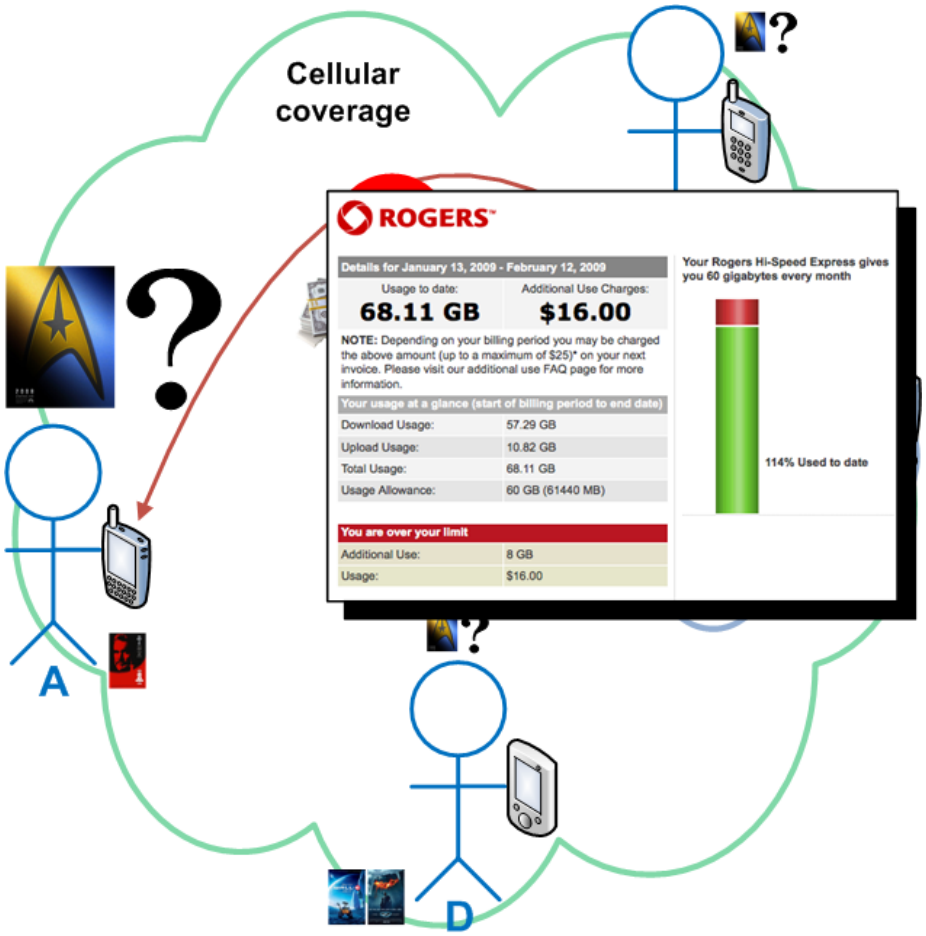
Cellular coverage
ROGERS
Details for January 13, 2009 - February 12, 2009
Usage to date:
68.11 GB
Additional Use Charges:
$16.00
NOTE: Depending on your billing period you may be charged the above amount (up to a maximum of $25)* on your next invoice. Please visit our additional use FAQ page for more information.
Your usage at a glance (start of billing period to end date)
Download Usage: 57.29 GB
Upload Usage: 10.82 GB
Total Usage: 68.11 GB
Usage Allowance: 60 GB (61440 MB)
