A distributed measurement method for reducing measurement conflict frequency in overlay networks

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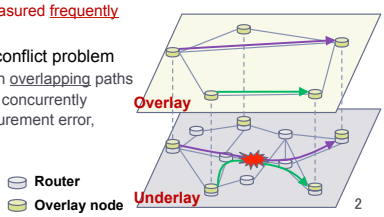
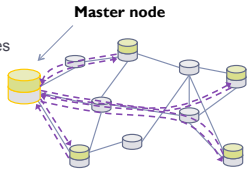
Measurement conflict in overlay networks

- Overlay networks
  - Logical network constructed on the underlay network
- Network resource information
  - Available bandwidth, delay, packet loss, etc
  - Essential for maintenance and improvement of the performance of network service
  - Should be measured frequently
- Measurement conflict problem
  - Happens when overlapping paths are measured concurrently
  - Causes measurement error, link stress



Existing measurement method[1] (1/2)

- Measurement overhead is concentrated at a master node
  - Aggregating topology information
  - Determining measurement timing
  - Giving instructions to overlay nodes
  - Receiving measurement results



The amount of time and network traffic for aggregation of topology information and measurement results is large

[1] M. Fraiwan and G. Manimaran, "Scheduling algorithms for conducting conflict-free measurements in overlay networks", *Computer Networks*, vol 52, pp. 2819-2830, Oct. 2008

Existing measurement method[1] (2/2)

- Measurement conflicts avoiding algorithm
  - The measurement tasks are divided into several groups
    - Measurement tasks of paths that do not overlap with each other are included in the same group
    - Tasks in same group are executed concurrently
    - Tasks in different groups are executed sequentially

Measurements conflict can be avoided completely

- Task groups are obtained using a heuristic algorithm
  - Number of task groups may become large

This method can not measure with high frequency

Overview of our measurement method

- A distributed traceroute-like measurement method
  - Each overlay node detects overlapping state of overlay paths it measures
  - Each overlay node determines the measurement frequency and measurement timing of overlay paths to avoid measurement conflict
- High measurement frequency
  - Only reduce measurement frequency if necessary to avoid measurement conflict

Outline of our measurement method

- Classify overlapping states
  - Complete overlapping
  - Half overlapping
  - Partial overlapping
- Detect overlapping paths
- Reduce measurement conflict
  - Avoid measurement conflict of complete overlapping paths
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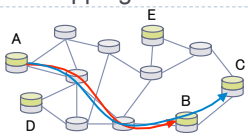
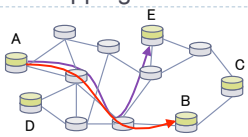
Path overlapping classification



- *Complete overlapping* : One path completely includes another path
  - Can be detected by traceroute

Path overlapping classification



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- *Half overlapping* : Two paths share a route from the source overlay node to a router that is not an overlay node
  - Can be detected by traceroute

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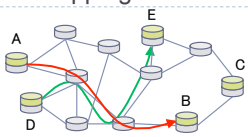

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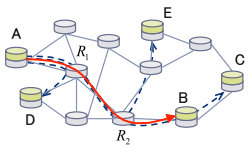
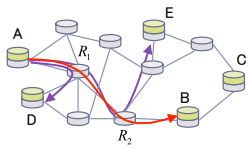
Detecting partial overlapping paths



How can A detect partial overlapping paths of AB?

- Issues traceroute to other overlay nodes

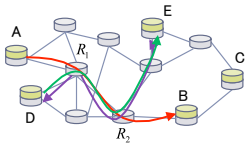
Detecting partial overlapping paths



How can A detect partial overlapping paths of AB?

- Issues traceroute to other overlay nodes
- Detects half overlapping paths

Detecting partial overlapping paths



How can A detect partial overlapping paths of AB?

- Issues traceroute to other overlay nodes
- Detects half overlapping paths
- Infers partial overlapping paths

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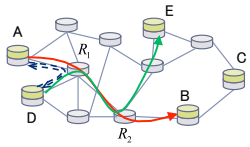
Detecting partial overlapping paths



How can A detect partial overlapping paths of AB?

