Yale Univ.
Ronghui Gu

Internet Indirection Infrastructure (i3)

Ronghui Gu
ronghui.gu@yale.edu

Outline

- Introduction
- i3 Overview
- Using i3
- Implementation and optimization
- Experimental Results
- Conclusion

Introduction

MOTIVATION

- Unicast point-to-point communication
  - One sender, One receiver
  - Fixed location, which is well-known
  - Host A sends packet p to host B, identified by IP
- Highly scalable and efficient
- Not appropriate for:
  - Multicast
  - Anycast
  - Mobility

Introduction

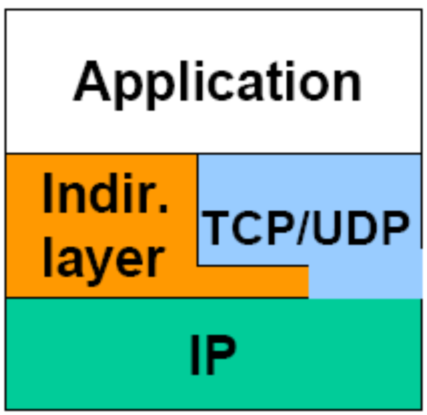
MOTIVATION(2)

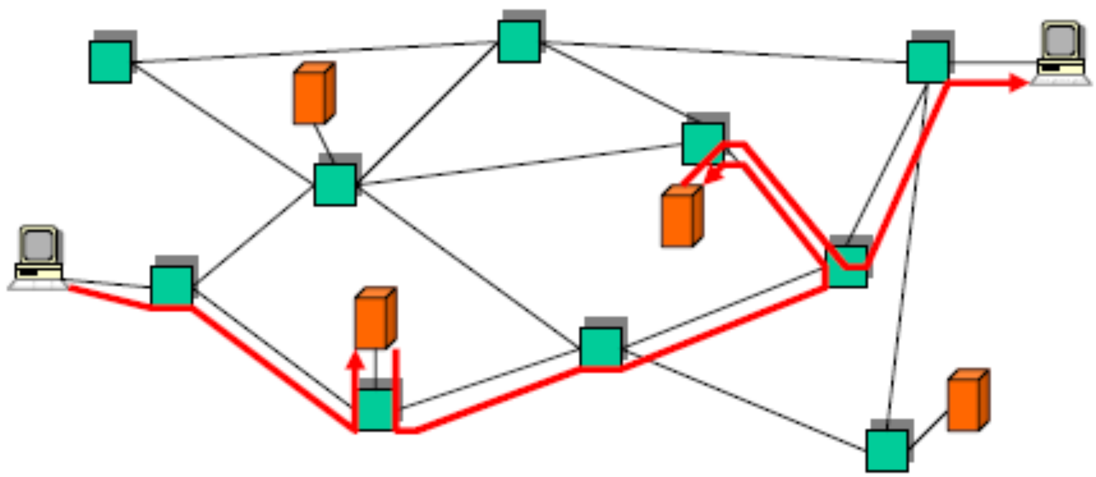
- Why not appropriate?
  - IP layer: lose scalability, requires consensus
  - Application layer: in a disjointed fashion
- Indirection
  - More general abstraction
  - Decouples the sending hosts from the receiving host
  - Send packet p to a “rendezvous”
  - IP layer will send p to the receiver(s)

i3 Overview

SOLUTION

- Build an efficient indirection layer on top of IP
  - Use an overlay network
  - Incrementally deployable
    - IP layer remains the same
    - Application layer is not aware of its existence

