InterestSpread: An Efficient Method for Content Transmission in Mobile Social Networks

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- The large coverage of Wi-Fi

- The widespread usage of smartphone

Number of smartphone users in the U.S. from 2010 to 2018 (in millions)
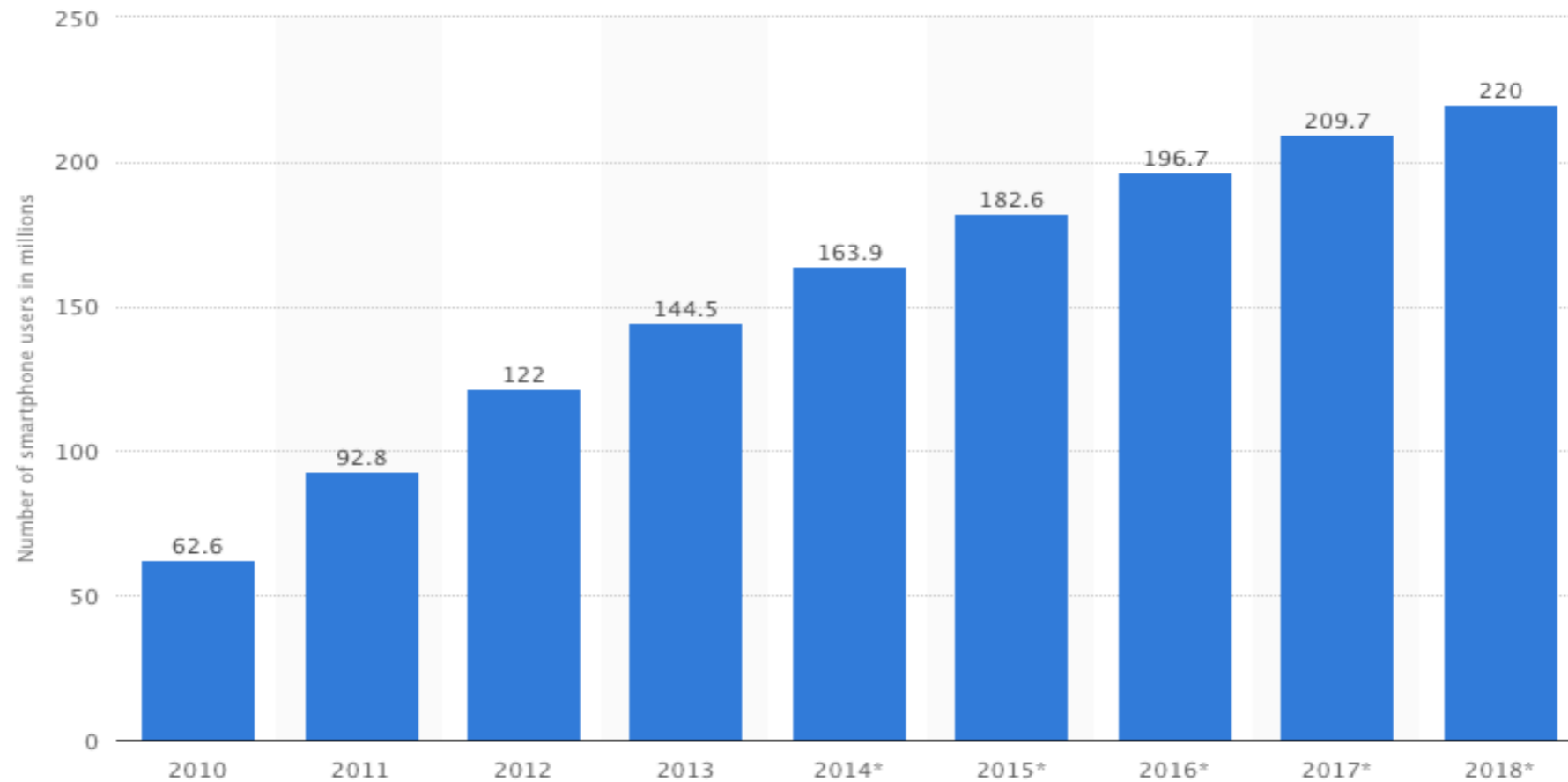
Concept of mobile social networks (MSNs):

- People walk around with smartphones and communicate with each other via Bluetooth or Wi-Fi when they are in the transmission range of each other.

Characters:

- No end-to-end connectivity
- Using store-carry-forward fashion
- Exploiting node's mobility
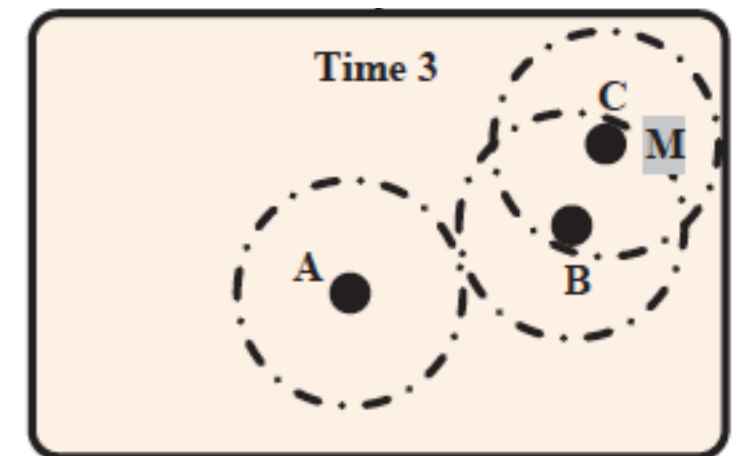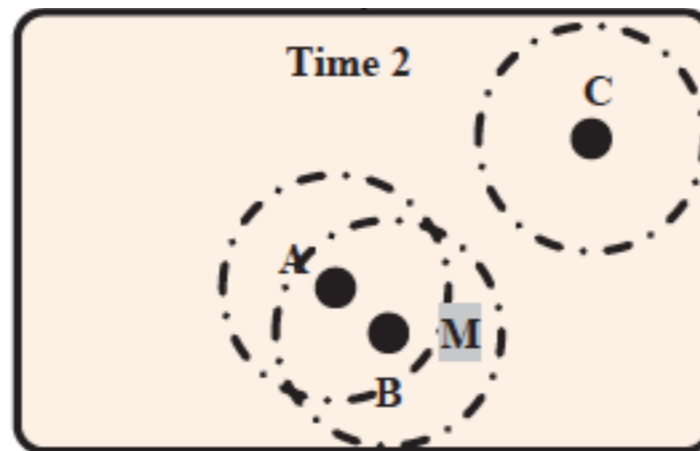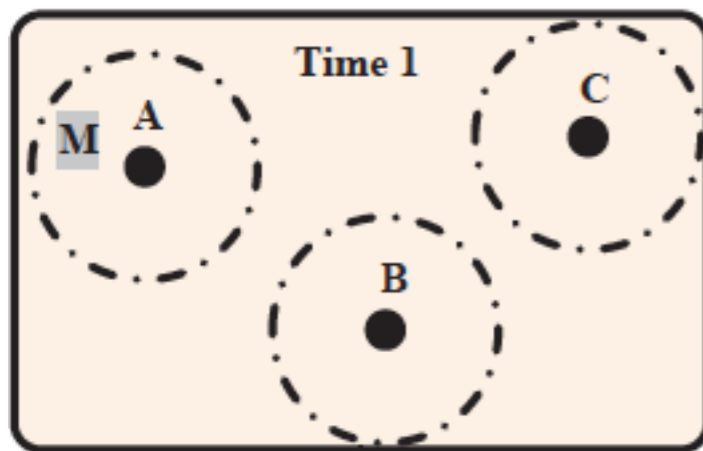
Content dissemination in MSNs

- ## Characters:

  - Personalized content dissemination

  - Increasing content size

  - Publish/Subscribe (Pub/sub) paradigm is an excellent method for this type of content dissemination

