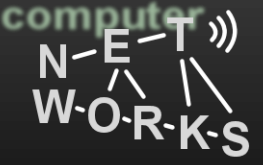


ACN course

Content-Centric Networking (II)

Presenter: Mayutan Arumaithurai

Computer Networks Group, Institute of Computer Science

Georg-August-Universität Göttingen

Acknowledgement

- Thanks to Dr. Jiachen Chen for helping with the slides

Is Query/Response (Data Pulling) Enough?

- **RSS Feed**
  - User doesn't know ***what*** is going to be the next data in his/her interest
  - Network doesn't know ***where*** to forward the request (if there is)
  - Existing solutions (in HTTP/TCP/IP):
    - Server-based solution (e.g., Twitter)
    - Information aggregators (e.g., Google)
  - Issues:
    - Overhead caused by polling server(s)
    - Timeliness
- **Gaming**
  - Player doesn't know ***when*** the next data might come
  - Existing solutions (in IP):
    - Long-term link
    - Browser games (slow paced)
  - Issues:
    - Overhead caused by maintaining links
    - NAT

Content-Oriented Pub/Sub Systems (COPSS)

Requirements of Efficient Pub/Sub

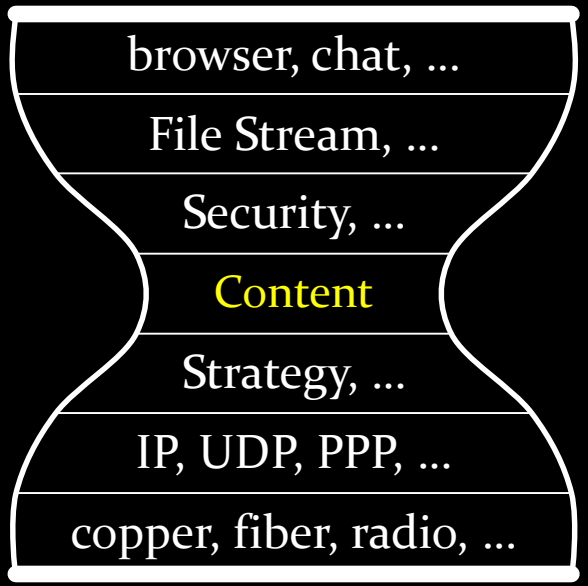
- Push
- Temporal Separation
- Scalability
- Efficiency
- Rendezvous-Point (RP) based communication

- Hierarchical topic management
- Two-step communication
- Offline-support

- Minimal changes, but significant architectural & functional improvement!

Protocol Level Modification

- Adopt Content Descriptor (CD)
  - Using the same form of a Content Name
  - Different relationship between CD vs. Data



Content Name:

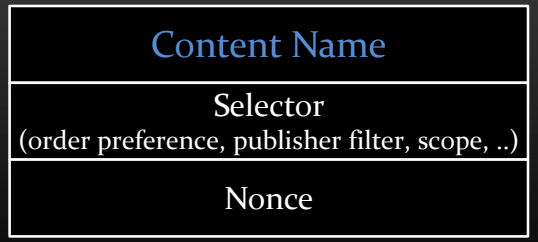
/ugoe.edu/jchen/acn14-ICN.pdf/_v1/_s1

Content Descriptors:

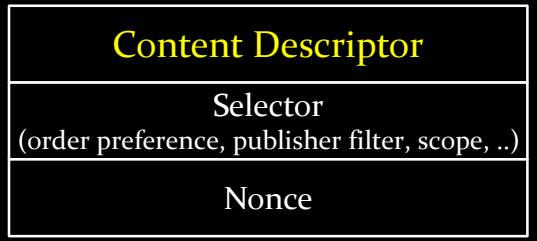
/networking/ICN
/ugoe.edu/acn/2014
/ugoe.edu/jchen

Packet Level Modification

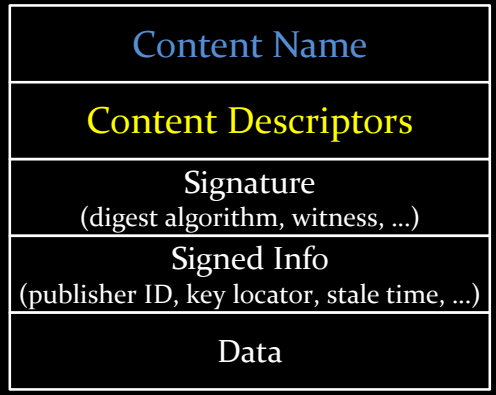
- Adopt 2 new packet types:
  - Subscription
  - Publish [reuse Data packet]