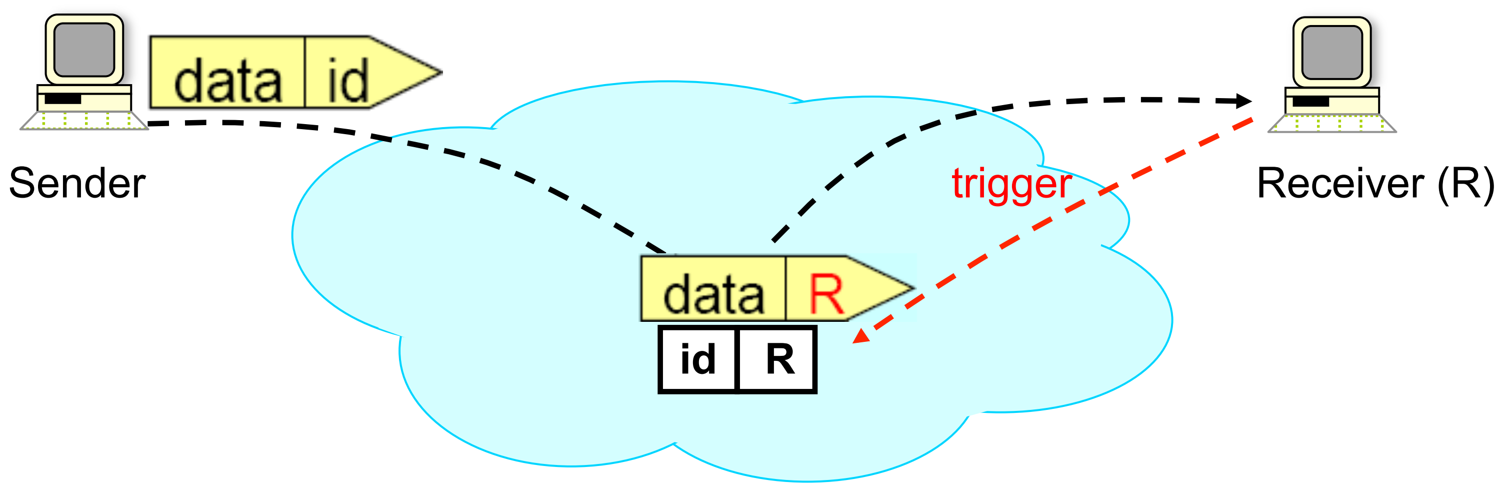




i3 Overview

SERVICE MODEL

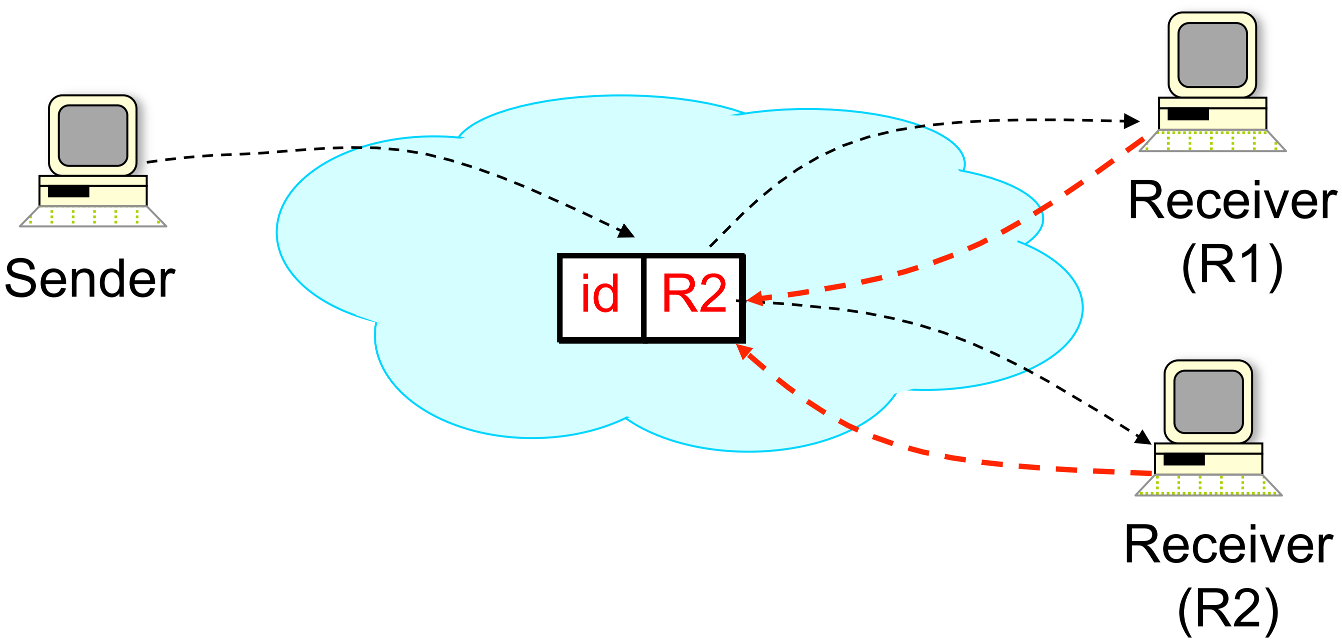
- Rendezvous-based communication (simple)
  - Packet is associated with an identifier **id** (256B)
  - Receiver **R** maintains the trigger (**id**,**R**)
  - Triggers have same id are stored on same server
- Best-effort service model



