IEEE ISCC 2017
July 2017

Message Bundling on Structured Overlays

Kazuyuki Shudo
Tokyo Institute of Technology

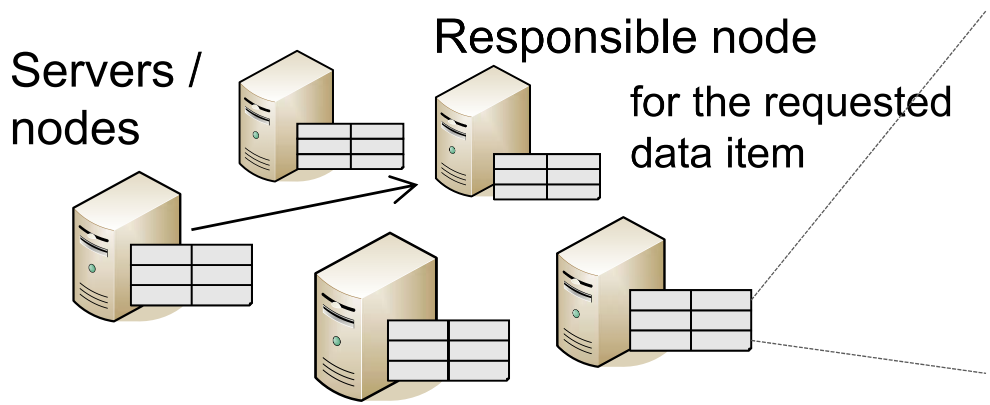
首藤 一幸
東京工業大学

Overlay Weaver

Tokyo Tech

Background: Structured Overlay

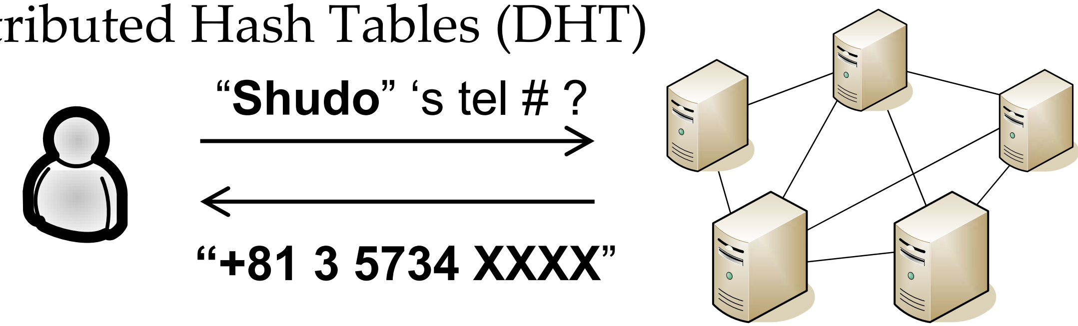
- An application-level network
  - routes a query to the responsible node.



Index range (digest)	Responsible node
ab – dz	192.168.0.2
ea – gb	192.168.0.3
gc – …	192.168.0.4

