Service-Centric Networking with SCAFFOLD

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Outline

- Motivation for Content Centric Networking
- Related Work
  - DONA
  - Networking Named Content
  - Triad
- SCAFFOLD
- Summary

Motivation

- The Internet started out to facilitate remote resource sharing
- Today's Internet mostly consists of HTTP requests, media streaming, and DNS traffic
- Service connections are also important
  - Services can be replicated and moved like data
- There is a disconnect between how the network operates and how it is used
  - Use: Retrieve a specific data item or service
  - Operates: Retrieve a connection with a specific host

Goals CCN

- Remove the need to make DNS lookups
  - New naming system for services and data
  - Place the name lookup scheme in the network
- Route to one of many possible service instances
  - Any-cast routing to a service instance
  - Find closest instance
  - Balance load of instances
- Allow for service instances to move locations
- Allow for self-certifying name

Related Work

- An Architecture for Content Routing Support in the Internet USITS 2001

  Mark Gritter, David R. Cheriton

- Networking Named Content CoNext 2009

  Van Jacobson, Diana K. Smetters, James D. Thornton, Michael F. Plass, Nicholas H. Briggs, Rebecca L. Braynard

- A Data-Oriented (and Beyond) Network Architecture SIGCOMM 2007

  Mohit Chawla, Teemu Koponen, Byung-Gon Chun. Kye Hyun Kim, Scott Shenker, Andrey Ermolinskiy, Ion Stoica

An Architecture for Content Routing Support in the Internet

Gritter and Cheriton

- URL naming scheme of services and data
  - e.g. bar.foo.com
- Network is made up of Content Routers (CRs) and Network Routers
  - Content Routers map URL names to a next hop
  - Content Routers also forward IP packets as usual
  - All other network routers are left unchanged

Content Routers

- Route based on URL suffixes
  - Content Routers map a longest-suffix match to a next hop location
  - Content Routers make use of a protocol similar to BGP to announce paths along Content Routers to services
- Routing ends at a CR adjacent to the content server
  - Adjacent CR returns the IP address of the content server to the user
- Once the IP address has been returned to the initiating client, standard IP communication will commence

Networking Named Content

Jacobson et al.

- Routers in the network route as well as distribute content
  - Cache recently seen data
  - Route data names to a next hop location
  - Keep track of pending requests for data
- Hierarchical naming
  - e.g. **/parc.com/videos/WidgetA.mpg/v3/s0**
- Routers in the network map longest-prefix matches to next hop locations

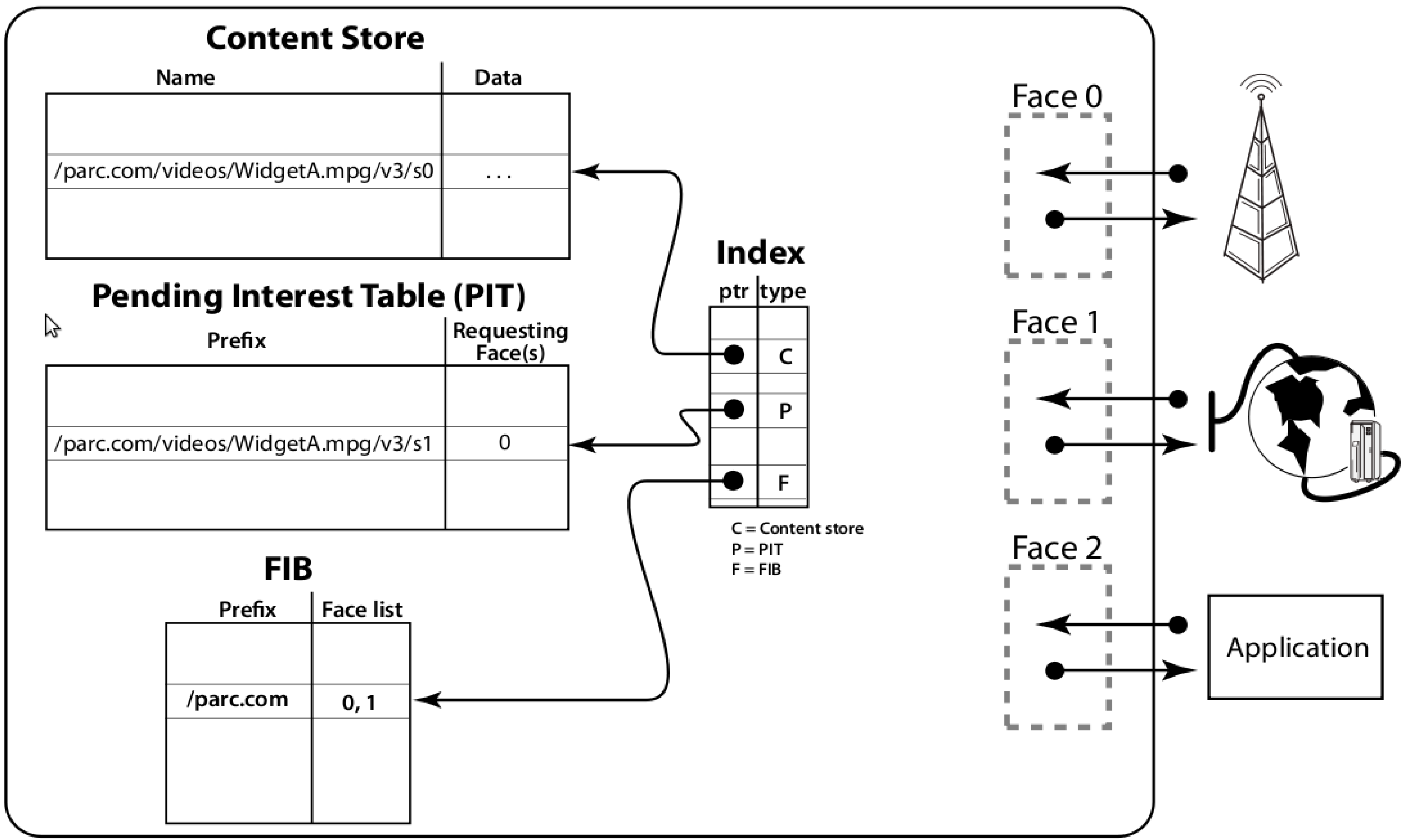
Networking Named Content

Jacobson et al.