i3 Overview

MOBILITY

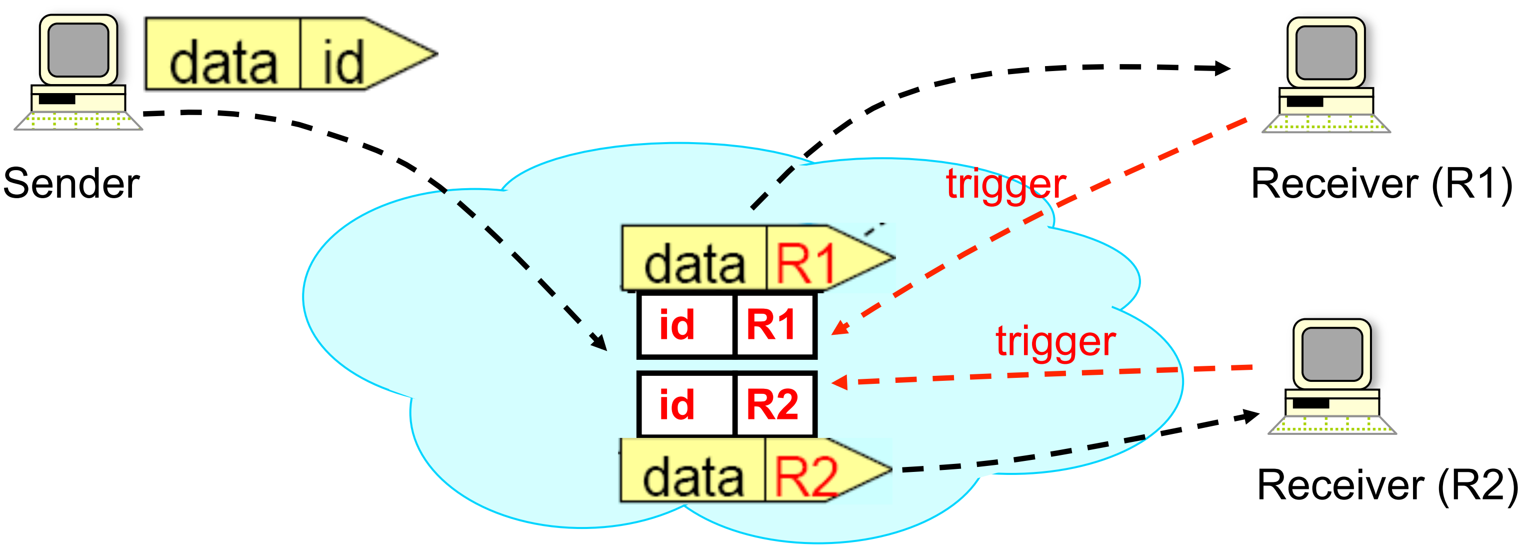
- Host only needs to update the trigger



i3 Overview

MULTICAST

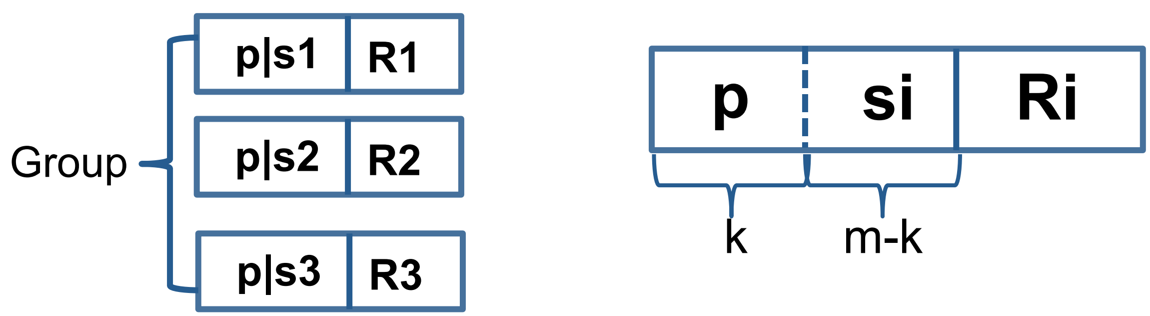
- The group member register triggers with same id
  - Packet matches **id** will be sent to all the members
- No difference between unicast or multicast



i3 Overview

ANYCAST(1)

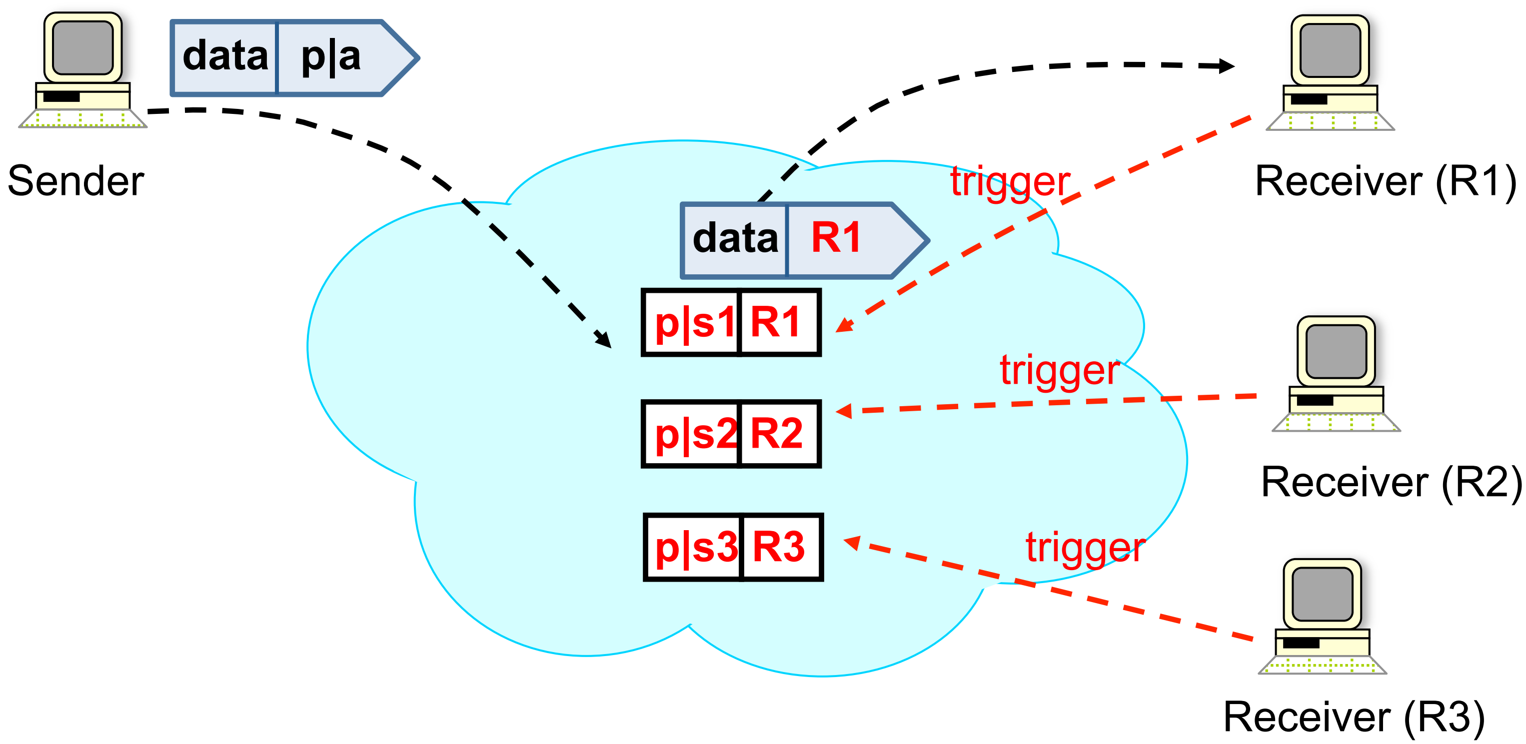
- Extended version 1: Use longest prefix matching
  - The length of matching prefix is at least k (125)
  - Id’s that have k-bit prefix are stored on same server
- Multicast group shared k-bit prefix
  - Members have different (m-k) bits suffix
  - When multicasting, send packet with id, which has a k-bit prefix match with all the members