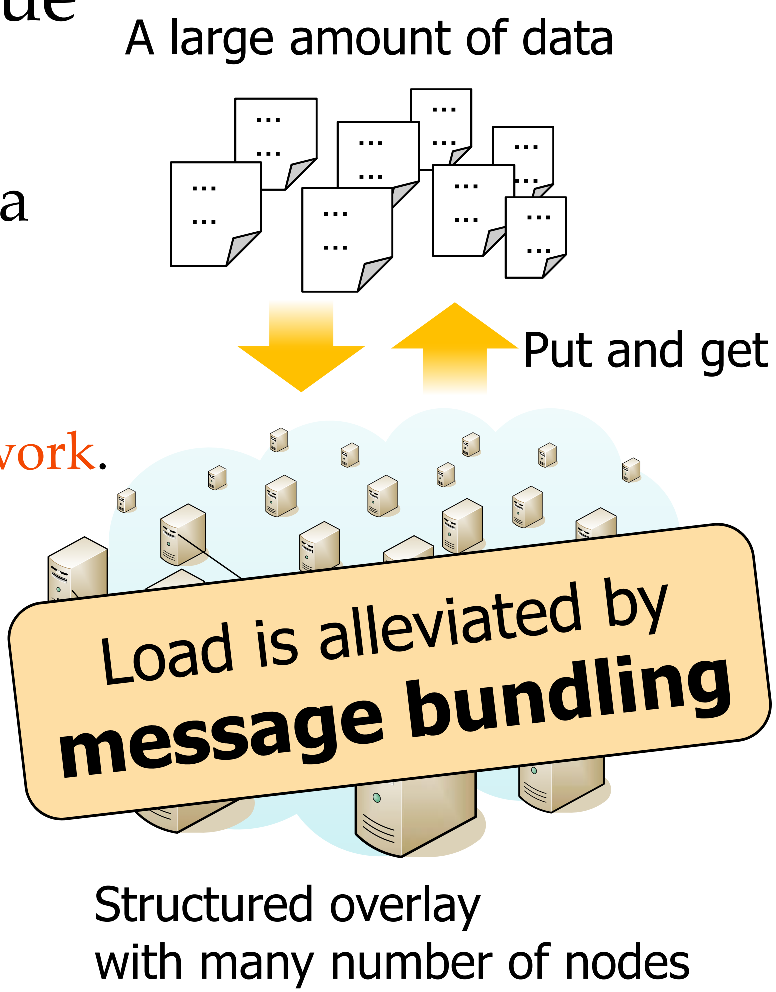
Routing table

  - enables scalable data store and messaging.
    - e.g. Distributed Hash Tables (DHT)



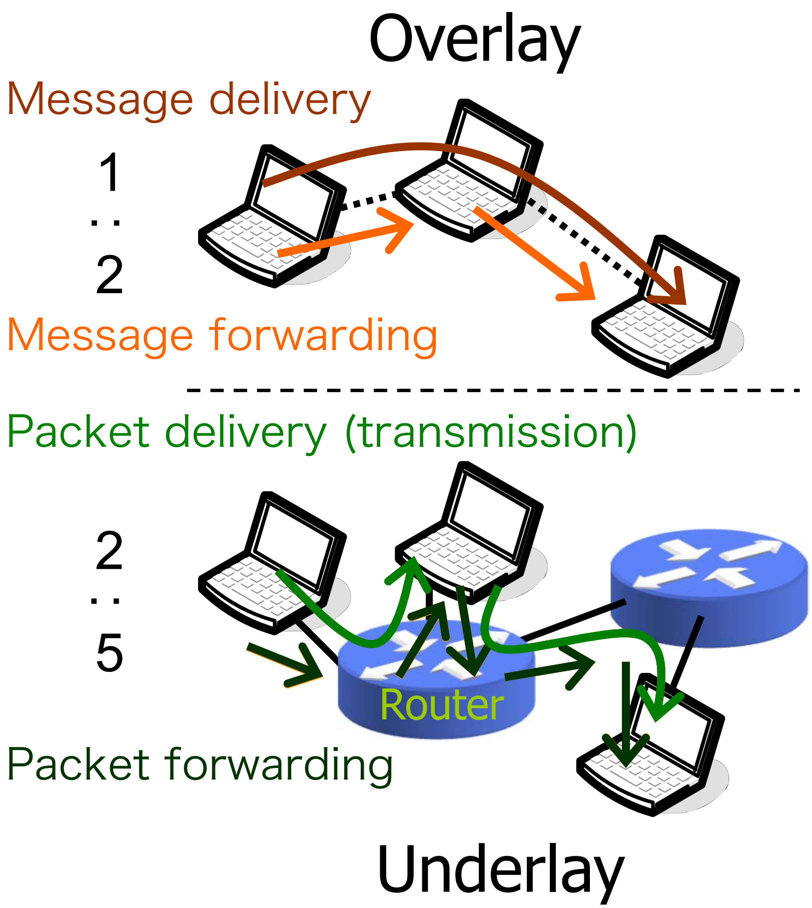
Contribution: Collective Forwarding

- A message bundling technique for structured overlays.
  - combines multiple messages into a single message.
  - mitigates
    - the load of nodes on the overlay network.
    - the load of Internet routers on an underlay network by reducing # of packet transmission.
  - Results
    - # of packet transmission: 34 % ~ 12 %
    - Data loading time: 13.0 % ~ 9.5 %