Pub/Sub paradigm
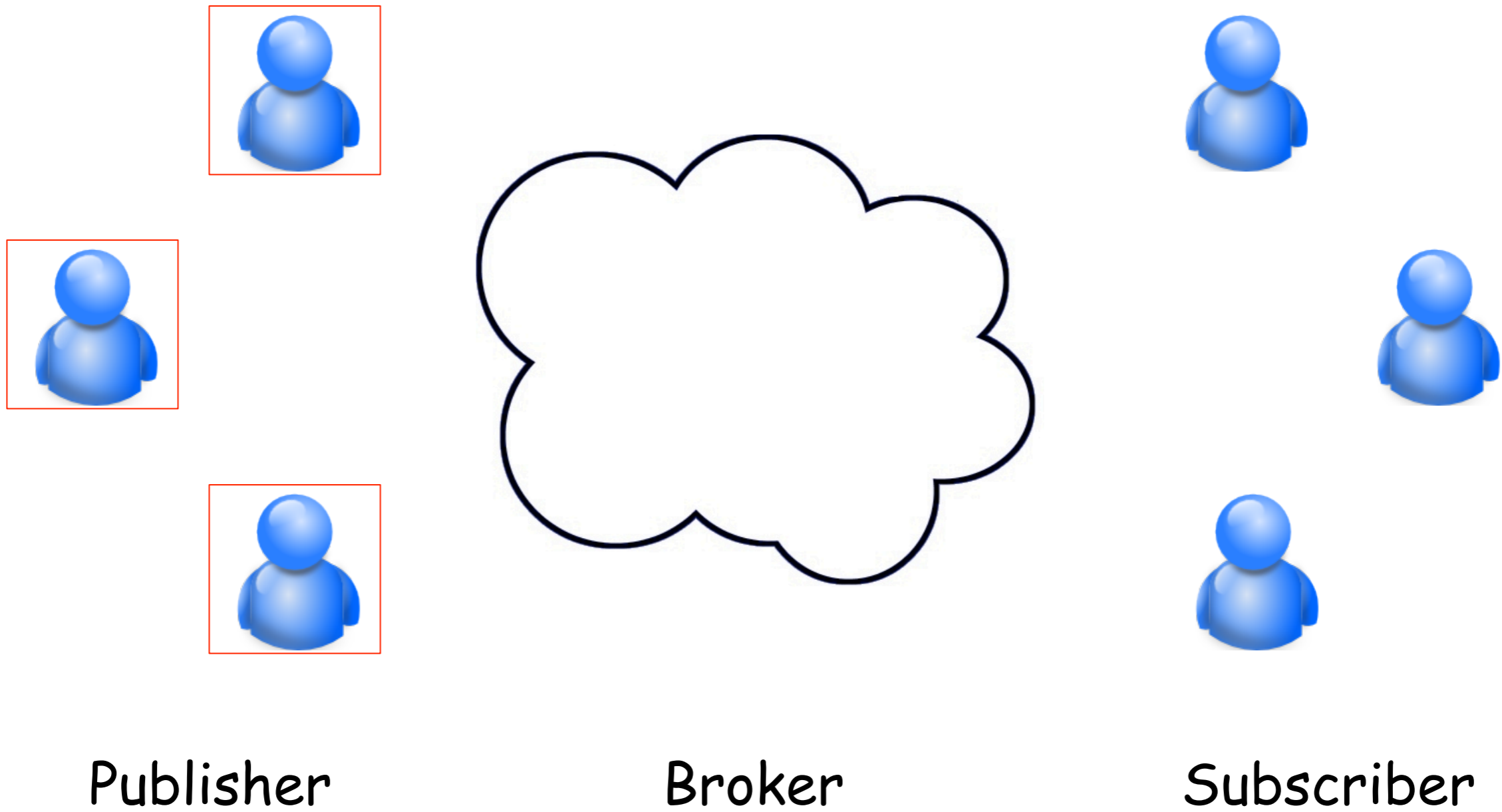
Publisher   Broker   Subscriber
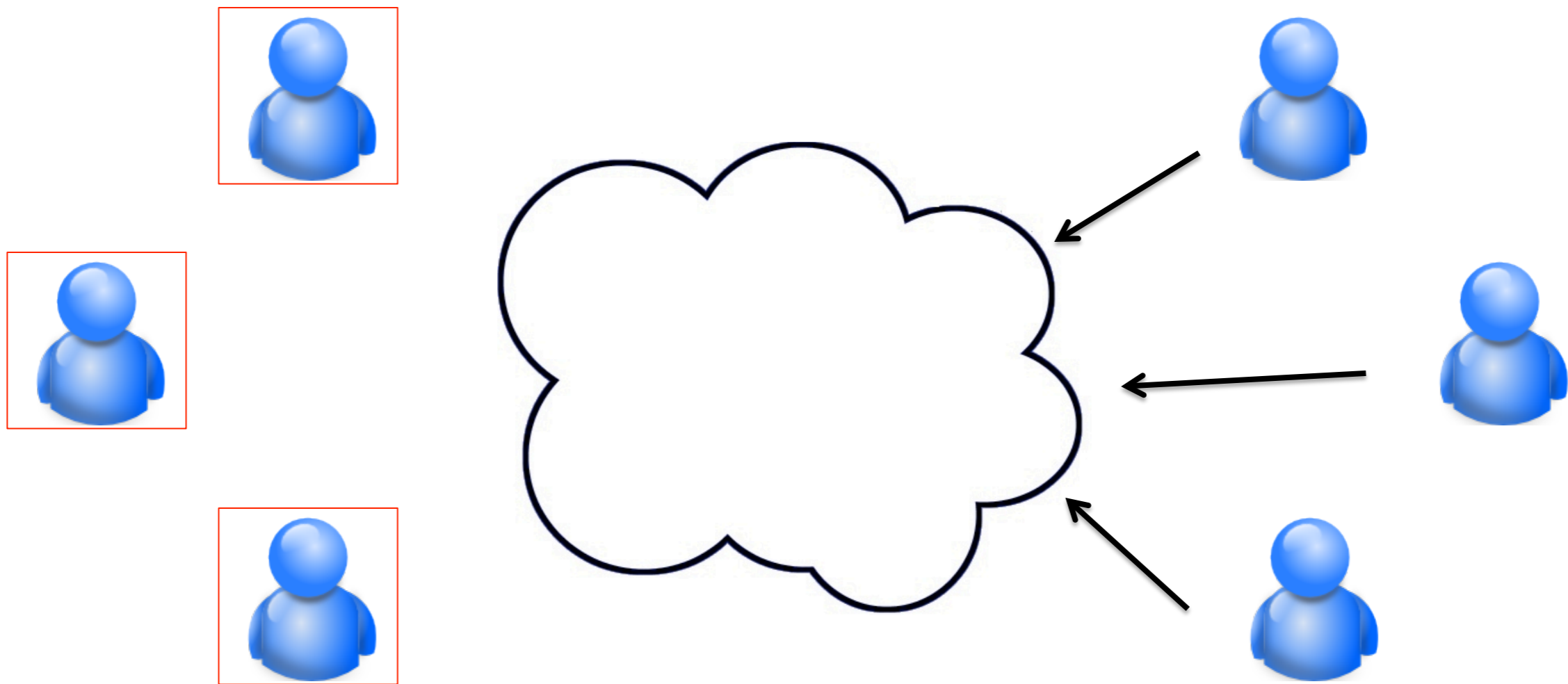
Pub/Sub paradigm