i3 Overview

ANYCAST(2)

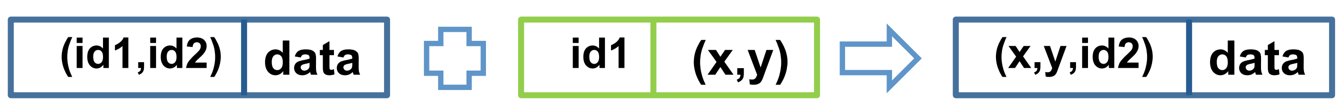
- Anycast: deliver packet to one receiver in a group
- Send packet to member with longest prefix



i3 Overview

STACK

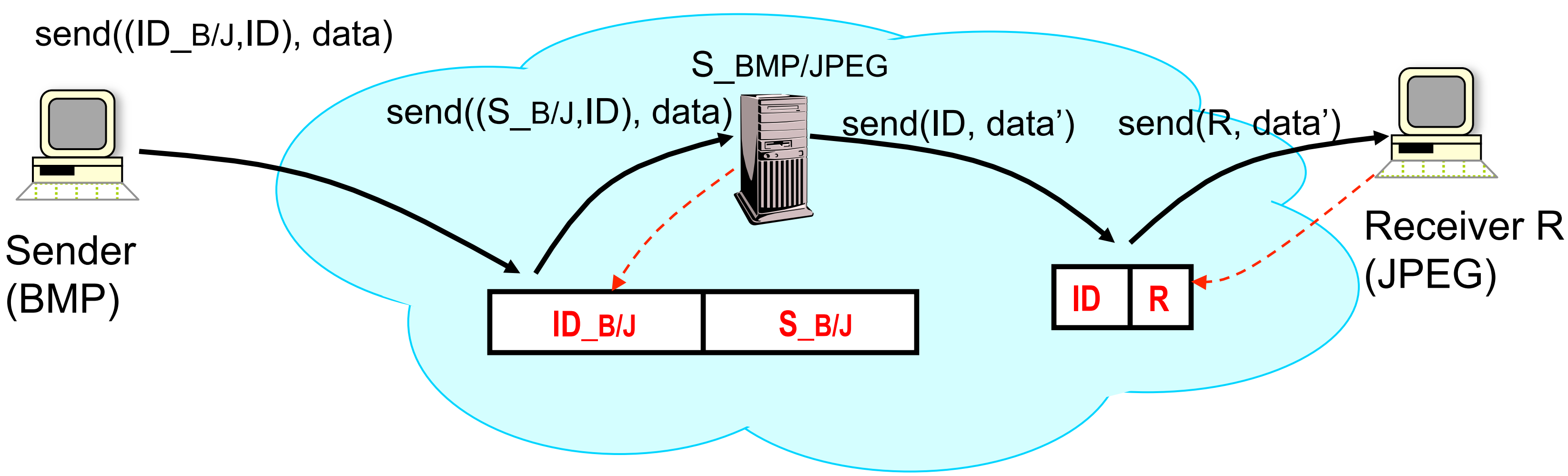
- Extended version 2
  - Replace identifier with identifier stack
  - Identifier stack is a list of identifiers
    - $id_{stack}=(id_1, id_2, id_3, \ldots\ldots, id_n)$
    - id_i: identifier or address
  - Packet p=(id_{stack},**data**) trigger t =(**id**,id_{stack})
- Match the head of p's stack with t
  - Pop p's stack
  - Prepend t's stack to p's stack