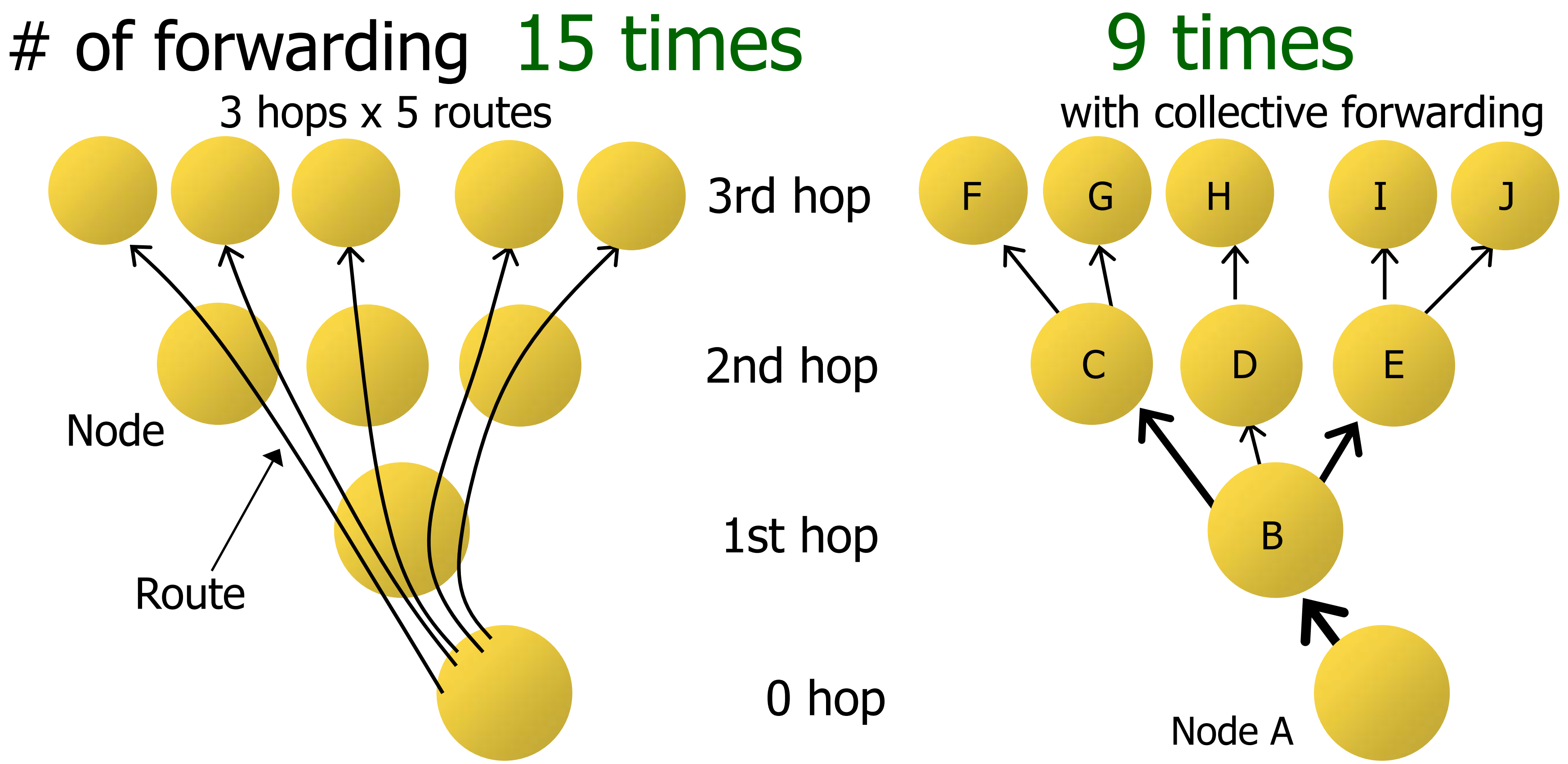
Problem:
Delivery time and underlay load

- Message delivery on a structured overlay takes much time.
  - 10,000 get operations on a DHT took 40 ~ 700 sec (Section IV.C) .
- An overlay imposes a burden on an underlay.
  - A message delivery requires multiple …



