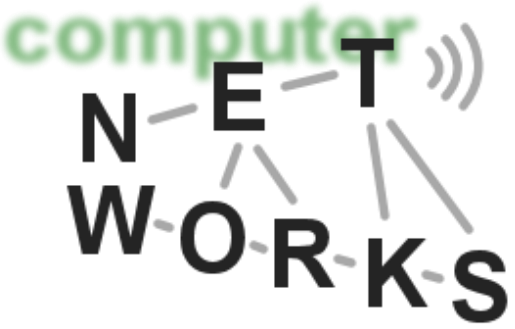
Content-Centric Network

Advanced Computer Networks

Summer Semester 2012



computer NETWORKS

Introduction to CCN

- **What?**
  - What is Content-Centric Network (CCN)?
- **Why?**
  - Why do we need CCN?
- **How?**
  - How CCN works?
- **Problems?**
  - Is there any problem in the design?

What is CCN?

- **Content-centric networking** (also **content-based networking**, **data-oriented networking** or **named data networking**) is an alternative approach to the architecture of computer networks. Its founding principle is that a communication network should allow a user to focus on the **data** he or she needs, rather than having to reference a specific, physical **location** where that data is to be retrieved from. [wiki]

I need data:
“/ugoe/networks/acn/ACN_CCN.pdf”

I need to communicate with:
“134.76.10.46:80”

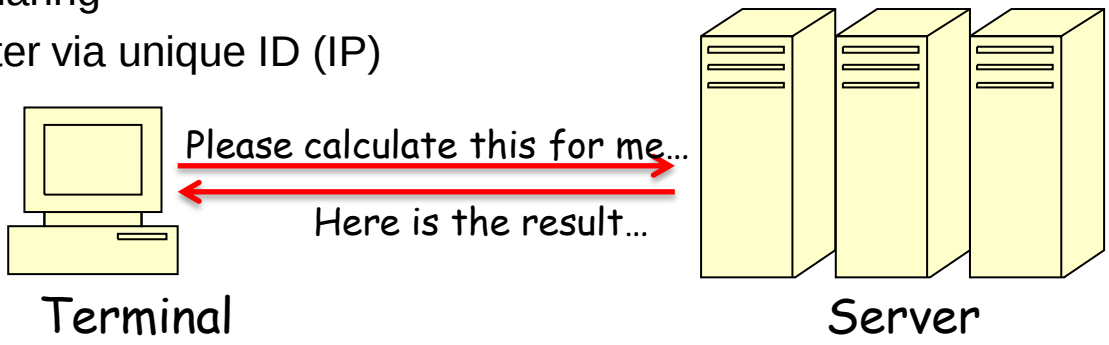
Related papers/projects

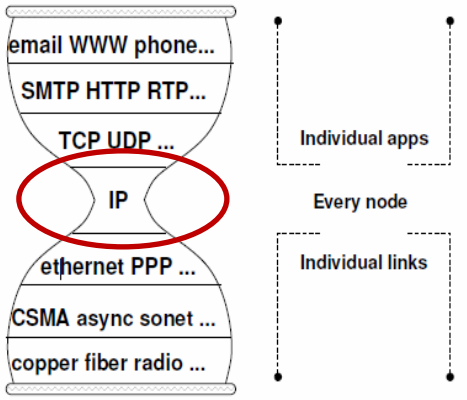
- TRIAD: a Scalable Deployable NAT-based Internet Architecture
  - Stanford 2000, TRIAD project
- Data Oriented Networking
  - IETF 2002
- XTreeNet: A Scalable Unified Overlay Network for XML Content Access and Distribution
  - WWW 2007
- A Data-Oriented (and Beyond) Network Architecture [DONA]
  - SIGCOMM 2007
- **Networking Named Content**
  - CoNext 2009
  - Park 2009, CCNx / NDN project

Why CCN?

- Internet is designed in 1960s
  - Main purpose: resource sharing

    Computer talk to computer via unique ID (IP)



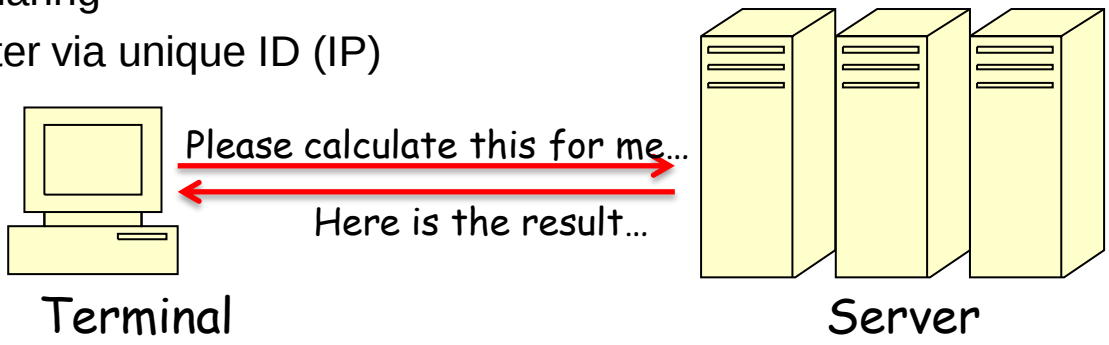


computer NETWORKS

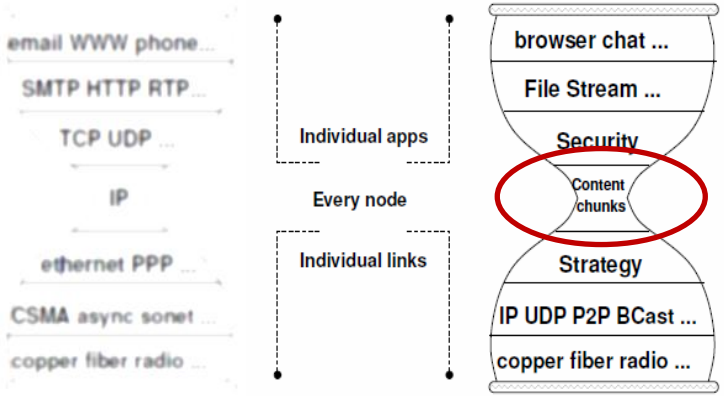
Why CCN?

- Internet is designed in 1960s
  - Main purpose: resource sharing

    Computer talk to computer via unique ID (IP)



- The ‘network’ will (has) become increasingly Information-centric
  - Information of all types becoming electronic and network accessible
  - Access of information based on content of interest, instead of location

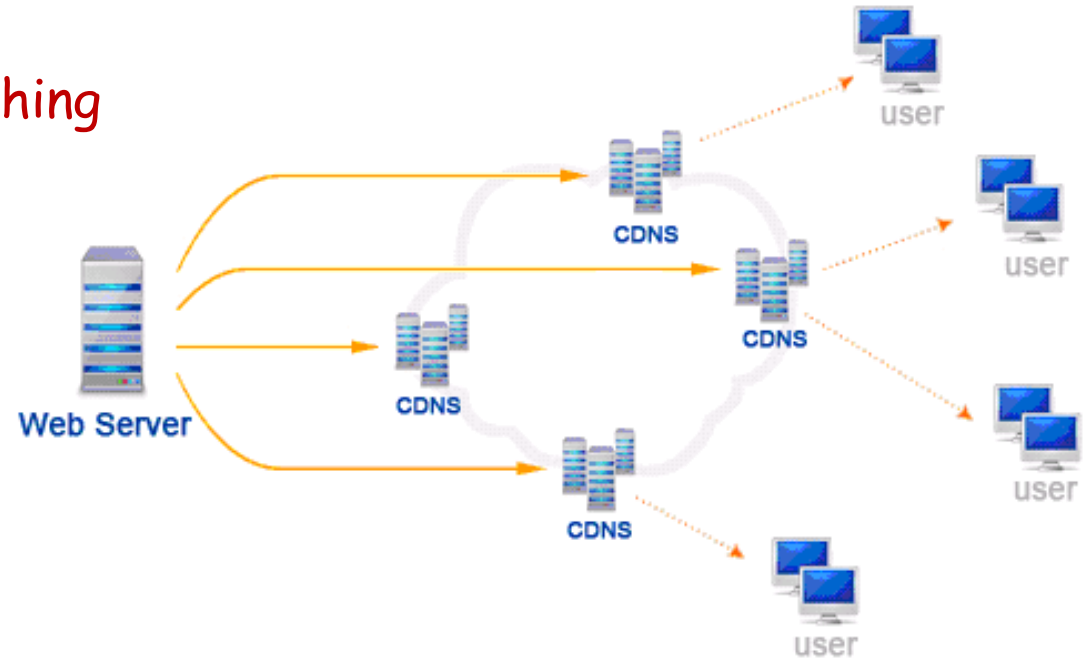


Solutions to the mismatch

- CDN

Problems:

- Bottleneck: bandwidth, CPU, …
- Maintenance
- Packet-level caching

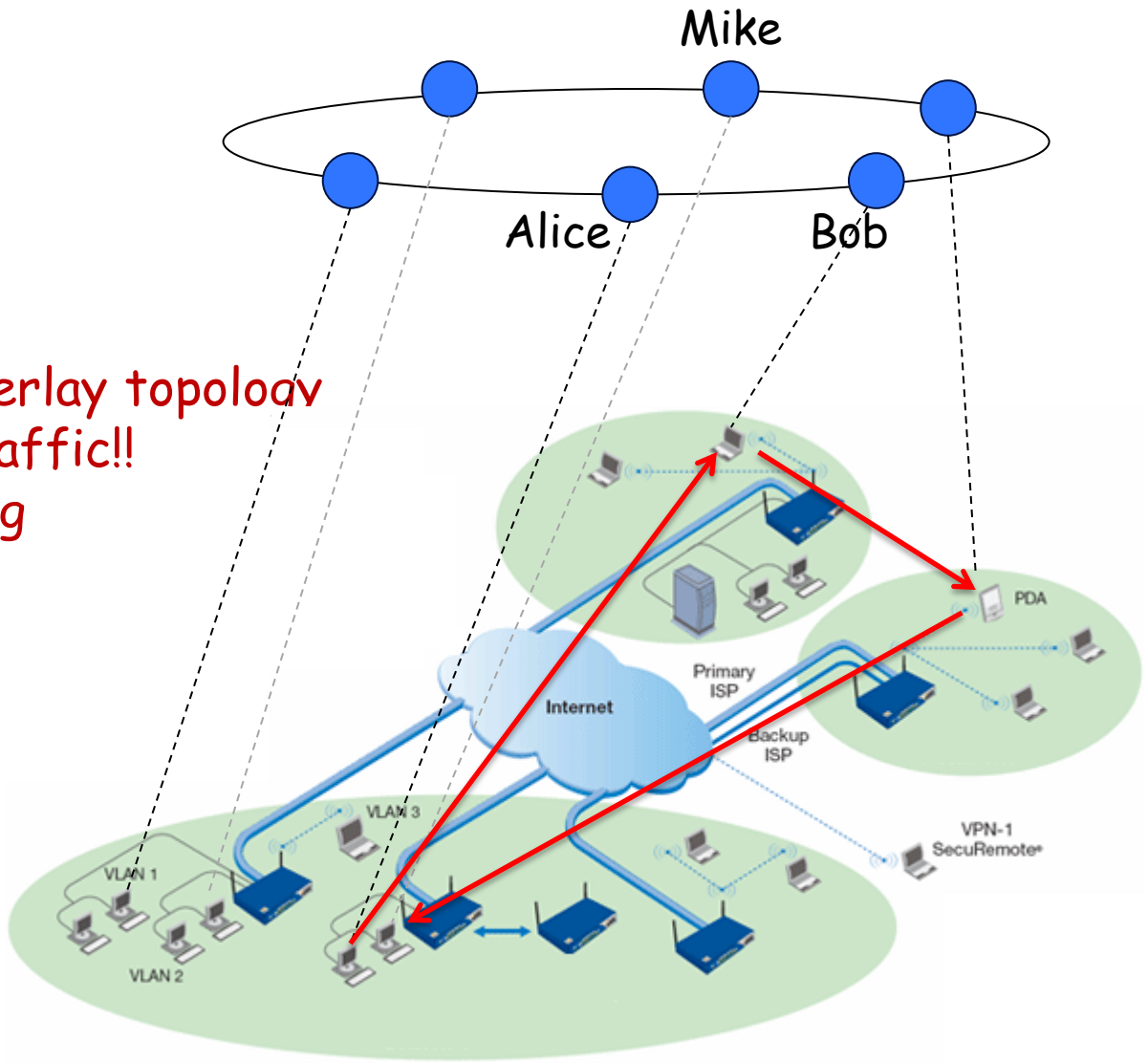


Solutions to the mismatch

- Peer-to-Peer

Problems:

- Agnostic to underlay topology
  - Inter AS traffic!!
- Efficient caching



Solutions to the mismatch

- IP/overlay multicast

Problems:

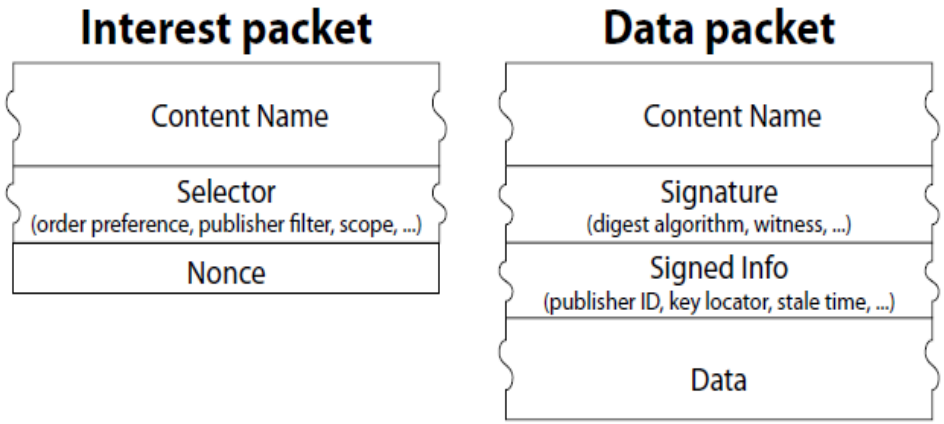
- Not well supported
- Async-data query
  - VOD

Objective?