Interest (Request)



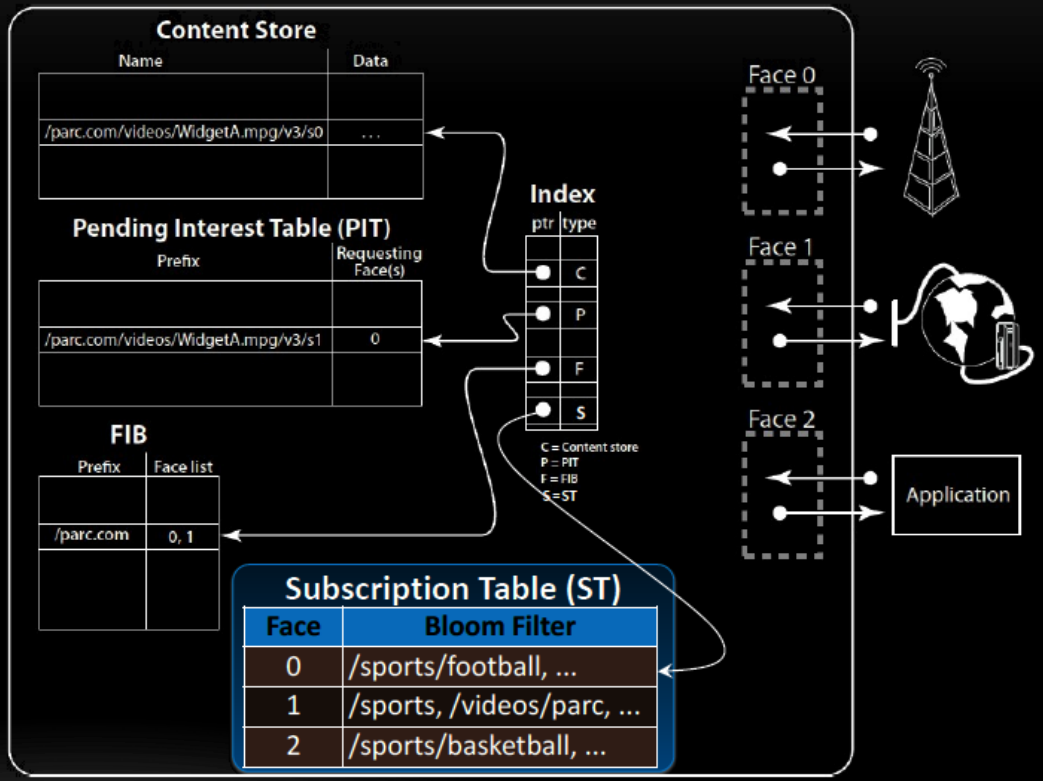
Subscription



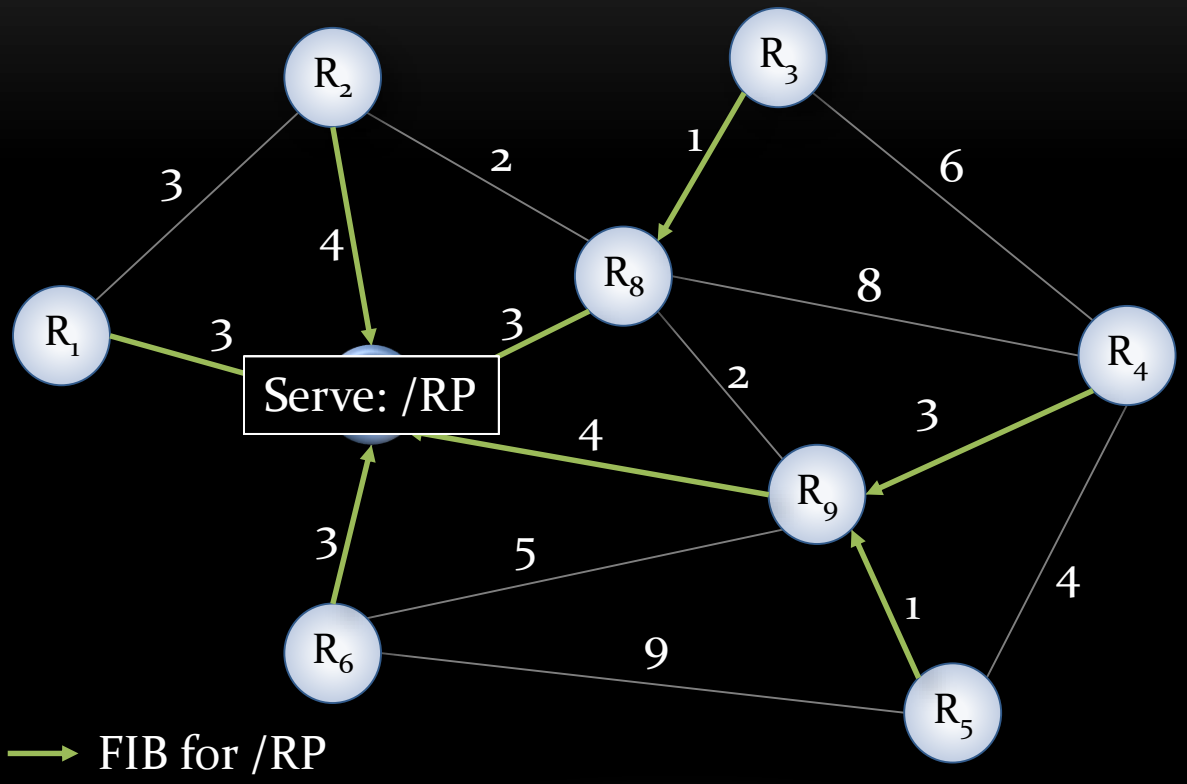
Data (Response)
or
Publish

Router Level Modification

- Adopt Subscription Table (**ST**):
  - Record the subscriptions downstream
  - CD → Face
- Global CD-RP Mapping Table
  - CD → RP Name