- Hosts send one of two packet types
  - Interest – A request for a specifically named data
  - Data – The data requested by an Interest packet
- Routers in the network have three main parts
  - Content Store
    - Cached data that the router has recently seen
  - Pending Interest Table
    - Interests, and where they came from, that have not been fulfilled by a data packet
  - Forward Information Base
    - A name prefix mapping to a next hop

Networking Named Content

Jacobson et al.



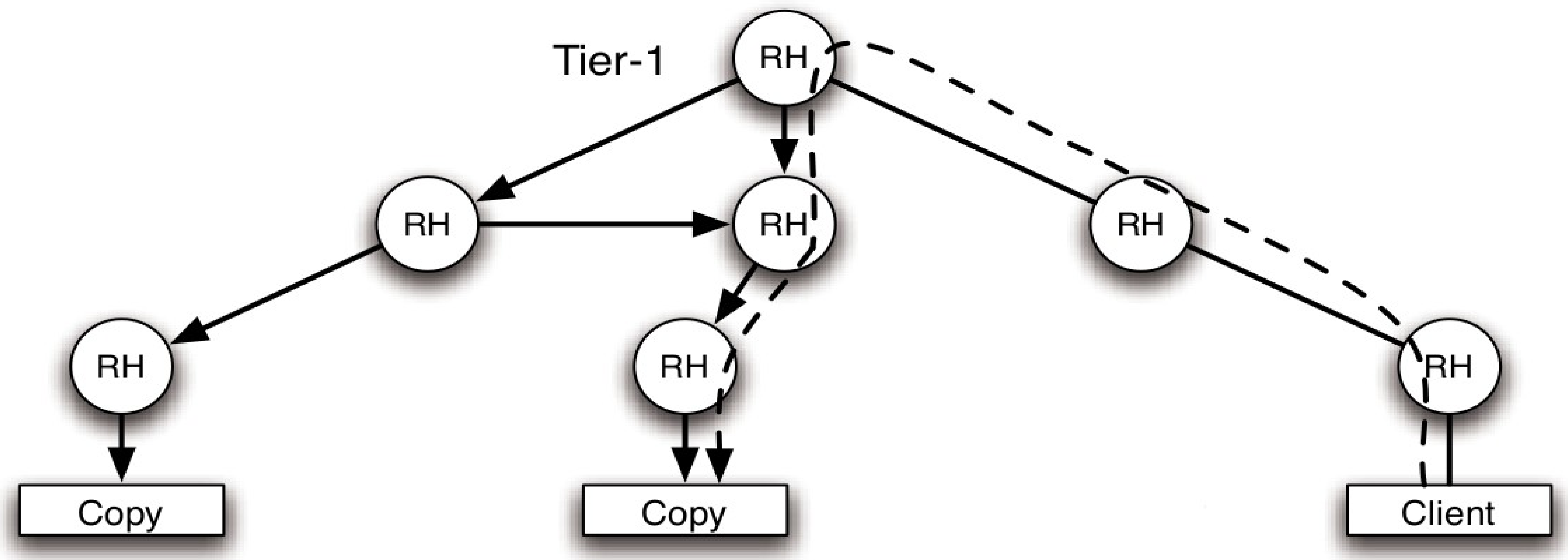
DONA

- Service Identifiers are pairs: P:L
  - The first element, P, is a hash of the owner's public key
  - The second element is a label assigned by the owner
- Networks maintain Resolution Handlers (RHs)
  - Services issue REGISTER(P:L) commands to RHs
  - Clients issue FIND(P:L) commands to RHs

Resolution Handlers

- A single logical Resolution Handler exists in a local network
- Maps service identifiers to a next hop and a distance to the copy of the service
  - If no mapping exists, the FIND request is sent to the parent RH (towards the core)
  - Tier 1 ASes must maintain a mapping for all service identifiers
- RHs can also be used to cache recently requested data

Name Resolution



SCAFFOLD

- Want to provide similar functionality to related work
  - Multiple service instances represented by one name
  - Service-selection through named based Anycast routing
- Also want to allow dynamics in the network
  - Server mobility
  - Client mobility
  - Connection recovery from failures