Publisher   Broker   Subscriber

Pub/Sub paradigm

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Pub/Sub paradigm

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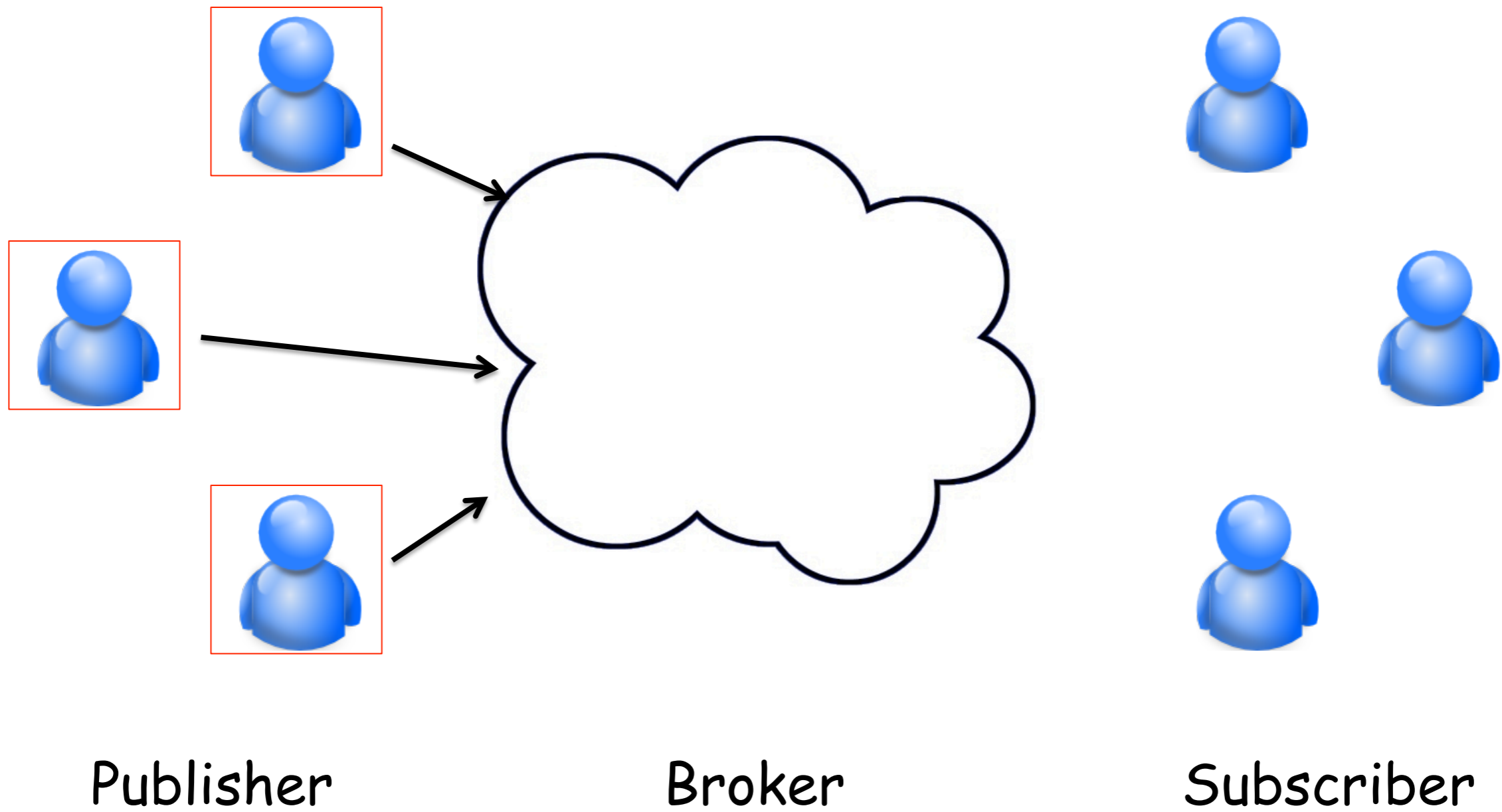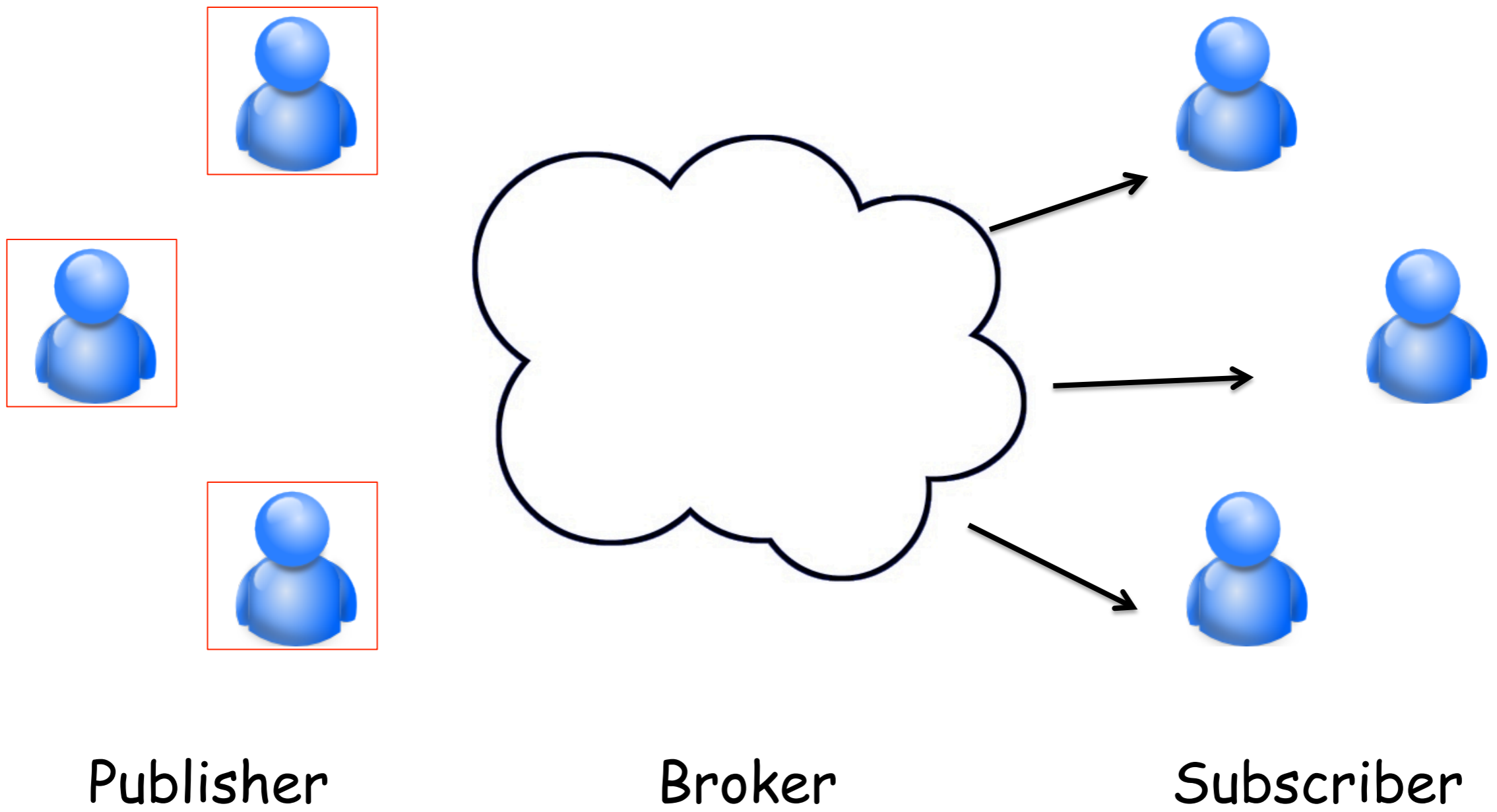
- Bandwidth (denoted by B_{ij}) between node i and node j in MSNs can be calculated by :
  - The average contact duration between nodes i and j,
  - The average meeting time of nodes i and j,
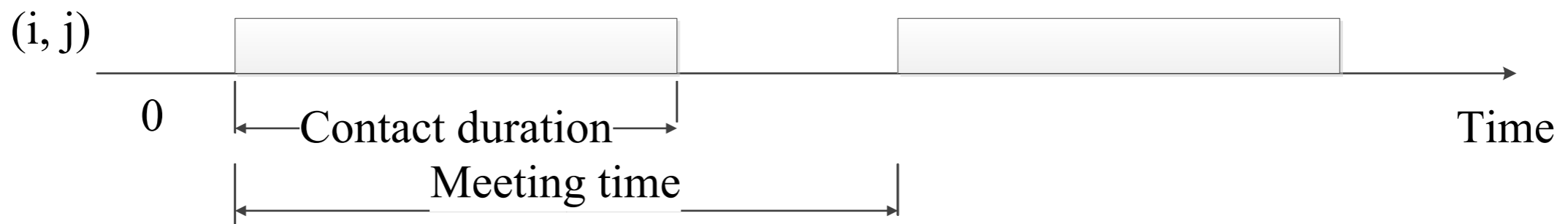
- Evaluating the node's ability as relay:

  - The **expected performance contribution** (defined by E_i) of node i is defined by its bandwidth summation.

  $$E_i = \sum_j B_{ij}$$

  - Popular nodes and unpopular nodes:

  - Popular nodes: $E \geq \beta$

  - Unpopular nodes: $E < \beta$

- Social characters of MSNs:

  - Interested nodes (nodes subscribe the topic):

    - nodes who are **interested in receiving the message**, and they would like to deliver the message **without cost**.

  - Uninterested nodes (nodes do not subscribe the topic)

    - nodes who are **not interested in receiving the message**, they can help to deliver the message **with certain costs**.