Using i3

SERVICE COMPOSITION

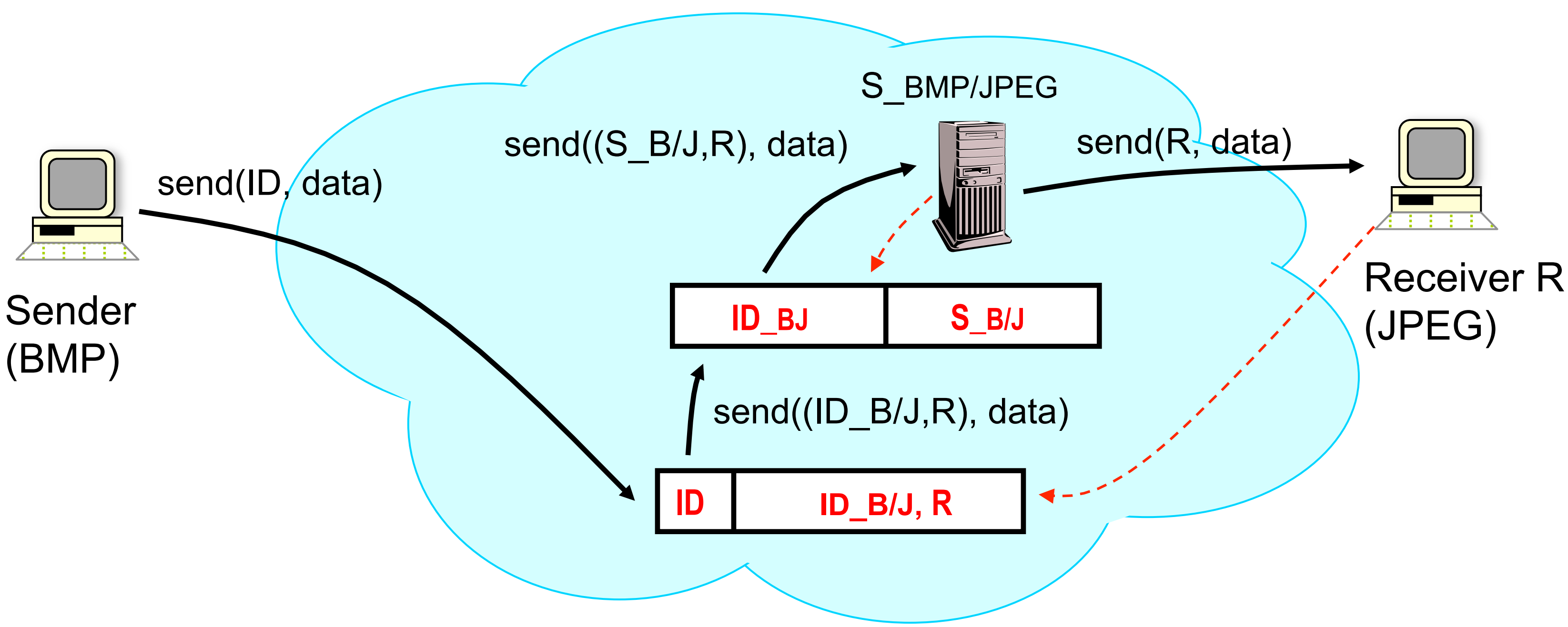
- Data is required to be processed before reach
- Use p's id_{stack} to encode the seq of operations
- Use ability of sender



Using i3

HETEROGENOUS MULTICAST

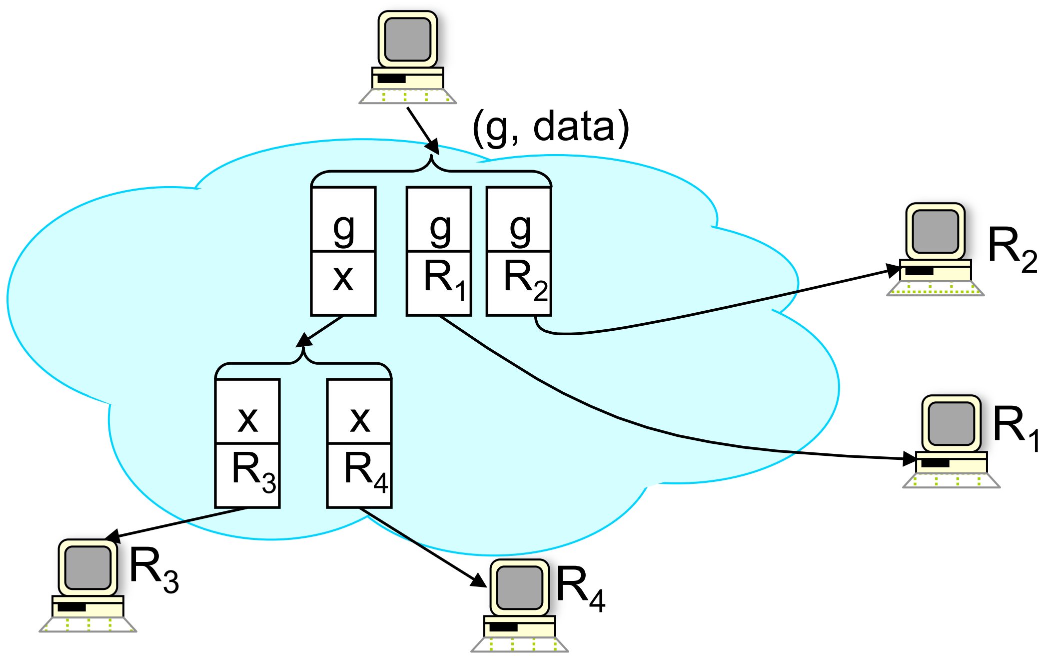
- Receiver could process the data before received
- Use t's id_{stack} to encode the seq of operations
- Use ability of receiver



Using i3

LARGE SCALE MULTICAST

- One server sends packets to all members
- Not scale to large multicast group
- Create multicast tree for scalability