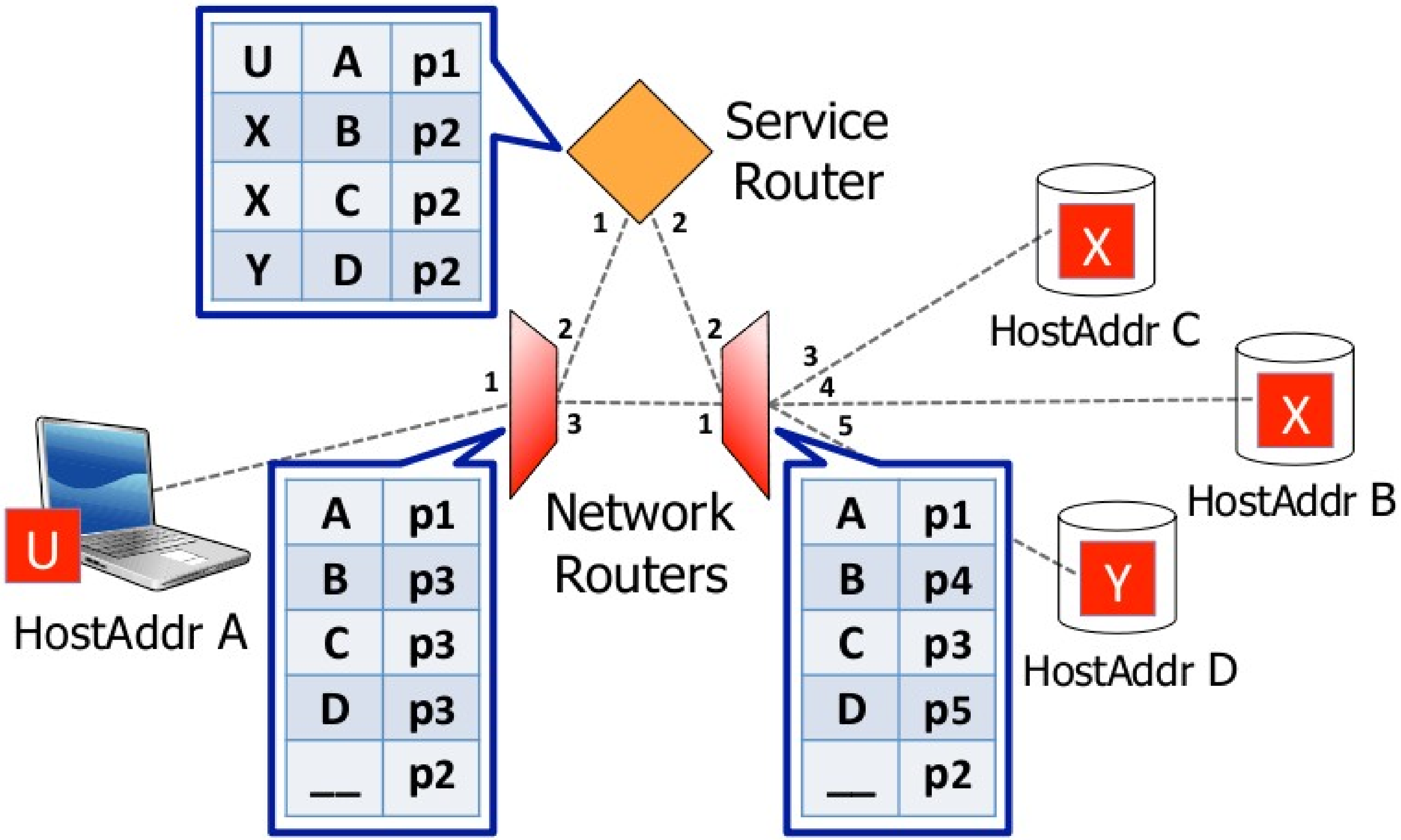
Naming

- SCAFFOLD makes use of serviceIDs
  - Fixed length
  - Location-independent
  - One serviceID can map to multiple service instances
- Like most flat named systems, serviceIDs allows for self-certifying instances of a service
- ServiceIDs are mapped to service instances by Service Routers

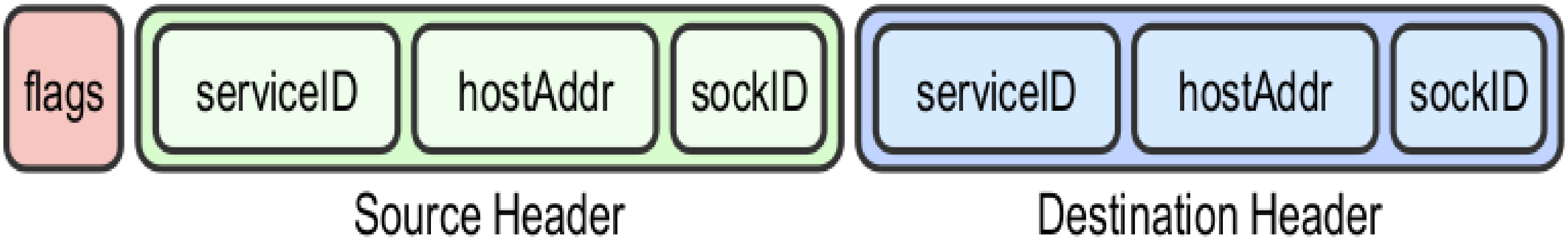
Service Routers

- Similar to Resolution Handlers and Content Routers
- Service routers resolve serviceIDs into end host IP addresses
  - Service router only has knowledge of services in the local network
  - Forwards requests towards the service after name resolution
- Services send *register* and *unregister* requests so service routers can keep track of instances of a service