Network model

- Combine the contact and social character together

  - Contact character: heterogeneous bandwidth

  - Social character: heterogeneous interest

    - Different interests are represented by different colors
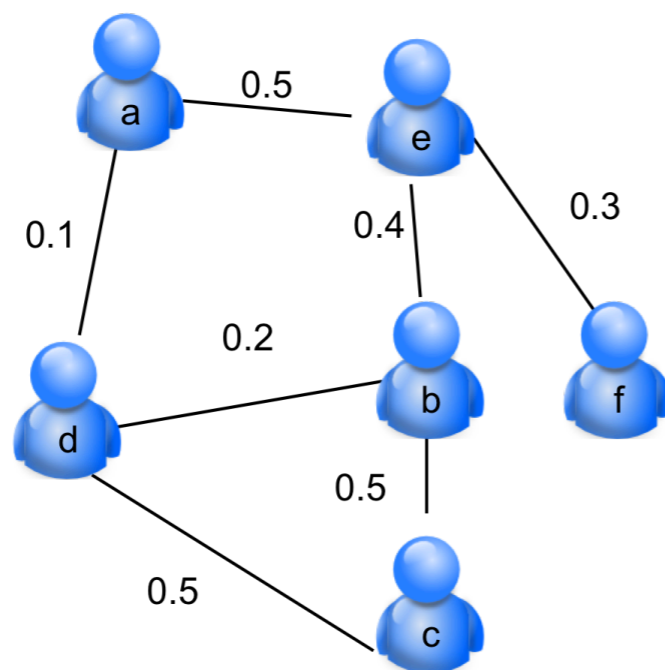
Contact graph
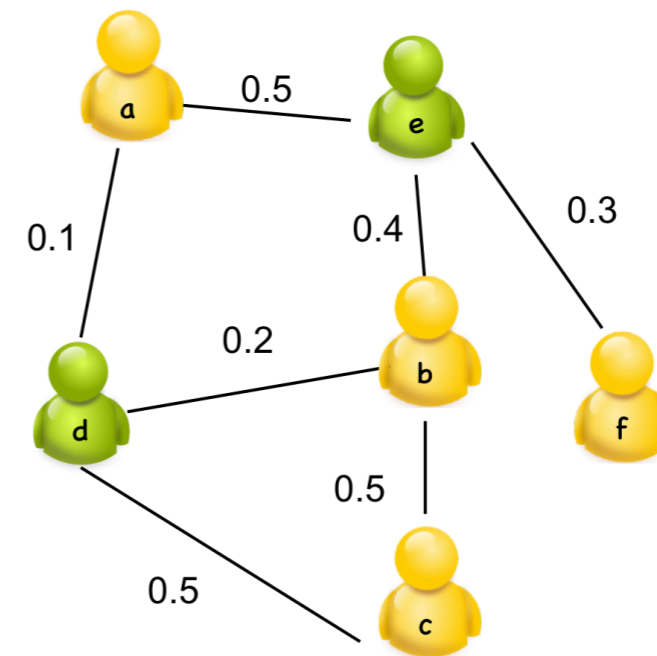
Combined graph

- Mobile Pub/Sub content dissemination:

  Suppose a node (publisher) holds a message for many interested nodes (subscribers), how should we design a multicast scheme with local information so that:

  - The message can be delivered to all the interested nodes.

  - The usage of uninterested nodes is limited.

  - The throughput of interested nodes is maximized.

Problem illustration

- An illustration to the mobile Pub/Sub content dissemination
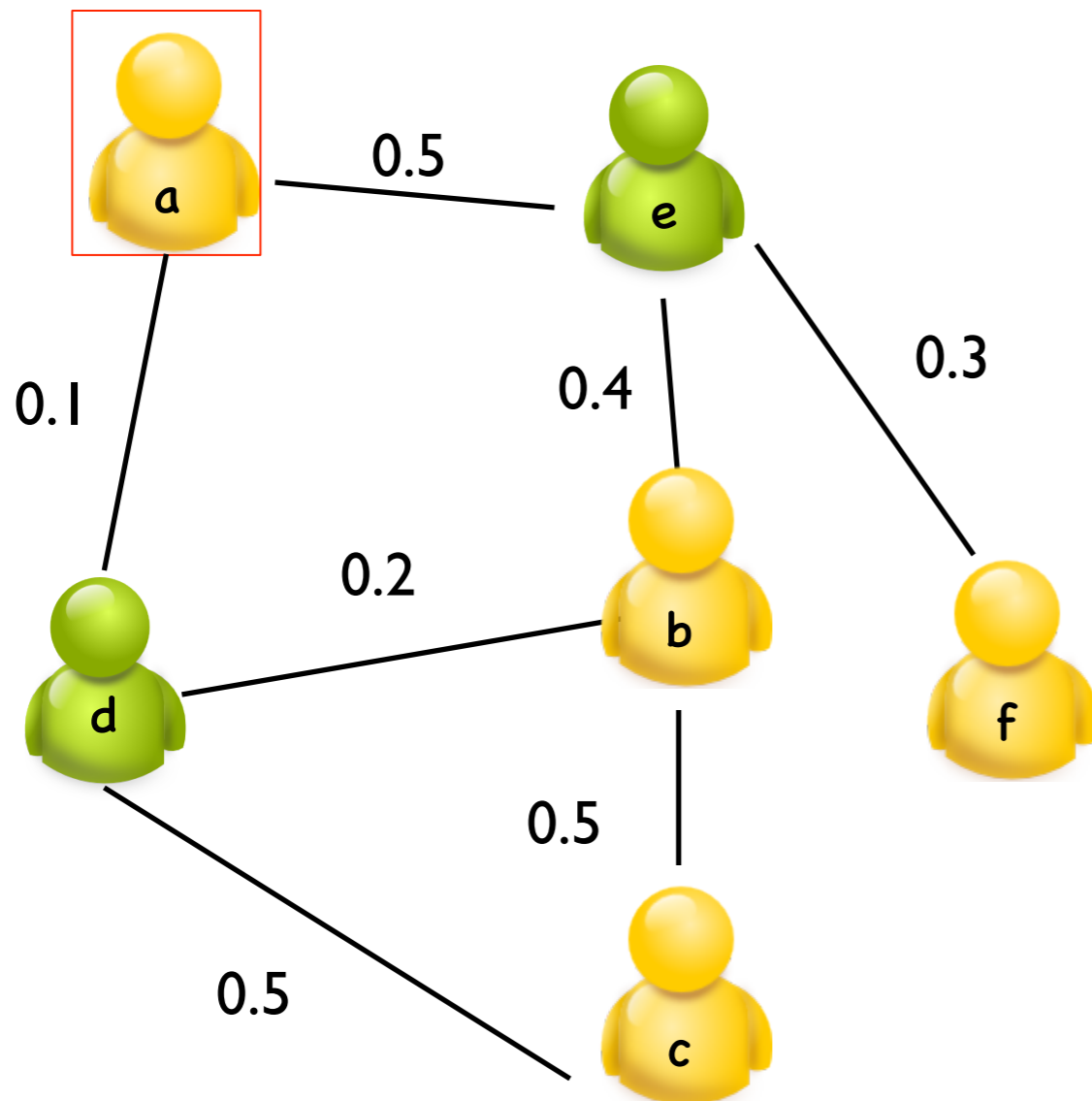
Publisher:

Interest nodes : b and c, and f;

Uninterested nodes : d and e;

Problem illustration

- An illustration to the mobile Pub/Sub content dissemination
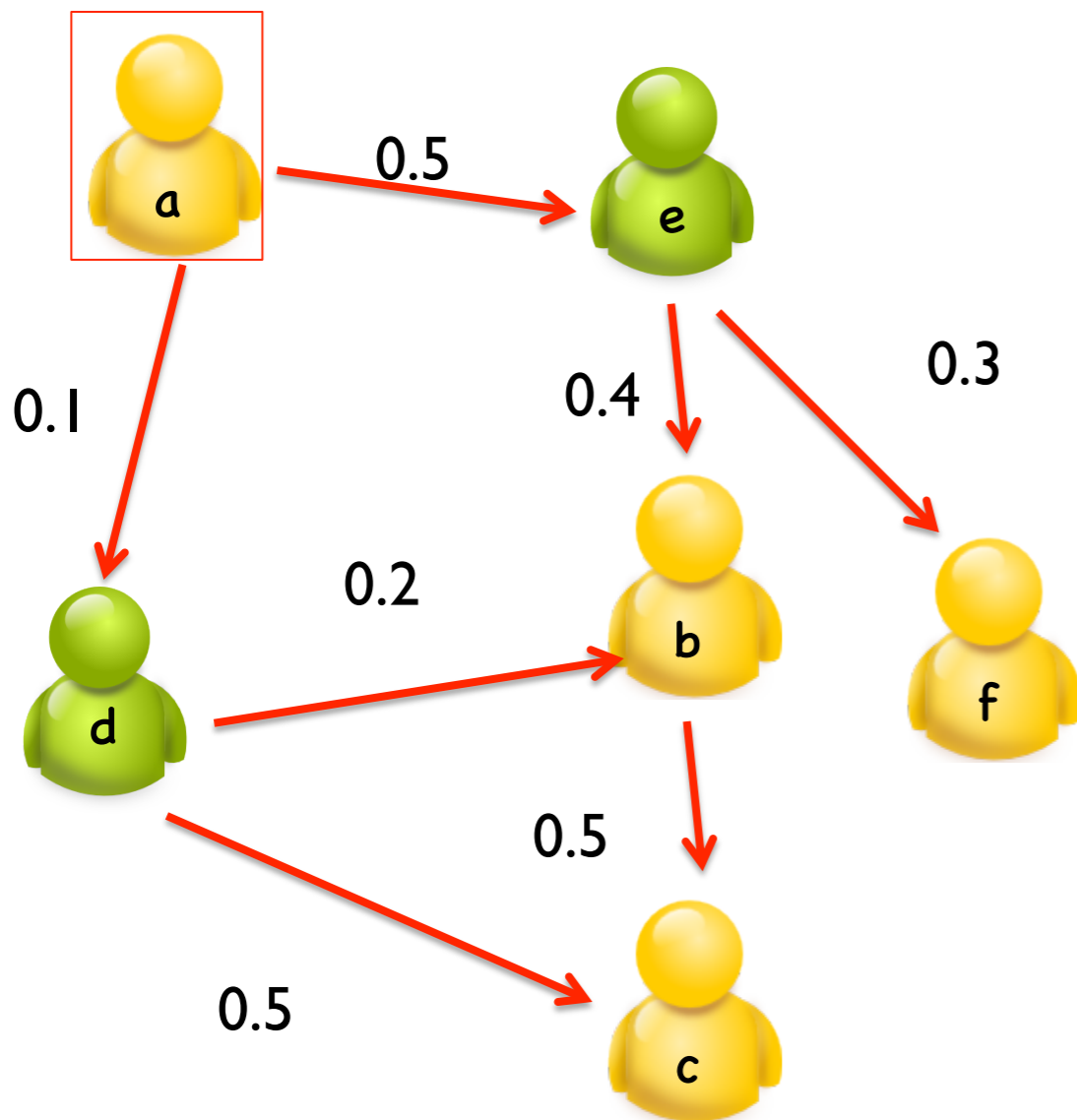
Popular nodes: b, d and e;