You are over your limit
Additional Use: 8 GB
Usage: $16.00
Your Rogers Hi-Speed Express gives you 60 gigabytes every month
114% Used to date
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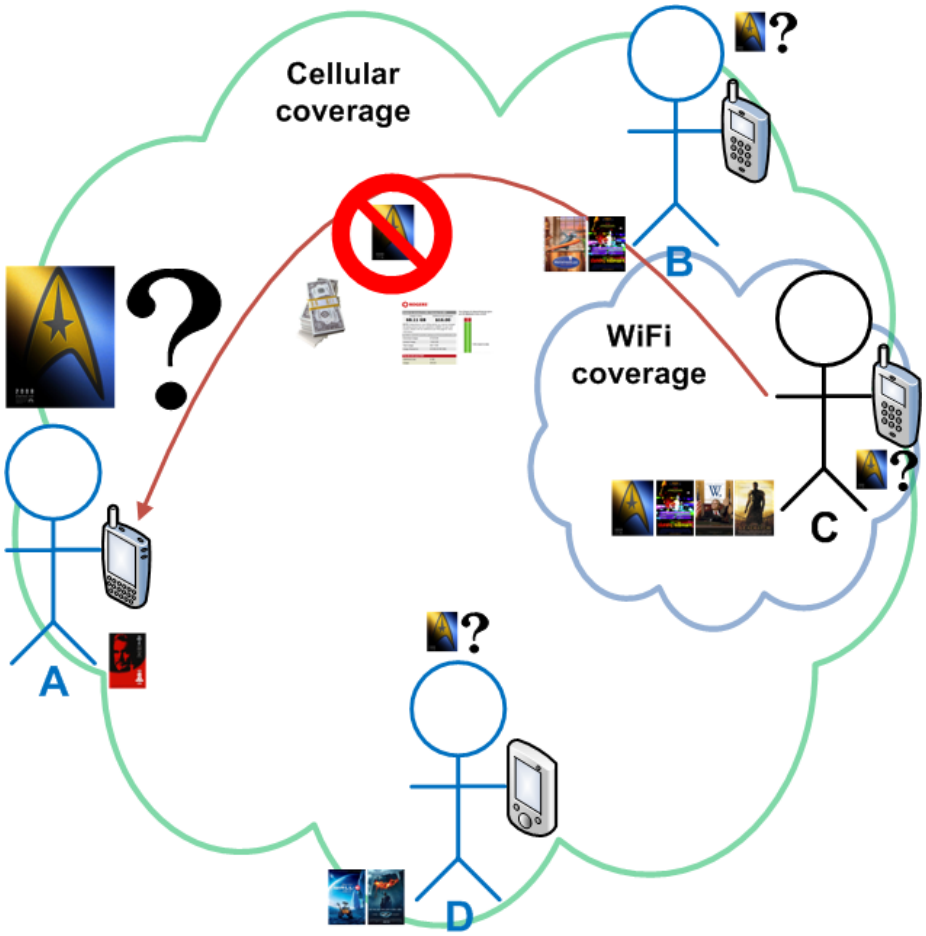
Cellular coverage
WiFi coverage
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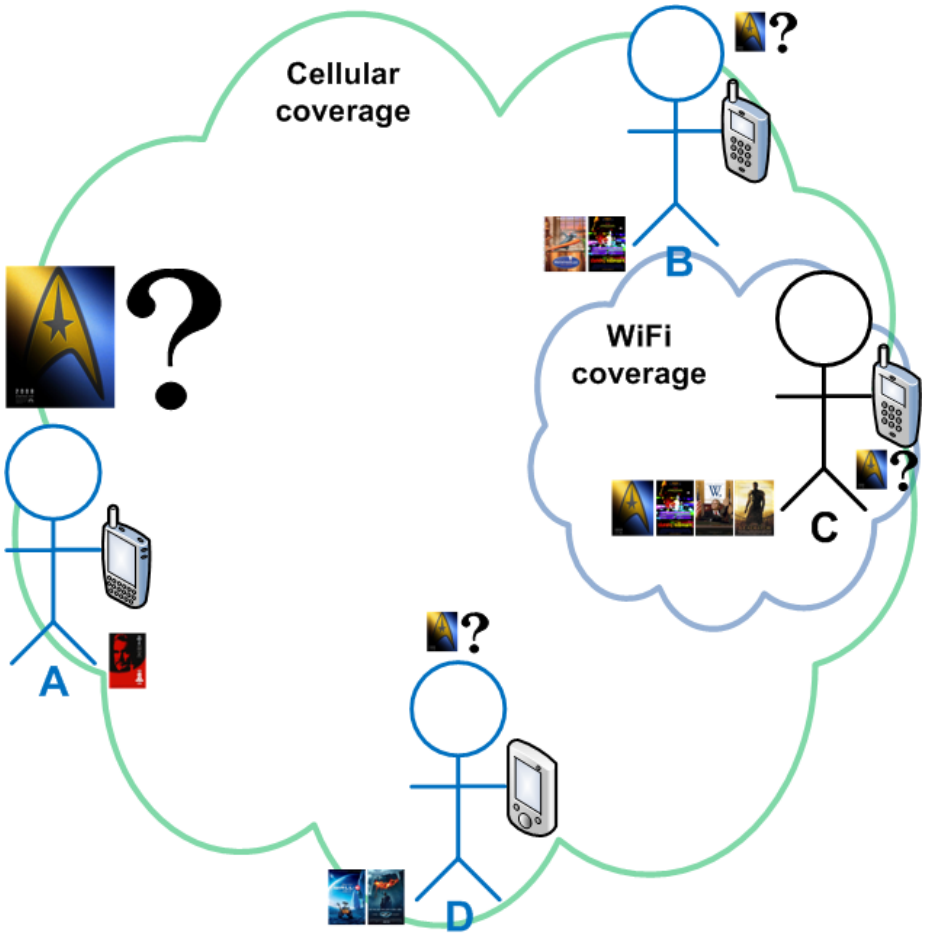
Cellular
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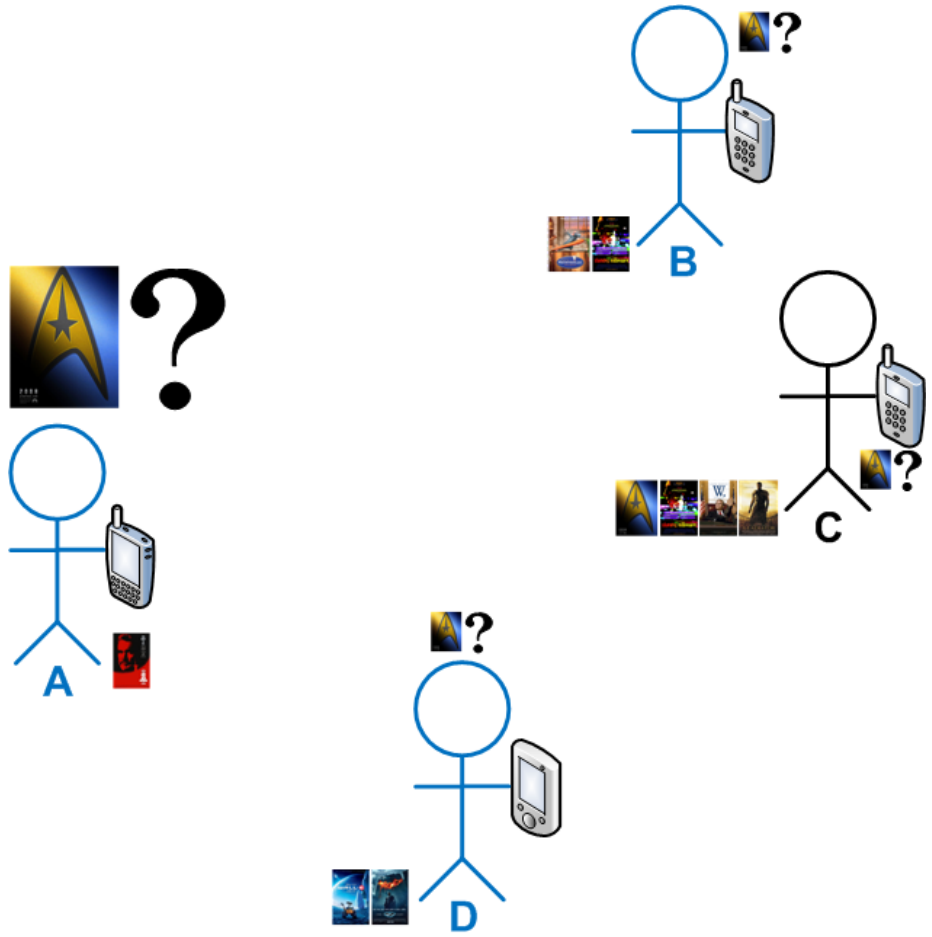
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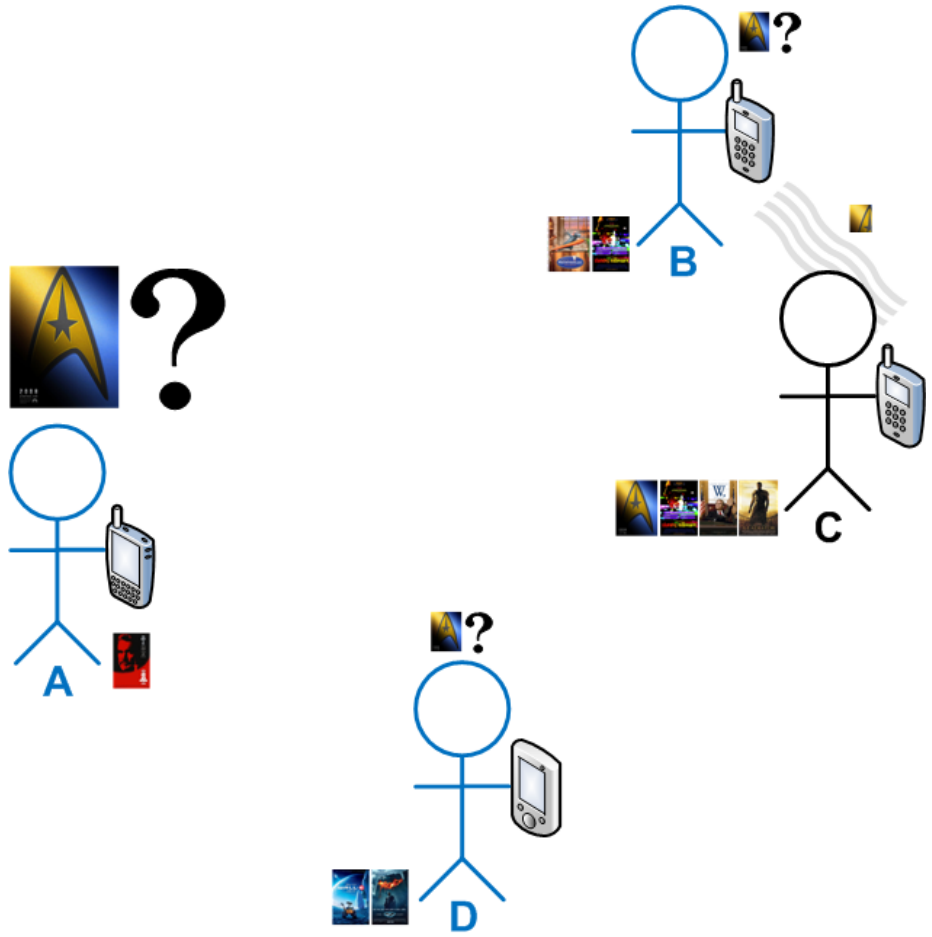