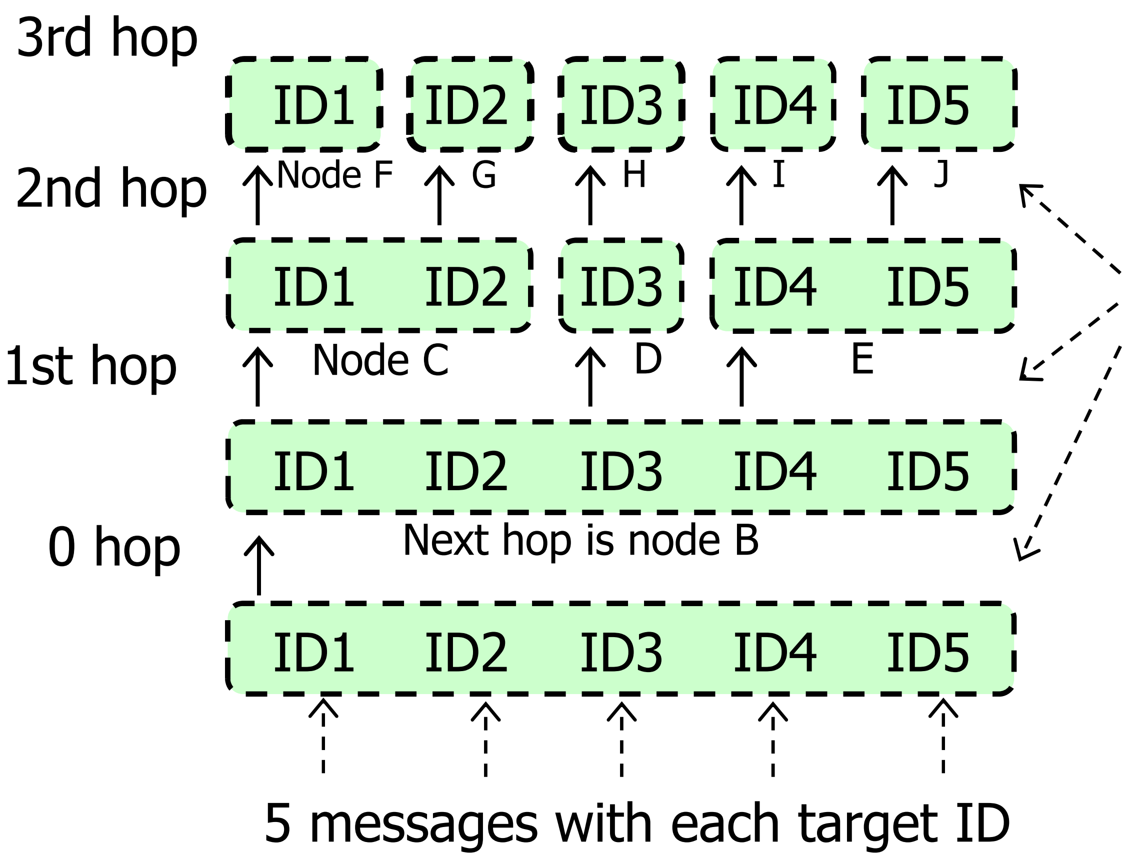
Proposed technique: Collective forwarding

- combines multiple messages whose next hops are the same node, and forward collectively.
  - A requesting node has a large number of requests. e.g. DB backup



Proposed technique: Collective forwarding

- Bundle
  - Messages with the same next hop.



1. Looks up next hops on routing table
2. Divides a bundle based on the next hops
3. Forwards the bundles to their next hops

Effects

- On an **overlay**
  - Throughput improvement
    - by handling multiple messages
      ➔ Parallel processing of multiple messages
  - Load reduction of nodes
    - by reducing message forwarding operations.
      e.g. message decode/encode, routing table lookup, …
- On an **underlay**
  - Packet transmission reduction
    ➔ Load reduction
    - cf. Performance of Internet routers is shown in pps (packets per second)

Measured

Initial bundle grouping

- A bundle is continuously divided once forwarding starts.
- How does the technique compose initial bundles?
  - It is not good to combine all the millions of messages. e.g. should be < MTU with UDP

- Policy
  - Size
  - Grouping
  - When? Who?

- In our experiments
  - 10
  - Target ID-clustered and random
  - Before routing, outside an overlay

Experiments

1. # of packet transmission on an underlay
   IP packet delivery from a node to another node
2. Message delivery time on an overlay

- Conditions
  - 1000 nodes simulated on a single PC.
  - Overlay Weaver [Shudo 2008]
    - runs structured overlay routing algorithms and
    - simulates a distributed environment. E.g. comm. Latency
  - Target IDs are randomly determined.
  - Routing algorithms: Chord, Koorde, Pastry, Tapestry and Kademlia
  - Forwarding styles: iterative and recursive

of packet transmission

- Ratio to # without the technique.