- Content (name) – Centric
- Aware of network topology
- Fine-grained caching
- Reliability
- Security

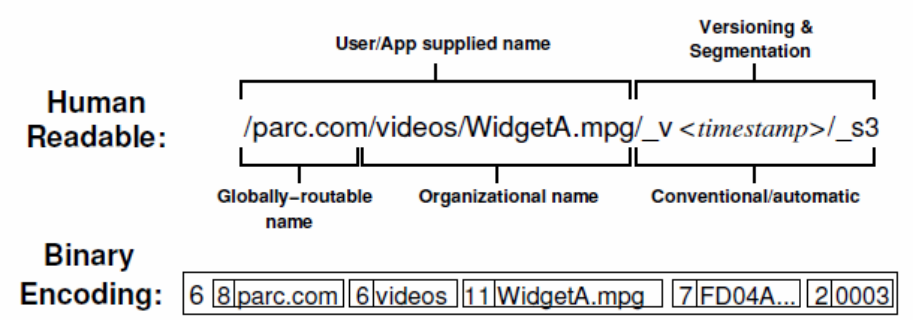
How CCN Works

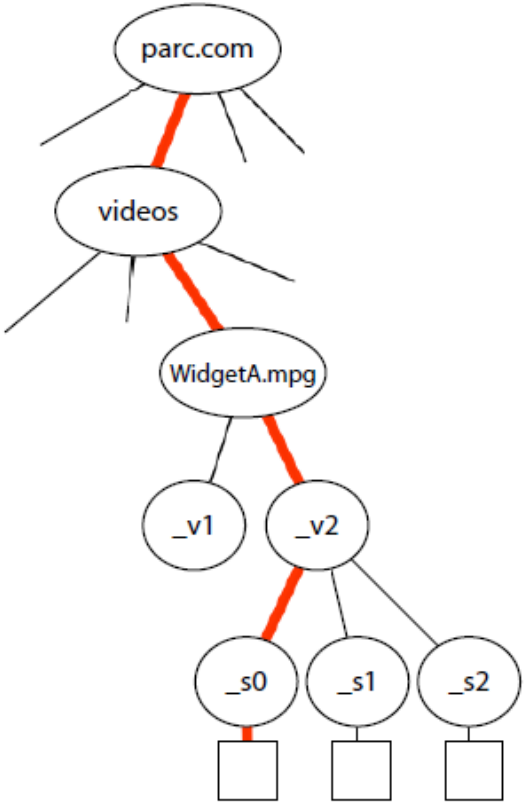
- Named Data Networks (NDN)
  - CCN moves the universal component of the network stack from **IP** to **chunks of named content**
  - Hierarchical human-readable *ContentName*
    - E.g. /conf/papers/NDN.pdf
  - *Interest* & *Data* packets
    - Query/Response model



How CCN Works

- Content Name (Name Tree)



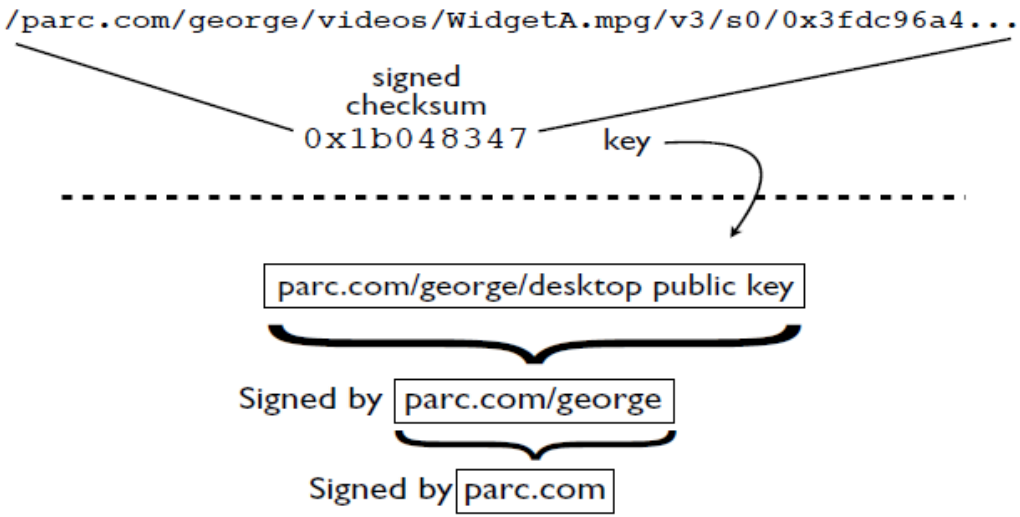


- Sequencing
  - _s0, _s1, _s2 are the segments of the file
  - Use relations to get relative segments
    - E.g. *previous*, *next*, *RightmostChild*, *LeftmostRightChild*, …

How CCN Works

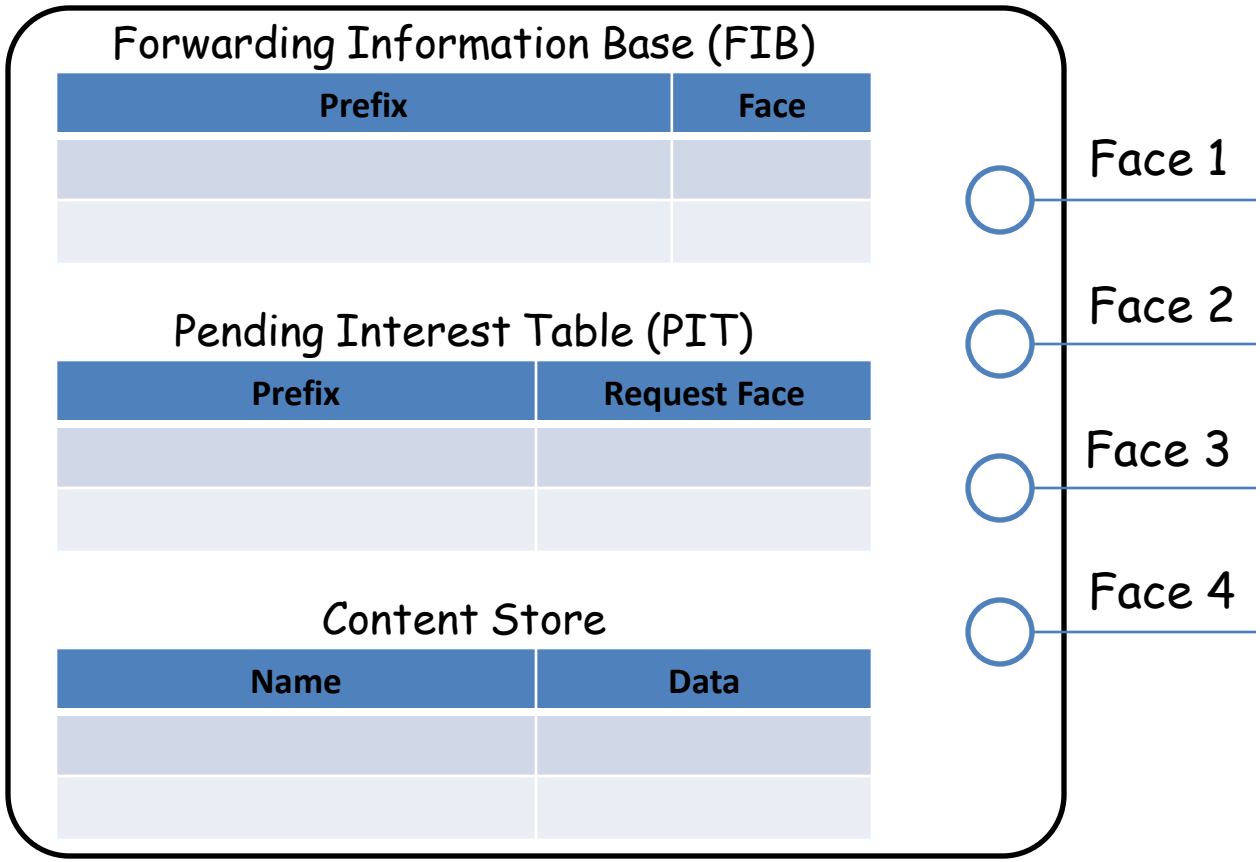
- **Content-based** Security
  - Securing data rather than securing channel

- Contextual trust
  - In the context of particular content
  - In the purpose for which it will be used



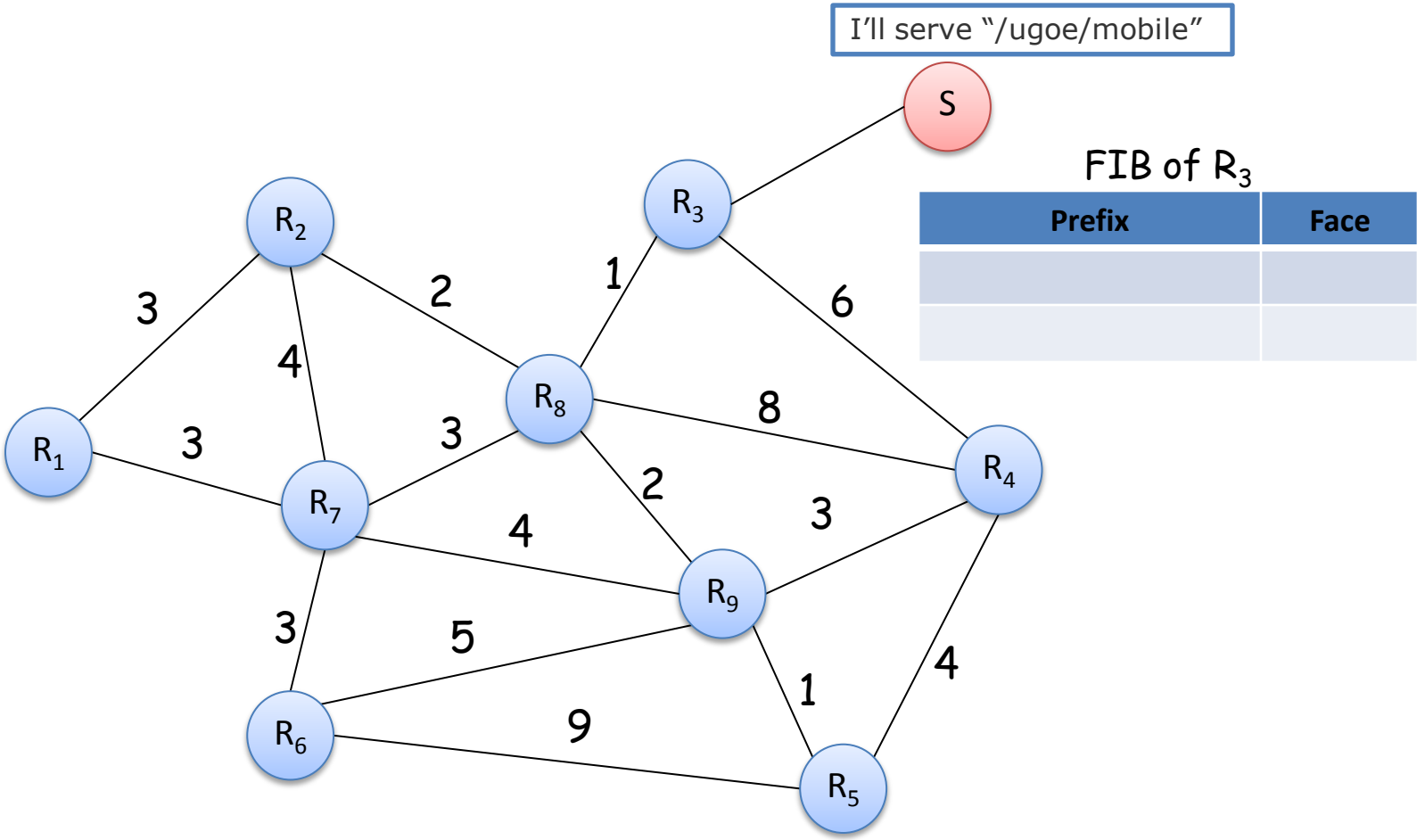
How CCN Works

- A new forwarding engine (router) needed:



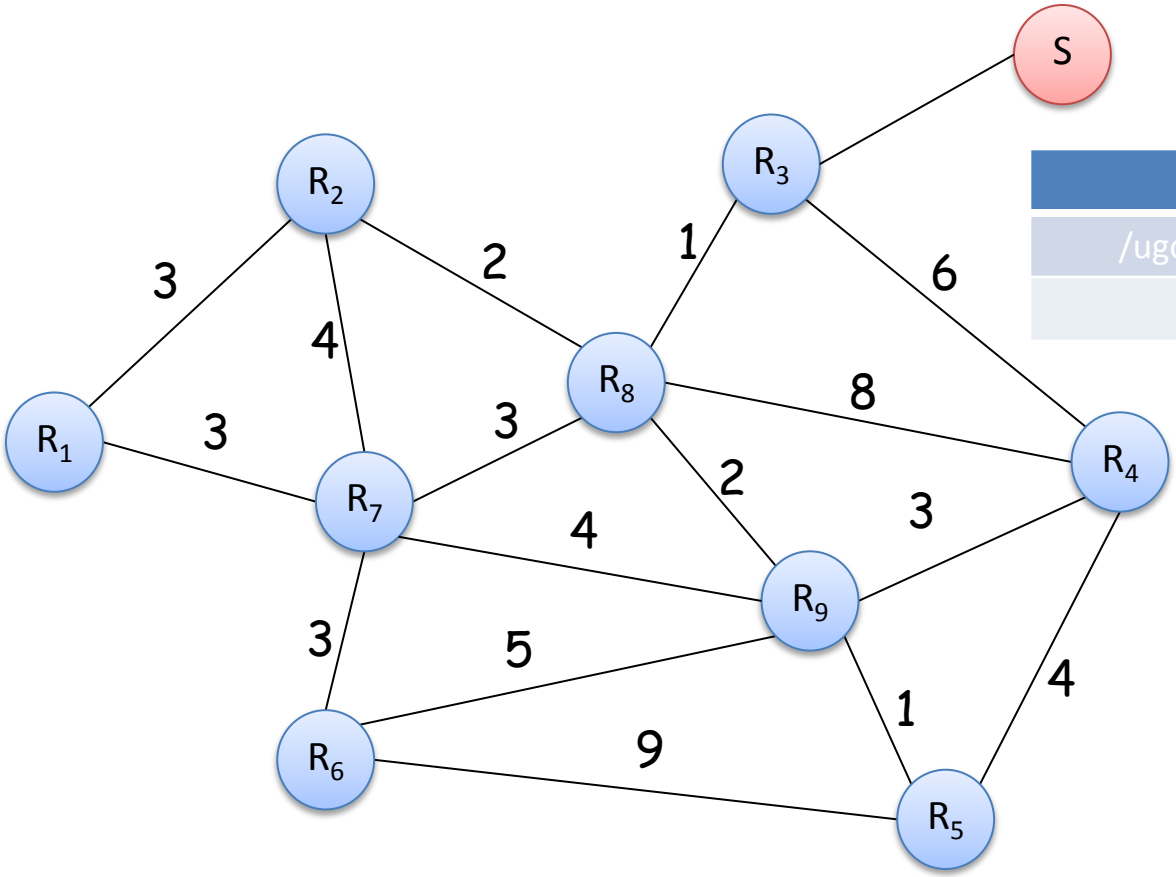
How CCN Works

- Processing a request



How CCN Works

- Processing a request

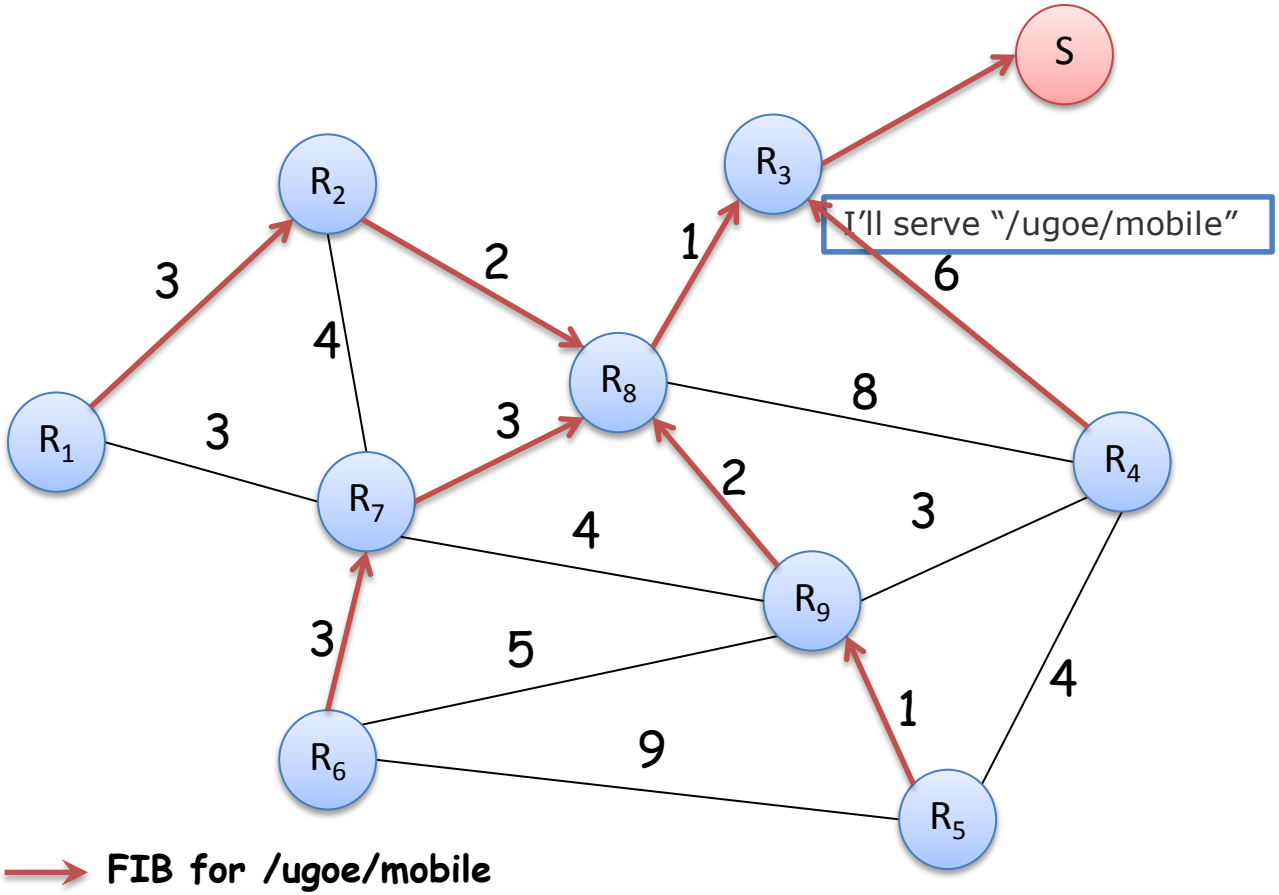


FIB of R_3

Prefix	Face
/ugoe/mobile	S

How CCN Works

- Processing a request

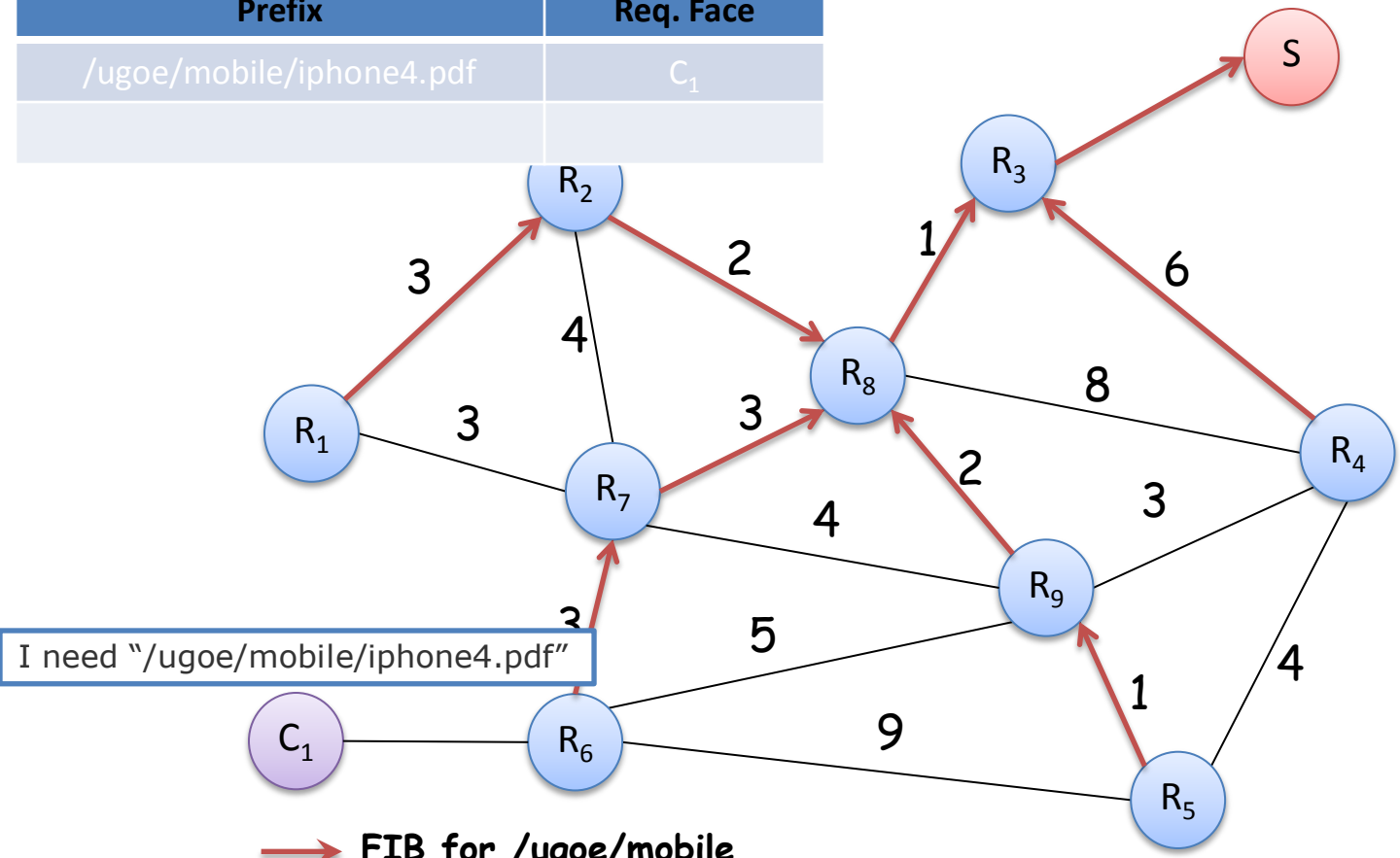


How CCN Works

- Processing a request

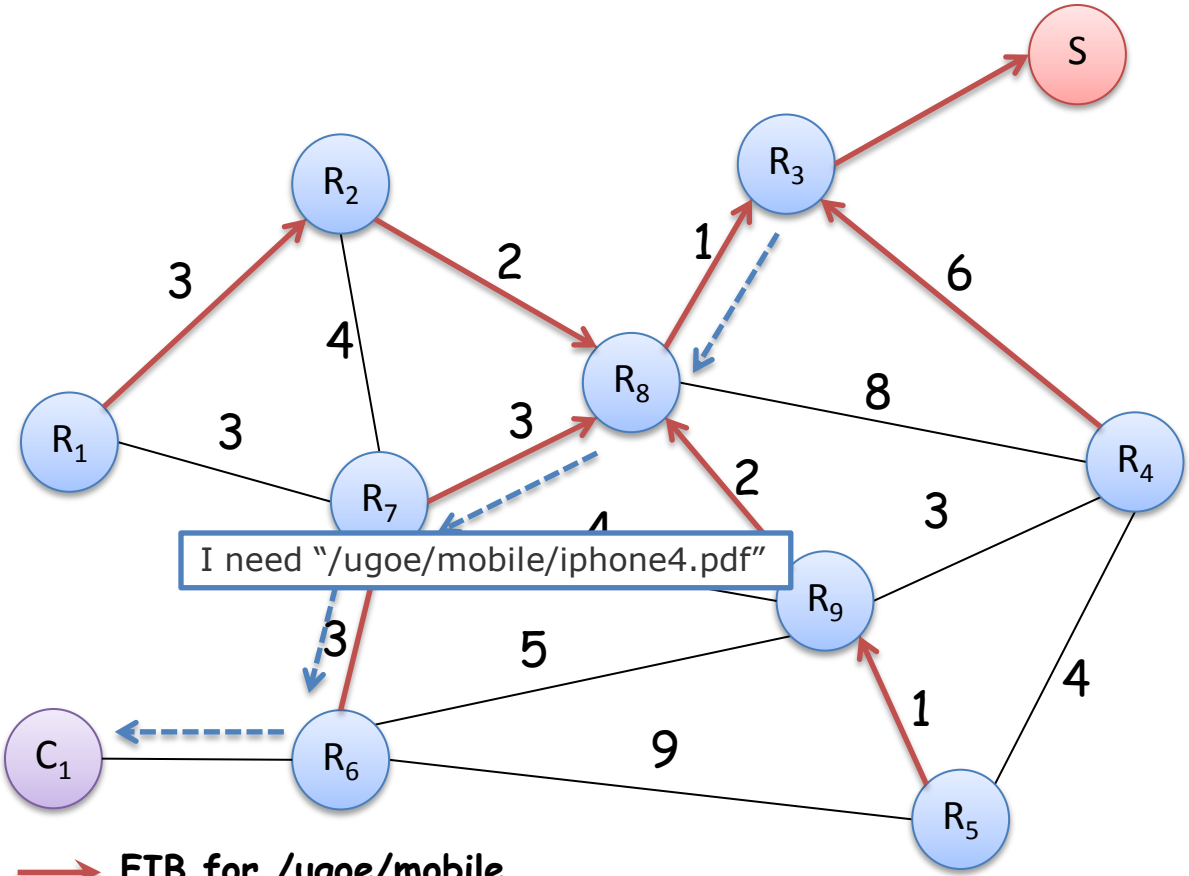
PIT of R_6

Prefix	Req. Face
/ugoe/mobile/iphone4.pdf	C_1



How CCN Works

- Processing a request