Service Router

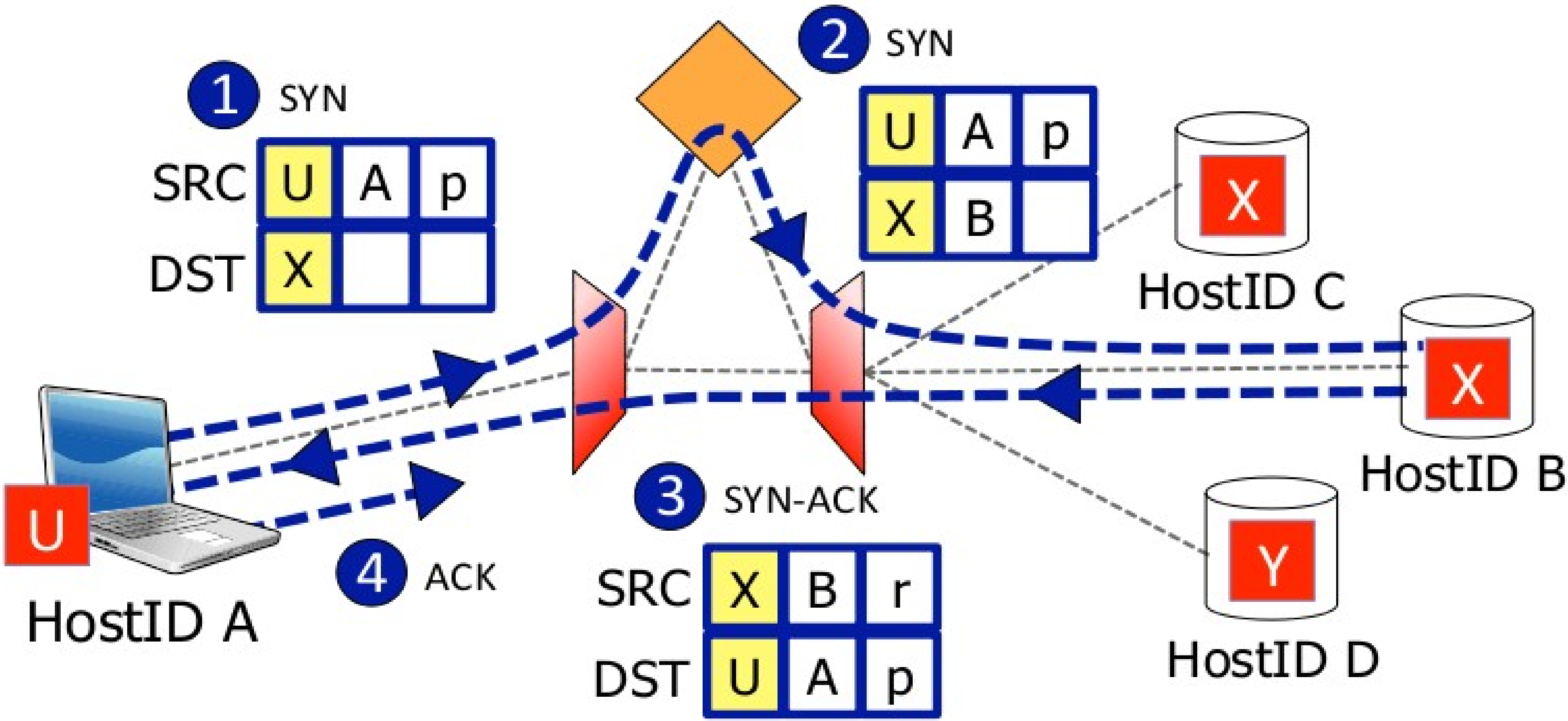


SCAFFOLD Packets



- serviceID: The flat-name for the given service
- hostAddr: Network attachment location.
- sockID: A specific flow's connection identifier

Setting up a connection



Setting up a connection cont.

User-Space Process

Socket Descriptor	Local Service ID	Remote Service ID
5	**U**	**X**
9	U	X
47	U	Y

Network Stack

Socket State	Local SrvID	Local Addr : SockID	Remote SrvID	Remote Addr : SockID
bound	**U**	**A : p**	**X**	**B : r**
bound	U	A : q	X	C : r
connecting	U	A : r	Y	---