Data Flow in COPSS – RP Registration



Data Flow in COPSS – Subscription

Global CD-RP Mapping

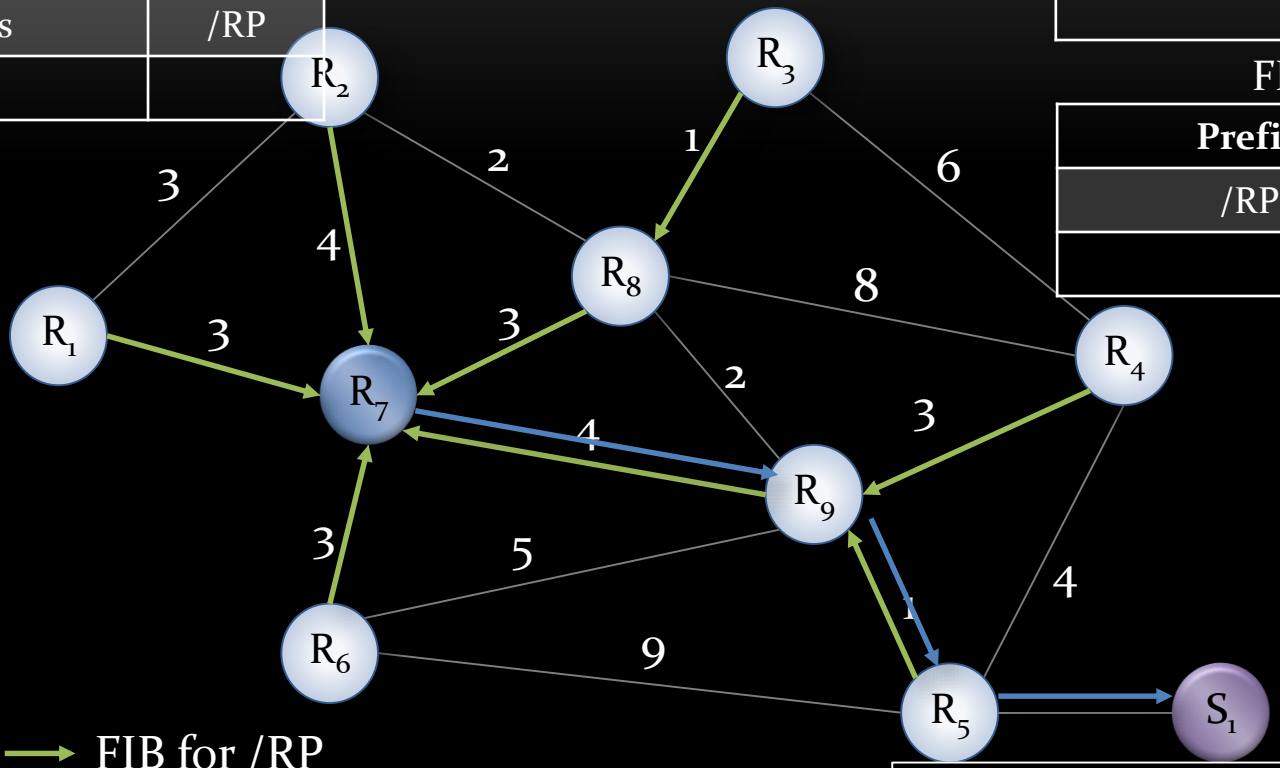
Prefix	RP
/sports	/RP

ST of R_5

Prefix	Face