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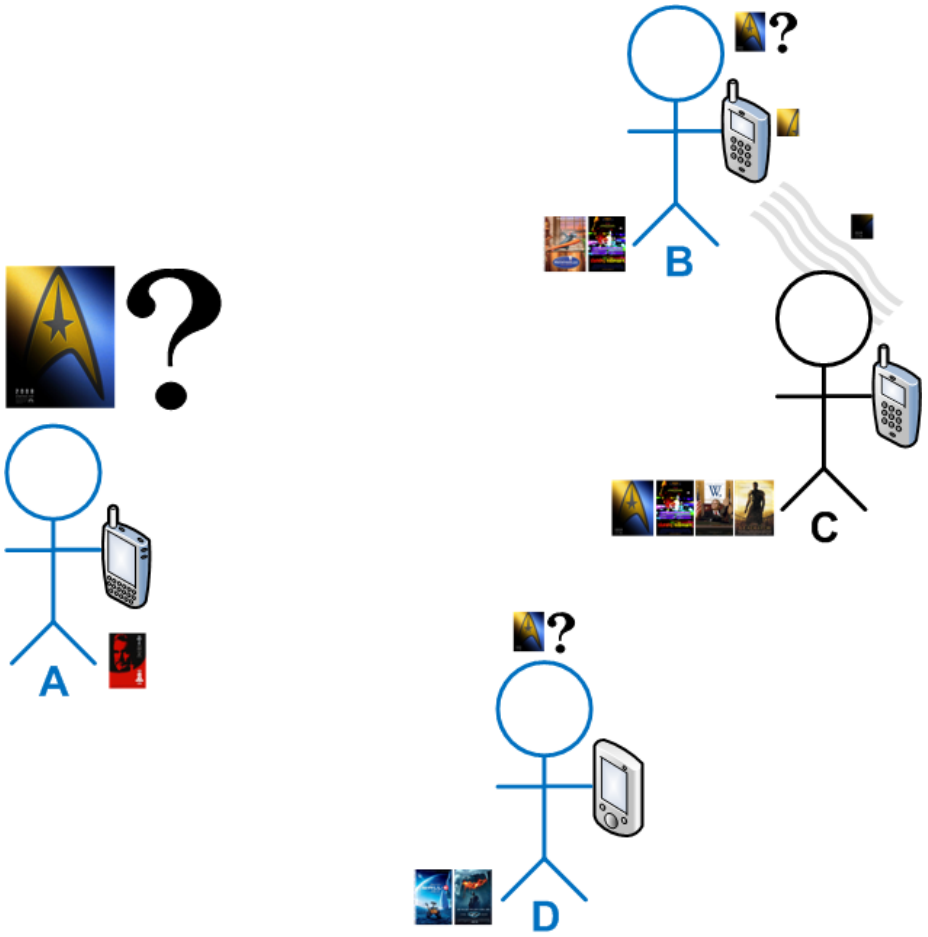
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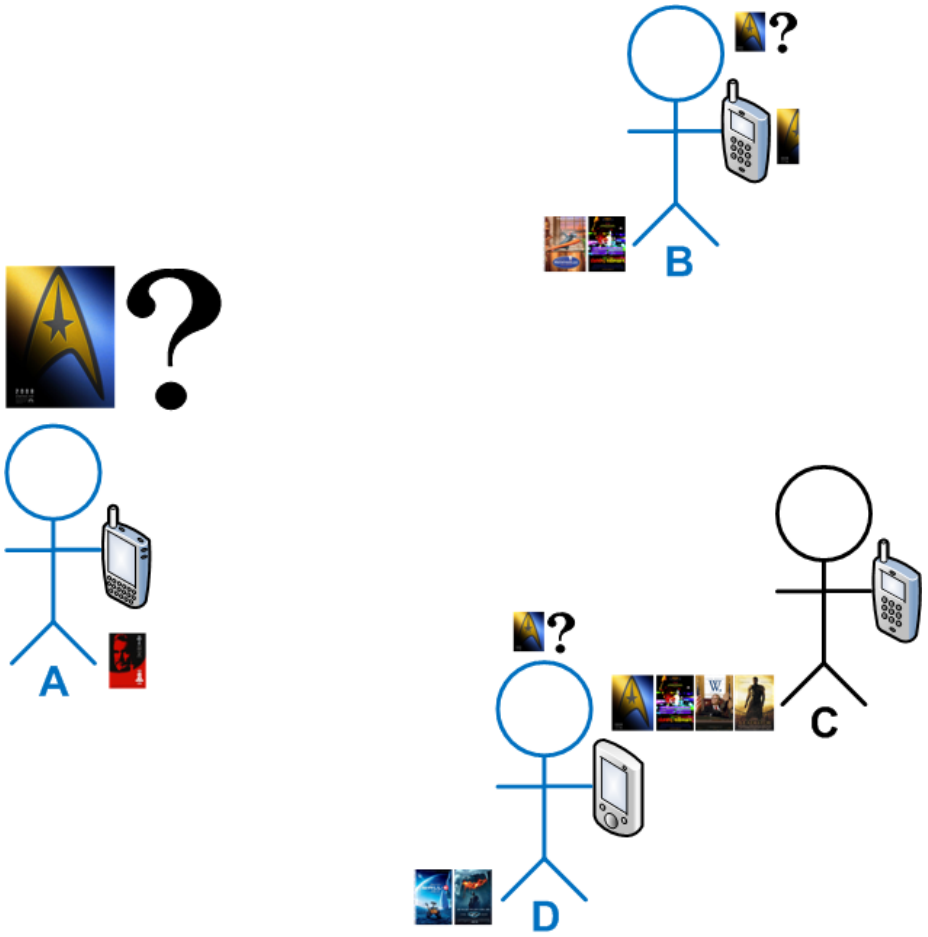
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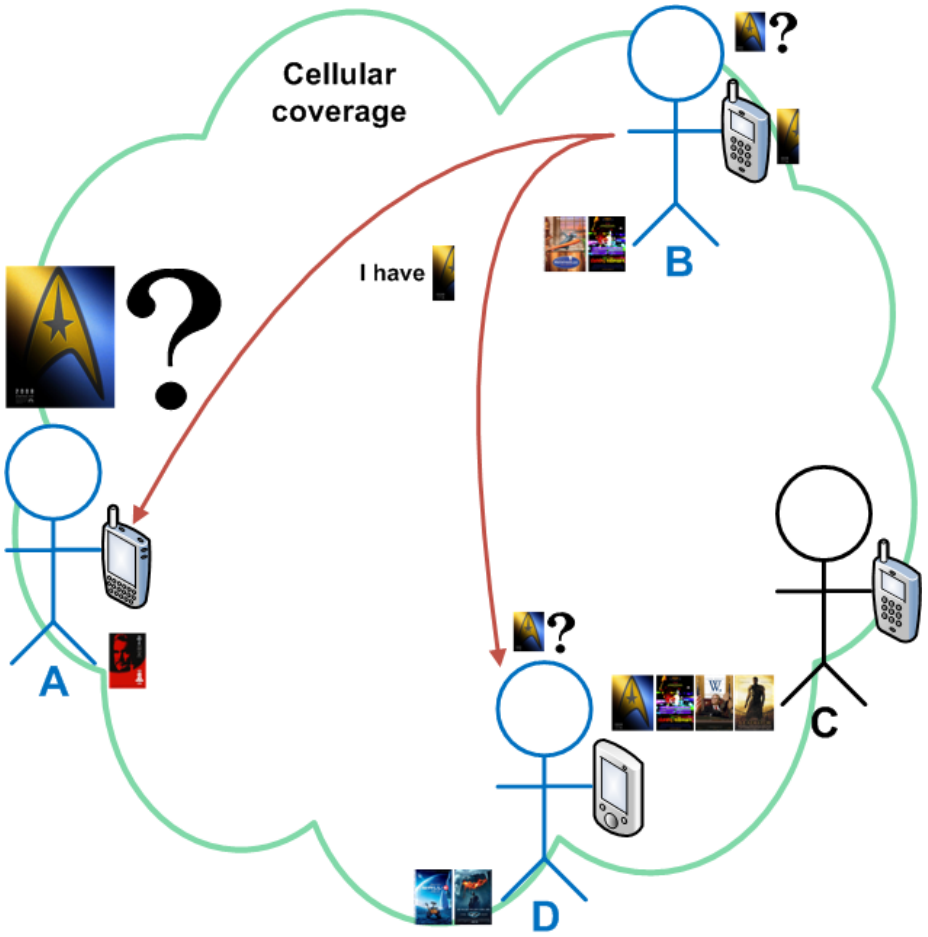
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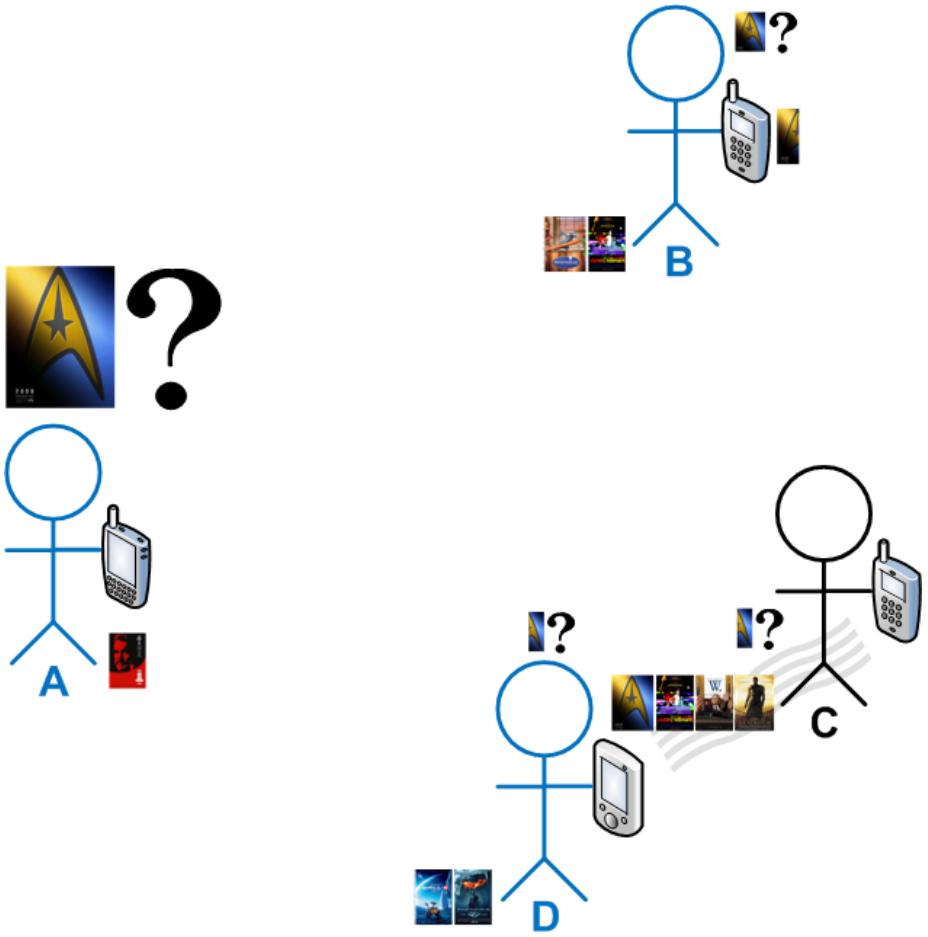
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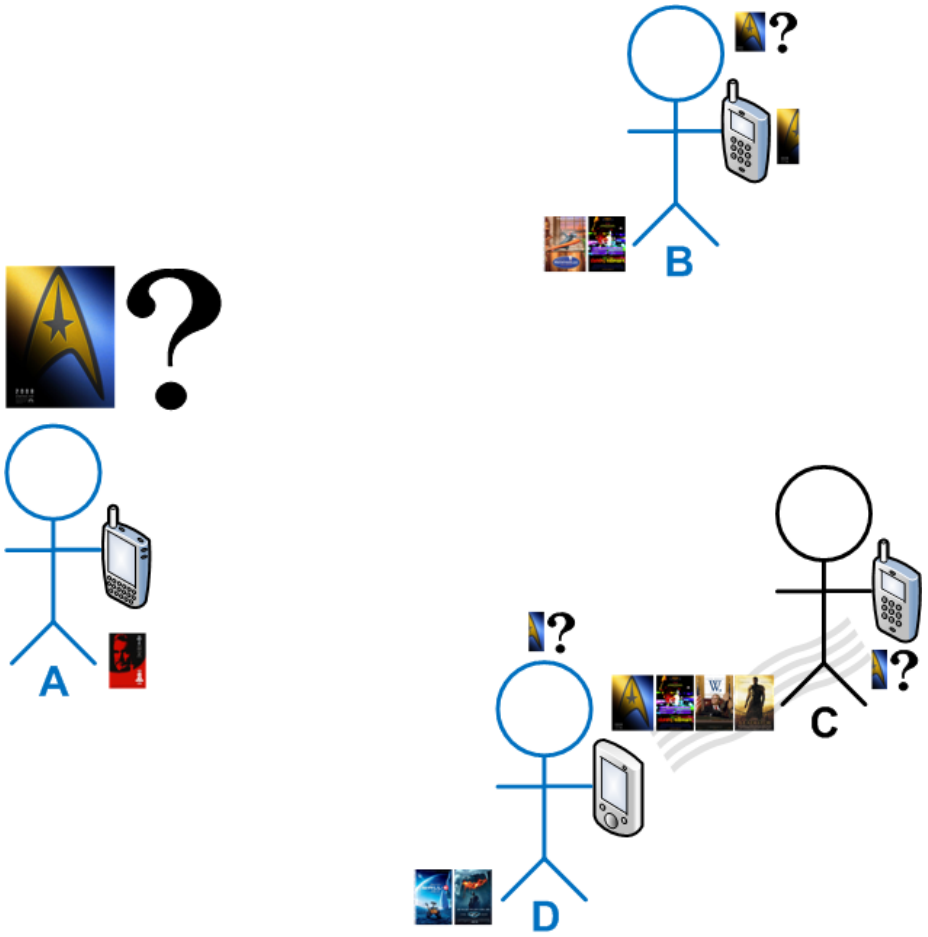
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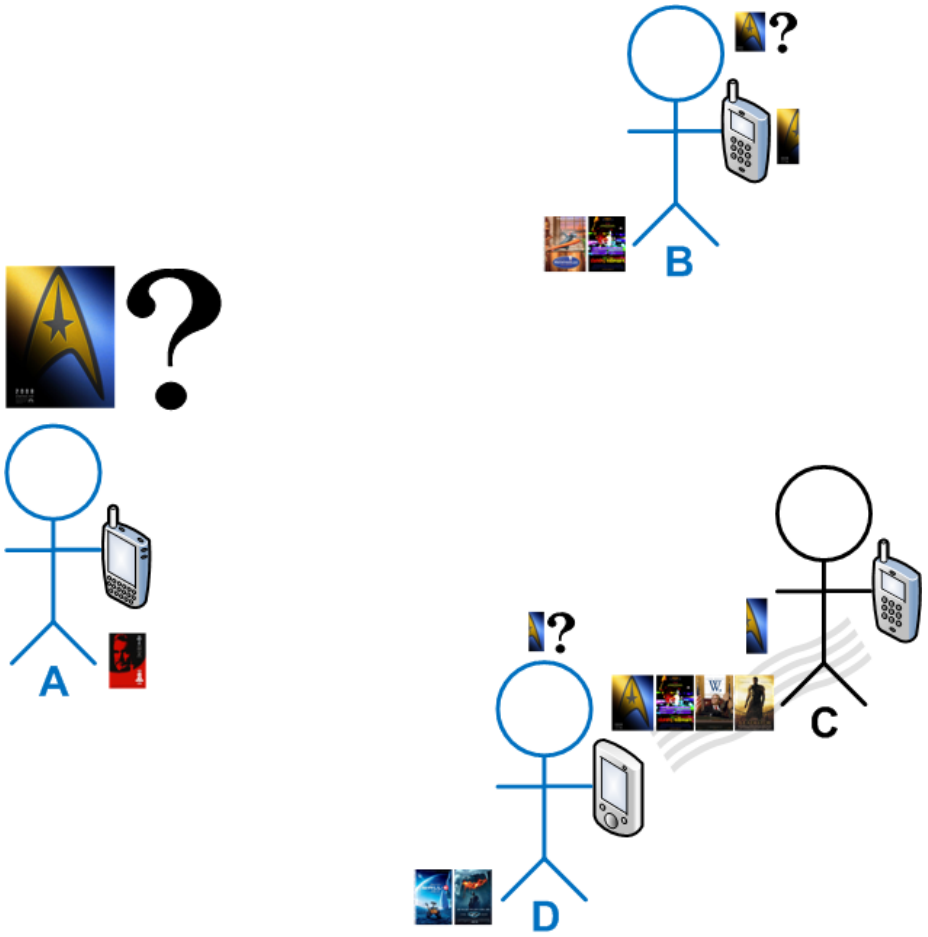