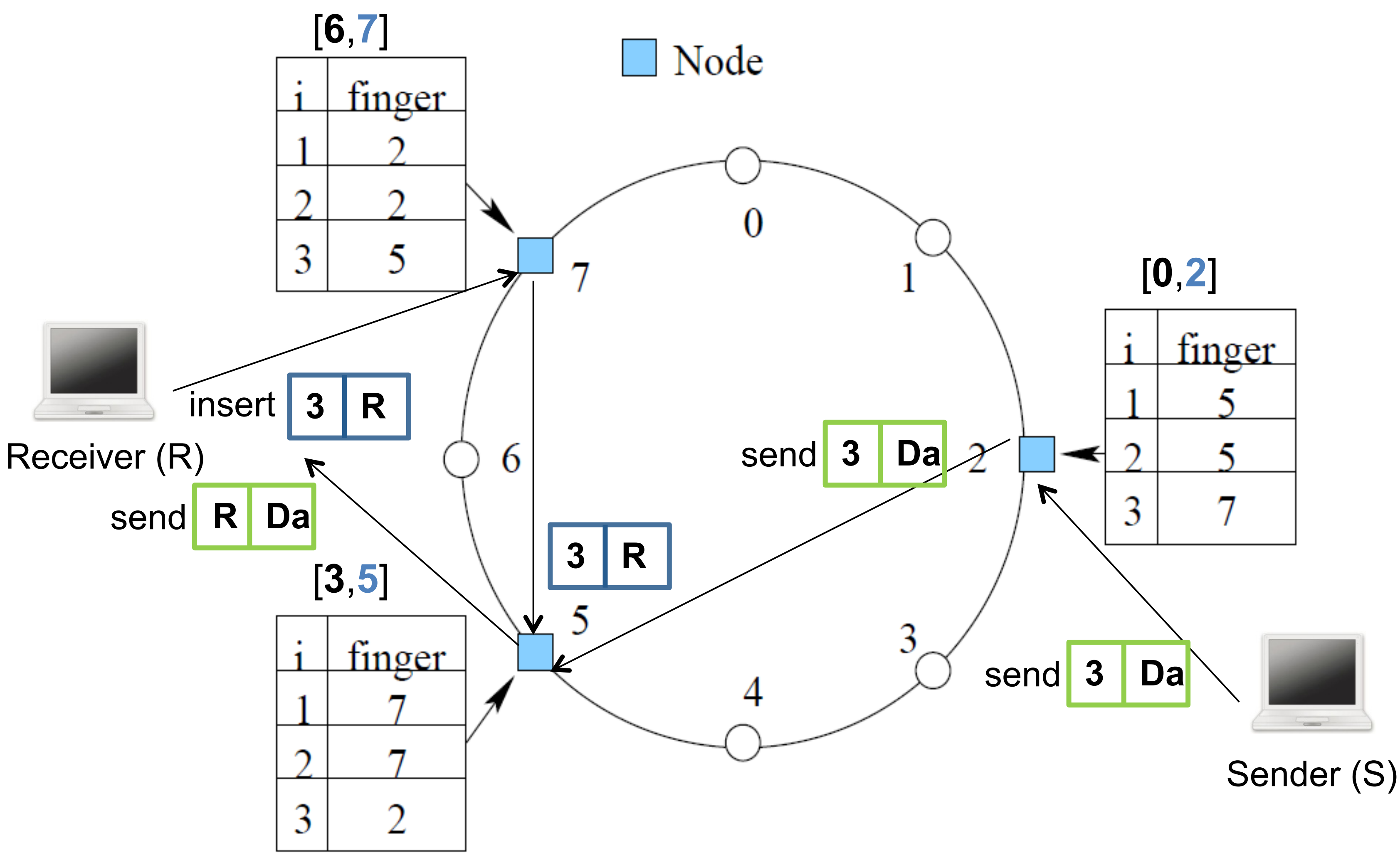
Implementation and Optimization

IMPLEMENTATION OVERVIEW

- Properties
  - Robustness, Scalability, Efficiency, Stability
- Chord lookup protocol
  - Route triggers and packets
  - N i3 nodes: O(logN) hops

Implementation and Optimization

IMPLEMENTATION OVERVIEW



Implementation and Optimization

OPTIMIZATION(1)

- Public and private triggers
  - Public trigger: long lived, contact
  - Private trigger: short lived, inform through public one
  - Increase efficiency and security
- Robustness
  - Refresh triggers
  - Back-up triggers
  - Replicate triggers (successor of node)

Implementation and Optimization

OPTIMIZATION(2)

- Routing efficiency
  - Cache i3 server's IP address
  - Triangle routing problem:
    - Choose location of private triggers
- Avoiding hot-spots
  - Copy triggers to the predecessor