- Issues traceroute to other overlay nodes
- Detects half overlapping paths
- Infers partial overlapping paths
- Exchanges topology information to confirm partial overlapping paths

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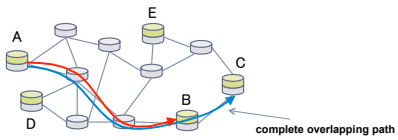
Measurement conflict avoiding method for complete overlapping paths



- Complete overlapping path is not measured directly
- The measurement result is estimated based on the measurement results of shorter overlay paths [2]
  - Example : delay of AC = delay of AB + delay of BC

[2] G. Hasegawa and M. Murata, "Scalable and density-aware measurement strategies for overlay networks", *in Proceedings of ICIMP 2009*, vol 52, pp.21–26, May 2009

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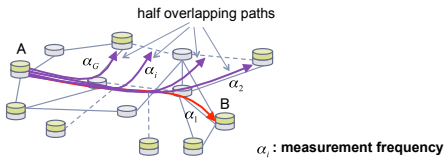
Measurement conflict avoiding method for half overlapping paths (1/2)



- Calculate *measurement frequencies* according to the degree of fluctuation of measurement results

$$\textit{Measurement frequency} = \frac{\text{Measurement time}}{\text{Measurement duration}}$$

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Measurement conflict avoiding method for half overlapping paths (2/2)

- Adjust measurement frequencies so that A can measure AB and its half overlapping paths sequentially
  - The sum of measurement frequencies must be smaller or equal to one ($\alpha_1 + \ldots + \alpha_G \le 1$)
  - If $\alpha_1 + \ldots + \alpha_G > 1$, reduce the measurement frequencies
    - The reduction rates should be the same

$$\frac{\alpha_1 - \beta_1}{\alpha_1} = \ldots = \frac{\alpha_G - \beta_G}{\alpha_G}$$ β_i : adjusted frequency

    - The reduction of frequencies should be as small as possible

$$\beta_1 + \ldots + \beta_G = 1$$

$$\beta_i = \frac{\alpha_i}{\alpha_1 + \alpha_2 + \ldots + \alpha_G}$$

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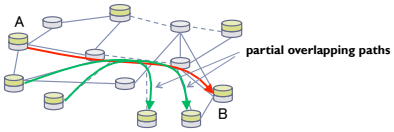
Measurement conflict reducing method for partial overlapping paths



- Measurement conflicts cannot be completely avoided
  - Because partial overlapping paths are measured by the different overlay nodes
- Reduce probability of measurement conflict

1. Adjust measurement frequency of AB
   - If path AB has K-1 partial overlapping paths, set the frequency of path AB to a value not greater than 1/K

$$\gamma_1 = \min(\beta_1, 1/K)$$

2. Take the measurement timing of AB randomly

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Performance evaluation

- Evaluation metrics
  - Measurement execution ratio : average value of measurement frequencies of all overlay paths
  - Measurement success ratio : average value of frequencies of measurement tasks that do not conflict with other measurement tasks
- Network models
  - Underlay topology
    - AT&T
    - BA model (10 topologies)
    - Waxman model (10 topologies)
  - Overlay topology
    - Overlay nodes are chosen randomly
    - Density of overlay node : 0.05～0.4

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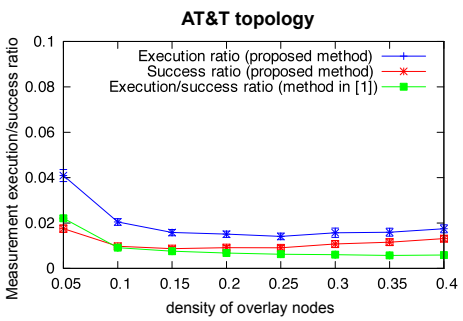
Performance evaluation result (1/3)



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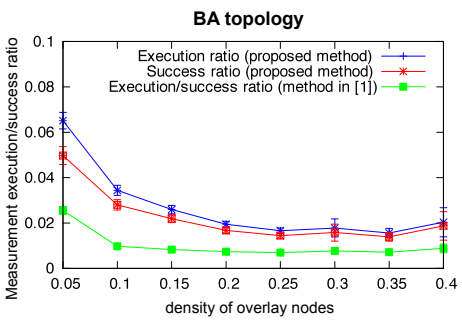
Performance evaluation result (2/3)



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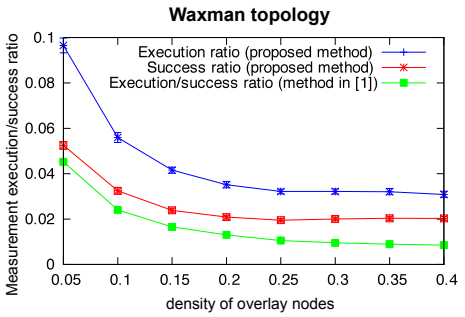
Performance evaluation result (3/3)



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Conclusions and future works

- Conclusions
  - Proposed a distributed overlay network measurement method that reduces the probability of measurement conflicts
    - Infer the overlapping of paths
    - Adjust the measurement frequency and the measurement timing of paths
- Future works
  - Evaluation of measurement overhead
  - Construction of measurement system

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Thank you for your attention!

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