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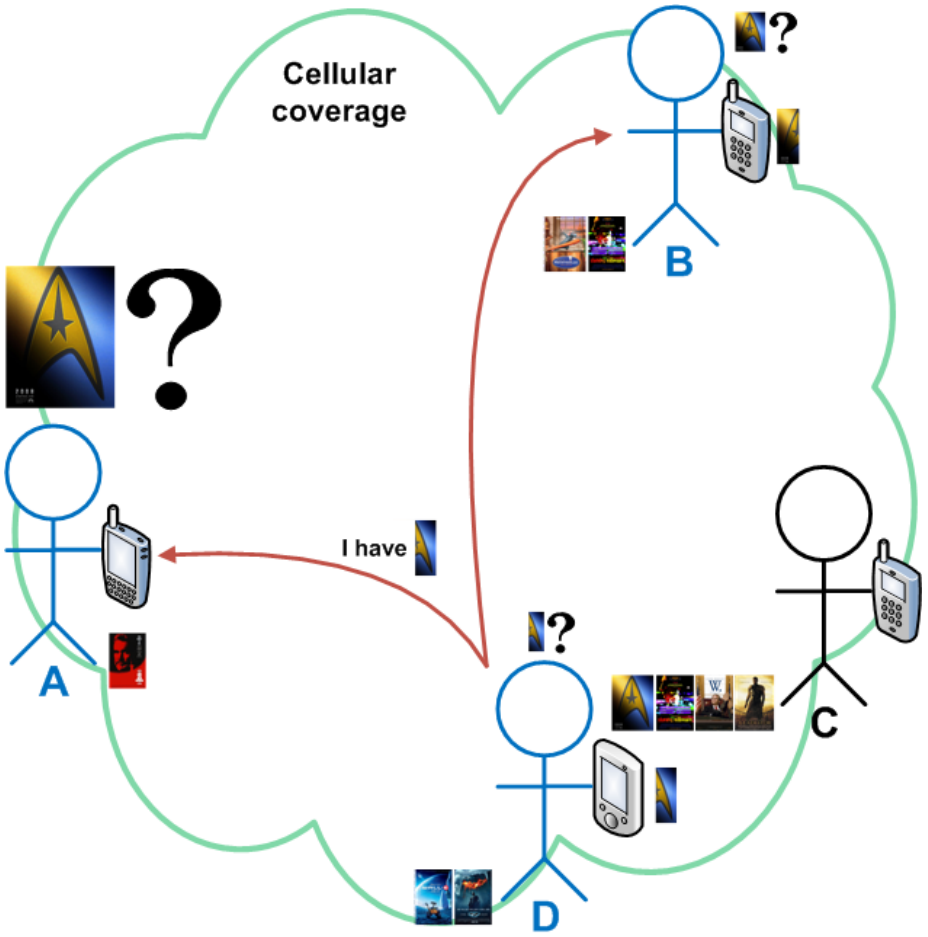
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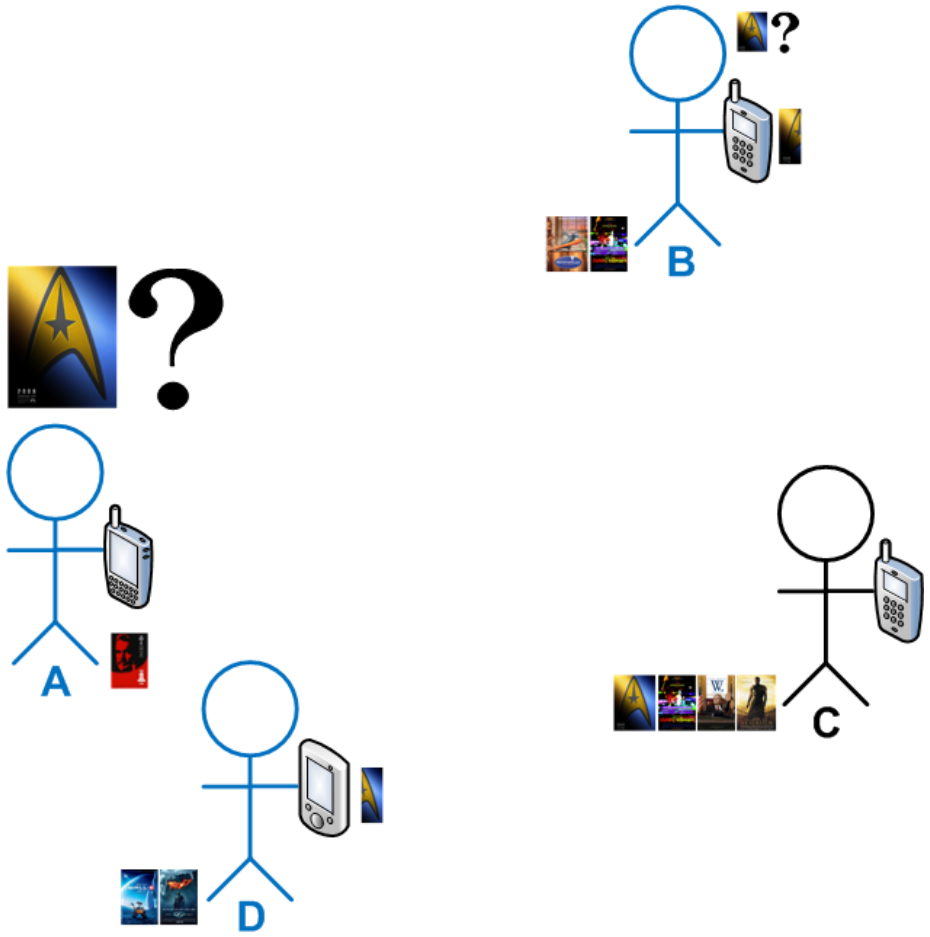
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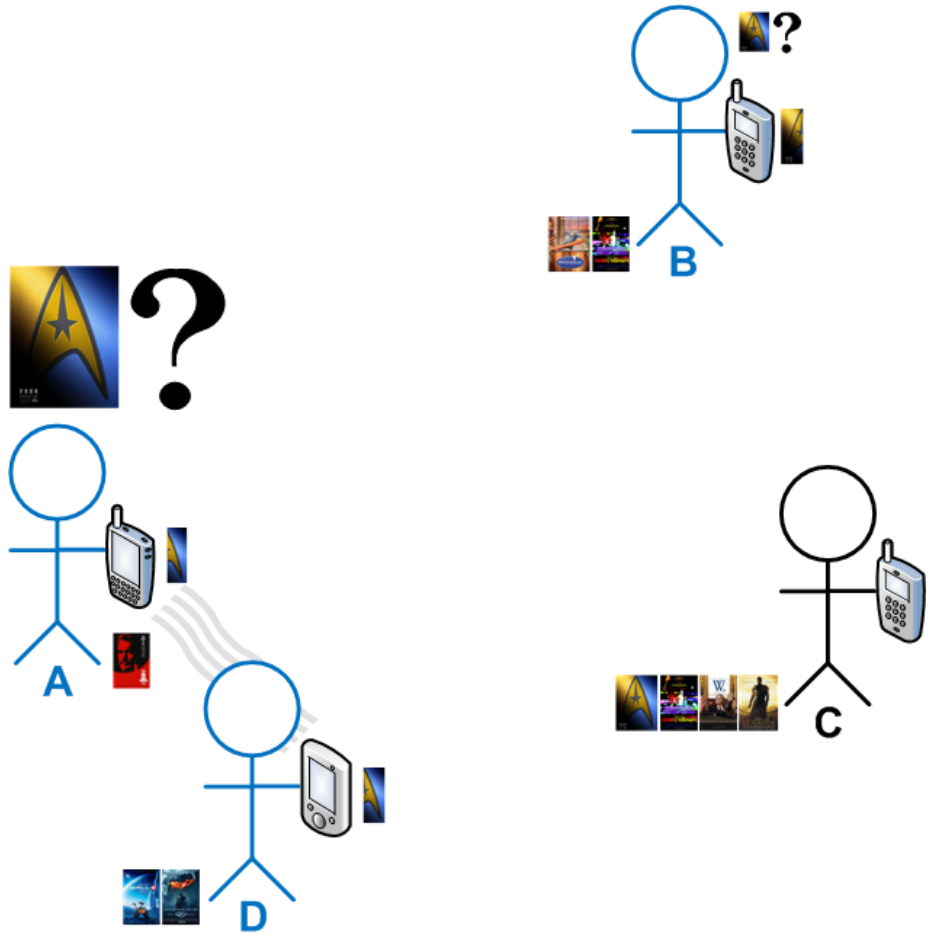
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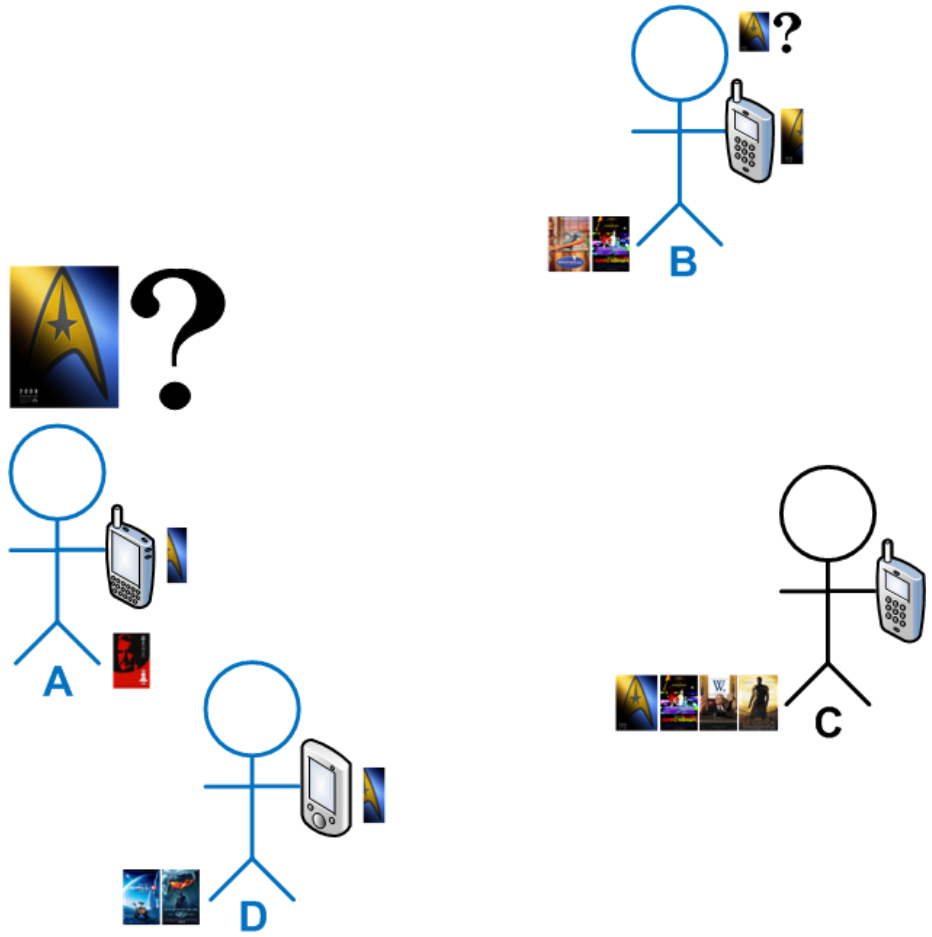
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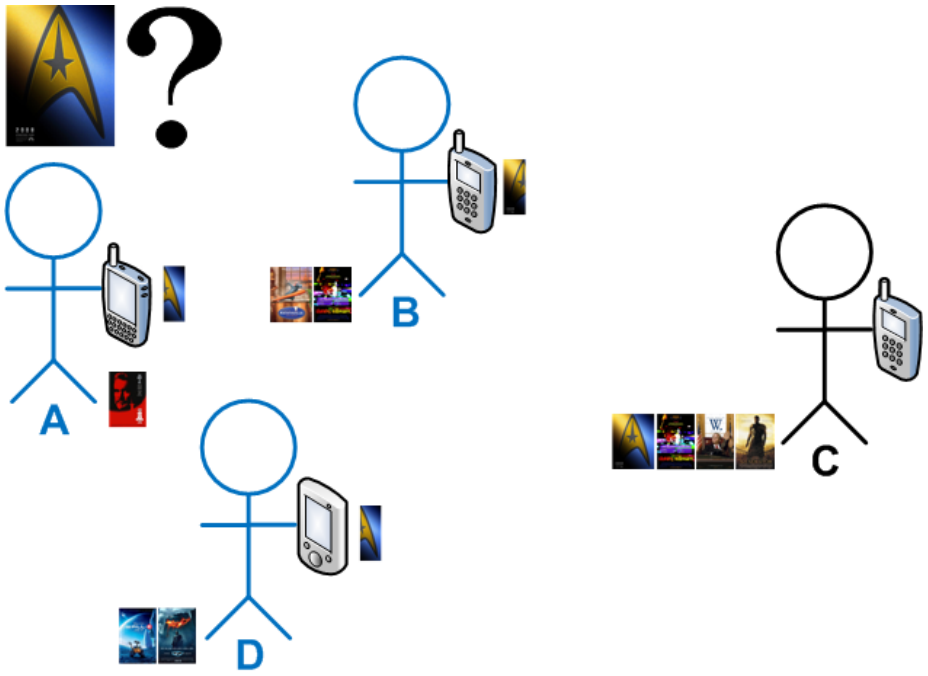