/sports/football	S_1

FIB on R_5

Prefix	Face
/RP	R_9



→ FIB for /RP

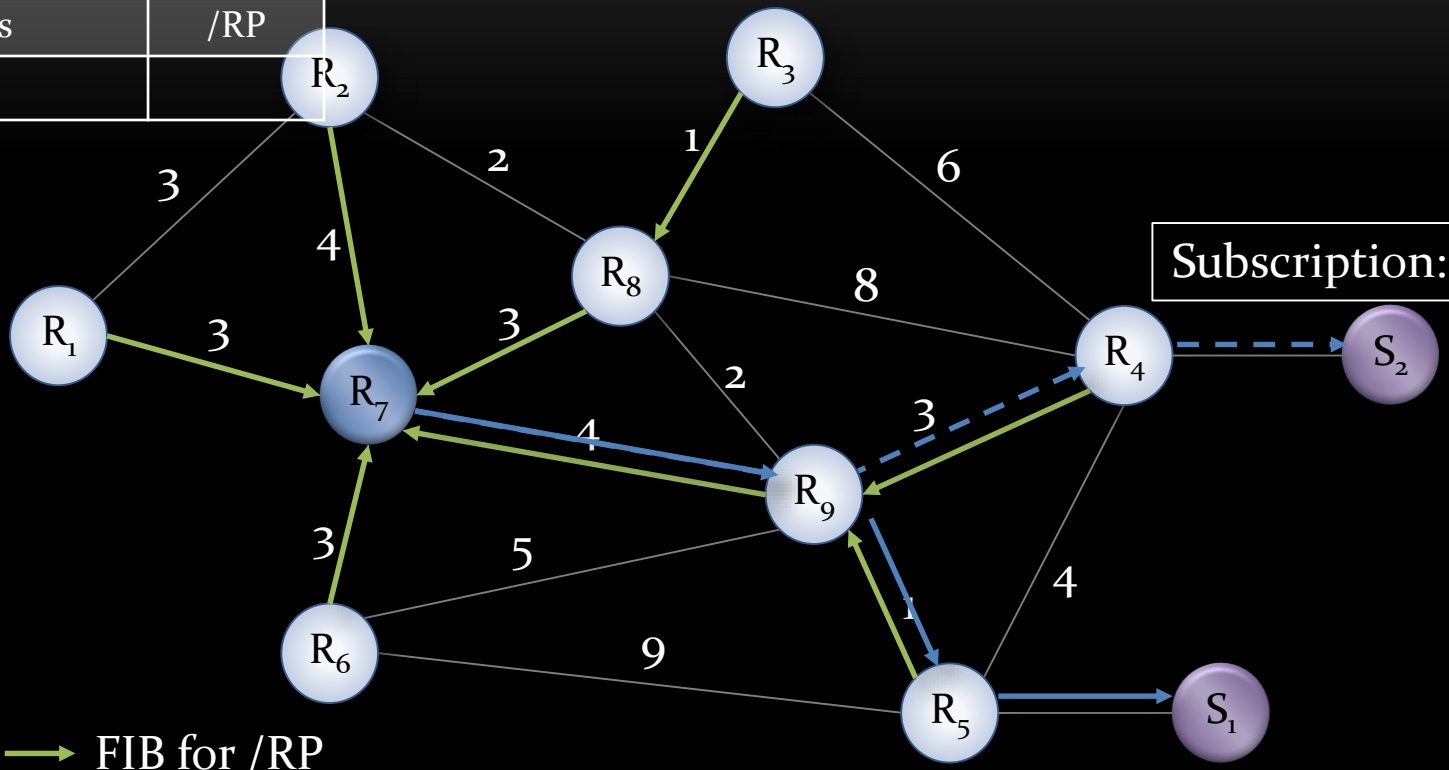
→ ST for /sports/football

Subscription: /sports/football

