A Flooding Method for Exchanging Routing Information in Power-Law Networks

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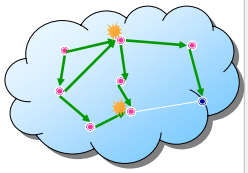
Overview

- Background
- Objective
- Flooding in power-law networks
  - Examine the problems of flooding on the Internet-like topology
- Proposed method
  - Mechanism and Evaluation
- Conclusion and future works

Background(1/2)

Flooding and its problem

- *Flooding* is used to deliver the routing information to entire network
  - Each node copies a message to all the neighboring nodes
  - Some nodes receive the same duplicated messages via different routes
- If the size of a network increases
  - Amount of traffic becomes critical problem [2] by increasing messages



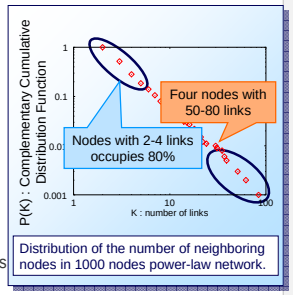
Example of flooding and how the duplication occurs

[2] L. Gao and J. Rexford, "Stable Internet routing without global coordination," in *Proceedings of* ACM SIGMETERICS 2000, pp. 307-317, June 2000.

Background(2/2)

Topological characteristic of the Internet

- Internet topology follows "Power-law"
  - Connectivity of nodes exhibits power-law attributes
    - A *few nodes* have many connections to other nodes
    - *Many nodes* have a few connections to other nodes
- How the flooding in power-law networks behaves?
  - Messages tend to concentrate on nodes with many connections
  - It is important to know the feature of Internet-like networks



Distribution of the number of neighboring nodes in 1000 nodes power-law network.

Objective

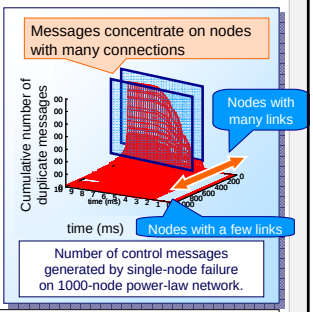
- Clarify a behavior of simple flooding in Power-Law networks
  - Estimate the amount of control messages
  - Examine problems with a simple flooding method
- Propose a new flooding method
  - Based on the observation found above
  - Decreases the number of control messages

Evaluation of simple flooding (1/2)

Duplicate messages in Power-Law network

- Simulation setup
  - Topology generated by BA model [4] with 1000 nodes ($m=m_0=2$)
  - Failure on a node with many connection
  - A failure occurred at the highest degree node
- Messages concentrate on nodes with many links

Flooding in power-law network does not scale well



Number of control messages generated by single-node failure on 1000-node power-law network.

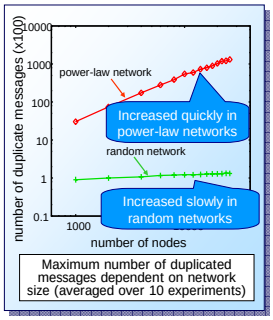
[4] A. Barabasi and R. Albert, "Emergence of scaling in random networks," *Science*, vol. 286, pp. 509–512, Oct. 1999.

Evaluation of simple flooding (2/2)

Duplicate messages in different networks

- Compared with random networks
  - Connections between nodes are setup randomly
- Many duplication found in power-law network
  - Duplication increased rapidly in power-law networks
  - Duplication increased slowly in random networks

A method to reduce messages is required to perform flooding in large power-law networks

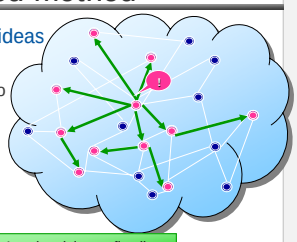


Proposed method (1/3)

Overview of proposed method

Our method consists from two ideas

(i) Probabilistic flooding
- Each node relays messages to a part of nodes chosen by a relaying probability *p*
- Duplicated messages are reduced at intermediate nodes