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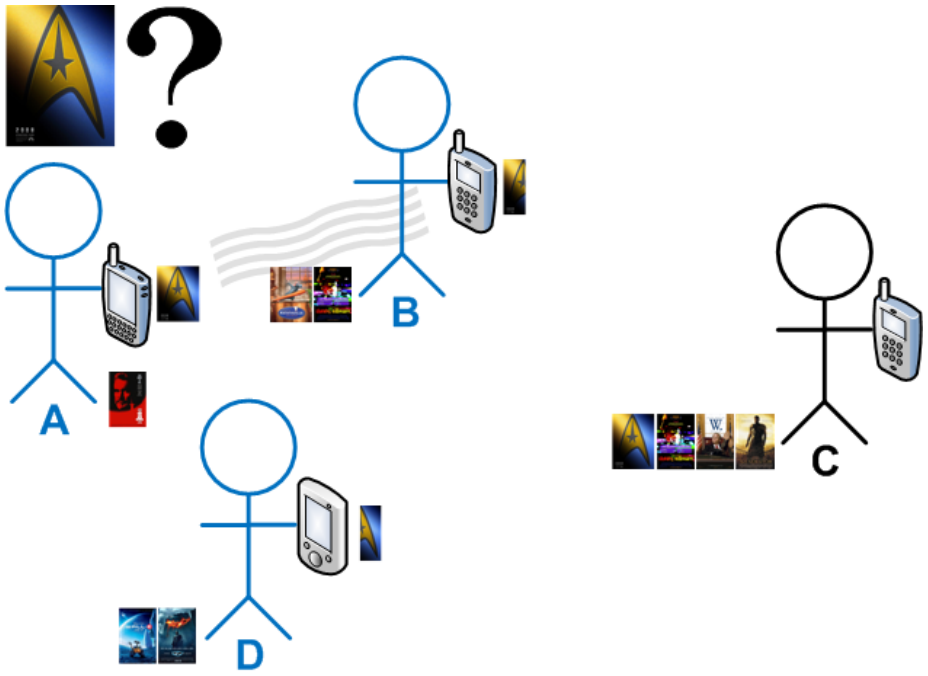
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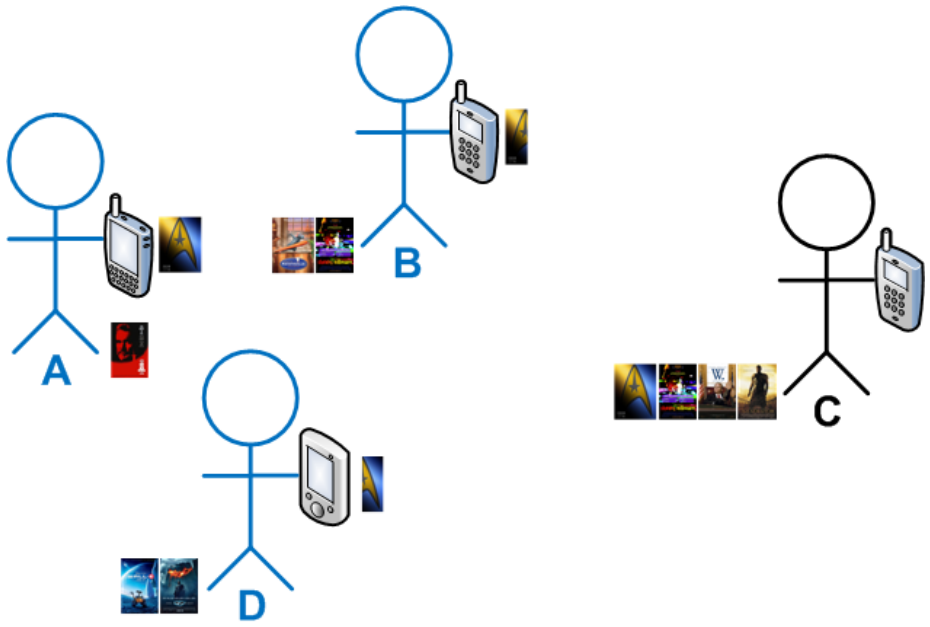
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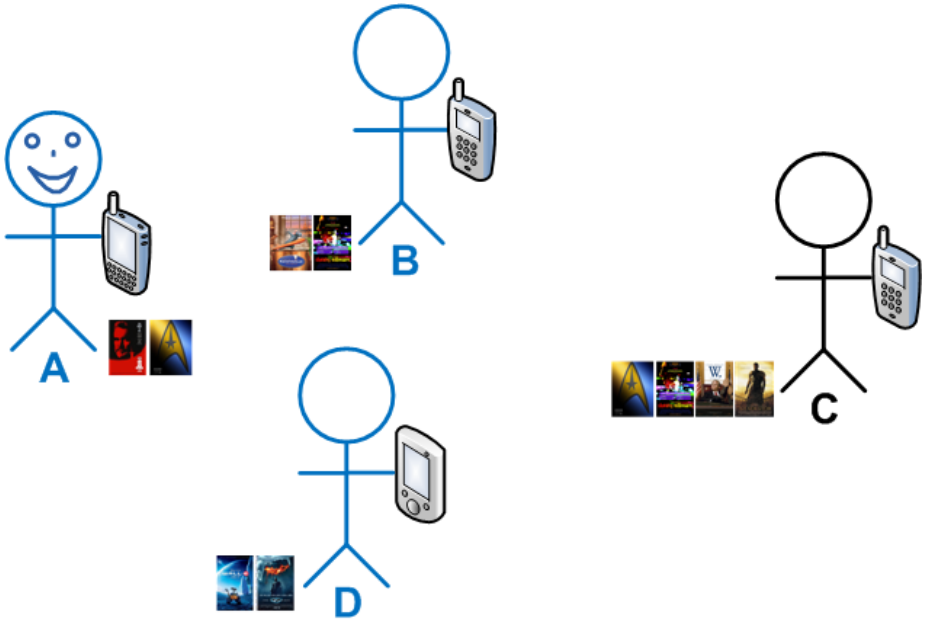
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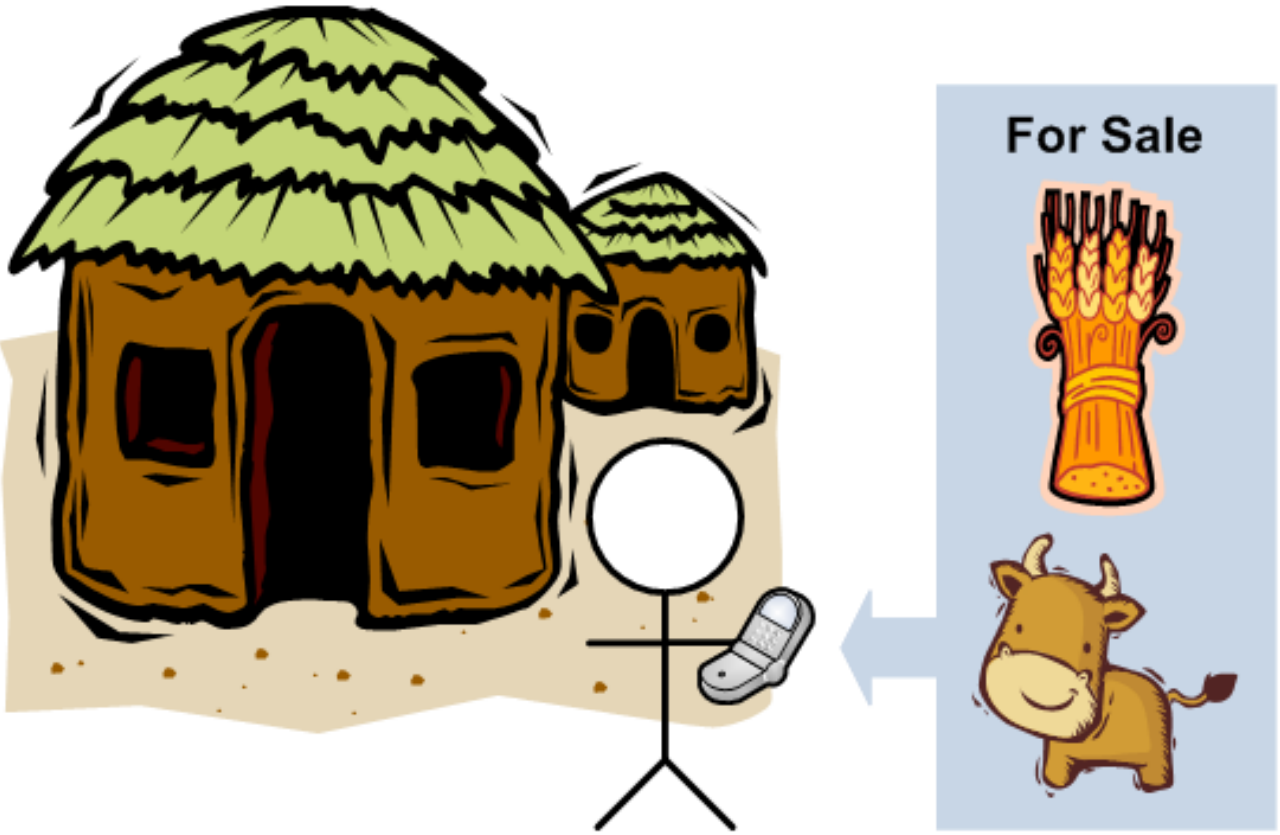
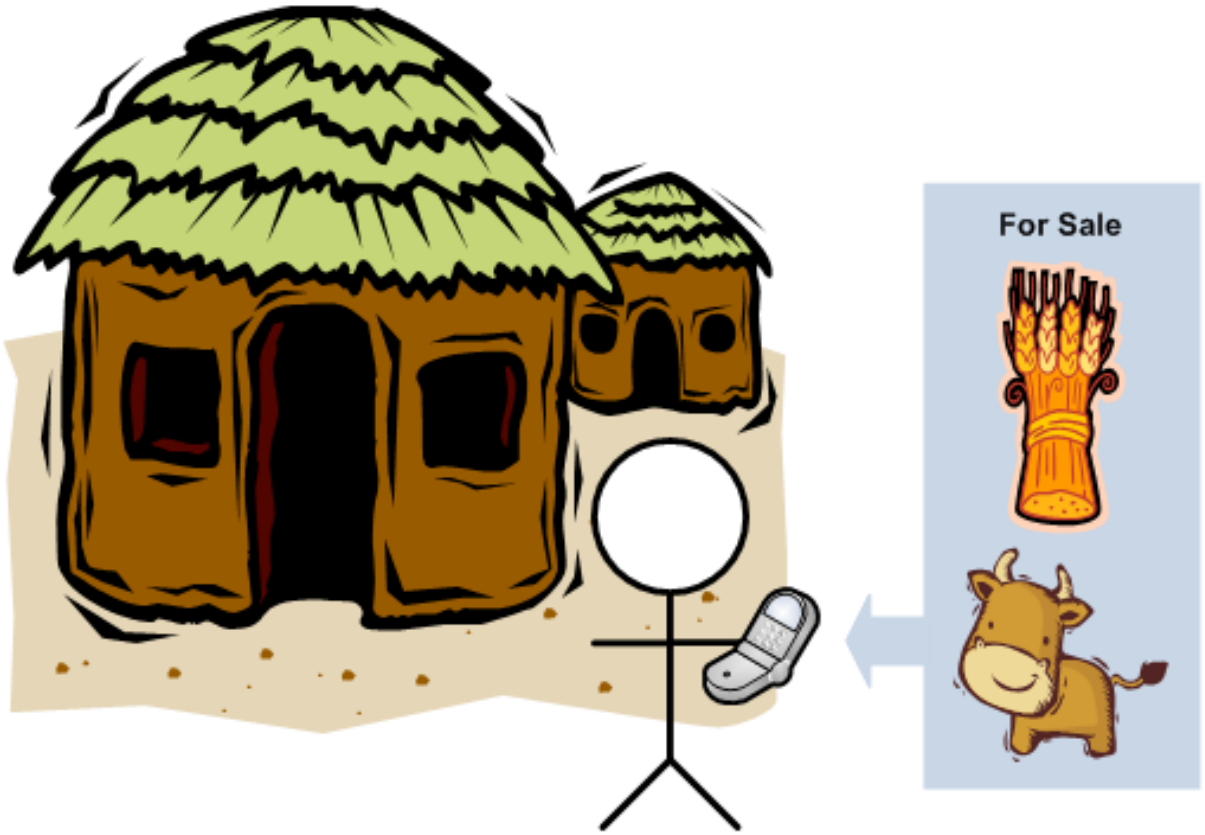
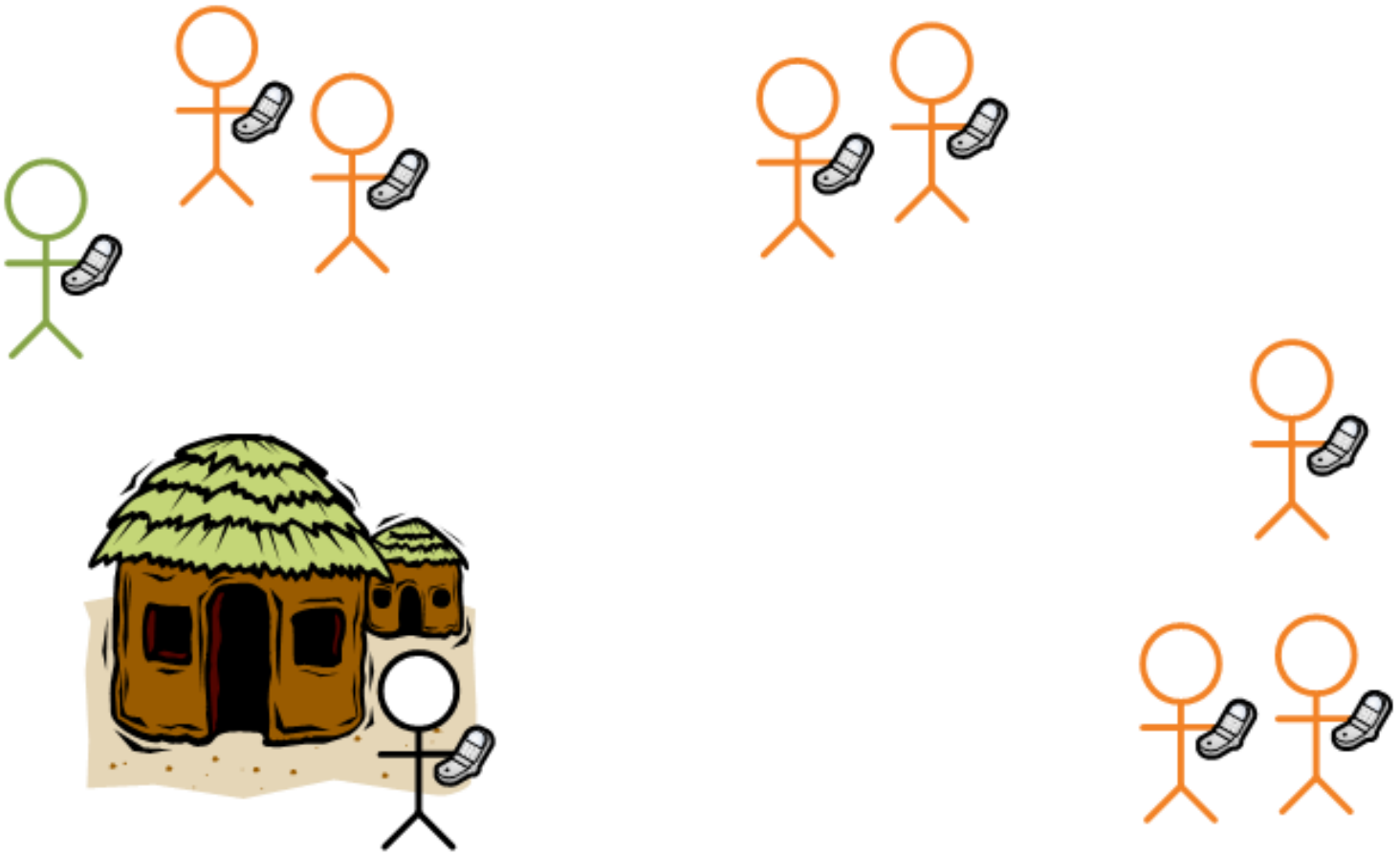
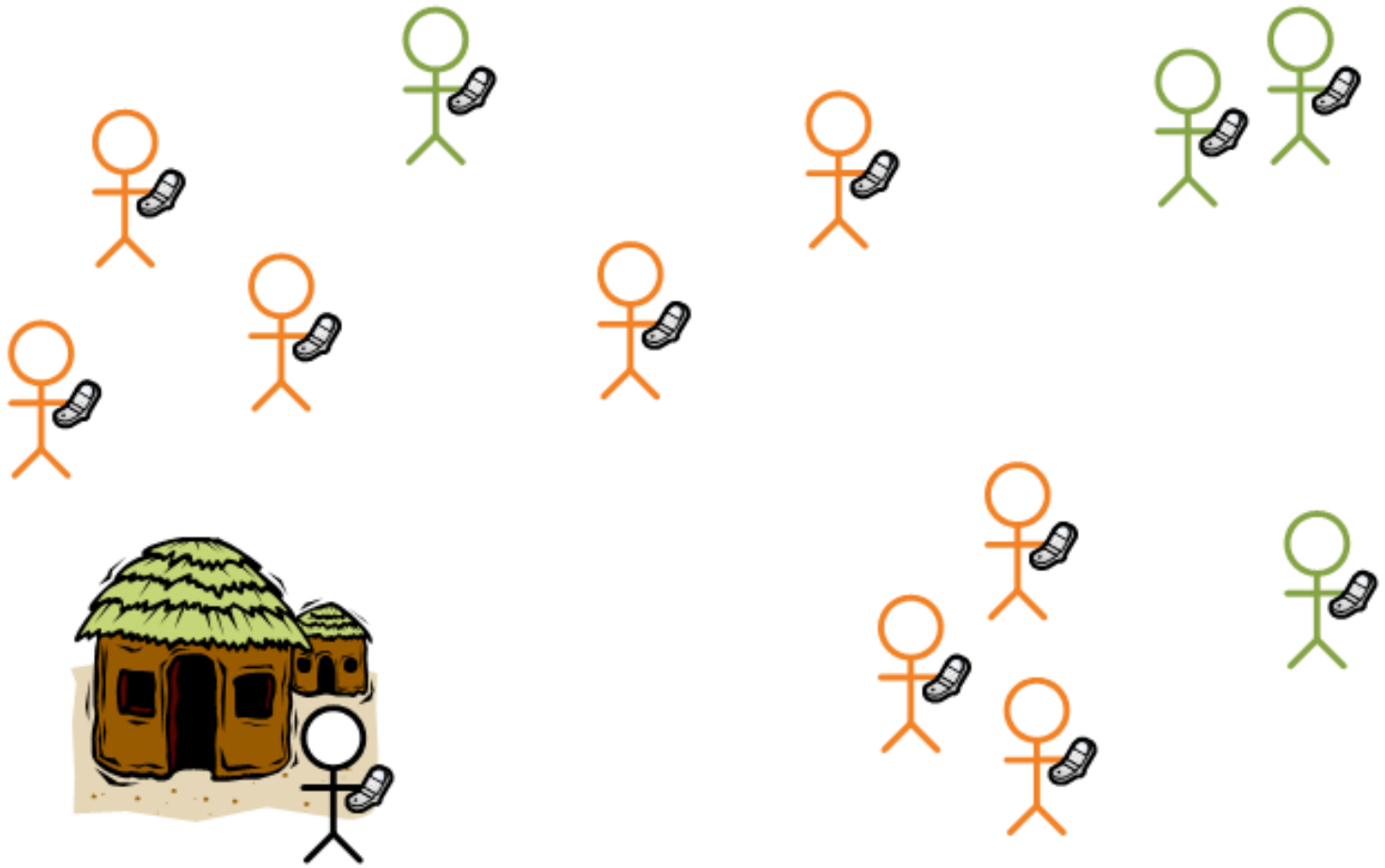
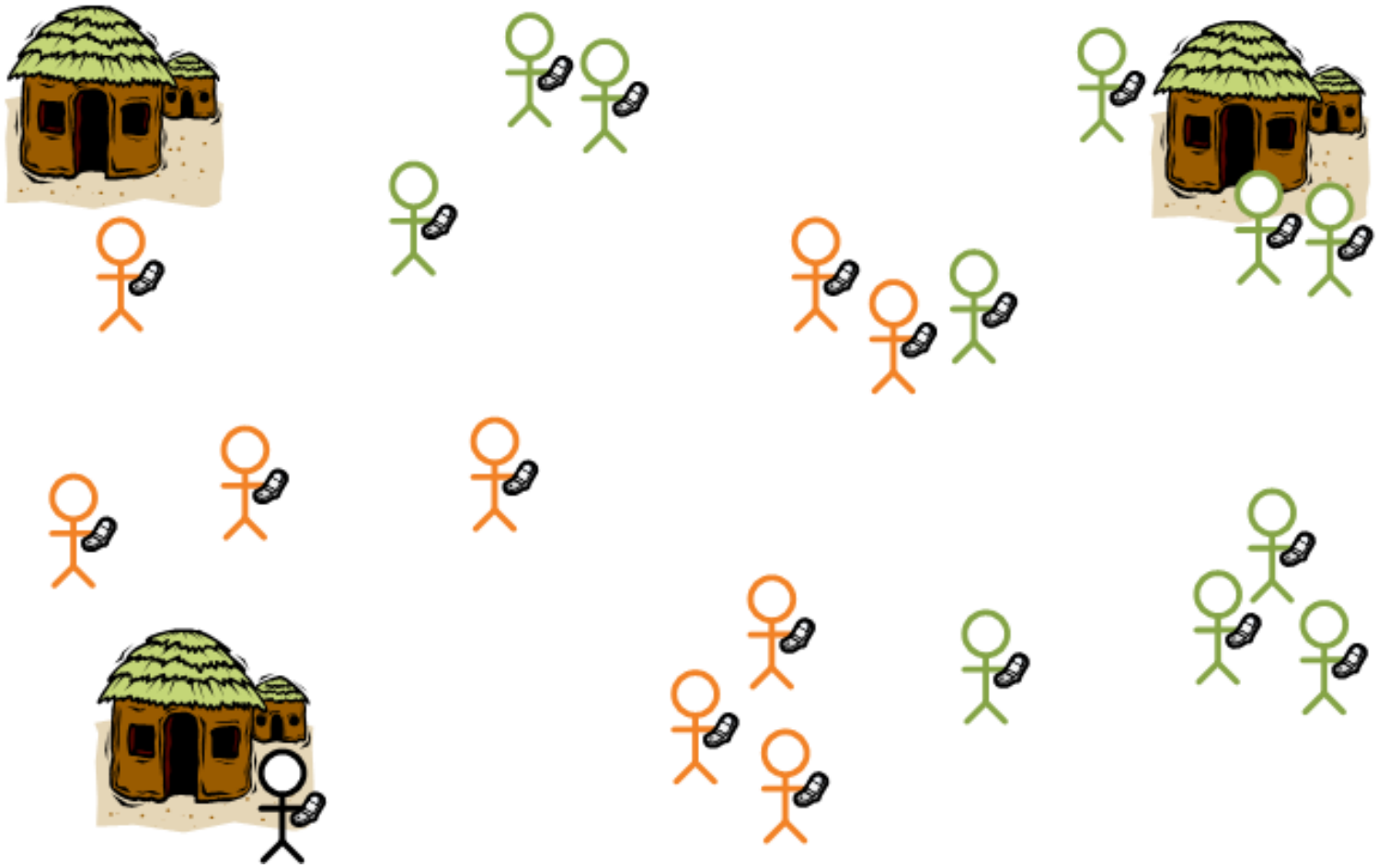
PocketBay