Data Flow in COPSS – Another Subscription

Global CD-RP Mapping

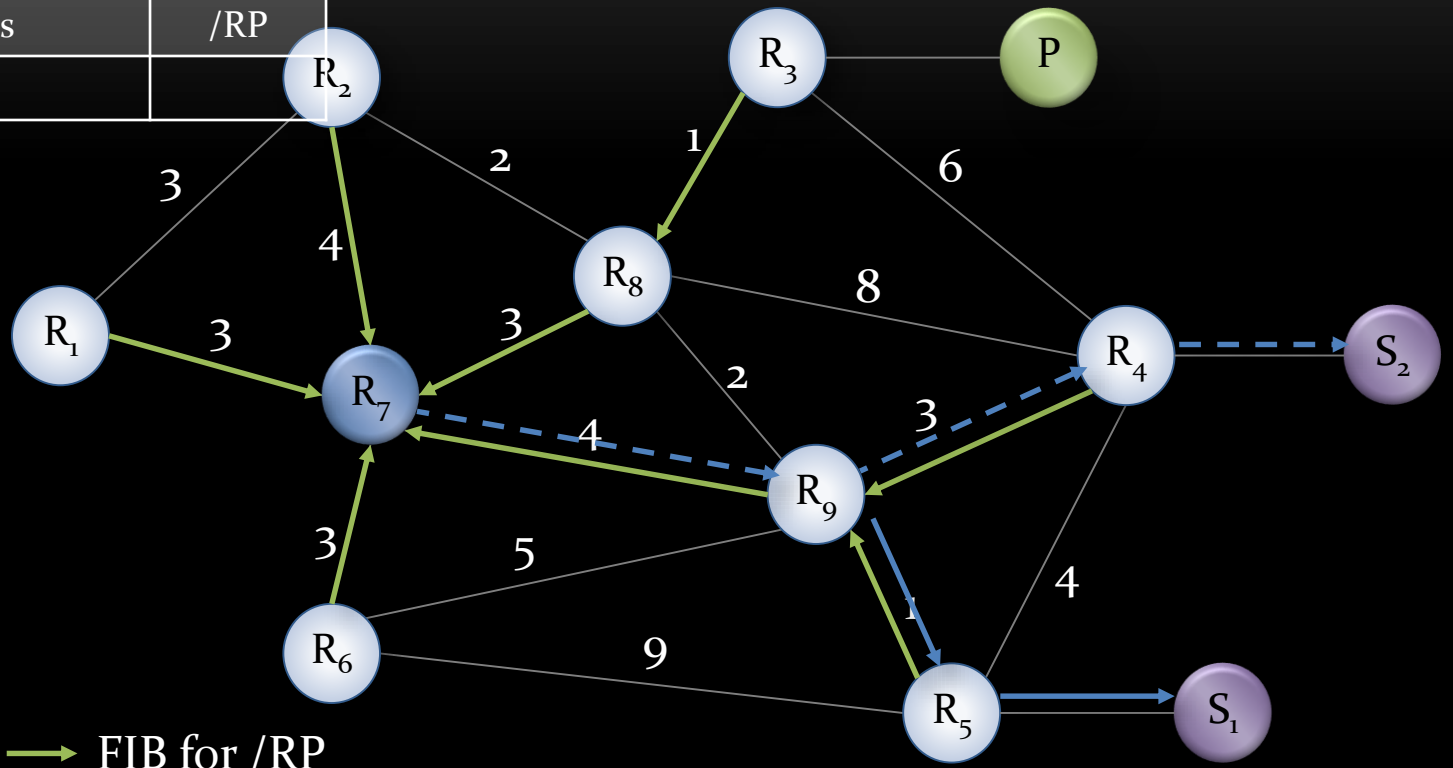
Prefix	RP
/sports	/RP



Data Flow in COPSS – Publication

Global CD-RP Mapping

Prefix	RP