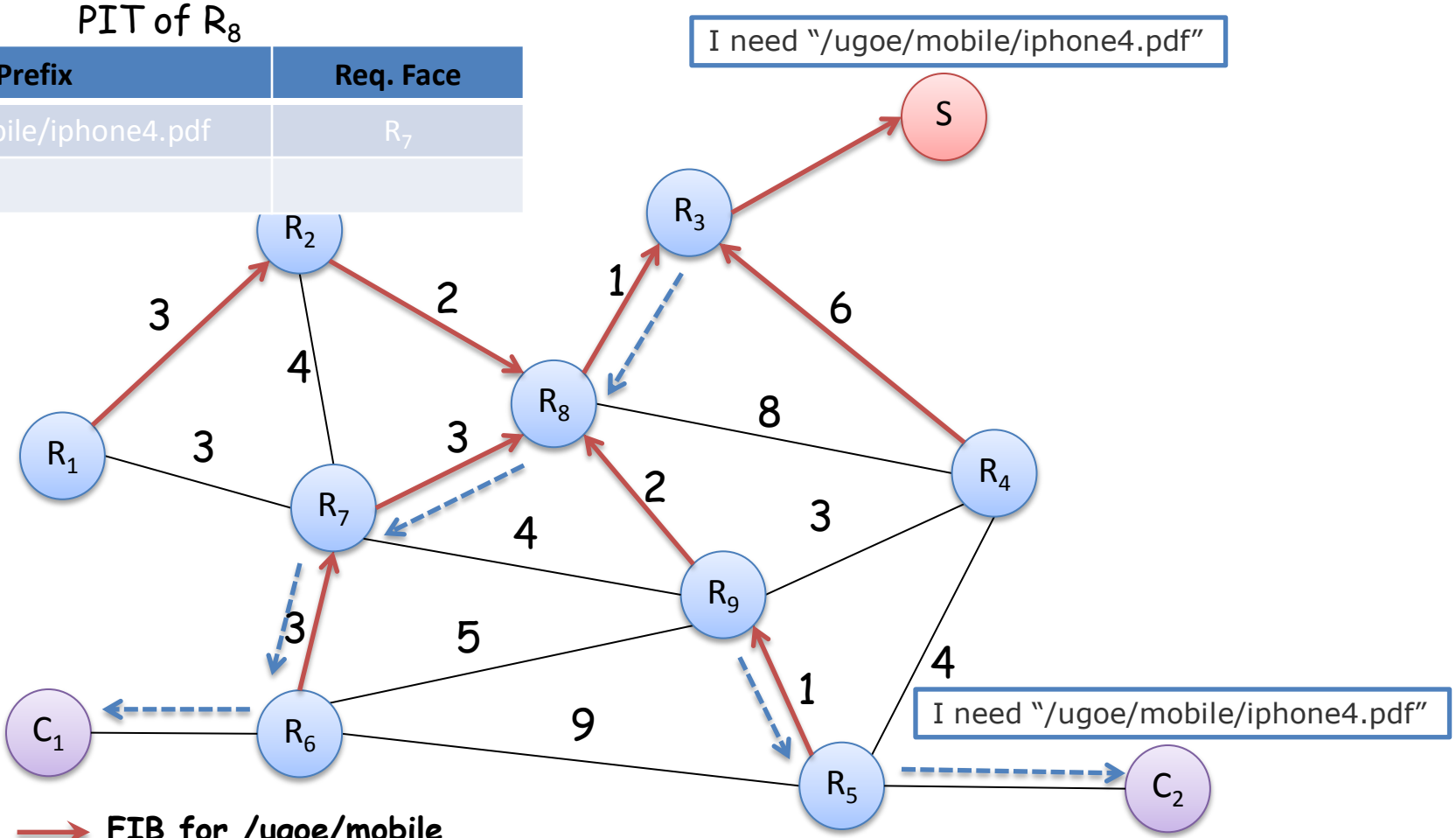


How CCN Works

- Processing a request

PIT of R_8

Prefix	Req. Face
/ugoe/mobile/iphone4.pdf	R_7

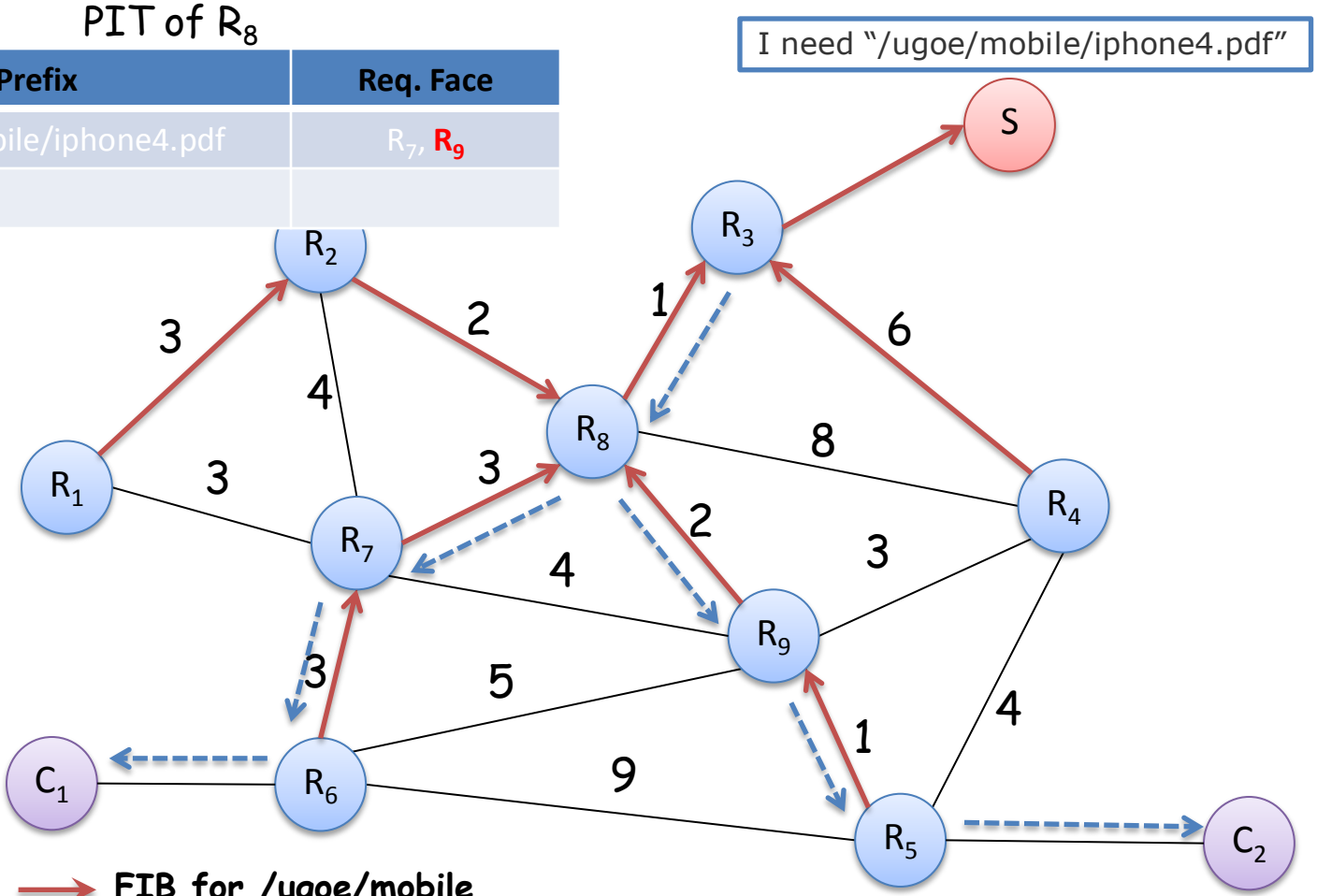


How CCN Works

- Processing a request

PIT of R_8

Prefix	Req. Face
/ugoe/mobile/iphone4.pdf	R_7, **R_9**



How CCN Works

- Processing a request – Forwarding Data

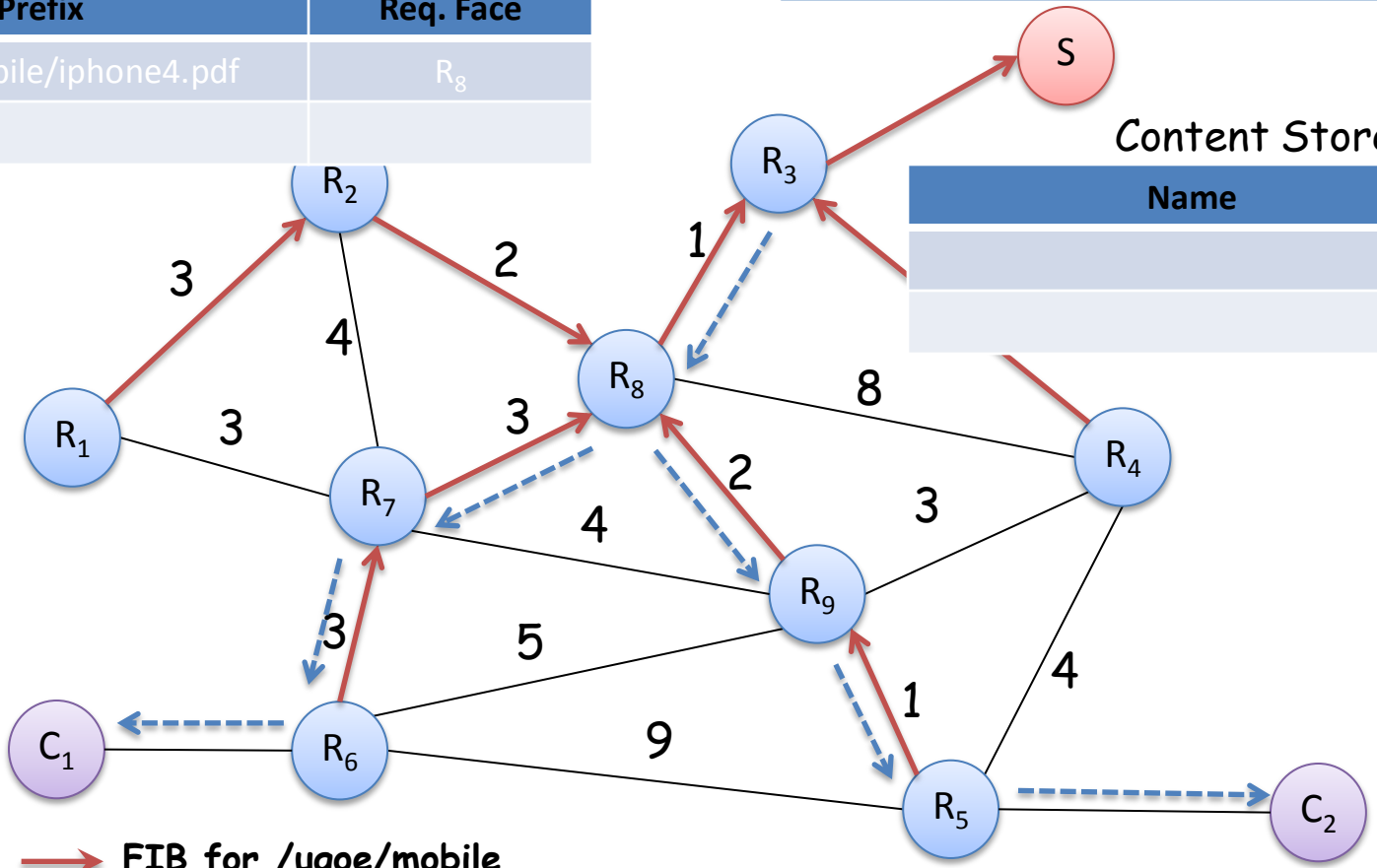
PIT of R_3

Prefix	Req. Face
/ugoe/mobile/iphone4.pdf	R_8

Data "/ugoe/mobile/iphone4.pdf/v1"