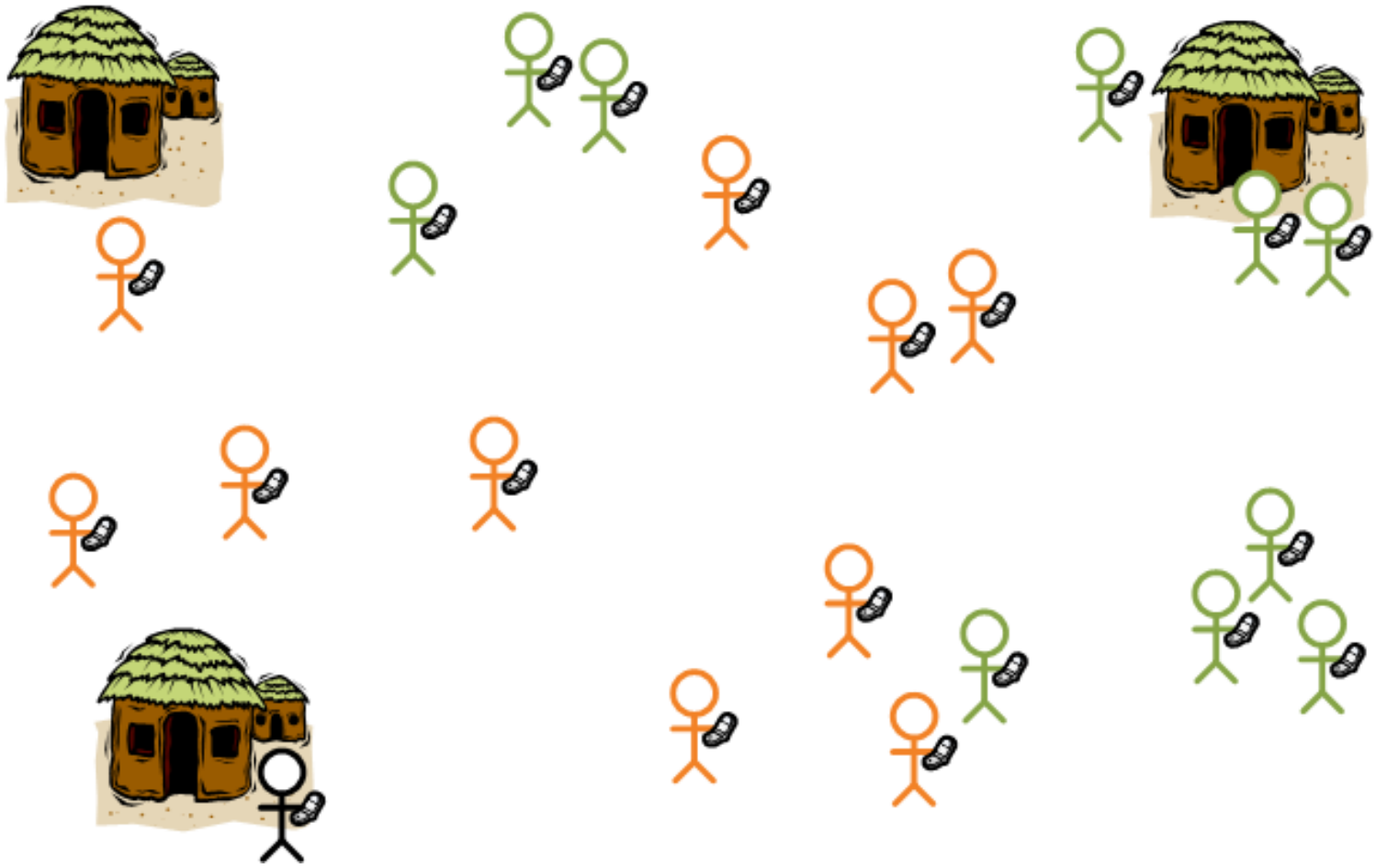

For Sale

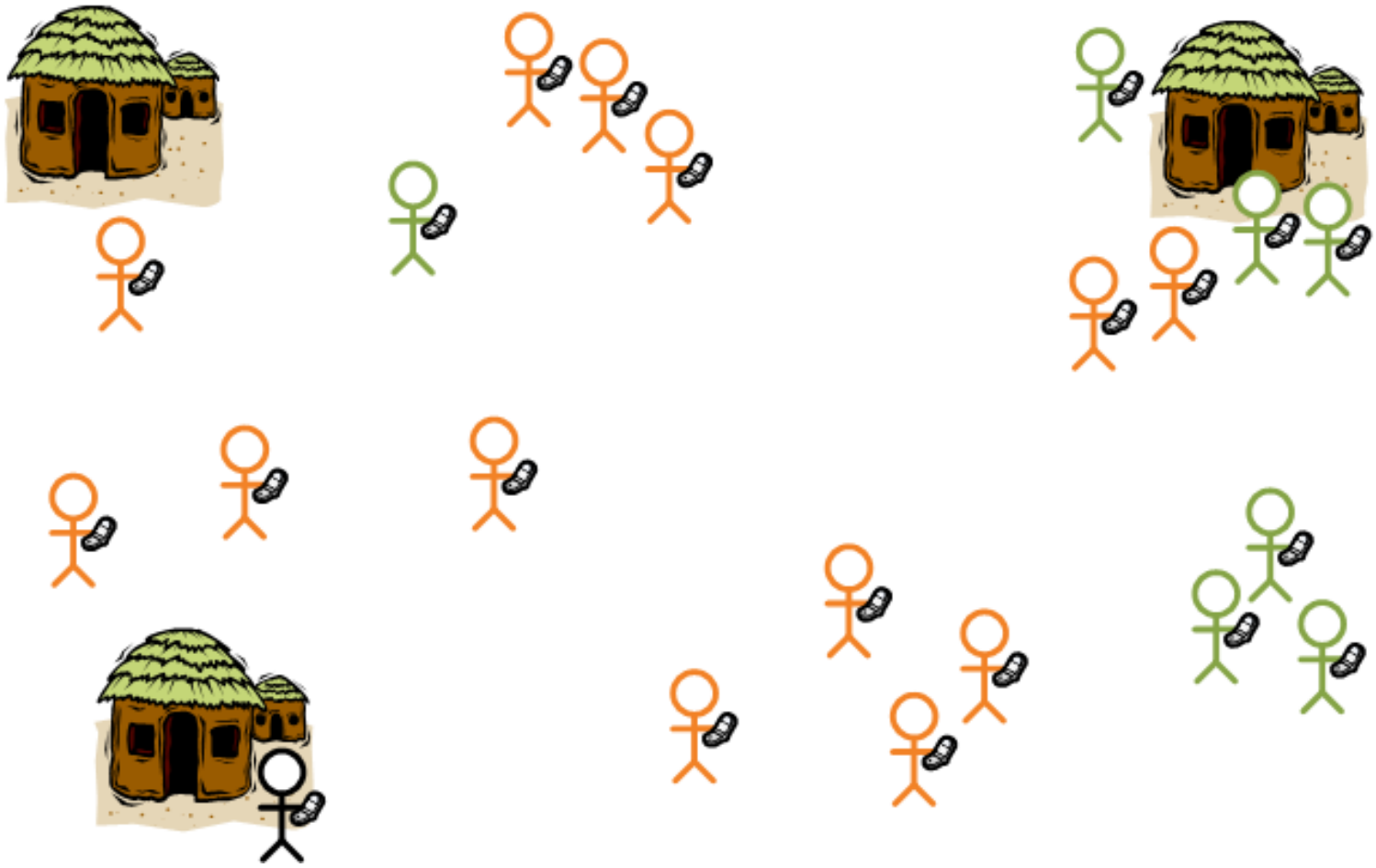

For Sale

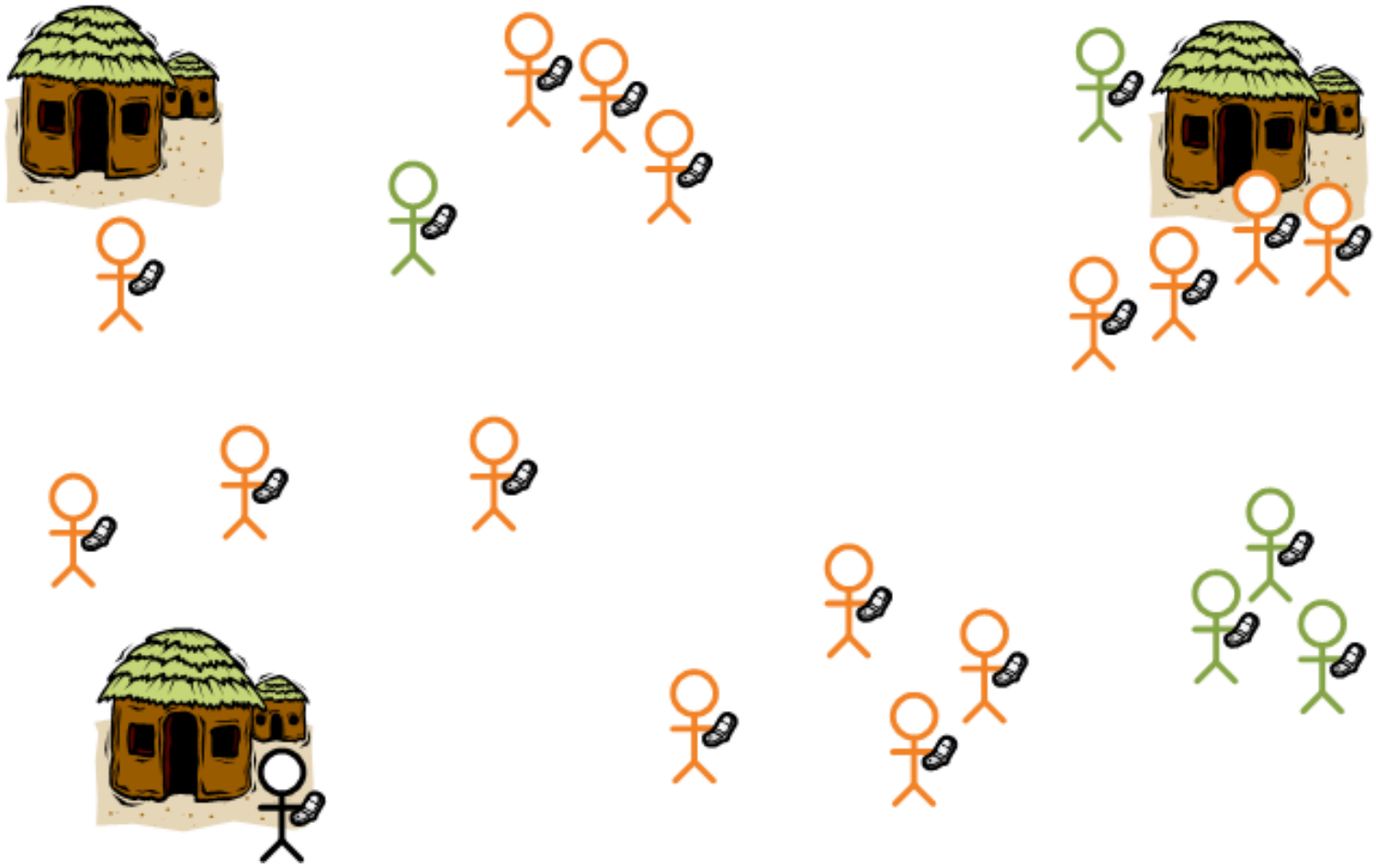


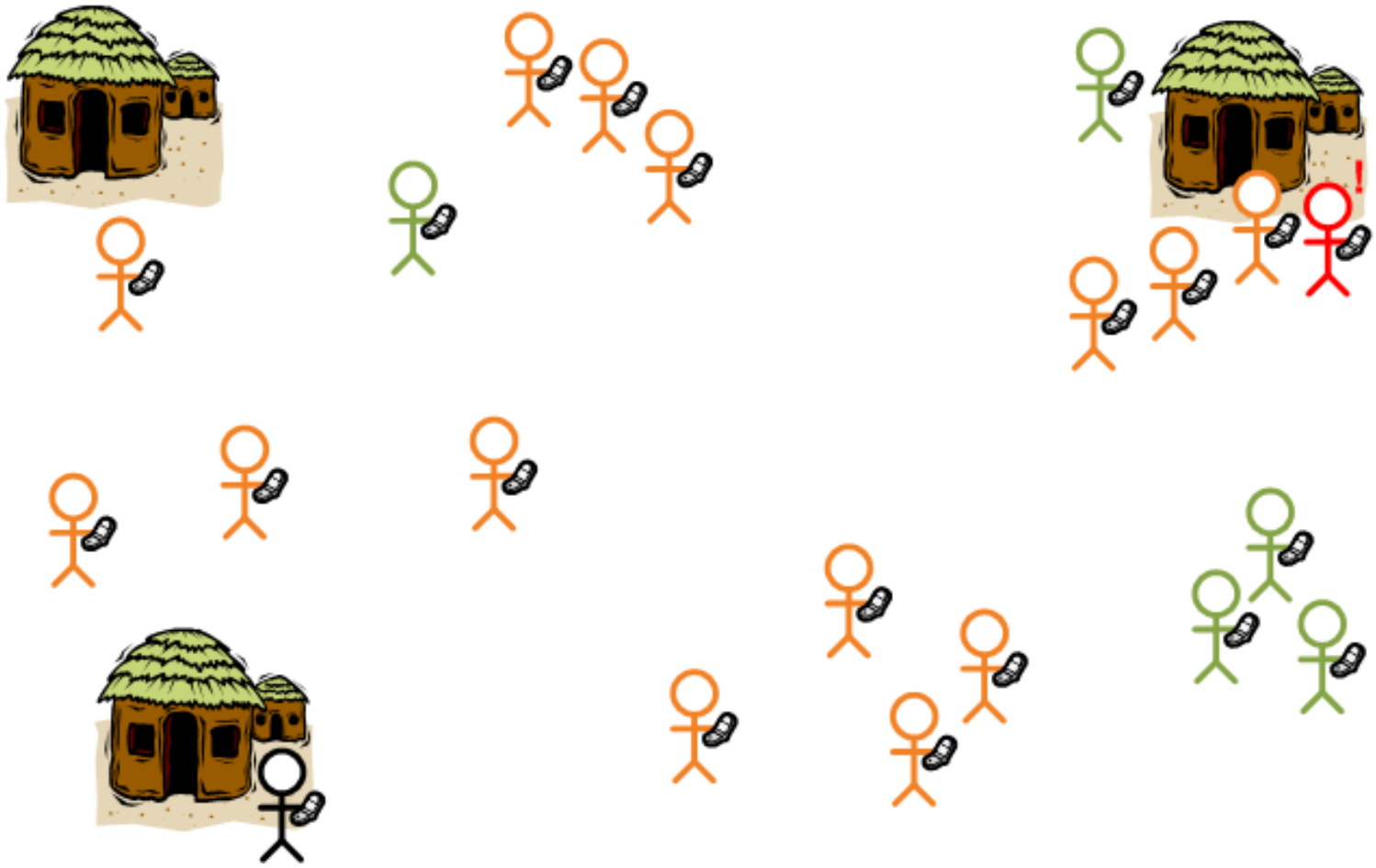


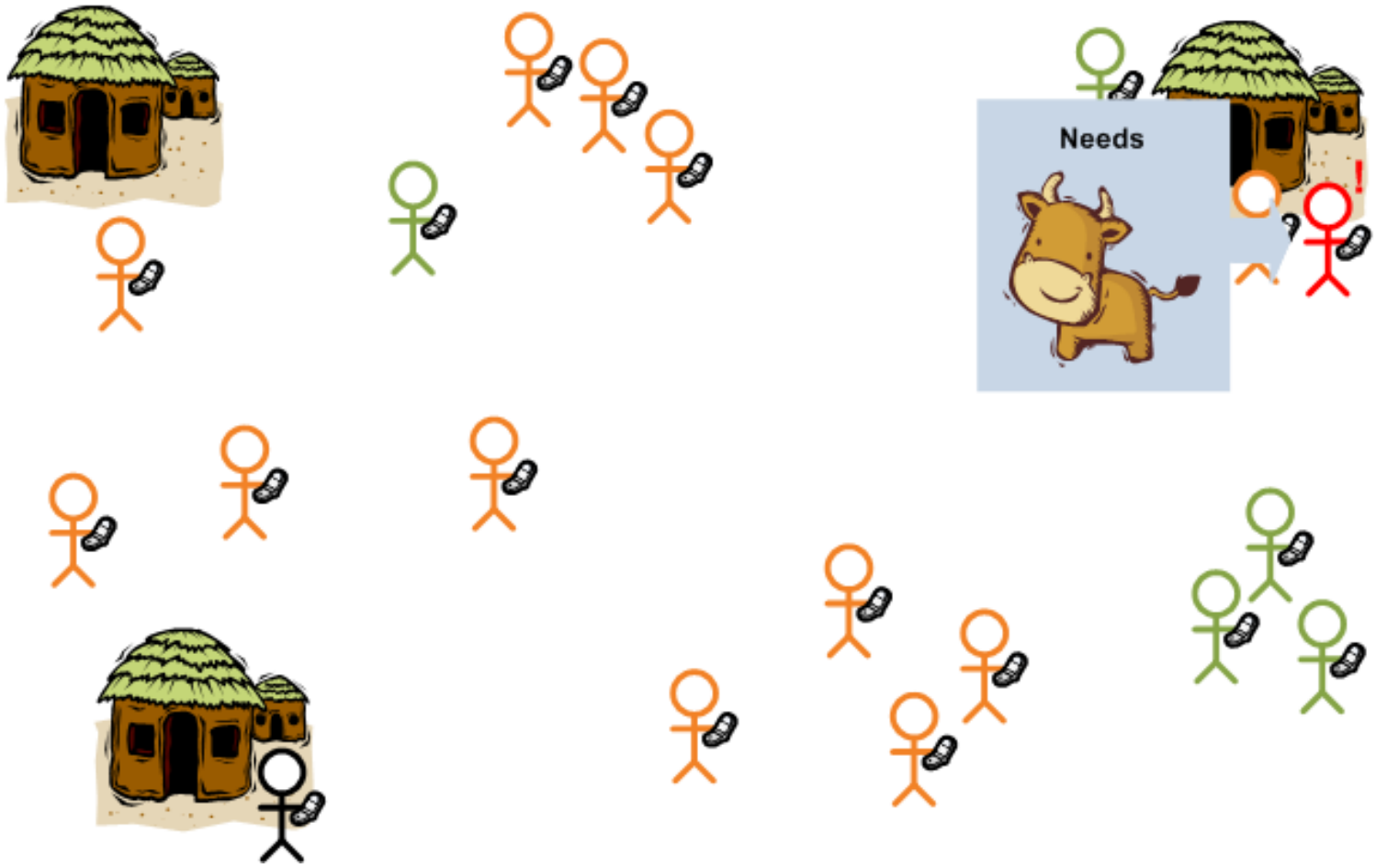


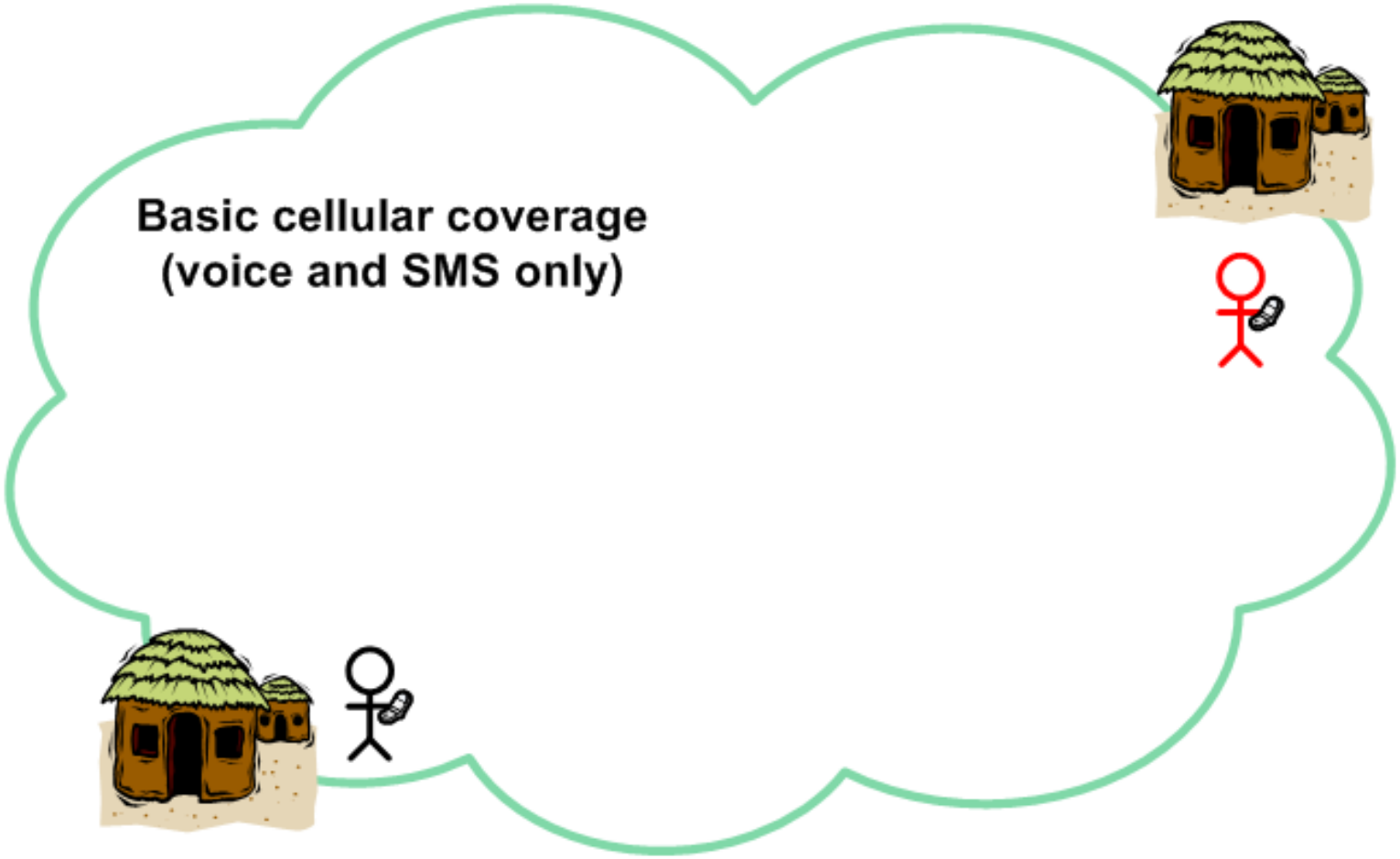


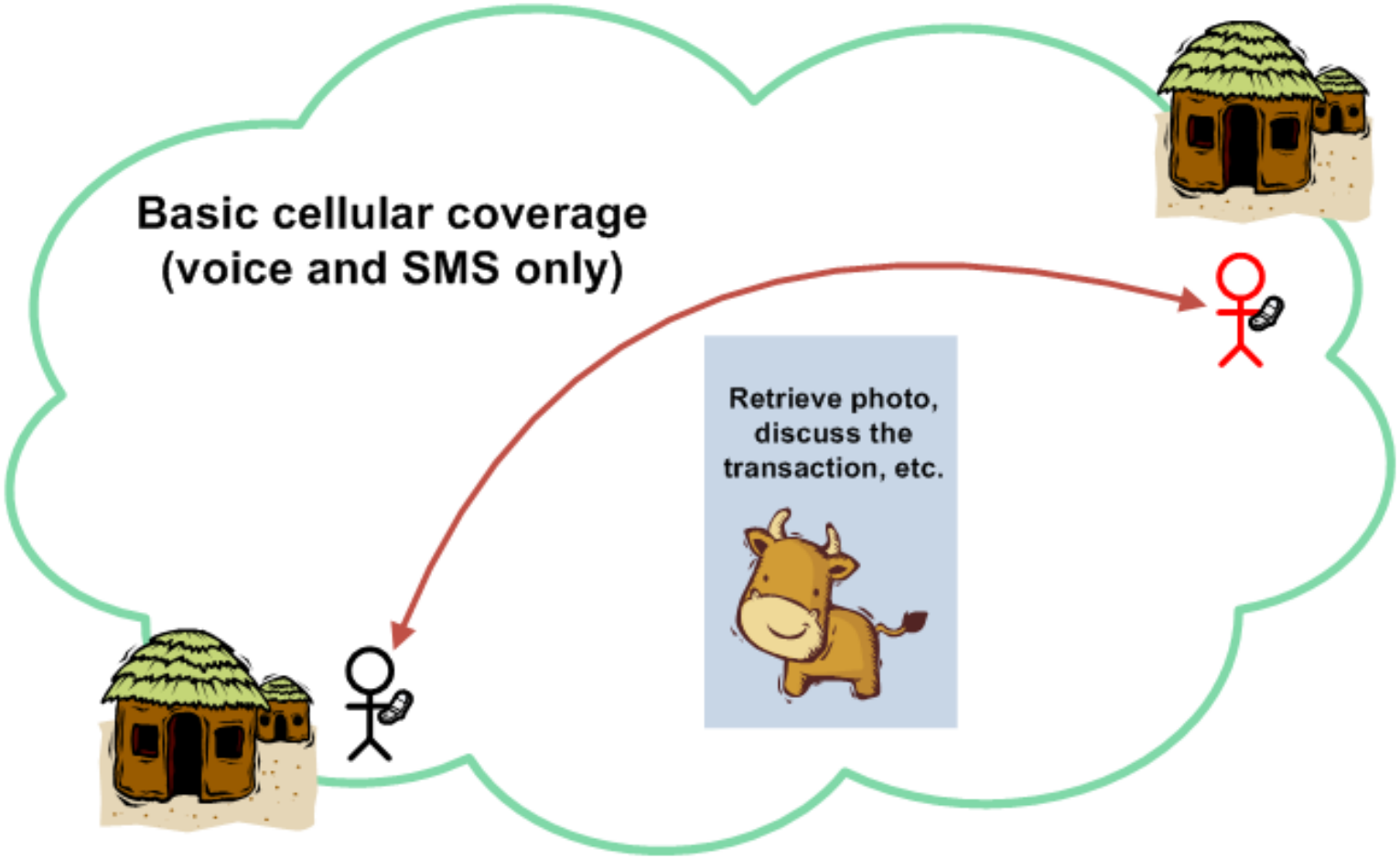







Needs


Basic cellular coverage
(voice and SMS only)


Basic cellular coverage
(voice and SMS only)
Retrieve photo, discuss the transaction, etc.

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