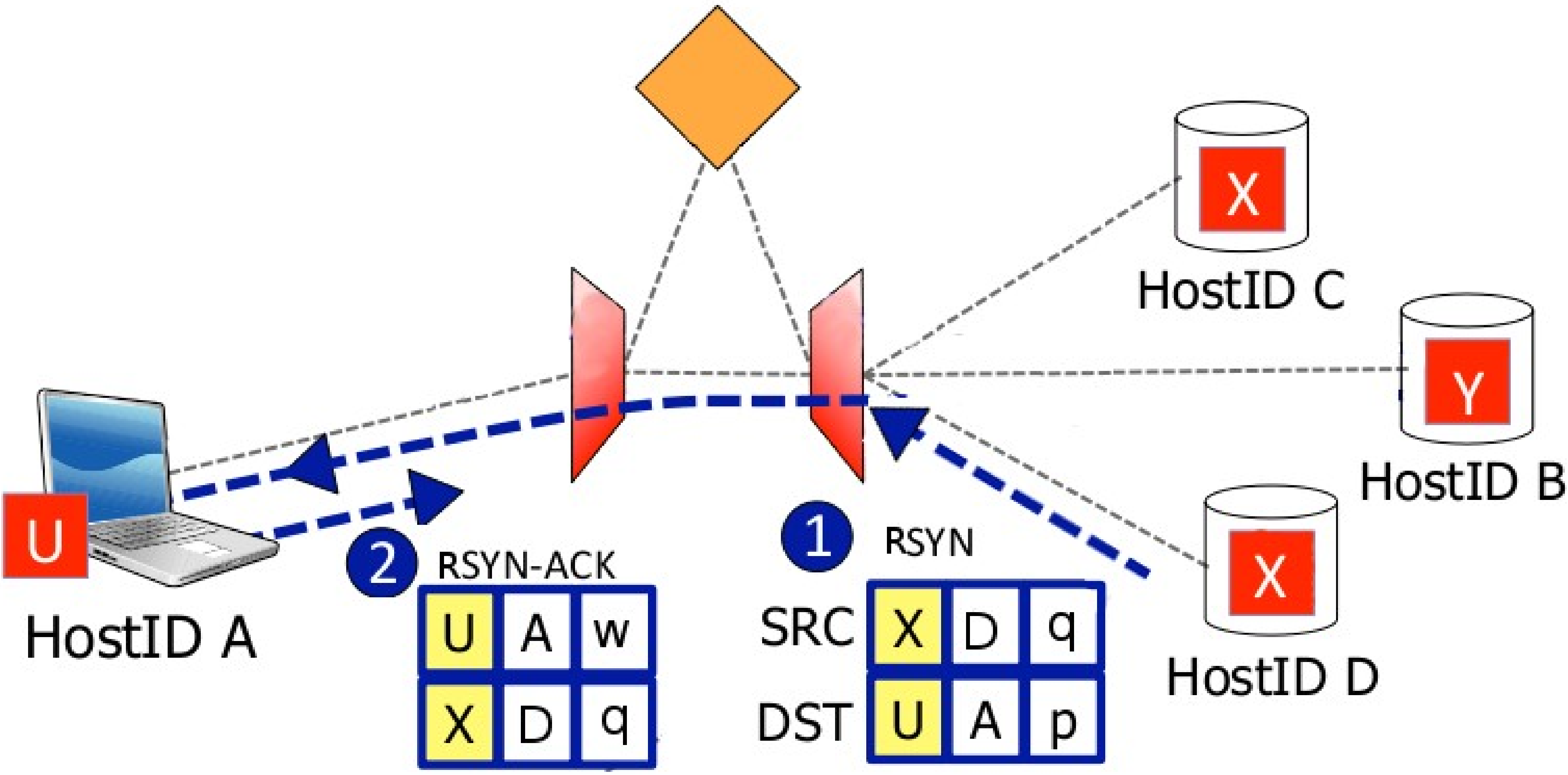
End-to-end design

- Unlike the presented related work, SCAFFOLD introduces a partial end-to-end design
- By keeping track of connections with specific service instances on the network stack, a stable host can maintain a connection with service that is dynamic
- The authors call this *flow affinity*: Maintaining a flow between service instances even when a service changes hosts

Mobility

- If one of the end hosts changes addresses
  - The changed host sends an RSYN packet to the stationary host
  - The RSYN contains the new address and a new socket ID
  - The stationary host updates its network stack and sends an ACK for the RSYN
- The end-to-end design allows for persistent flows even when hosts are mobile