Content Store of R_3

Name	Data



How CCN Works

- Processing a request – Forwarding Data

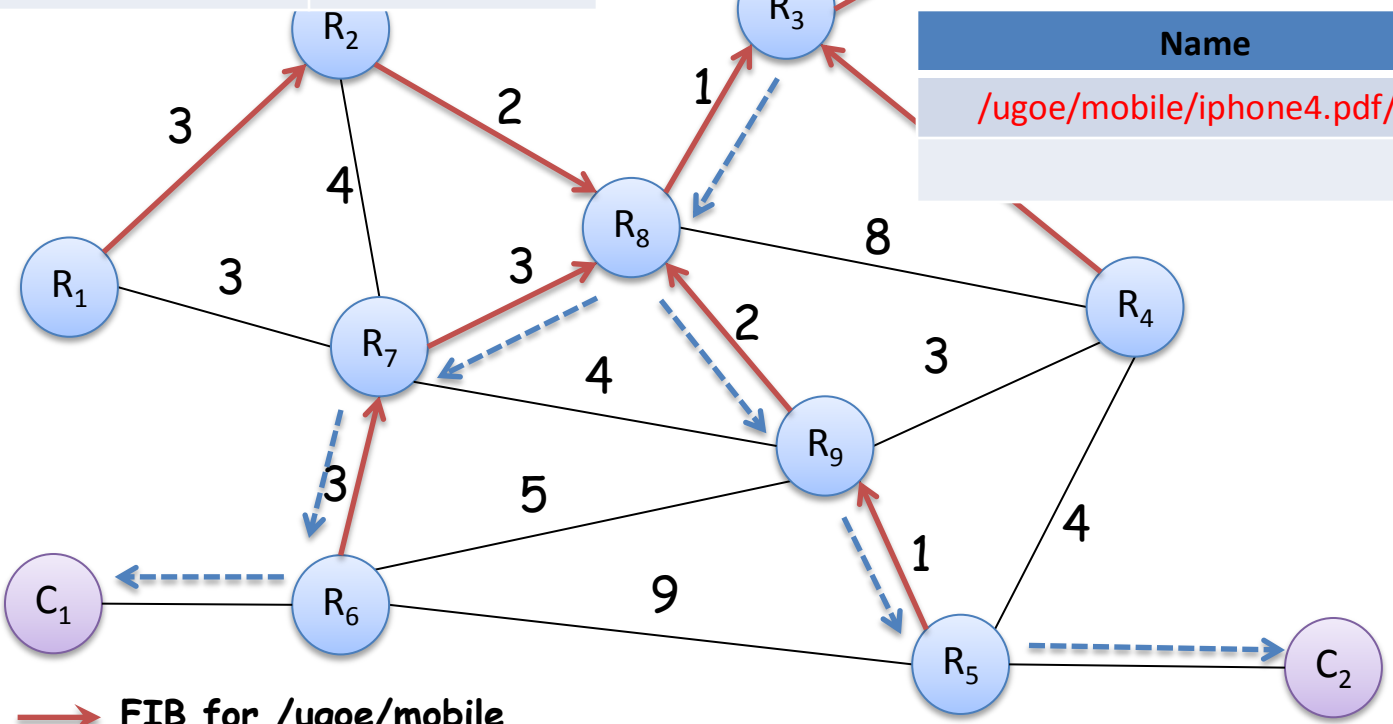
PIT of R_3

Prefix	Req. Face
/ugoe/mobile/iphone4.pdf	R_8

a "/ugoe/mobile/iphone4.pdf/v1"

Content Store of R_3

Name	Data
/ugoe/mobile/iphone4.pdf/v1	…



How CCN Works

- Processing a request – Forwarding Data

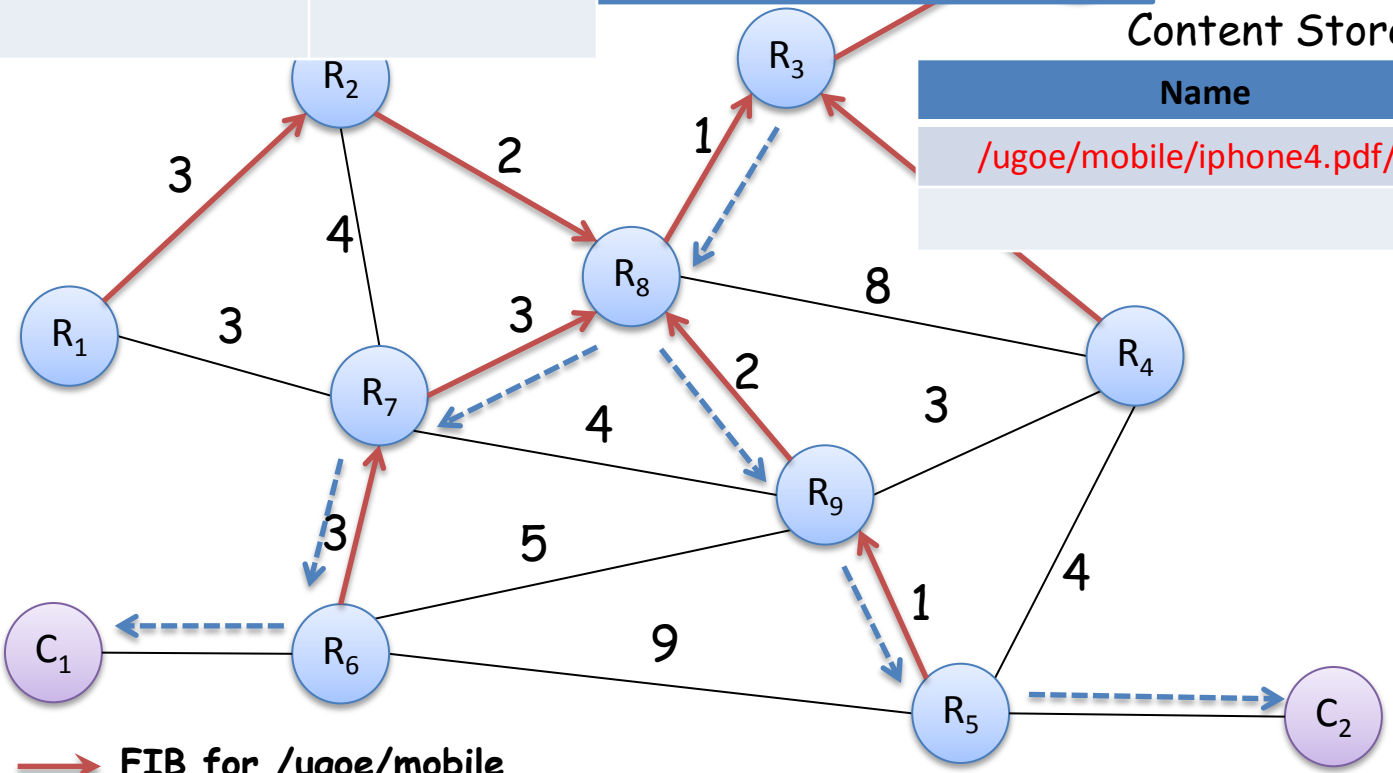
PIT of R_3

Prefix	Req. Face

a "/ugoe/mobile/iphone4.pdf/v1"