Publisher:

Interest node : b and c, and f;

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Problem illustration

- An illustration to the mobile Pub/Sub content dissemination
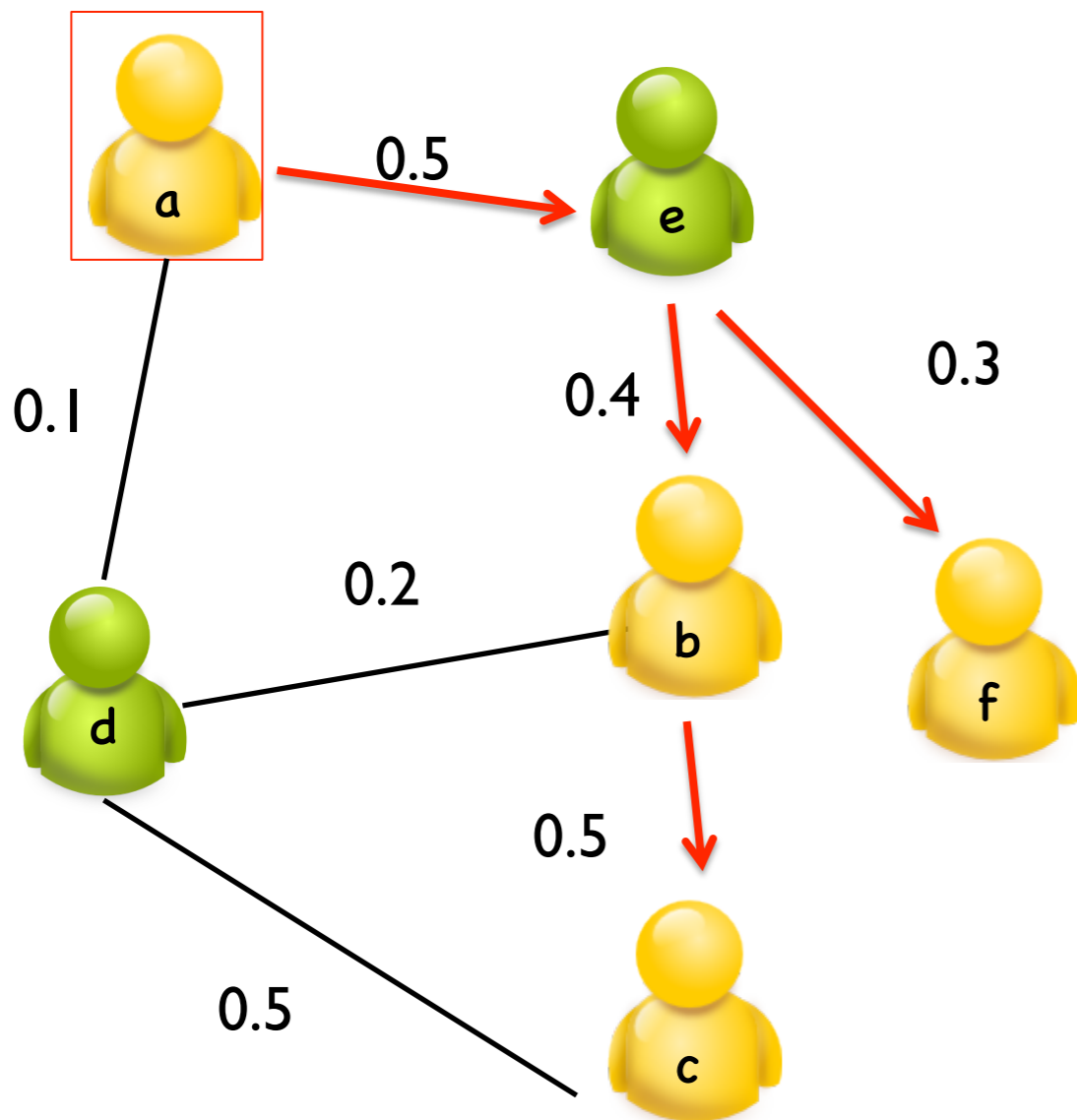
Popular nodes: b and e;

Publisher:

Interest node : b and c, and f;

Uninterested node : d and e;

Challenges and ideas

- Challenges:

  - How can we use the local information to guarantee the delivery of message to all the interested nodes?

  - How can we balance the performance and the cost?

- Ideas:

  - Locally construct a backbone (as the broker) for the publishers/subscribers.

  - Interested nodes and popular nodes have higher priorities for constructing the backbone.

Connected dominating set

- The **connected dominating set (CDS)** is an efficient method to build the virtual backbone, which keeps the connectivity of the graph.

- A connected dominating set of a graph G is a set D of vertices with two properties:
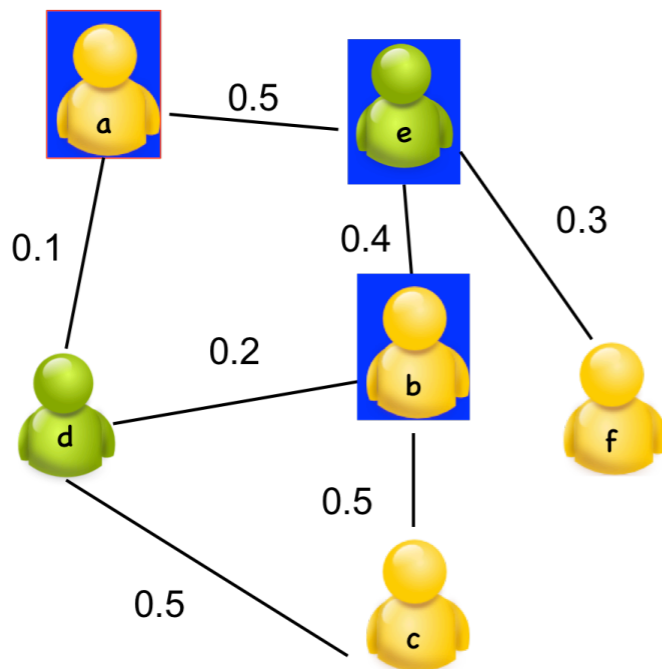

- Any node in D can reach any other node in D by a path that stays entirely within D. That is, D induces a connected subgraph of G.

- Every vertex in G either belongs to D or is adjacent to a vertex in D. That is, D is a dominating set of G.