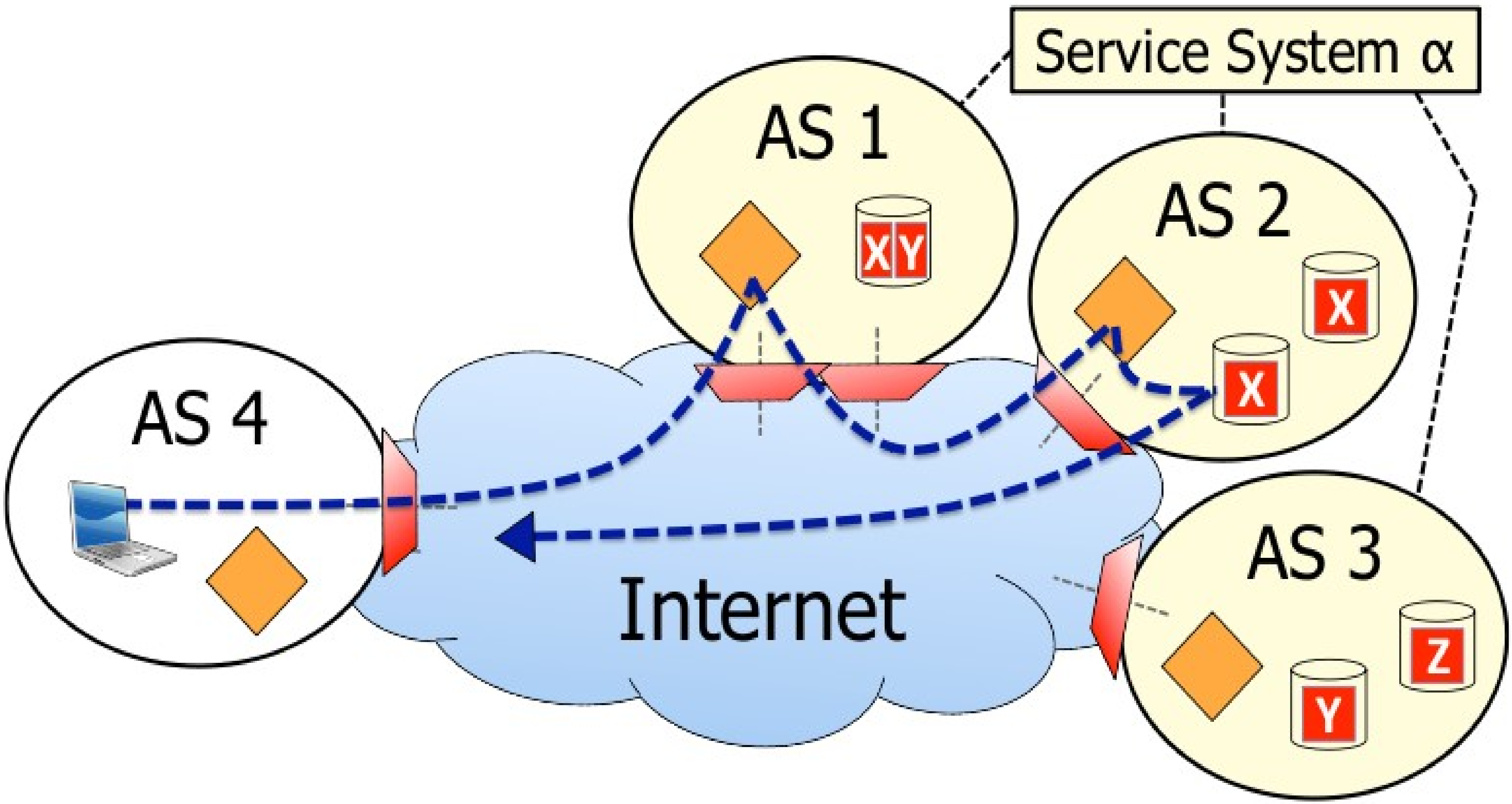
Mobility Update



SCAFFOLD in the WAN

- Introduce the notion of a Service System
  - Manages a subset of serviceIDs that an identity owns
  - Assigned a globally unique identifier called Service System IDs (SSids)
  - SSid form the higher order bits of a ServiceID
- A Service System is an administrative identity
  - e.g. Microsoft, Google, Amazon
  - Not physically constrained like an AS

SCAFFOLD in the WAN

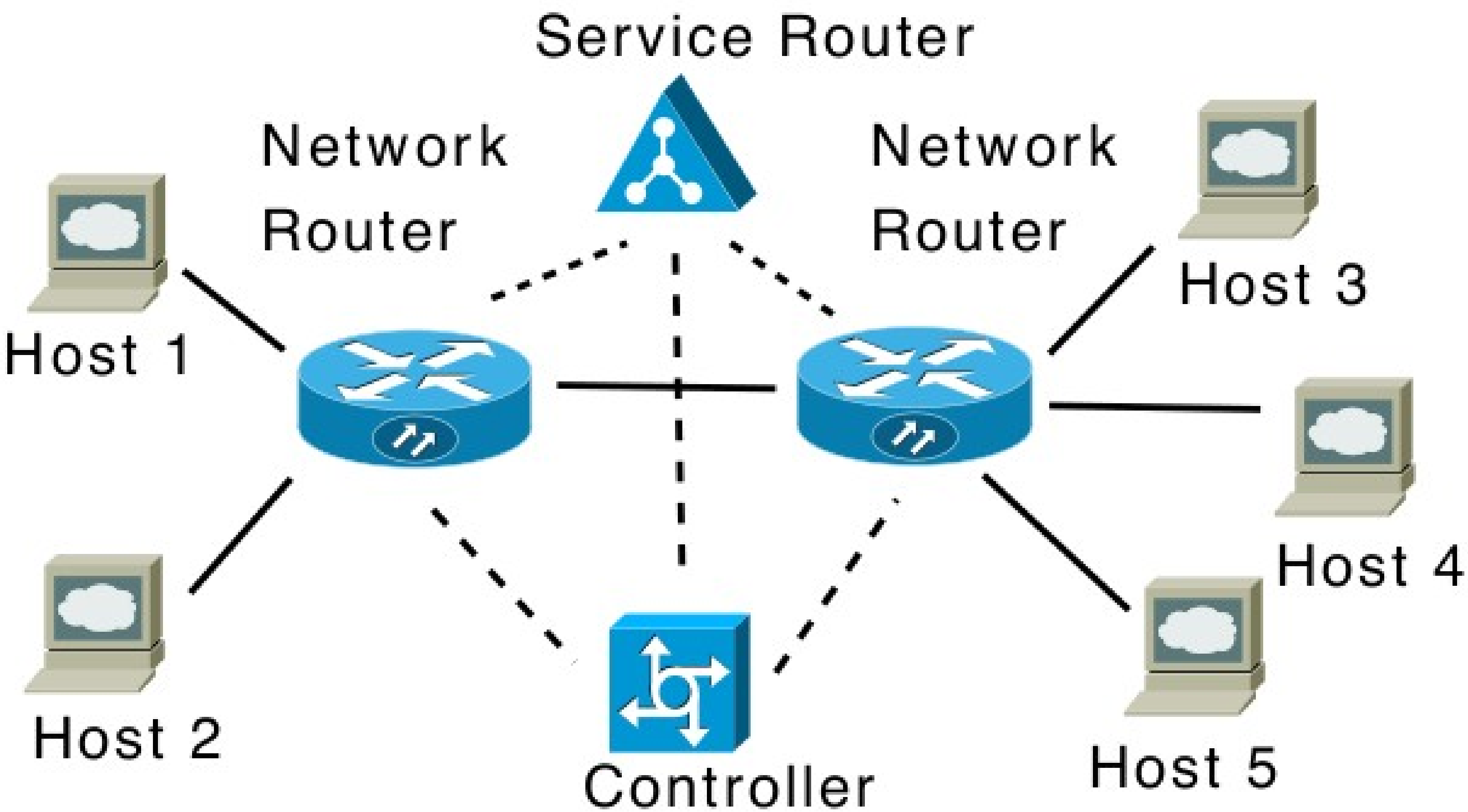


SCAFFOLD in the WAN

- SCAFFOLD does not implement how a client determines which AS to send a request to

- The authors suggest the following
  - A DNS like structure that maps ssIDs onto ASes that host that ssID's services
  - Use a global routing protocol where service routers announce the ssIDs they associate with