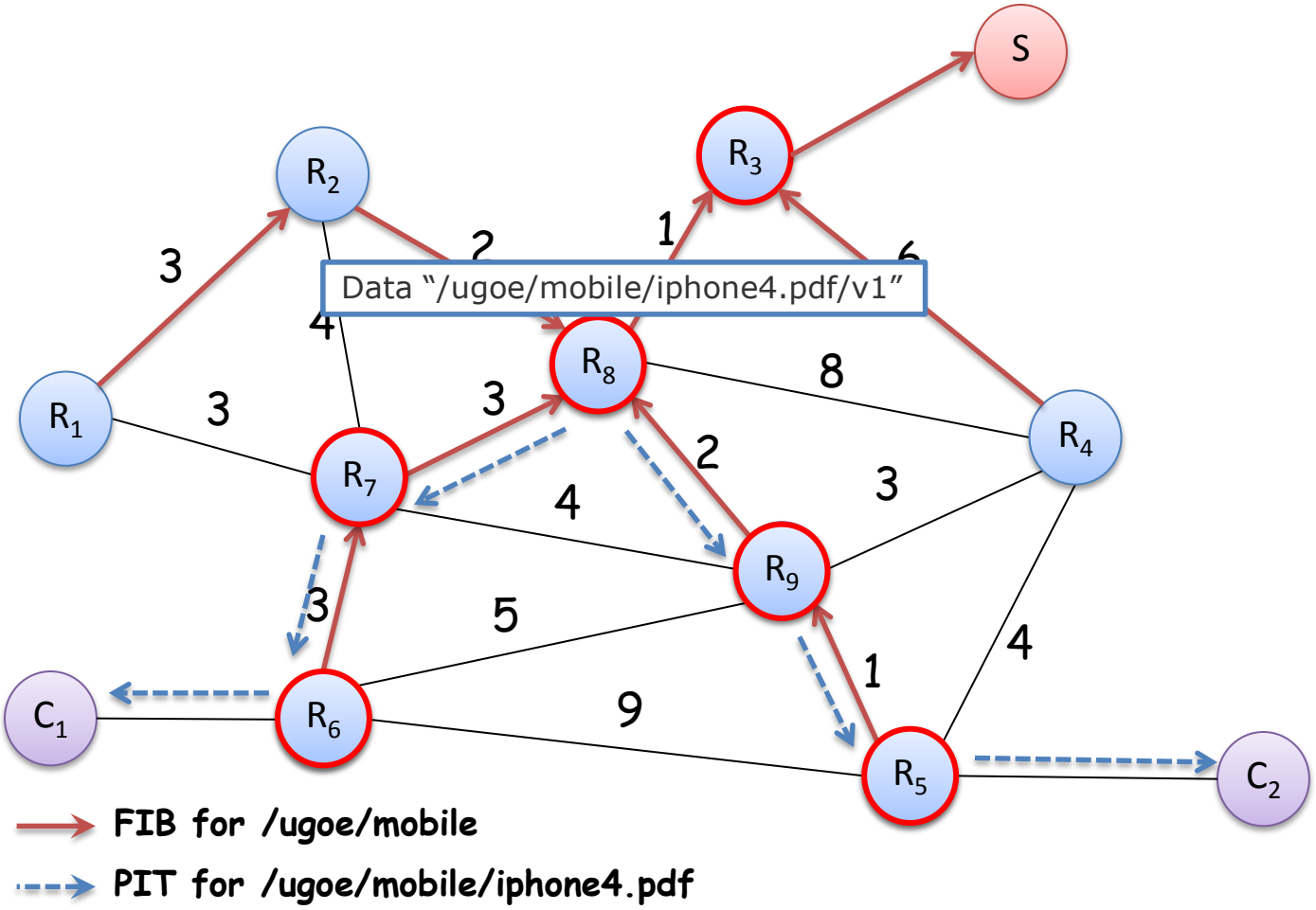
Content Store of R_3

Name	Data
/ugoe/mobile/iphone4.pdf/v1	…



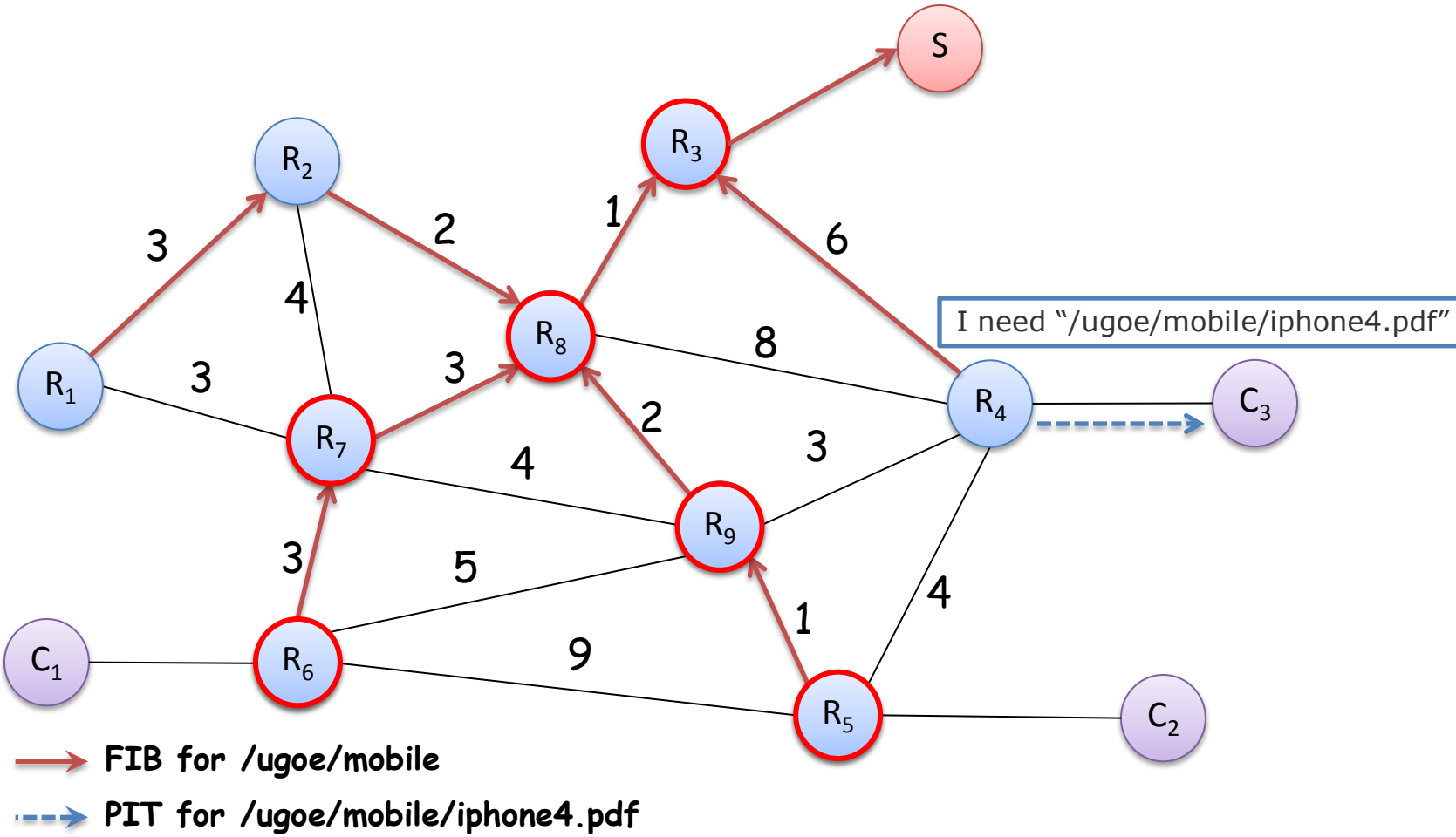
How CCN Works

- Processing a request – Forwarding Data



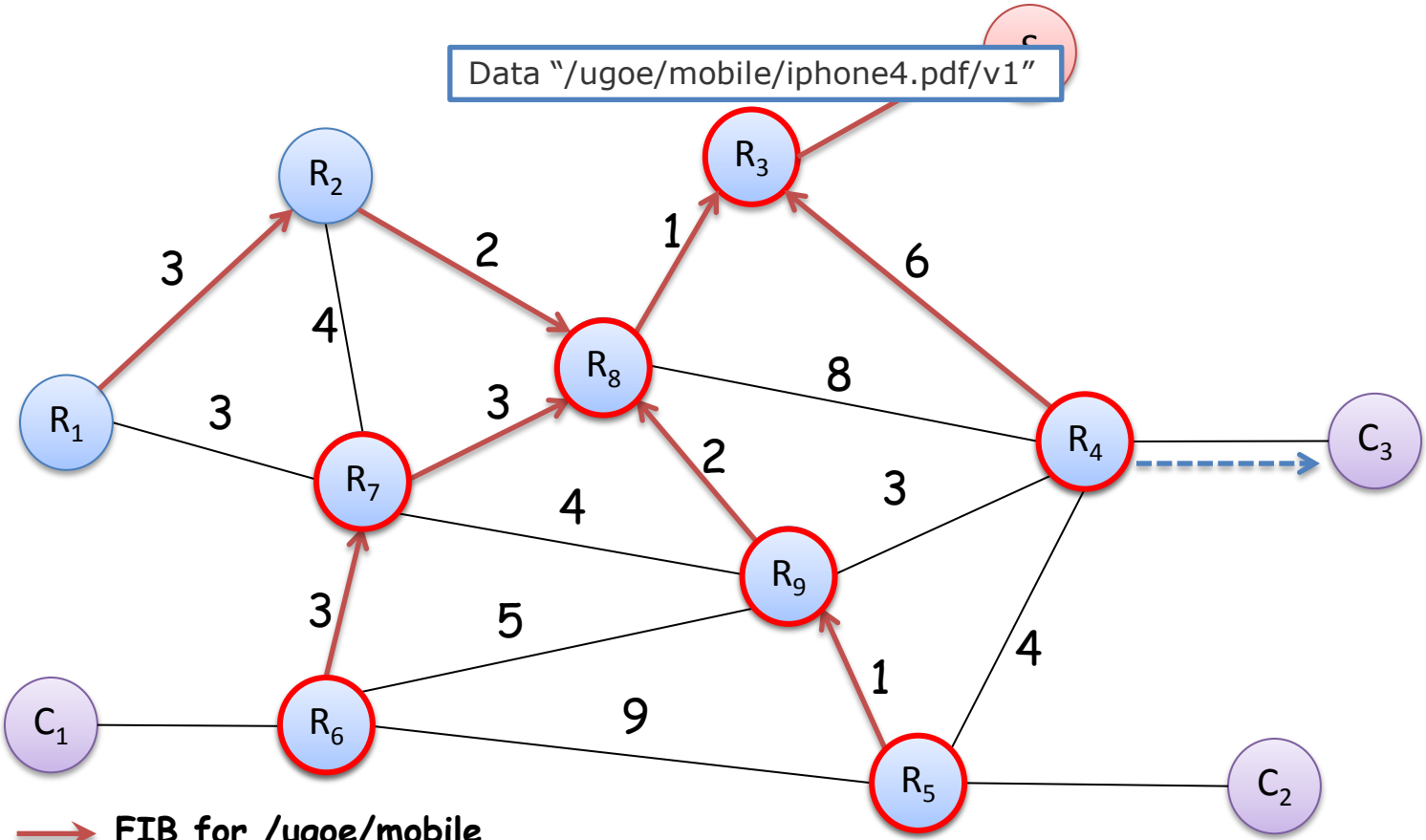
How CCN Works

- Processing additional requests



How CCN Works

- Processing additional requests



Features

- Packet (data chunk) identified by its unique name
  - Packet level caching
- Routing on names
  - Have full knowledge of network topology
  - Longest prefix match (similar to IP forwarding)
- Flow balancing
  - Query-response model of data dissemination

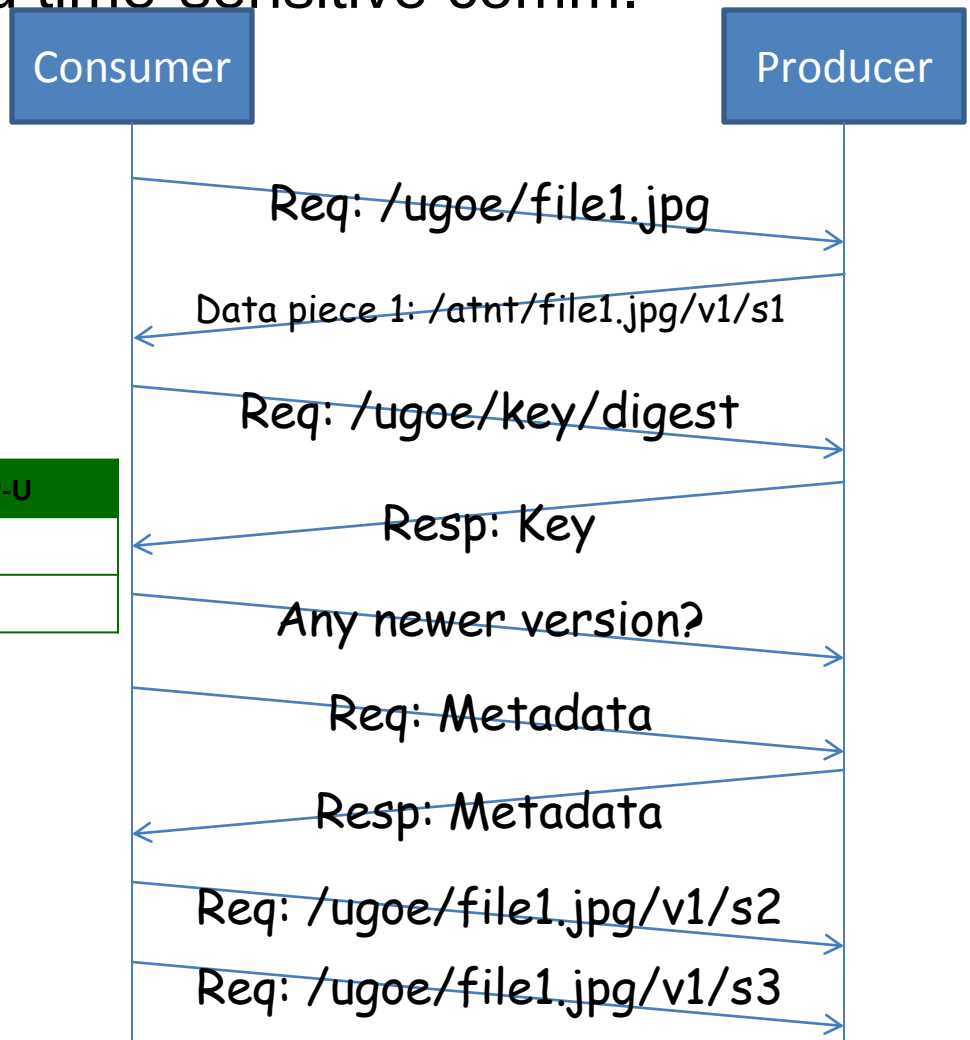
Problems

- CCN fits well with current data access requirement
- But it is a clean-slate design
  - Requires the routers in the whole network be replaced
- And, what will happen if the network is replaced by CCN forwarding engines?
  - FIB size?
  - Cache efficiency?
  - Underlay resilience?
  - **Live streaming / highly interactive communication?**
  - Other usage (IPTV? Cloud? Data Center?...)

Time-sensitive communication

- Barriers between CCN and time-sensitive comm.
  - Protocol complexity
    - Q/R based
    - Control overhead
  - Processing overhead

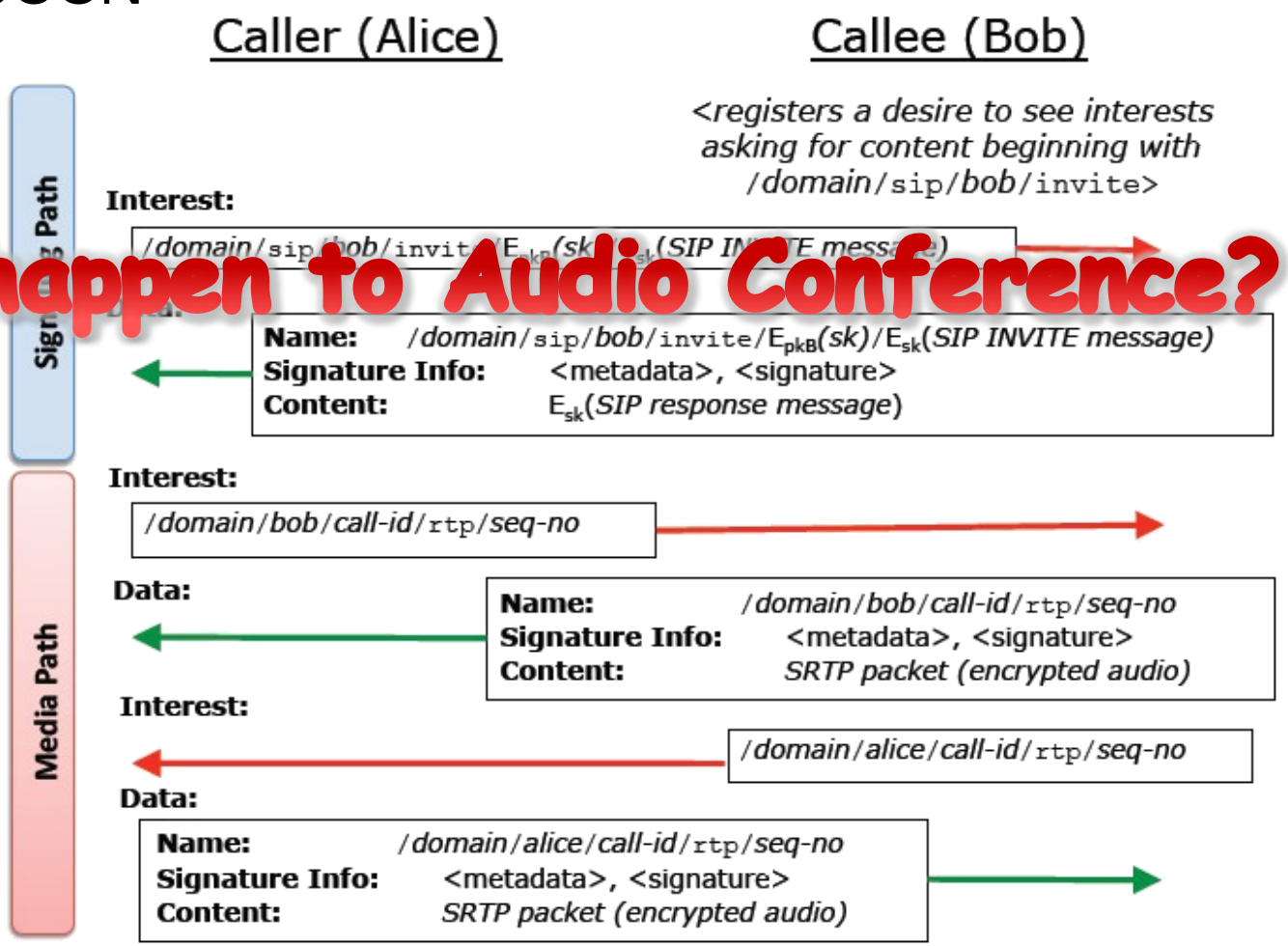
	CCNx	UDP-K	UDP-U
200B/Interest			
4096B/Data			



computer NETWORKS

Time-sensitive communication

- Example: VoCCN



What will happen to Audio Conference?