Build a CDS

- Marking principle

  - All the nodes in the network are unmarked initially, then through neighbor exchange about node's neighbor set, The node which exists two unconnected neighbors are marked. and the marked nodes form a connected dominating set.
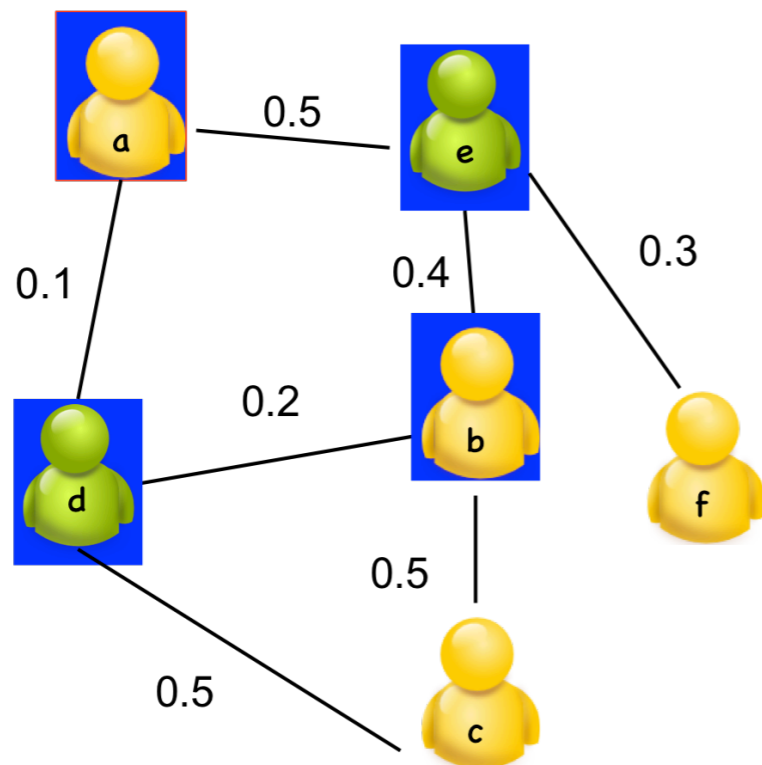
| Node	Neighbor set	Marking
a	d, e	Yes
b	c, d, e	Yes
c	b, d	No
d	a, b, c	Yes
e	a, b, f	Yes
f	e	No

  - Mark all the interested nodes and popular nodes.

- Reduce the usage of the uninterested nodes

- Priority setting
  - Interested nodes > uninterested nodes
  - Nodes with higher expected bandwidth contribution has higher priority.

- Rule k
  - If all the neighbors of a node are covered by the neighbors set of a connected set of nodes with higher priorities, then this node can be pruned (Rule k needs only 3 hops local information).
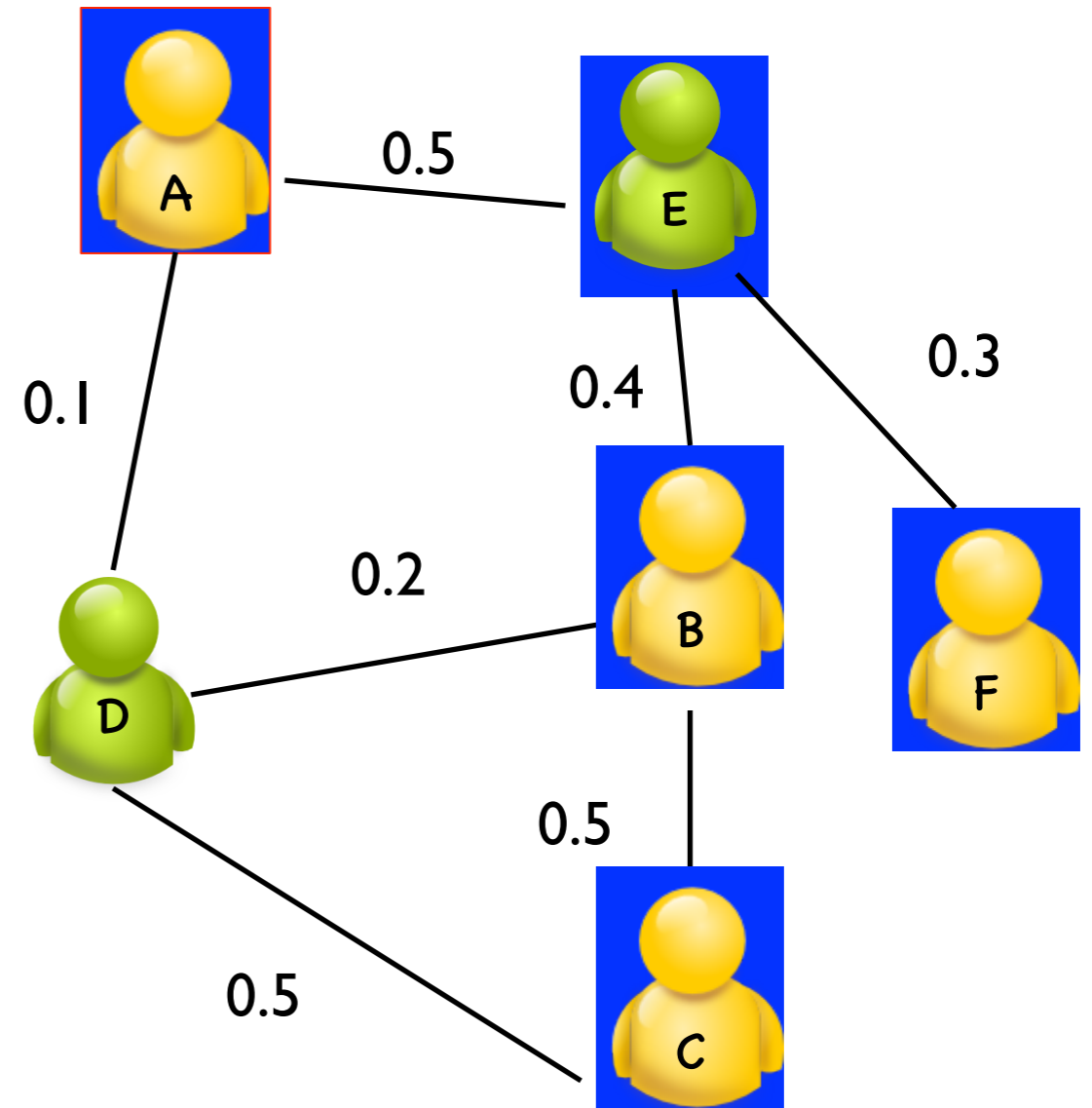 - We never prune the interested nodes and popular nodes.