Experimental Setup



Server Failure

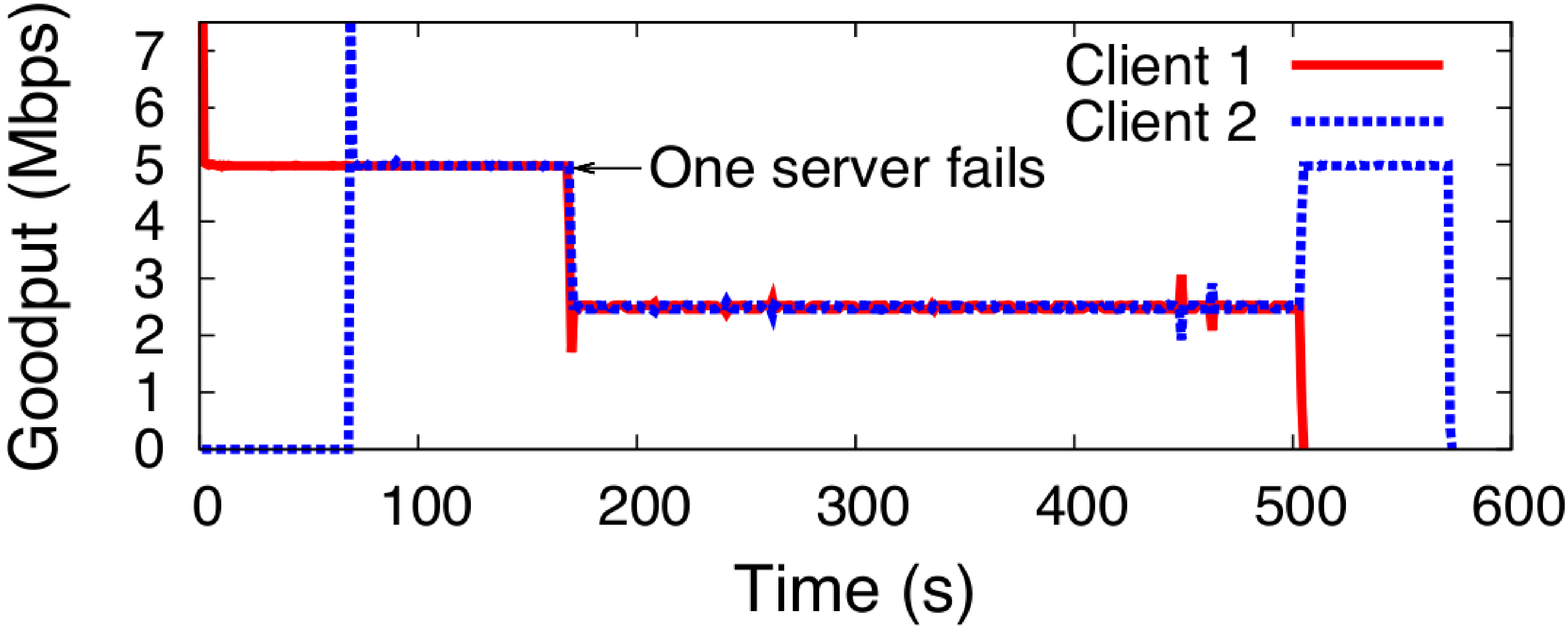


Figure 7: **High availability with two clients and two servers, showing how a client is transparently redirected to another service instance as failure happens.**