Time-sensitive communication

- Content-Oriented Publish-Subscribe System (COPSS)
  - Information Overload - Scale: Producers and Consumers face challenges
    - Large number of producers (publishers; data sources)
    - Even larger number of consumers (subscribers, users querying/looking for content)
      - Tremendous number of information producers makes it difficult for a consumer to know where to find relevant information
    - Significant challenge: “whom and what to ask” & “whom and what to tell”
  - A network-based Information Dissemination and Retrieval environment
    - Obtain “information” of interest by asking the network to find it
    - Tell the network to deliver “information” of interest
    - Ask the network as to what “information” I should be interested in

Time-sensitive communication

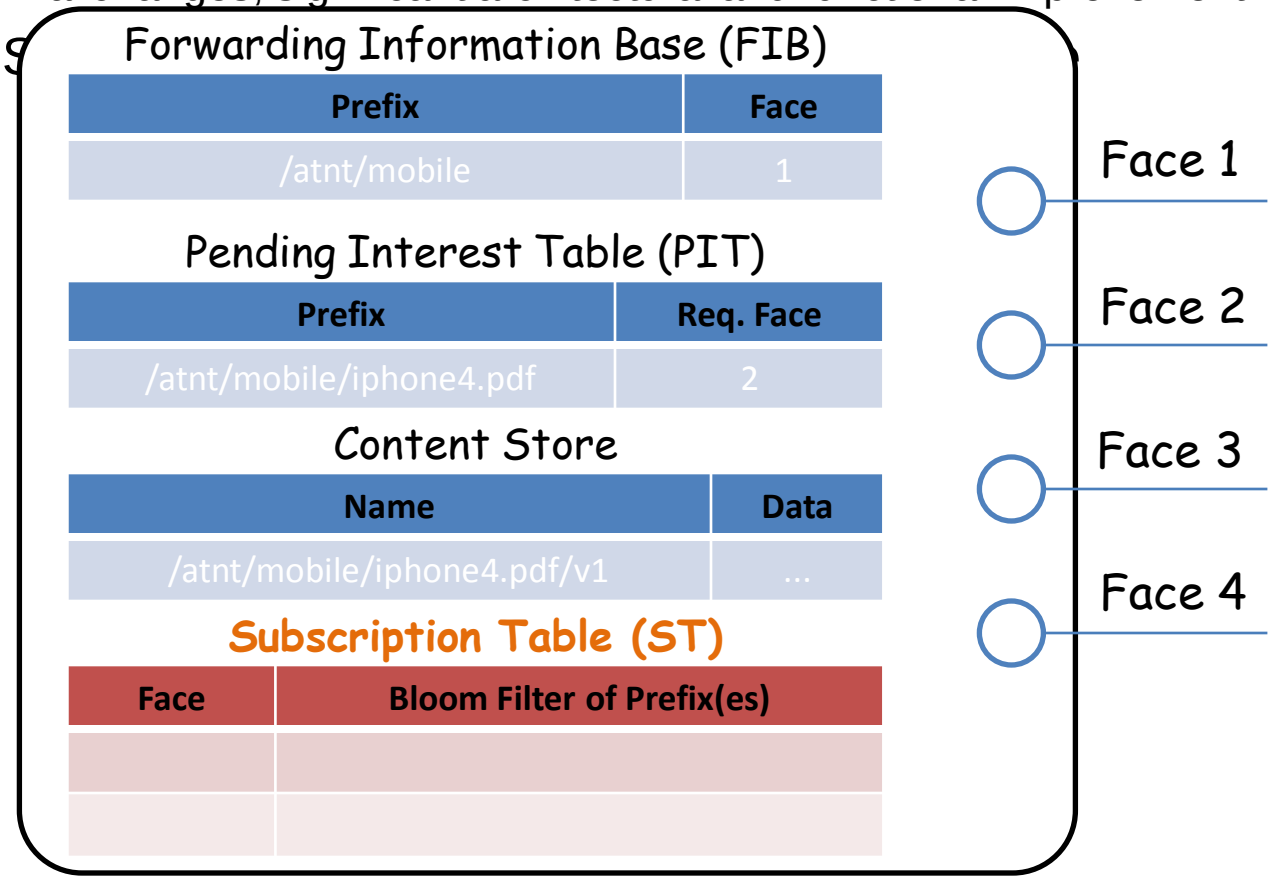
- Content-Oriented Publish-Subscribe System (COPSS)
  - Push enabled dissemination
    - Subscribers receive information in a timely manner
  - Decouple publishers and subscribers
    - Content-centric subscription and publication of information
  - Scalability
    - Load on the network & publisher/server grow sub-linearly with increasing subscribers
  - Efficiency
    - Utilize network and server resources efficiently
  - Incremental deployment
    - Beneficial for early adopters **and** seamless migration from an IP dominated environment

Time-sensitive communication

- Content-Oriented Publish-Subscribe System (COPSS)
  - Support hierarchies and context in naming content
    - Richer identification of content
    - Allows aggregation
    - Allows grouping/subscription at various levels
  - Support two-step dissemination, enabling:
    - Policy control
    - Efficiency
  - Subscriber offline support
    - Asynchronous delivery of information

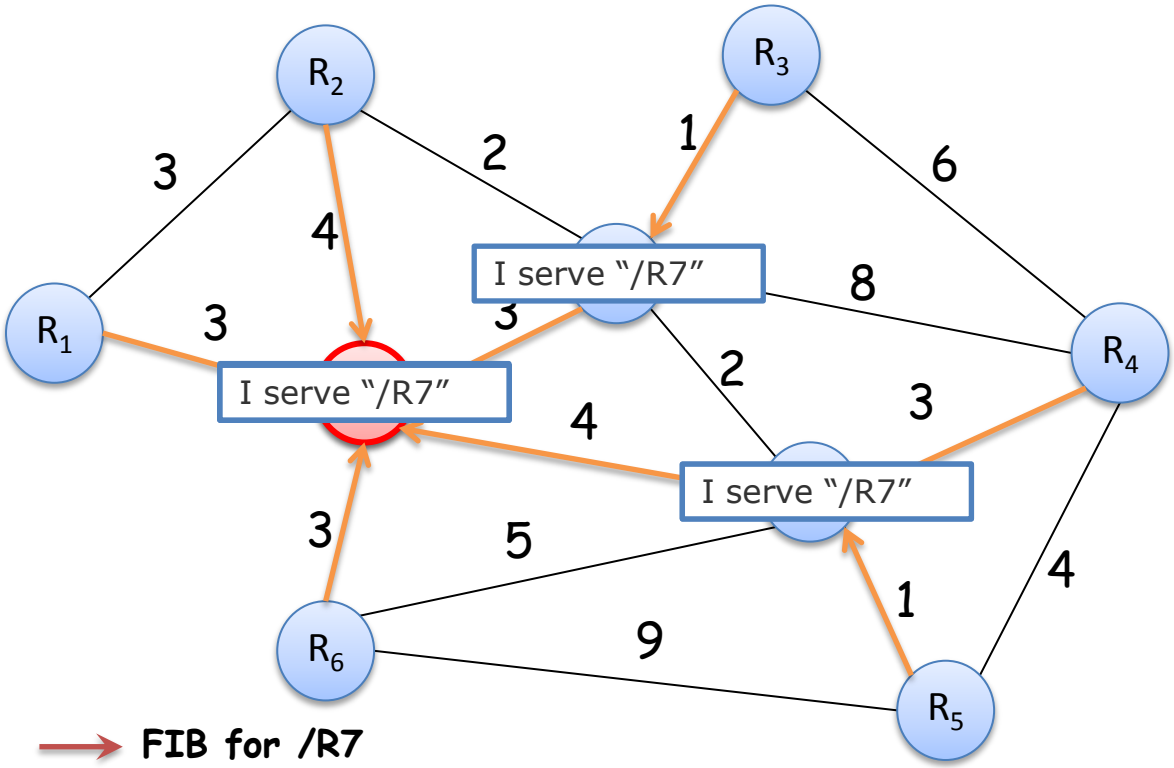
Time-sensitive communication

- COPSS Architecture
  - Built on top of the NDN framework
    - minimal changes, significant architectural and functional improvement
  - Add a S



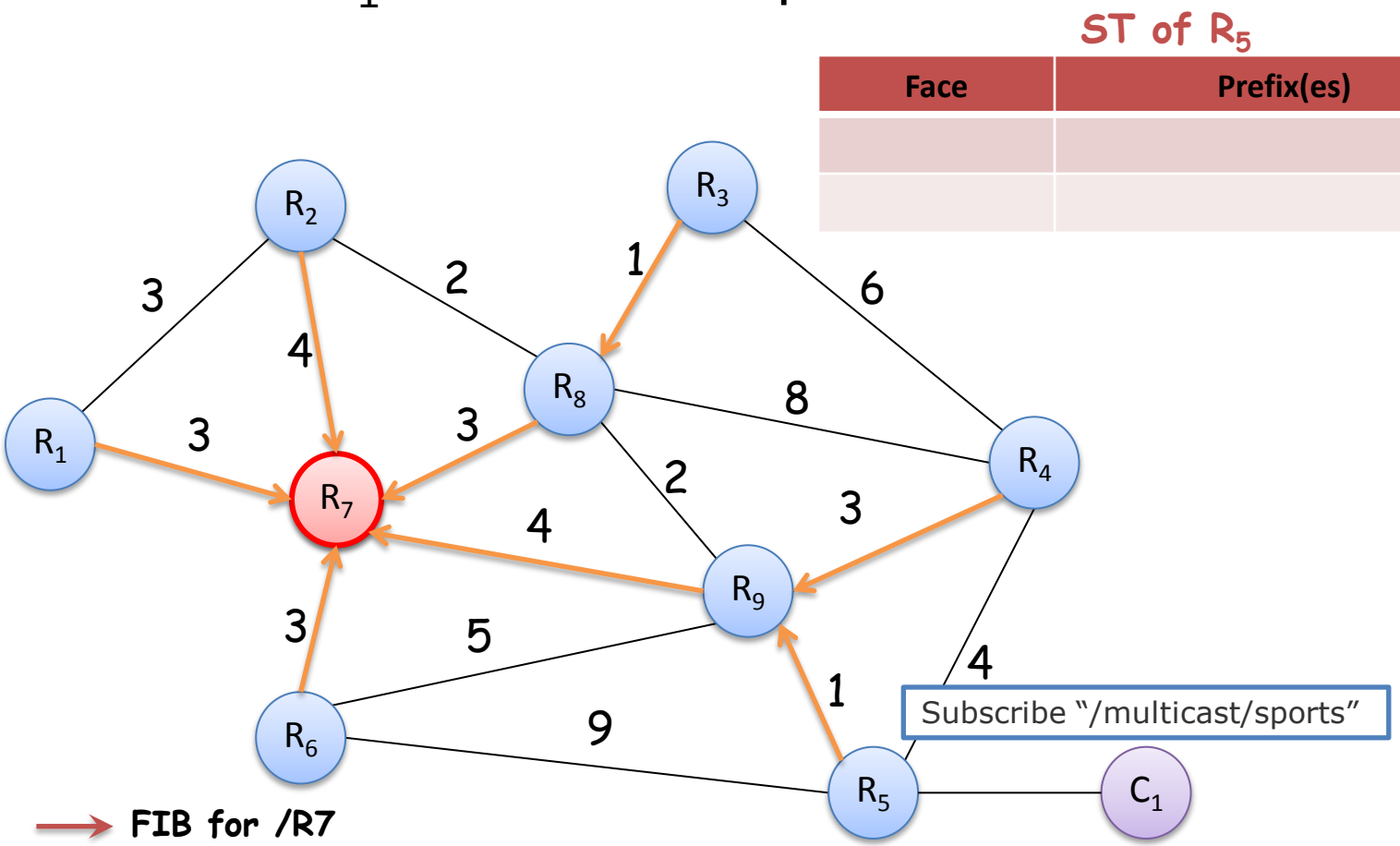
COPSS Communication

- Basic one-step communication
  - Select rendezvous node (like CBT multicast's core) and propagate info



COPSS Communication

- Basic one-step communication
  - Subscribe: C_1 -> “/multicast/sports”



COPSS Communication

- Basic one-step communication
  - Subscribe: C_1 -> “/multicast/sports”

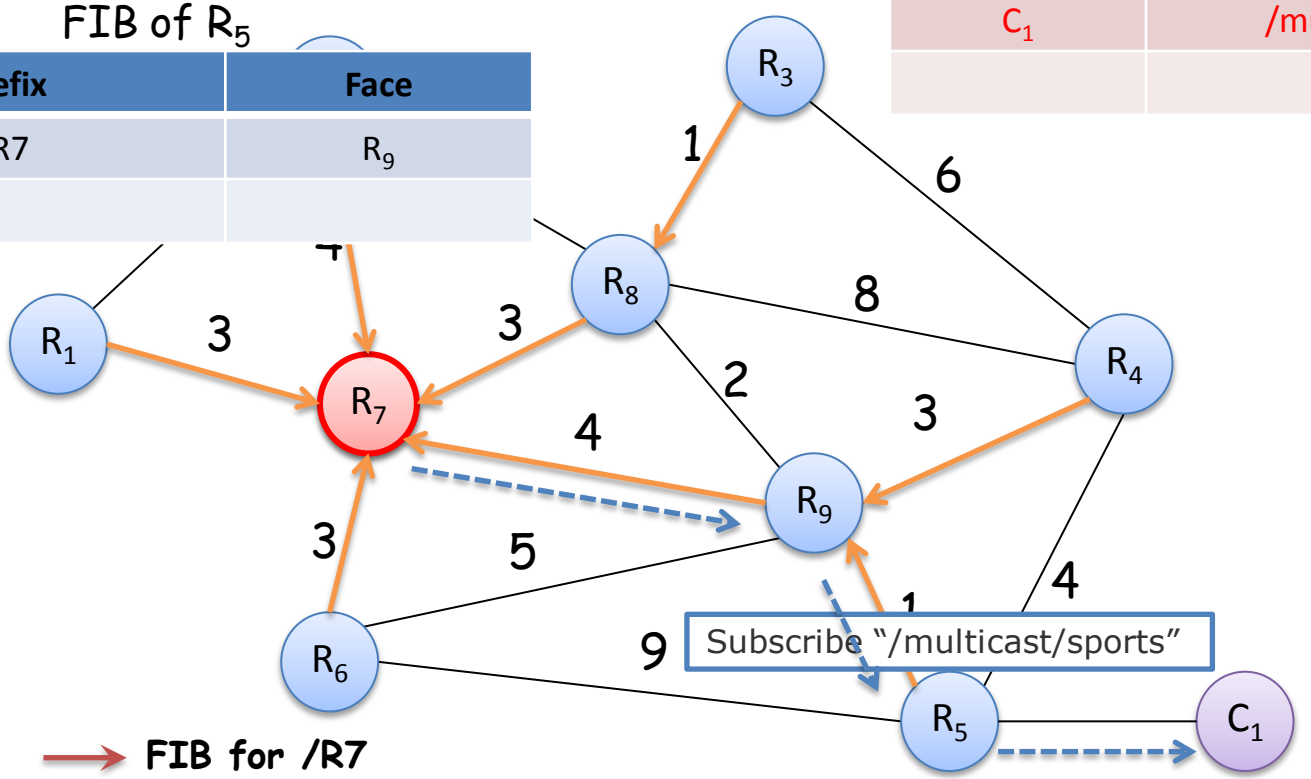
$Hash(\text{"/multicast/sports"}) = \text{"}/R7\text{"}$