An illustration of pruning
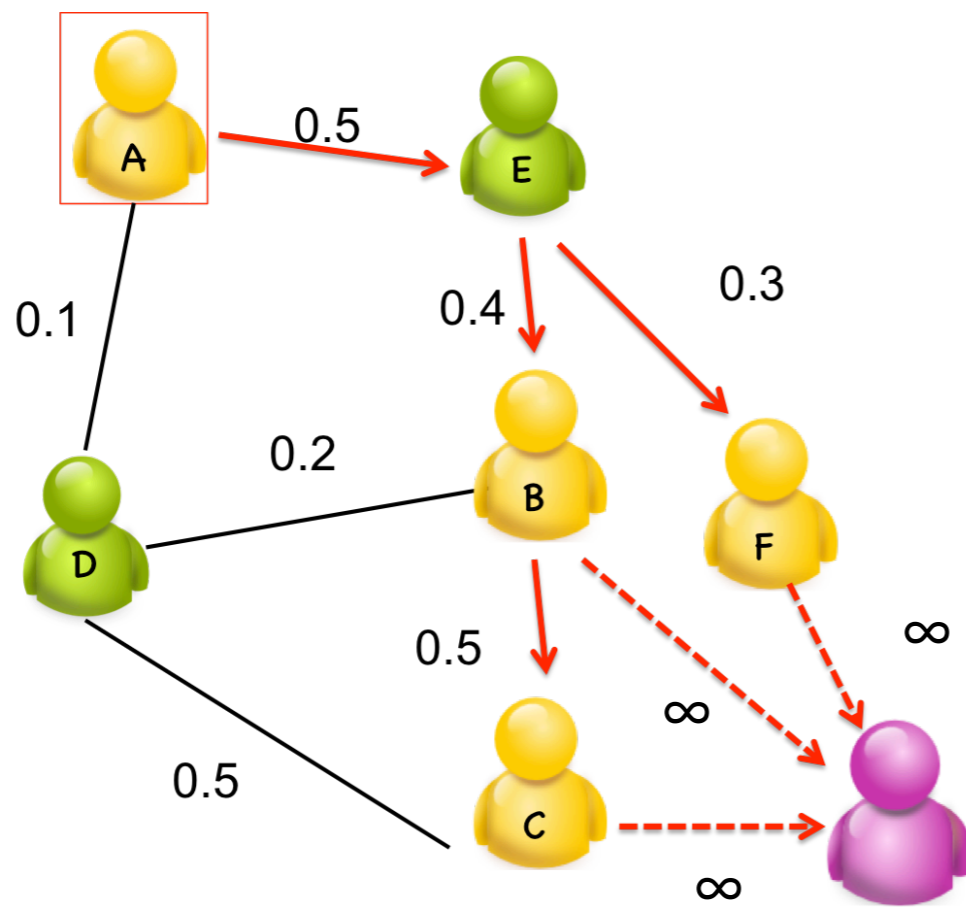
When β is larger than 0.8
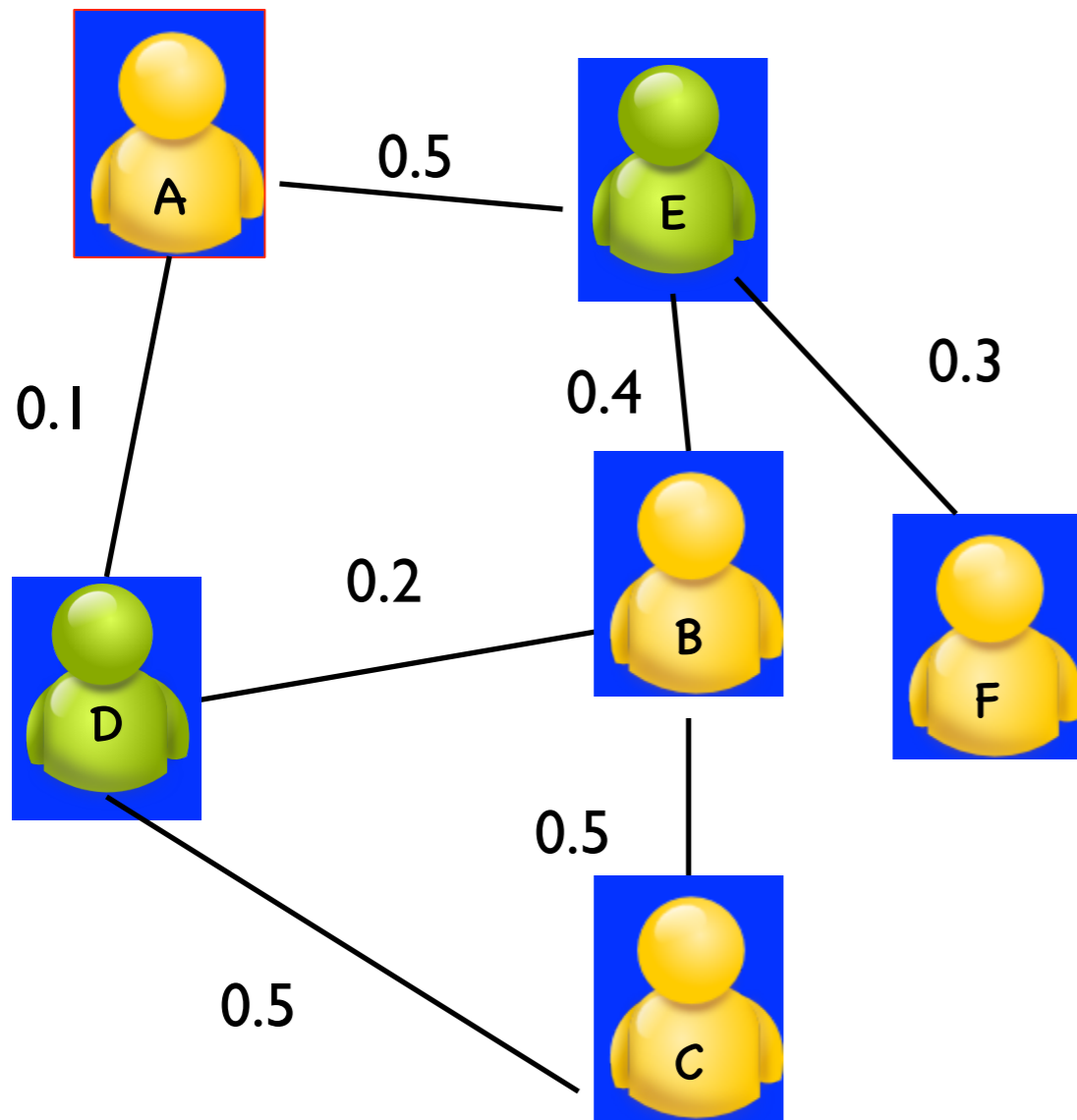
Before pruning

After pruning

Extension

- Through backbone information exchange, we can get a picture of the whole network.

- The network throughput is defined by the max flow from the publisher to the virtual sink.

Publisher:

Interest nodes : B and C, and F;

Uninterested nodes : D and E;

Virtual sink:

- ## Real trace:

  - ### Infocom2006
    - 78 nodes
    - The interest information is included in the questionnaire.

- ## Synthetic dataset
  - 100 nodes
  - The contact, bandwidth and interest information is generated randomly for 100 rounds.
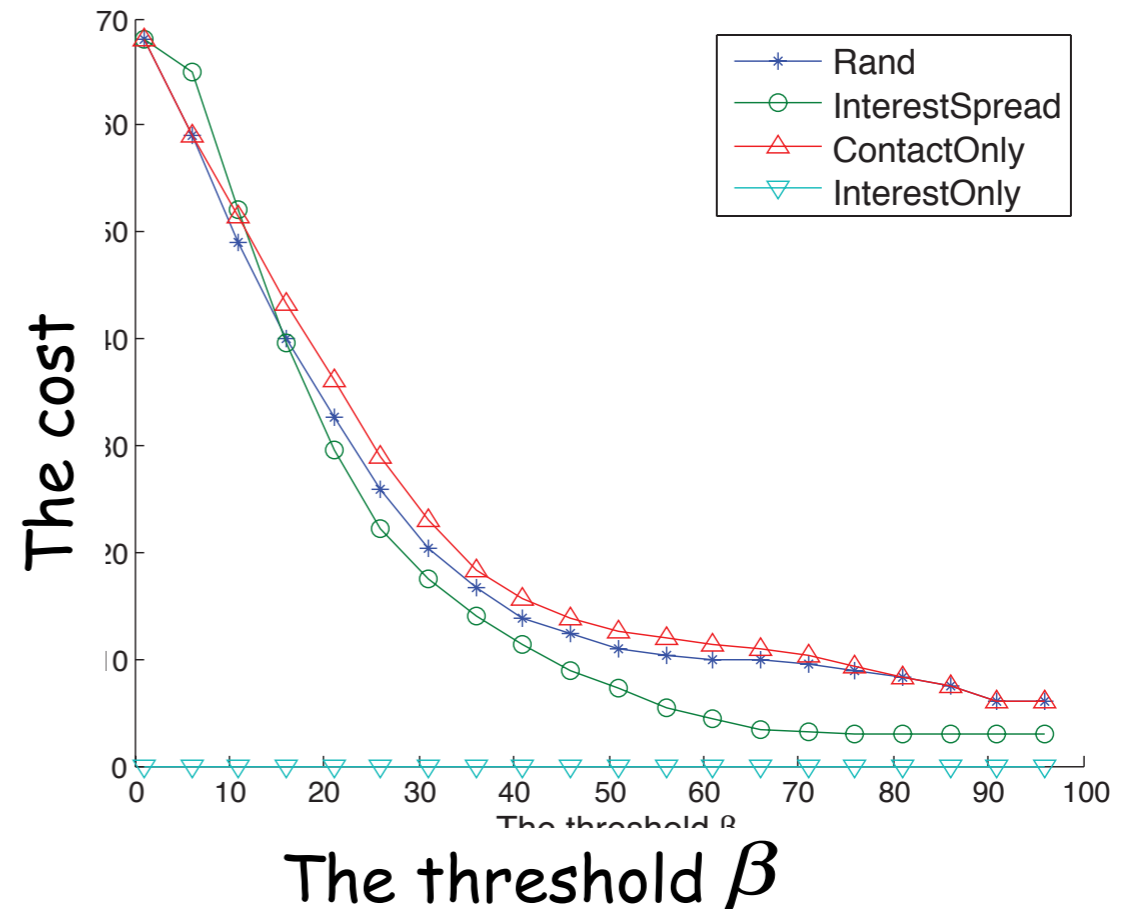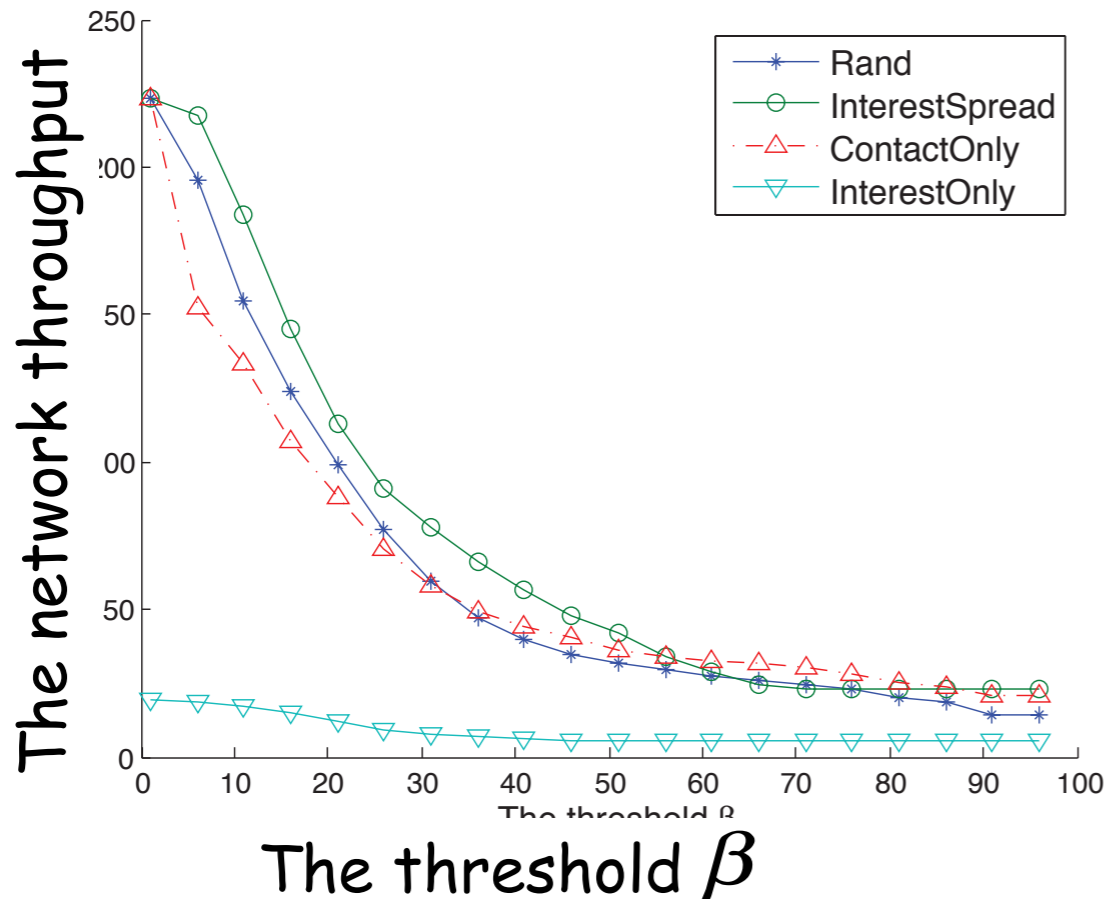
Algorithm comparion