Load Balancing

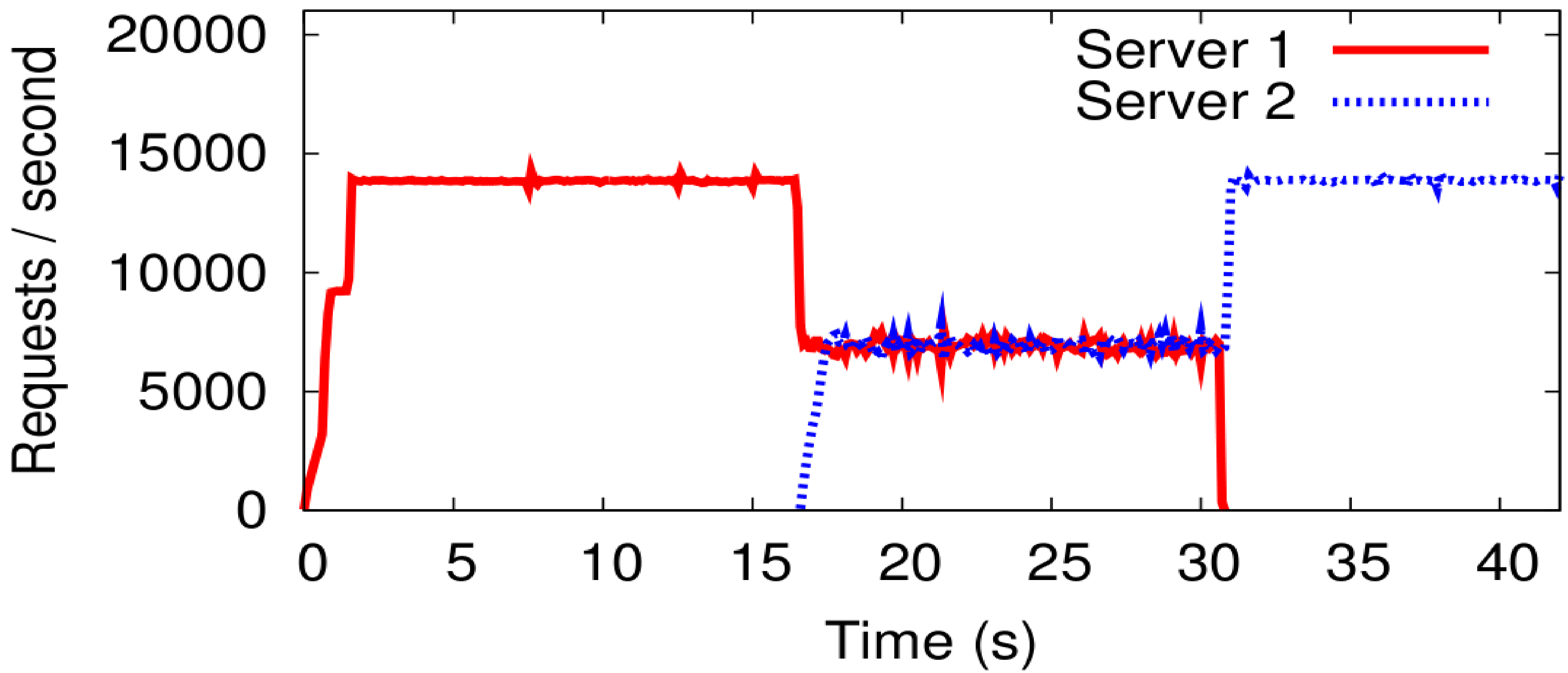


Figure 9: ***Memcached Server Throughput.*** **Server 2 joins the network after around 15 seconds; server 1 leaves after 30 seconds. In both cases, the network transparently redistributes the data partitions (named by unique serviceIDs) over the available servers.**

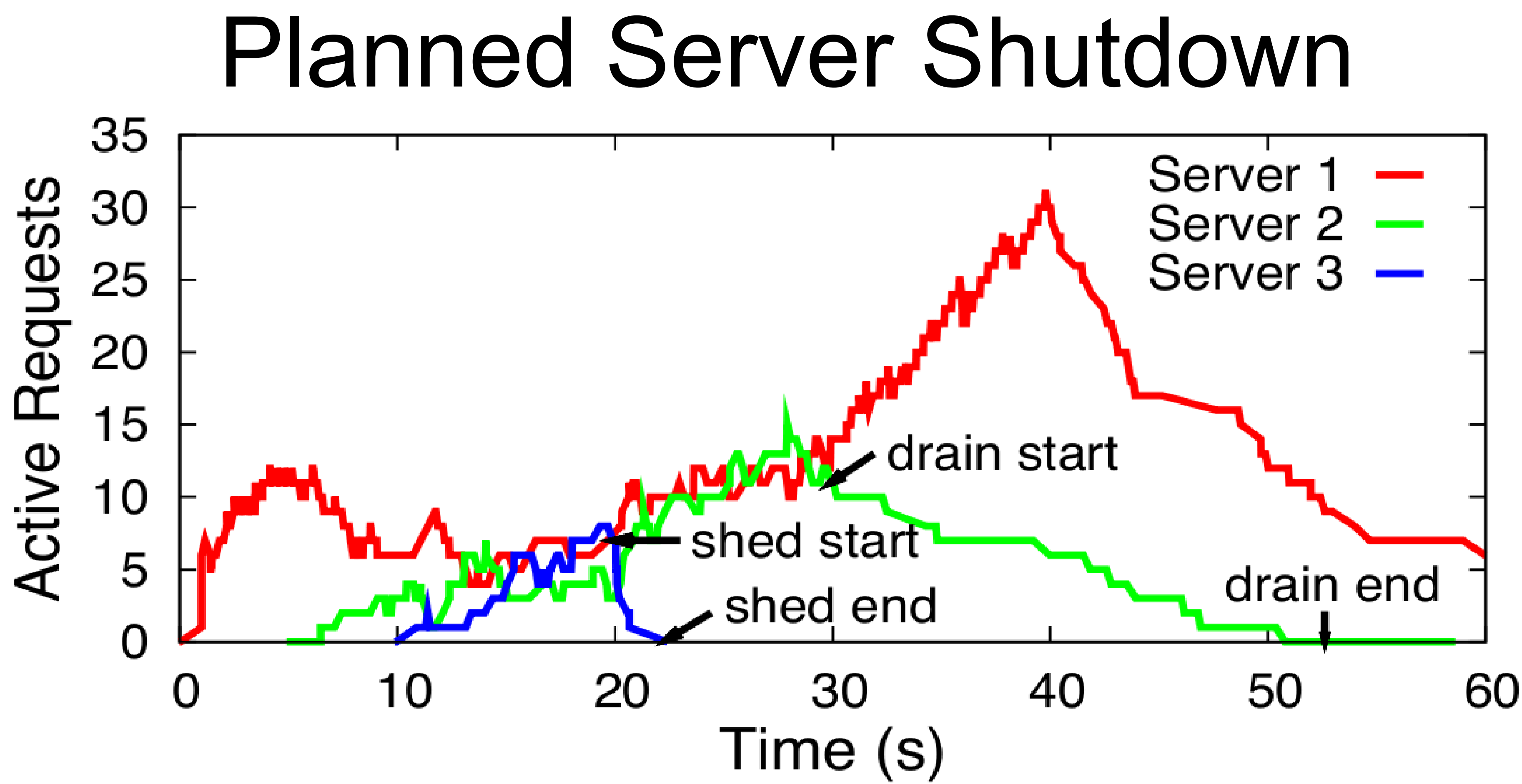


Figure 8: **Replicated service support with 2 clients and 3 servers showing load-balancing as additional servers are added, request shedding for planned maintenance, and the residual effects of lingering requests with draining.**

Comparisons

	SCAFFOLD	DONA	Cheriton/Gritter	Jacobson
Naming System	Flat names	Flat names	URL	Hierarchical
Routers Return	Connection	Connection/Content	Address of Host	Content
Content	At Hosts	At Hosts/Cached	At Hosts	At Hosts/Cached
Host Mobility	RSYN/Net. Stack	N/A	N/A	N/A
Mainly Concerns	Services	Services/Data	Services	Data
Content Routers	1 logical router	1 logical router	Many	Many in a network

Questions?