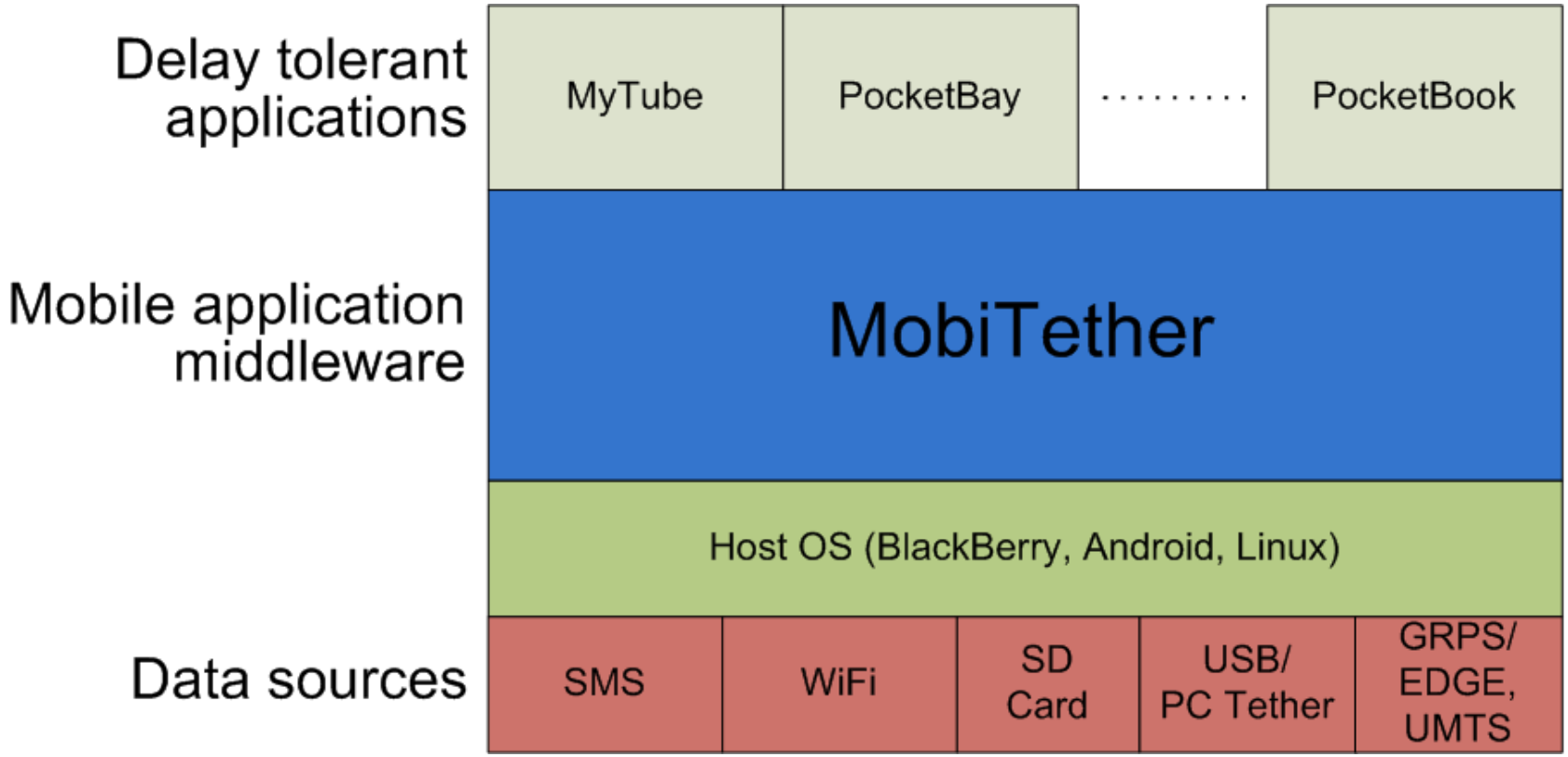
Summary of applications

- 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.

Outline

- The mobile application space
- Mobile application middleware
- Related work
- Challenges
  - Timeline

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

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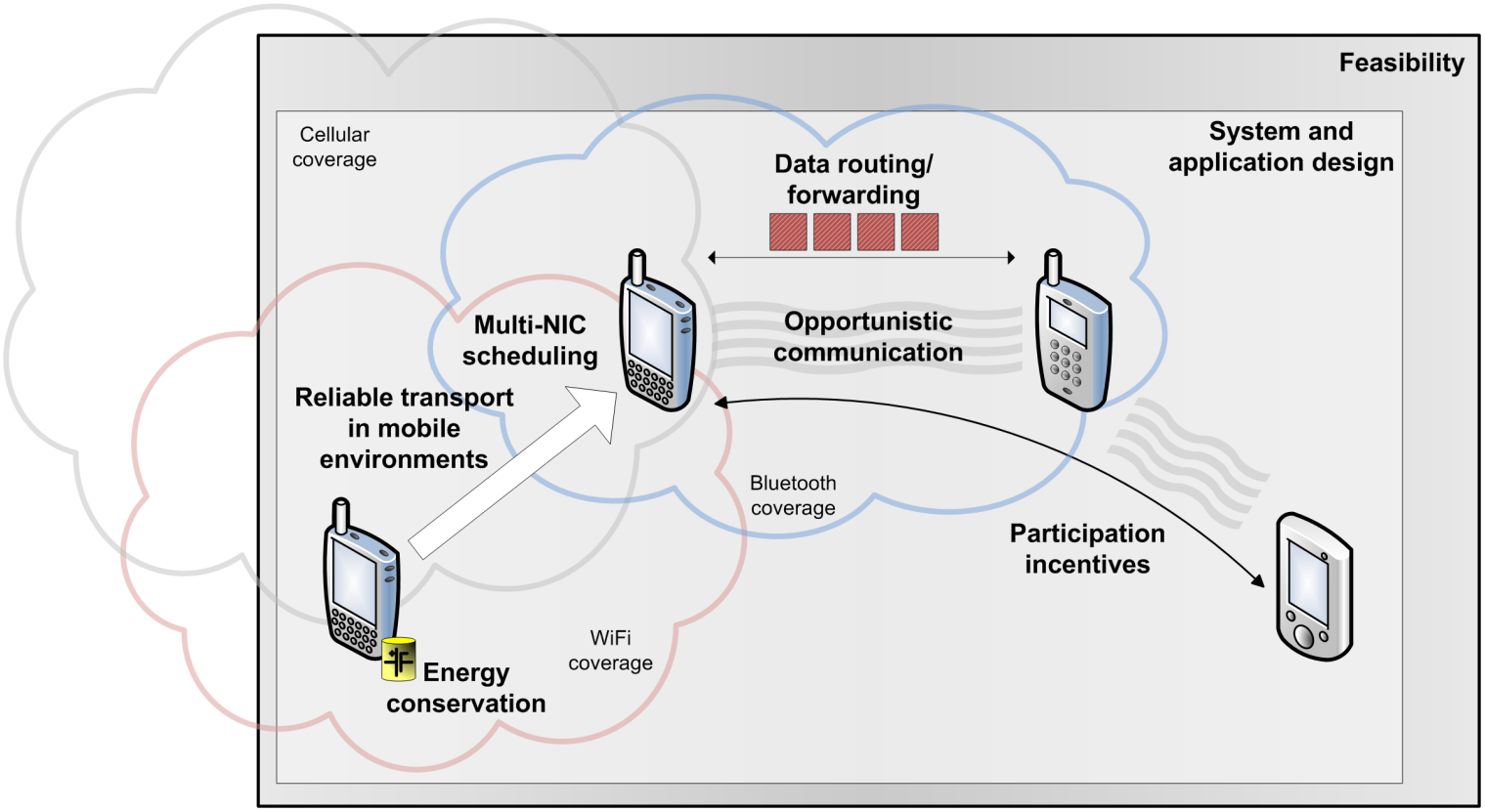
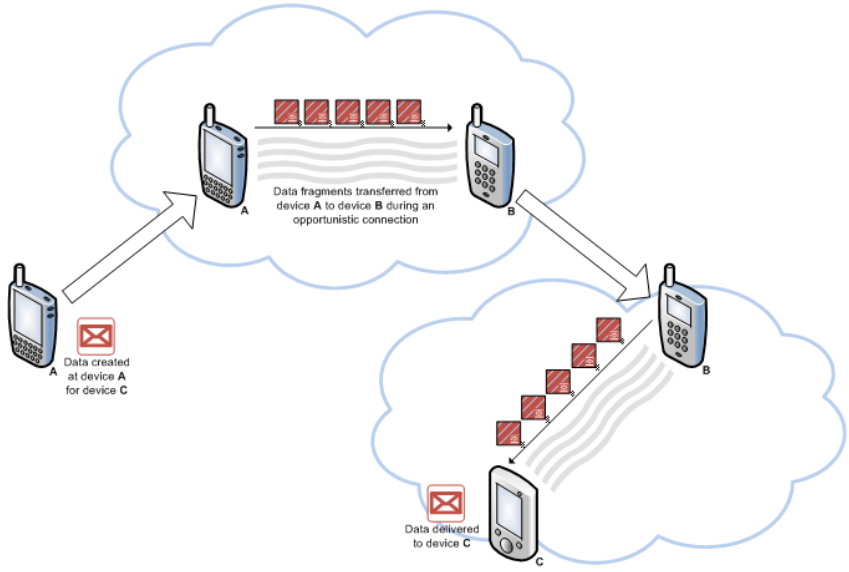
Related work



- Most relevant related work:
  - Haggle
  - MobiClique
  - Opportunistic Connection Management Protocol