Some nodes do not receive messages by its nature

But in routing protocols, all nodes have to receive routing information

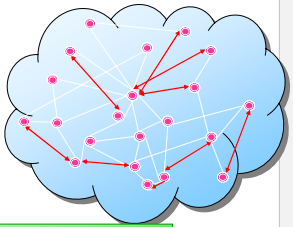
A node originates flooding

Flooding continues with probability *p*

Proposed method (2/3)

Overview of proposed method

(ii) Periodic information exchange
- Each node asks its neighbors weather they have a new information
- If new information is found, a node receives it from the neighbor node



Nodes that couldn't received control messages can get routing information

Using this mechanism, we can choose lower relaying probability

A node originates flooding

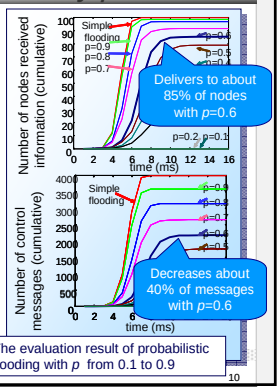
Flooding continues with probability *p*

Deliver information to all nodes by periodic exchange

Proposed method (3/3)

Choosing relaying probability *p*

- How many nodes receive information by periodic exchange?
  - About 15% of nodes according to the simulation result (not presented here)
- Relationship between probability *p* and the number of nodes received messages
  - Probability *p*=0.1 ~ 0.9 (fig.)
  - *p*=0.6 enables this method to inform 85% of nodes



The evaluation result of probabilistic flooding with *p* from 0.1 to 0.9

Evaluation of proposed method (1/3)

Simulation experiments

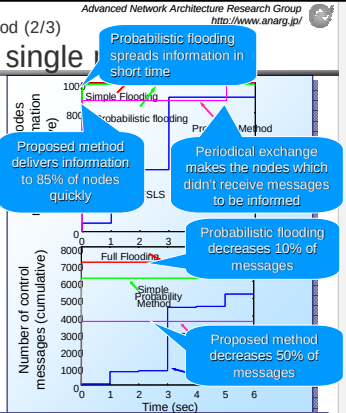
- Two scenarios of flooding
  - Flooding from a single node
  - Flooding from different nodes
- Evaluate two indexes
  - The number of nodes that received messages
  - Amount of control messages
- Compared with two methods
  - Simple flooding
  - Flooding based on critical probability (p_c =0.9)
    - With this probability, 99.9% of nodes receive messages [6]
- Other parameters
  - Periodic exchange is performed at every 5 seconds
  - Evaluated on 1000 nodes power-law network (BA model : m_0=m=2)

[6] F. Banaei-Kashani and C. Shahabi, "Criticality–based analysis and design of unstructured peer-to-peer networks as 'complex systems'," in *Proceedings of GP2PC*, pp. 22–32, May 2003.

Evaluation of proposed method (2/3)

Flooding from a single

- Simple flooding and probabilistic flooding
  - Spread messages in short time, but cannot decrease messages
- Proposed method
  - Delivers to 85% of nodes in short time
  - Decreases about 50% of messages
  - Periodic exchange delivers information to all nodes



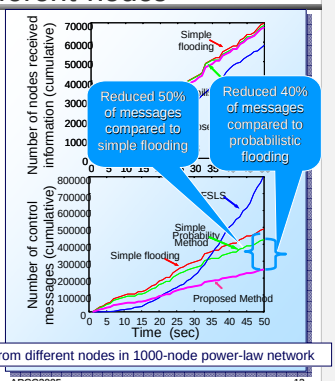
Evaluation result of single flooding in 1000-node power-law network

Evaluation of proposed method (3/3)

Flooding from different nodes

- **Flooding frequency**
  - Flooding performed based on Poisson arrival with a mean 1 / sec
- **Proposed method**
  - Reduced 50% of messages compared to simple flooding

Our method scales better than simple flooding



Evaluation result of flooding from different nodes in 1000-node power-law network

Conclusion and Future works

- **A flooding in power-law network**
  - Didn't scale well due to the concentration of messages at a part of nodes
- **Proposed flooding method**
  - Probabilistic flooding with periodic exchange of information
  - Decreased 50 % of control messages compared to simple flooding method
- **Future works**
  - Theoretical deriving of relaying probability
  - Evaluate in other network models that generate power-law attribute