- Four algorithms:

    - **InterestSpread**: consider the contact and social character:

    - **ContactOnly:** only consider the contact character

    - **InterestOnly:** only consider the social character

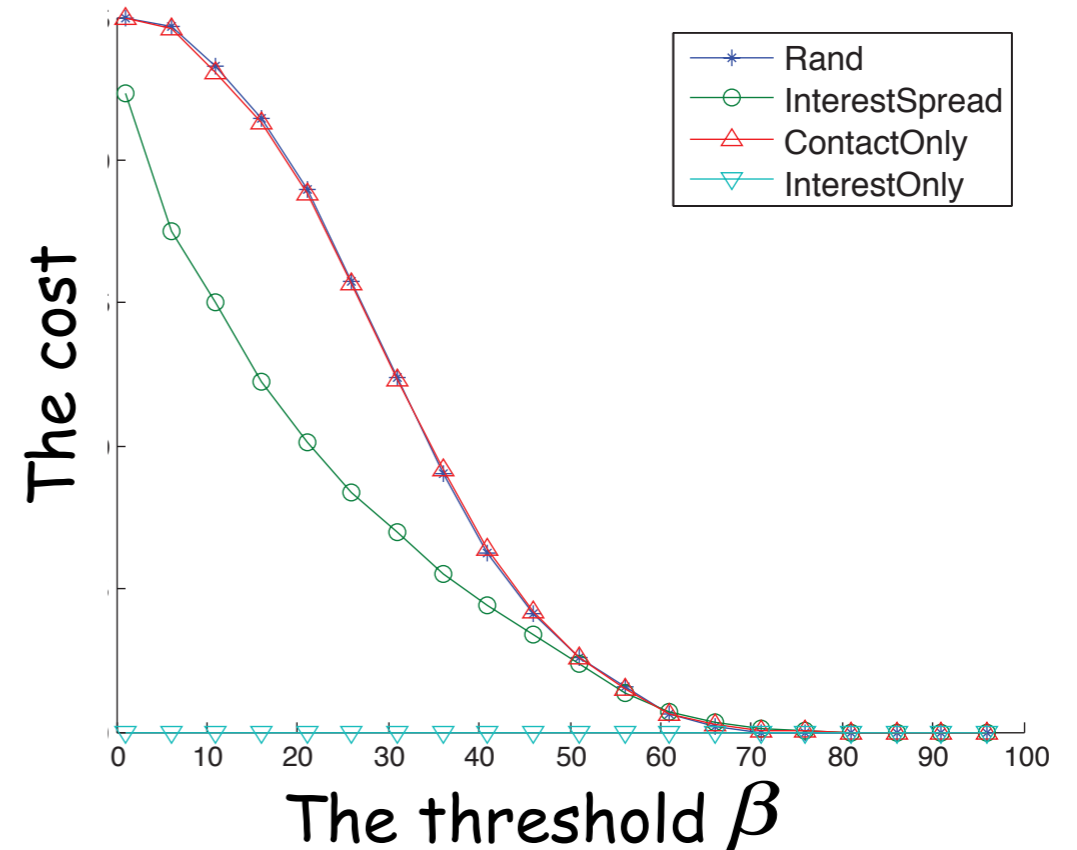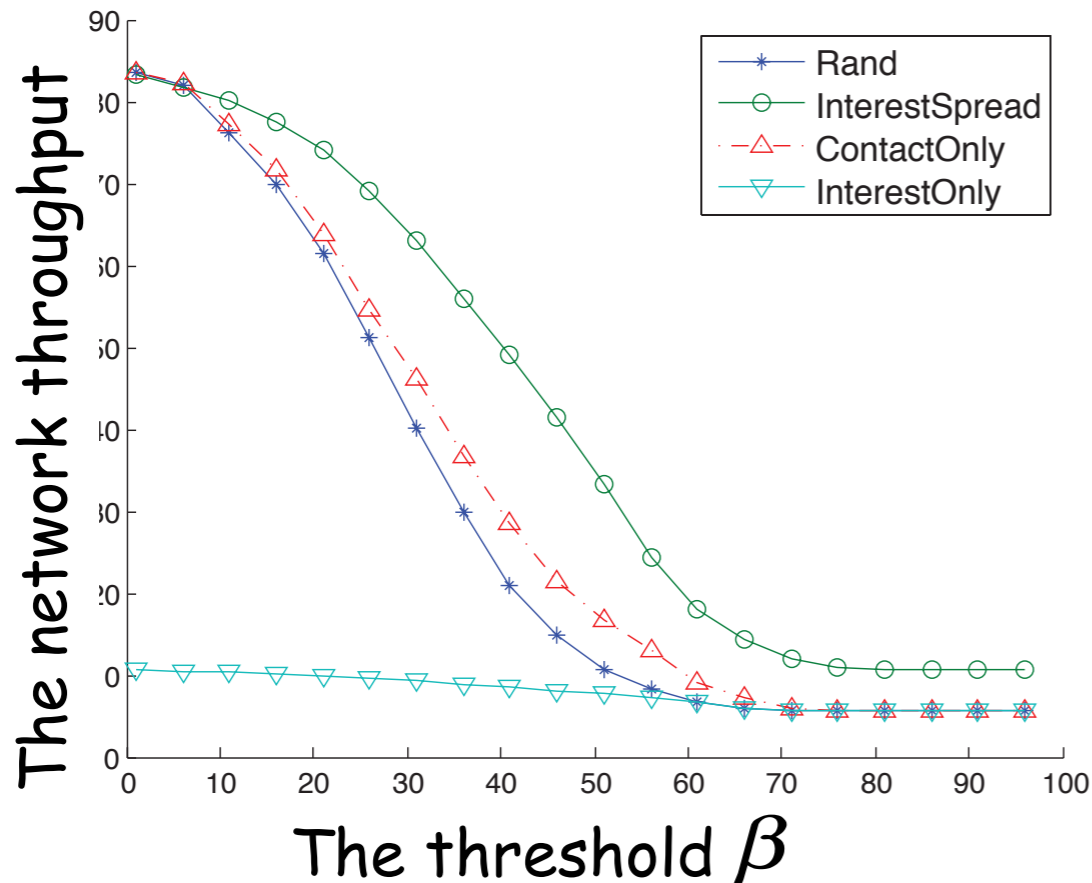   - **Rand:** randomly select the brokers

Real trace

In decrease of β, the performance decrease.

In the same β, our algorithm achieve highest performance with the least consumption of uninterested nodes

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In the same β, our algorithm achieve highest performance with least consumption of uninterested nodes

Conclusions

- We investigate a mobile pub/sub content dissemination problem in MSNs that exploits information about nodes' contact and social characters.

- A novel localized virtual backbone building method is proposed to balance the performance and cost.

- Limiting the relay selection into the virtual backbone achieves a good trade-off between performance and cost.

Thank you and Question

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