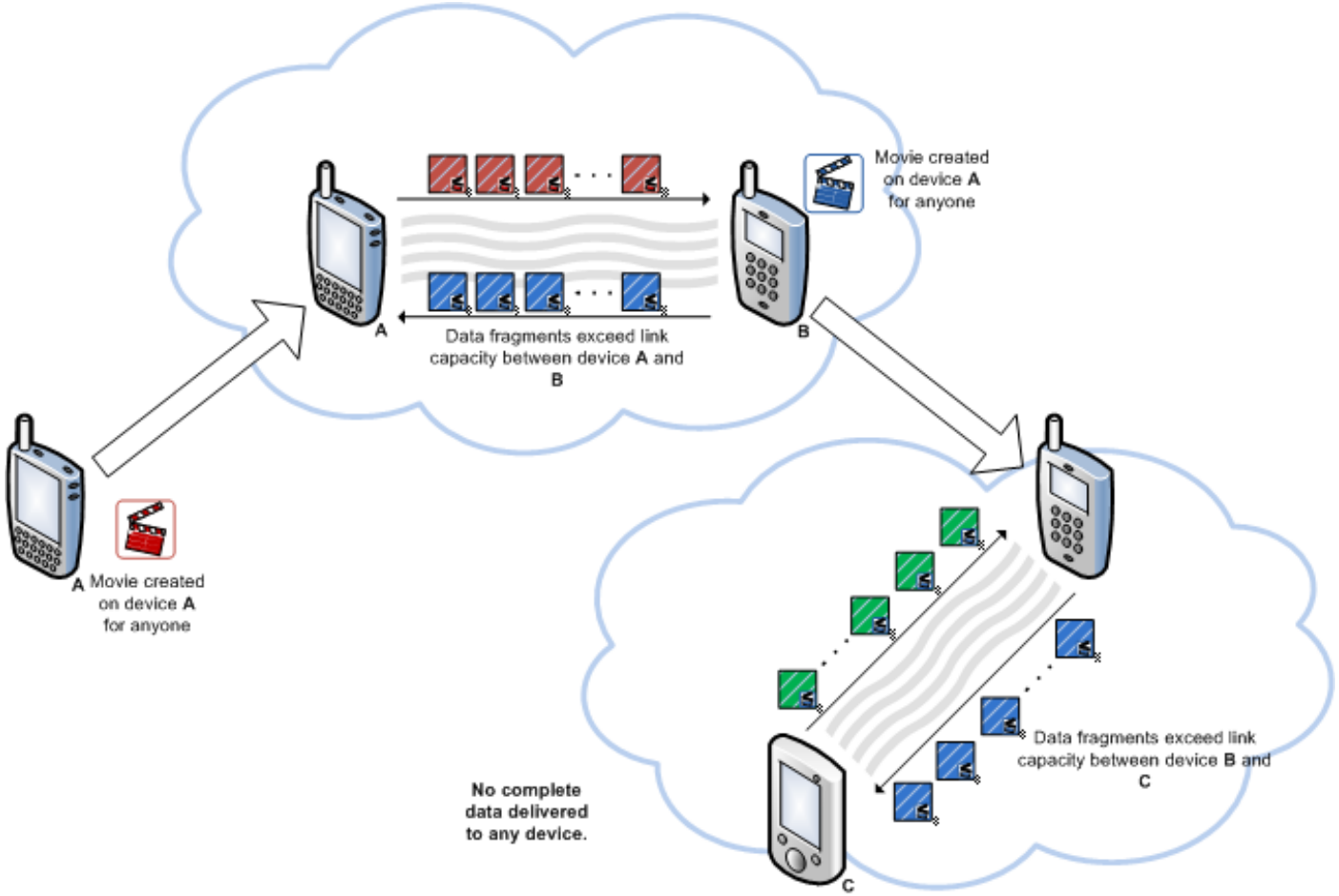
Haggle

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



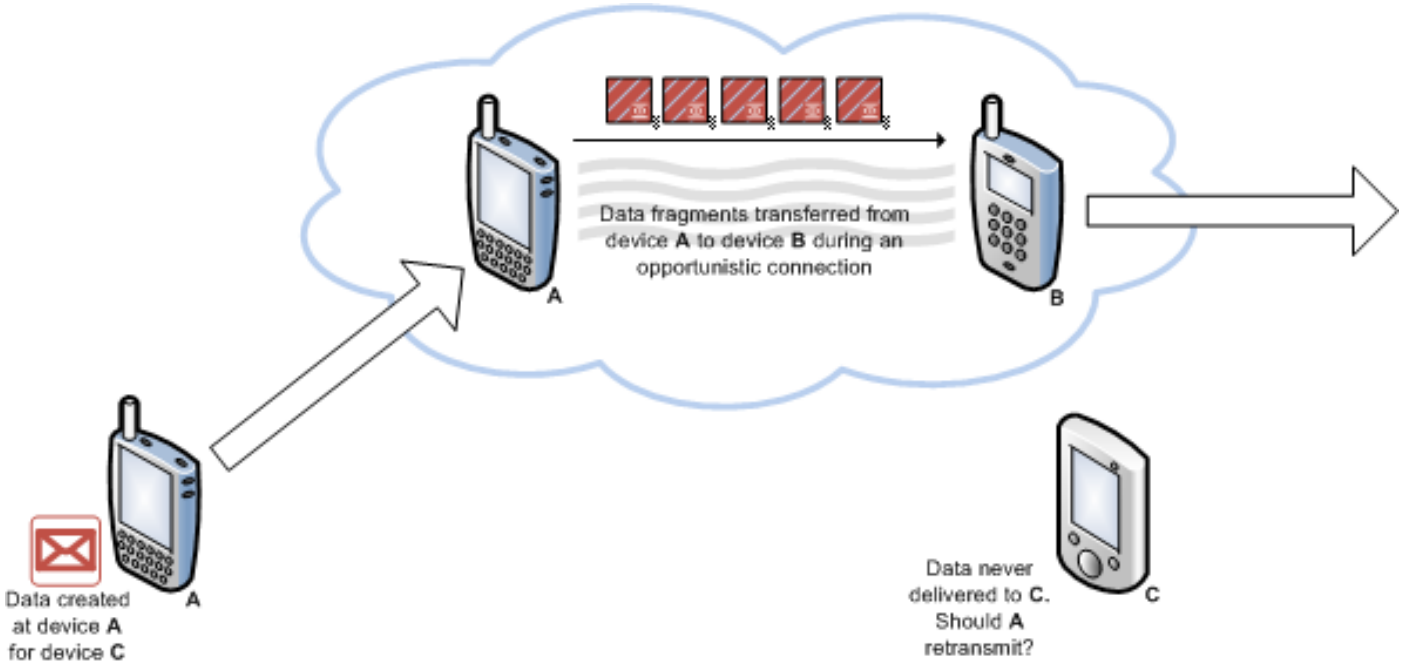
Problems with Haggle

Scales poorly



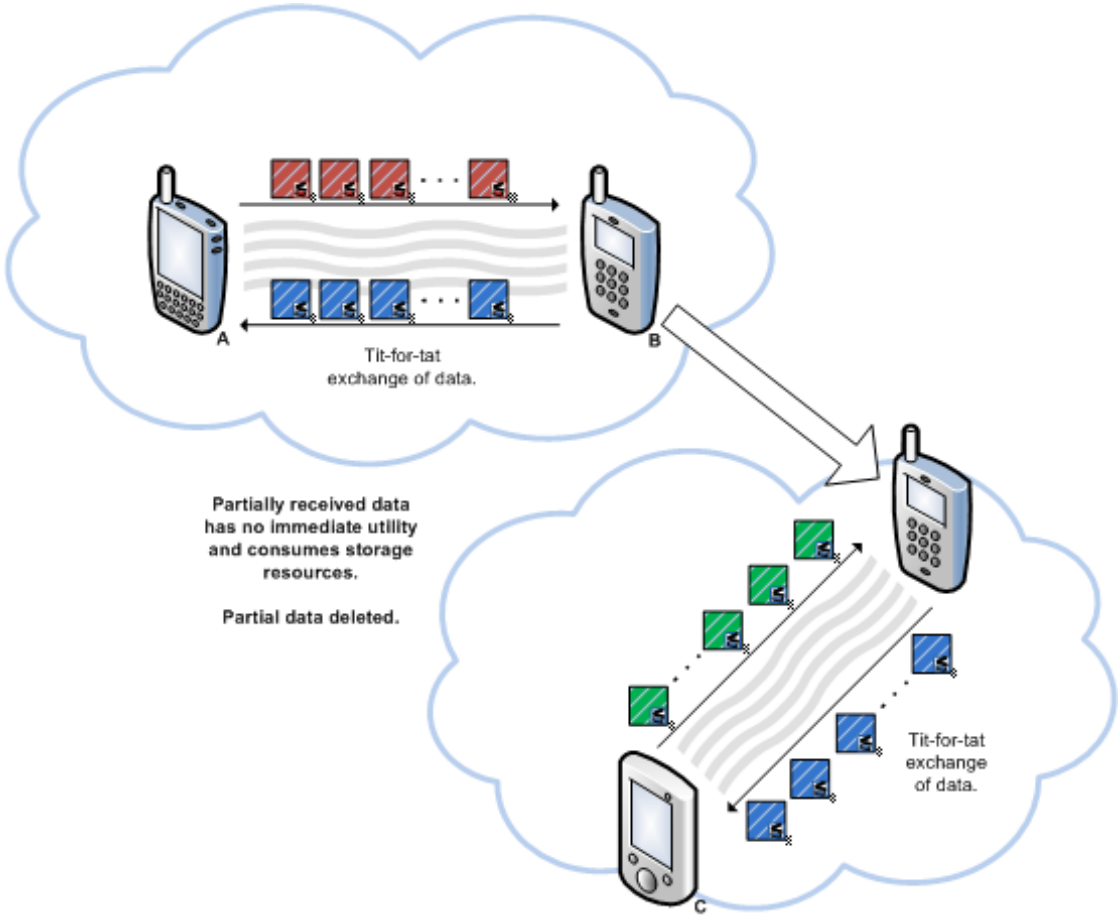
Problems with Haggle

Unreliable data transport



Problems with Haggle

No participation incentives



Problems with Haggle

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

MobiClique

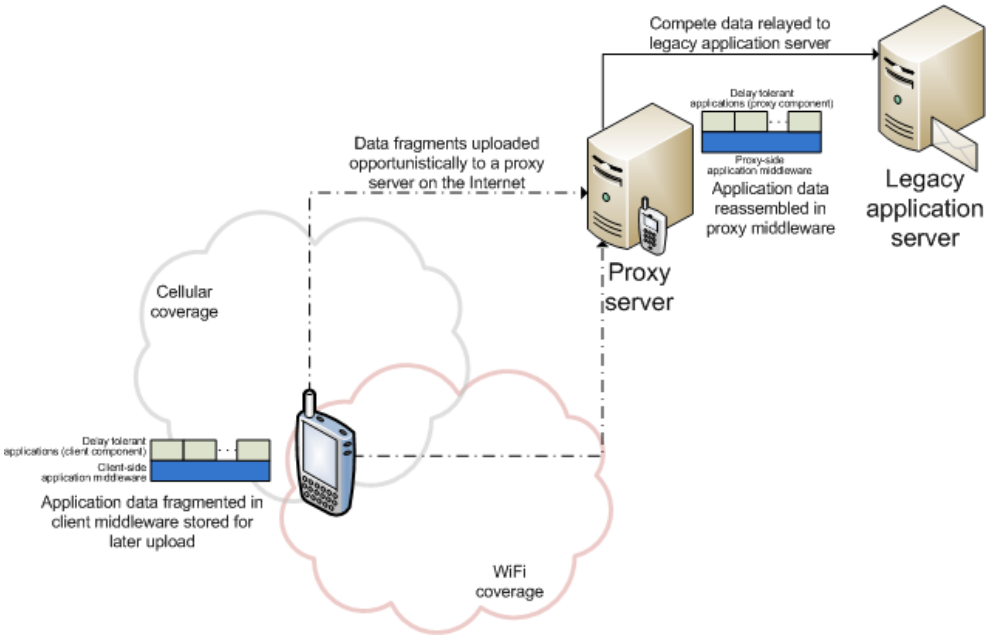
- Based on Haggle
- Infrastructure-less
- Attempts to solve the incentive problem through social networks
  - Seeded from existing online social network
  - Grown through opportunistic connections
- Data is disseminated purely among friends, friends-of-friends, and users with similar “interests”.

Problems with MobiClique

- First working prototype on a mobile device.
  - CPU and I/O intensive forwarding decisions.
  - Garbage collection during opportunistic connections.
- **Key take away:** mobile applications **must** be designed to adapt to resource constraints.

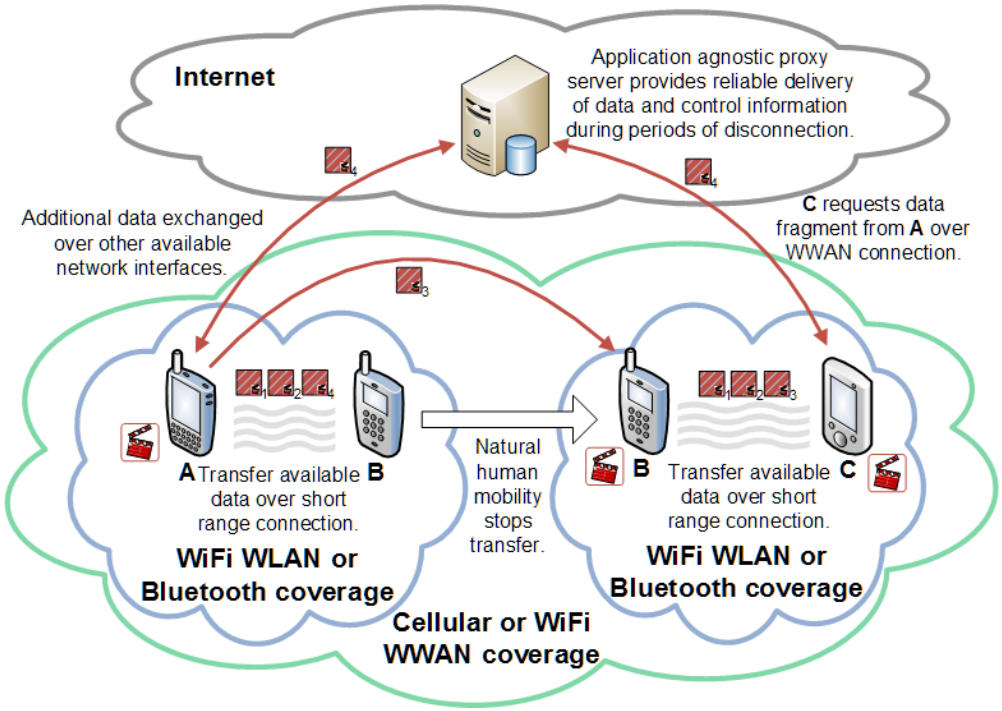
Opportunistic Connection Management Protocol

- 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’



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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?

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?
- How do can we exploit SMS has a control channel in delay tolerant networks.

Human Computer Interaction Challenges

- How do we design intuitive delay tolerant applications?
- How should users control the behaviour of a mobile application middleware?

Deployment Challenges

- How do we engineer simplicity into a large scale distributed mobile system?

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Timeline

- Completed
- June 2009 (4 months)
- August 2010 (14 months)
- December 2010 (4 months)

Summary

- Outlined a new class of mobile application.
  - Goals of a mobile application middleware.
- Positioned application middleware in existing mobile systems research.
- Identified research challenges to enable the new class of mobile applications.

Questions / Discussion