FIB of R_5

Prefix	Face
/R7	R_9

ST of R_5

Face	Prefix(es)
C_1	/multicast/sports



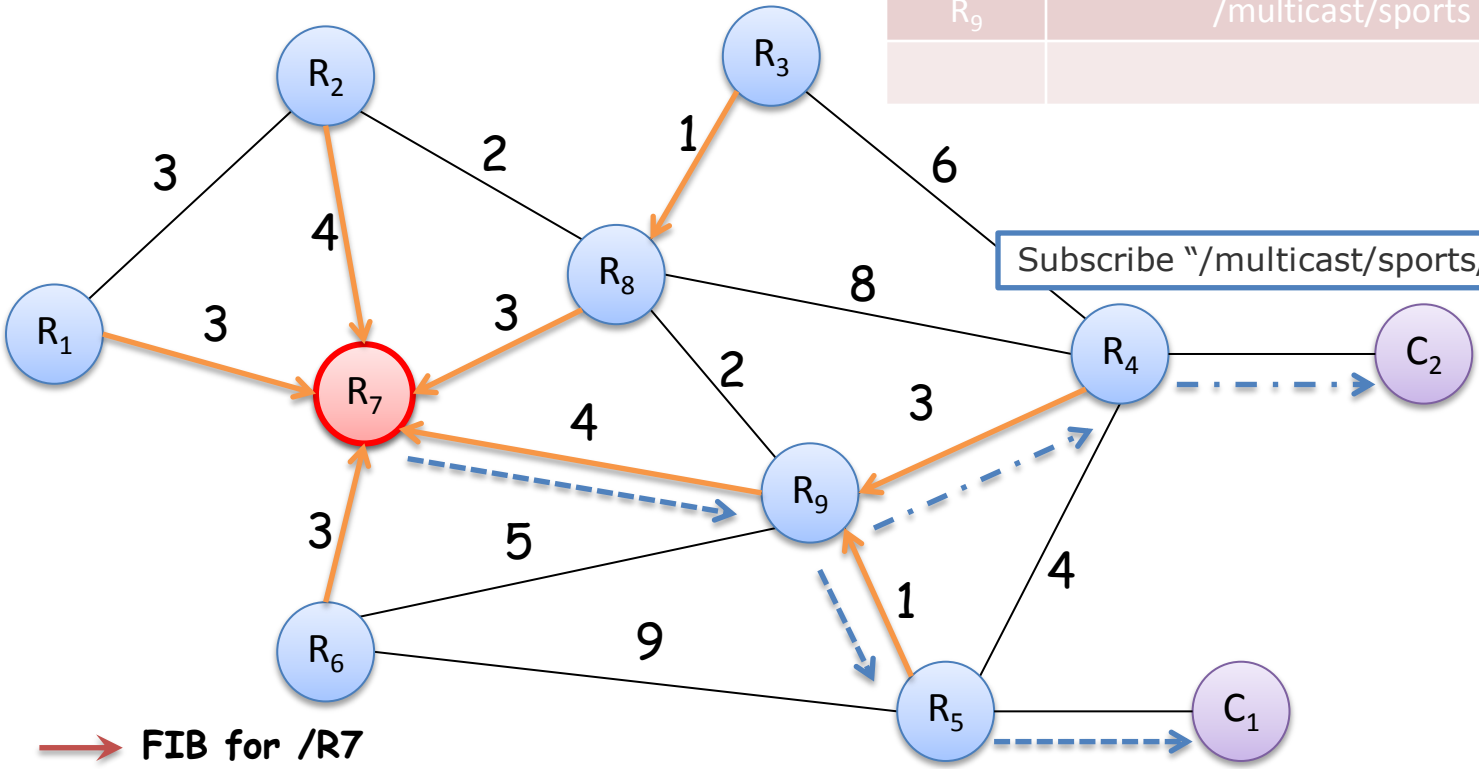
COPSS Communication

- Basic one-step communication
  - Subscribe: C_2 -> “/multicast/sports/football”

$Hash(\text{"/multicast/sports/football"}) = \text{"}/R7\text{"}$

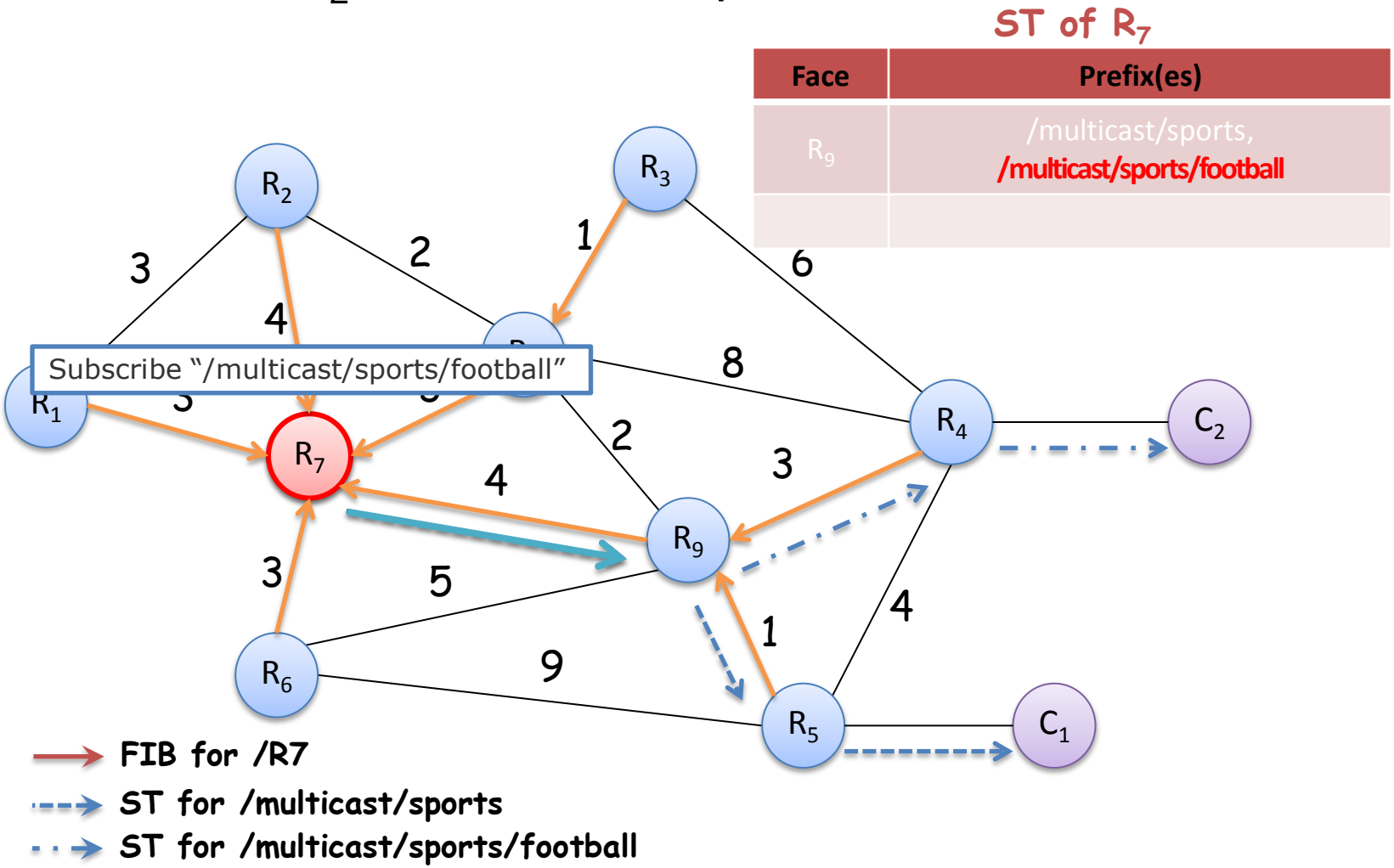
ST of R_7

Face	Prefix(es)
R_9	/multicast/sports



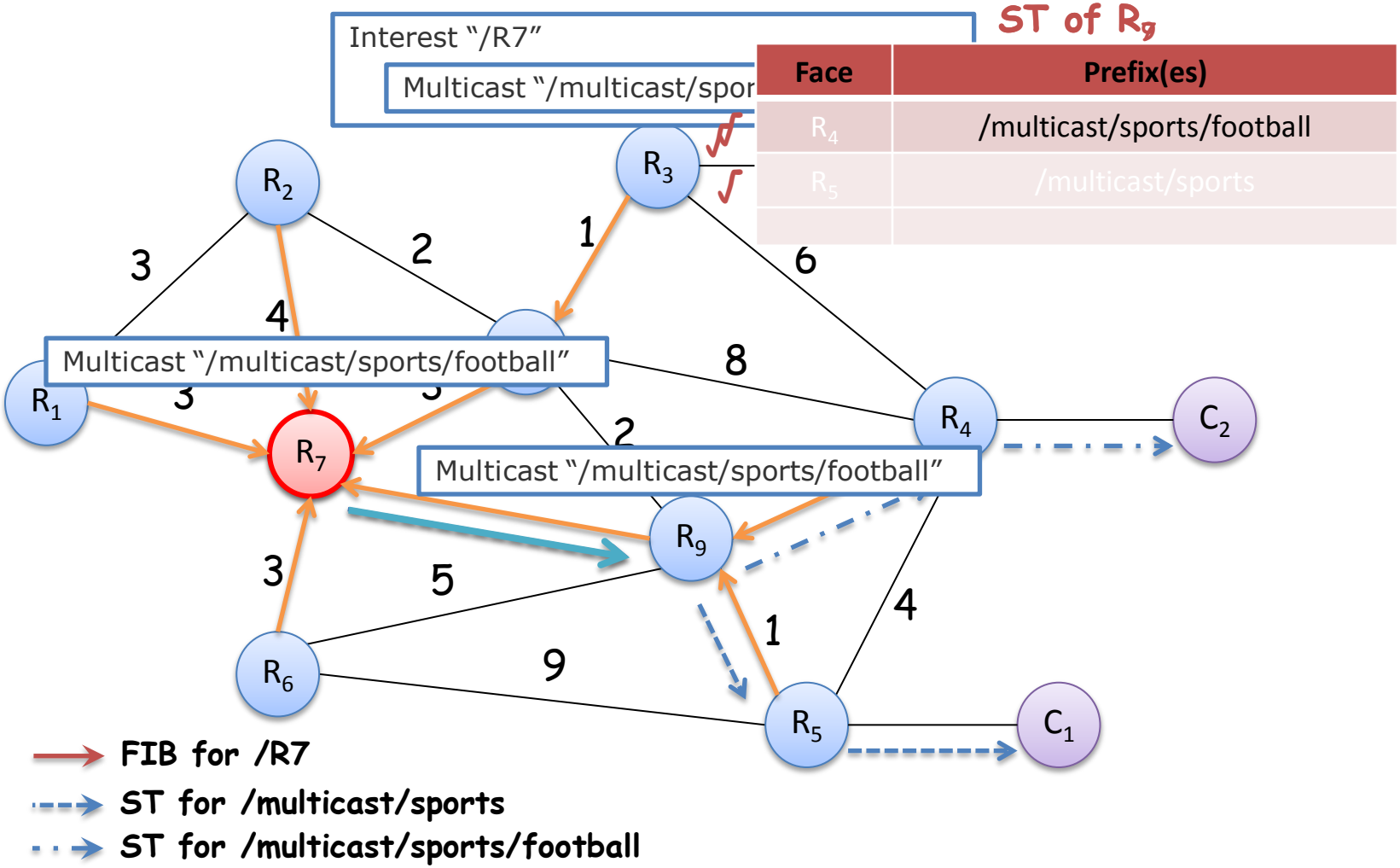
COPSS Communication

- Basic one-step communication
  - Subscribe: C_2 -> "/multicast/sports/football"



COPSS Communication

- Basic one-step communication
  - Publish: P -> “/multicast/sports/football”



COPSS communication

- Two-step communication
  - Publisher multicast snippet with content ID
  - Subscriber query for data if they are interested in the snippet
- Why?
  - Save network traffic
    - A subscriber of a topic is not necessarily interested in every data in that topic
  - Publisher policy control

COPSS communication

- Further Issues
  - Incremental deployment
  - Security
  - Spam
  - Other usage
  - …