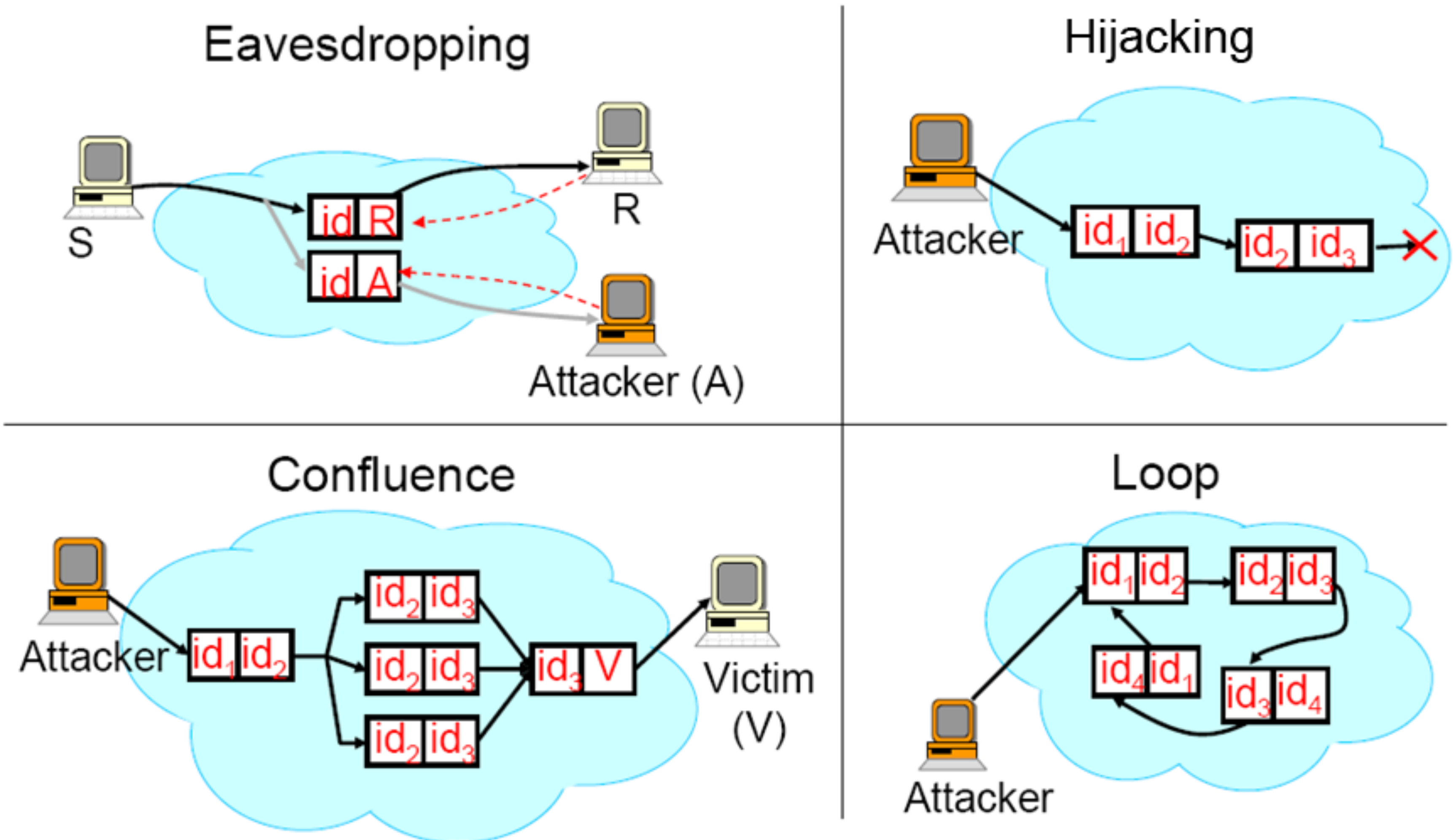
Implementation and Optimization

SECURITY(1)

- New opportunities for malicious users
  - IP: end-points can only send and receive packets
  - i3 end-points should maintain routing information
- Goal
  - Not worse than today's Internet

Implementation and Optimization

SECURITY(2)



Implementation and Optimization

SECURITY(3)

- Eavesdropping
  - Use private triggers, periodically change them
  - Multiple private triggers
- Trigger hijacking
  - Add a level of indirection
- DoS Attacks
  - Send challenges when a trigger is inserted
  - Limited triggers, limited packets
  - Loop detection