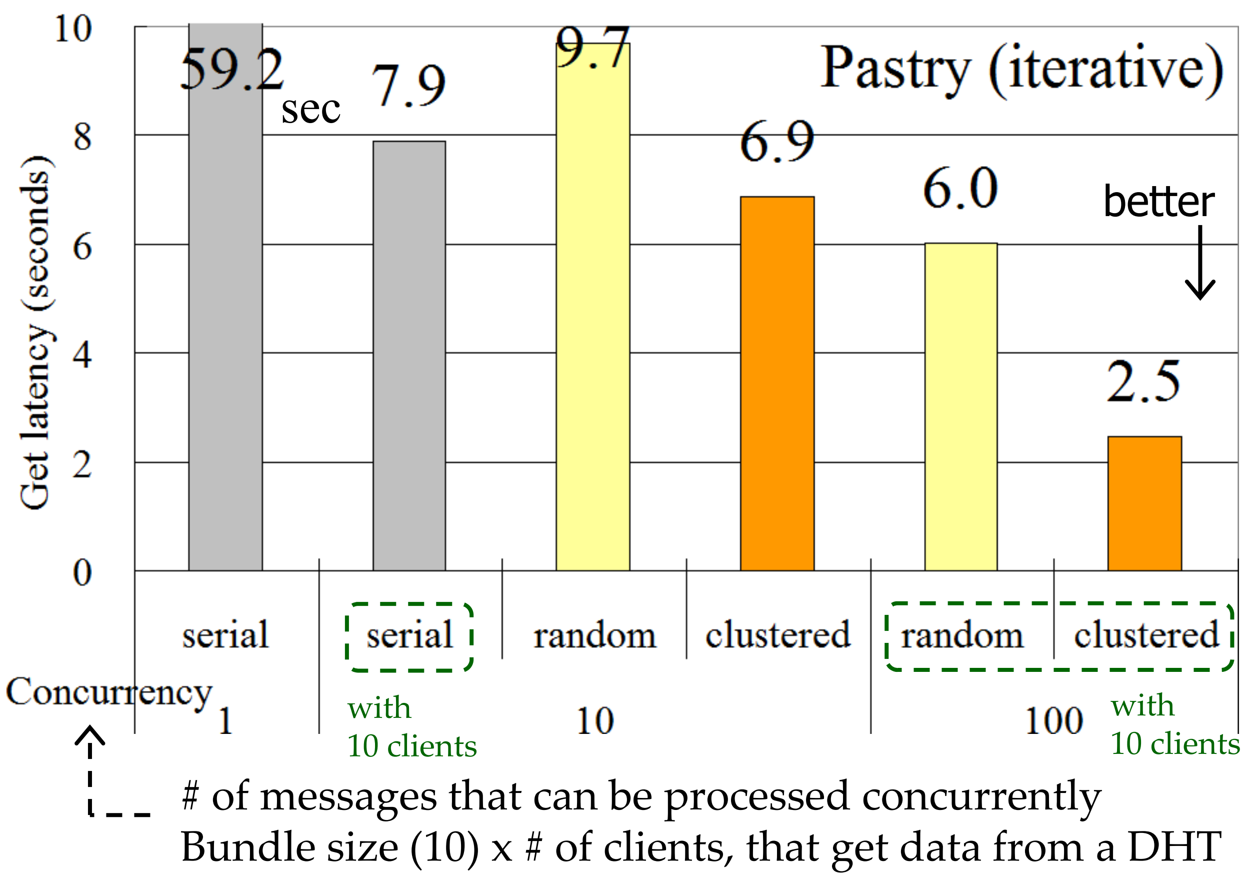
Note: the forwarding style is recursive

- Initial bundle grouping
  - "serial": the technique not applied.
  - "random"
  - "clustered": target ID-based clustering
- Consideration
  - **The # was reduced to around the theoretical limit 0.1.**
  - In Kademlia, a k-bucket was fulfilled and the node sends PING msg many times.

- Put and then got 50,000 data items on 1,000 nodes.
- Measured the # of packet transmission on an underlay, e.g. Internet.

Message delivery time

- Elapsed time to get 10,000 data items from 1,000 nodes
- 1 ms of comm. latency is simulated by Overlay Weaver.



- Two techniques for parallel processing
  - **Collective forwarding**
  - **Multiple** (10) **clients** send requests in parallel
- Consideration
  - With concurrency 10, delivery speeded up 7.5 ~ 8.5 times.
  - Effects of the two techs are comparative: 7.9 sec vs. 6.9 sec.
  - Effects of the two techs are cumulative.

Related work

- Message bundling
  - A common technique for networks.
  - Investigated for various networks:
    wireless sensor network, DTN, virtual machines, …
- MARIF [Mizutani 2013]
  - Bulk data transfer technique over a DHT
  - MARIF is dedicated to DHT, but collective forwarding works with structured overlays and supports multicast, for example.
- Techniques to improve efficiency of single message delivery
  - Proximity routing
  - 1-hop DHT

Summary

- Collective forwarding
  - combines multiple messages into a bundle and forwards it to the next hop.

- Effects
  - Improves throughput of an overlay
  - Reduces # of packet transmission on an underlay

- Experimental results
  - # of packet transmission: 34 % ~ 12 %
  - Data loading time: 13.0 % ~ 9.5 %
    - With 10 clients, 7.03 % 〜 3.12 %

Tokyo Tech