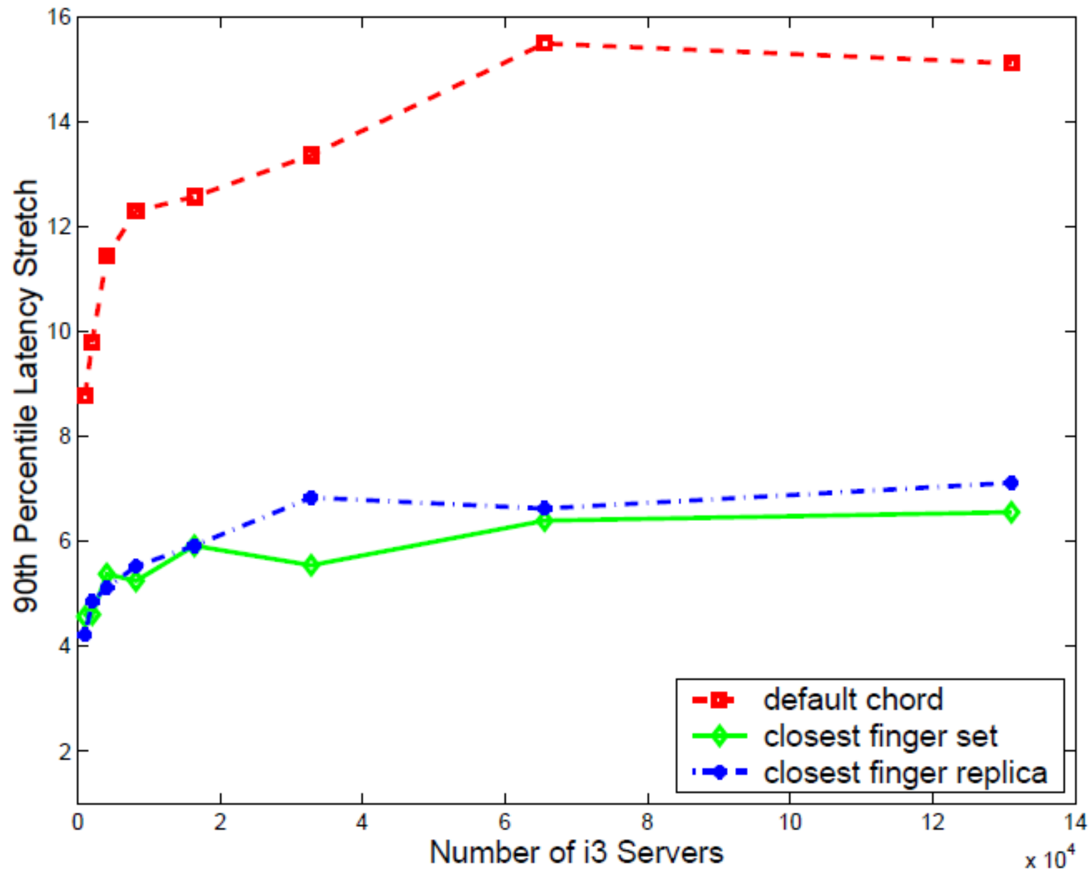
Experimental Results

PACKET LANENCY

- Latency stretch=(i3 latency)/(IP latency)
- First packet latency
  - Slow: need to find the trigger
- Improvement
  - Closest finger replica: store r succs of finger
  - Closest finger set:
    - Use base b<2 to find finger
    - Consider closest $\log_2 N$ when routing
  - $\log_b N = r \cdot \log_2 N$

Experimental Results

FIRST PACKET LATENCY

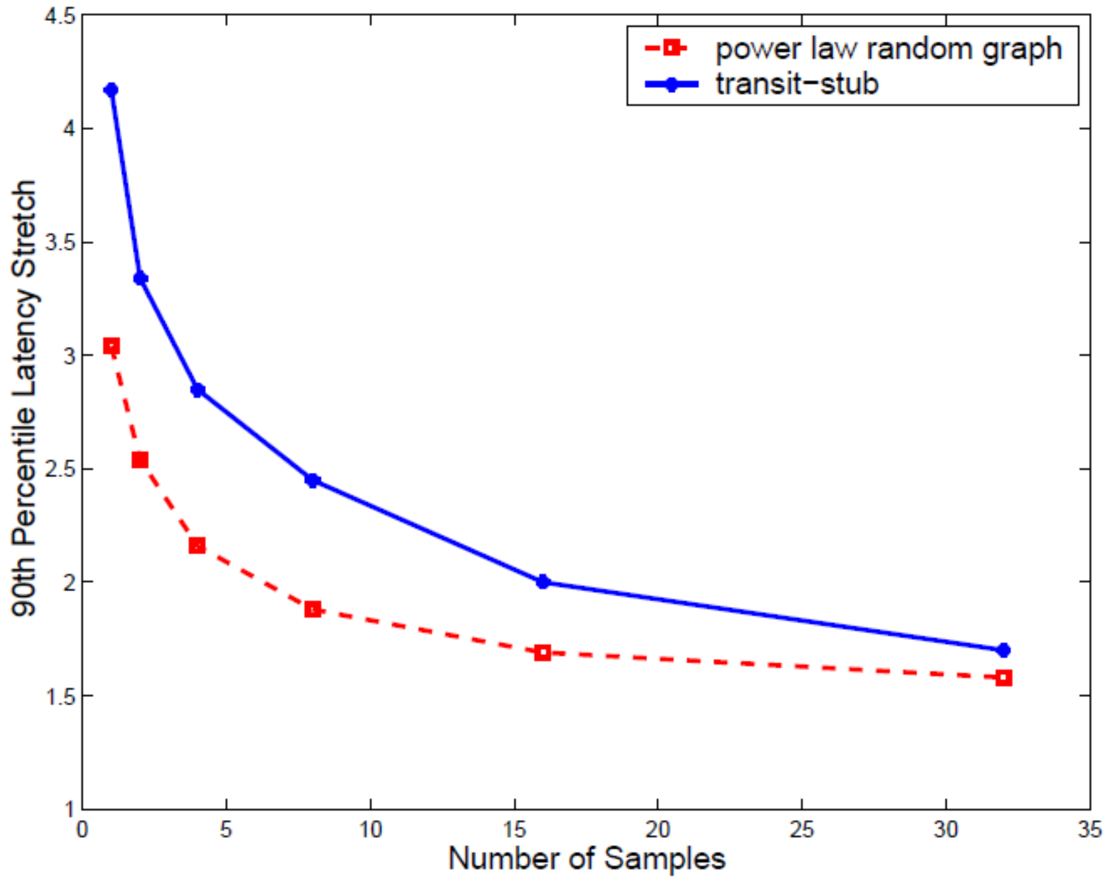


90^{th} percentile first packet latency stretch vs. no of i3 servers for Transit-stub topology

Yale Univ.
Ronghui Gu

Experimental Results

END-TO-END PACKET LANENCY



90[th] percentile latency stretch vs. no of samples (16384 ***i3*** servers)

Conclusion

WHAT THE PAPER HAS DONE

- Main idea: indirection
- More general abstraction in one overlay
  - Multicast
  - Anycast
  - Mobility
- Based on Chord

THANKS FOR YOUR TIME

QUESTIONS?