/sports	/RP



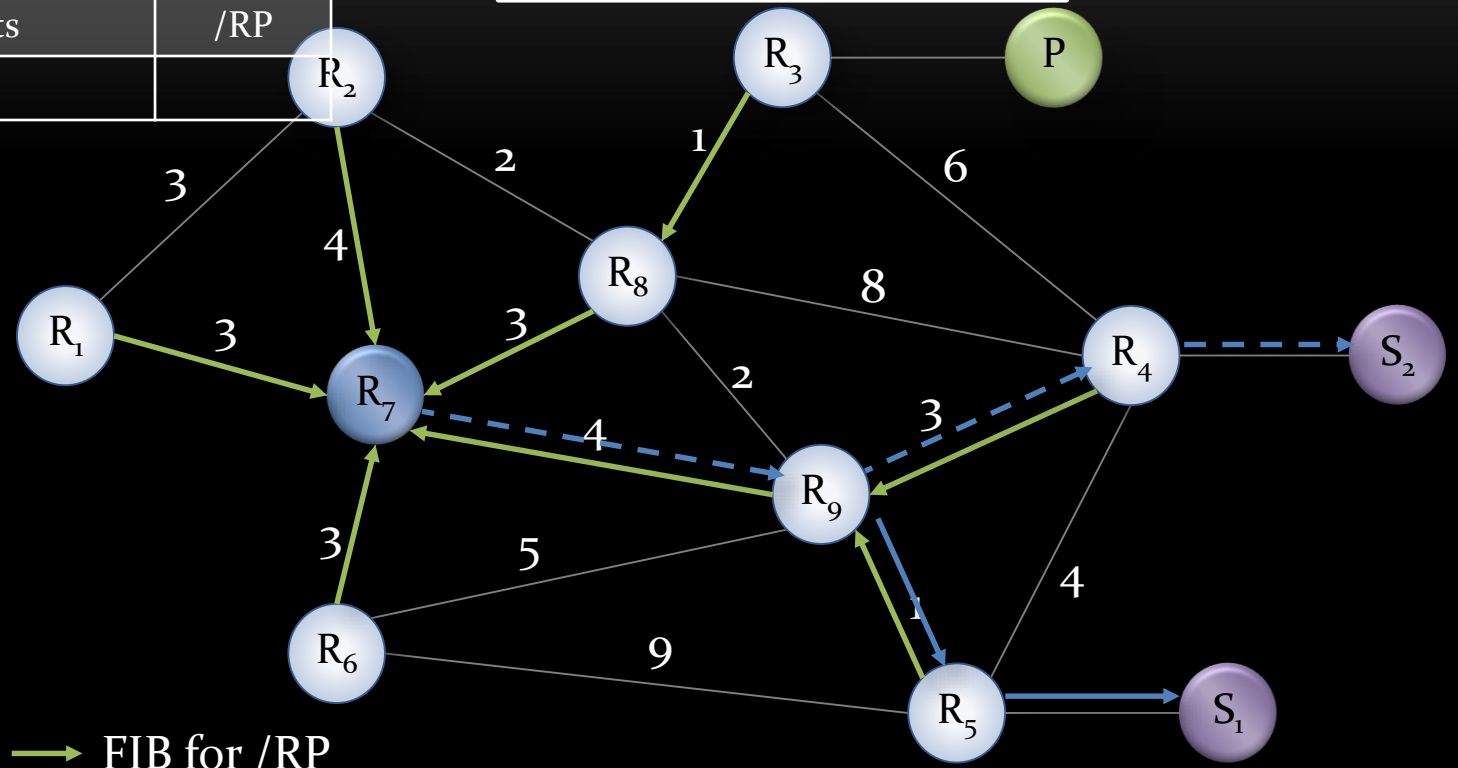
Data Flow in COPSS – Publication

Global CD-RP Mapping

Prefix	RP
/sports	/RP

Interest: /RP

Publish: /sports/football



FIB for /RP

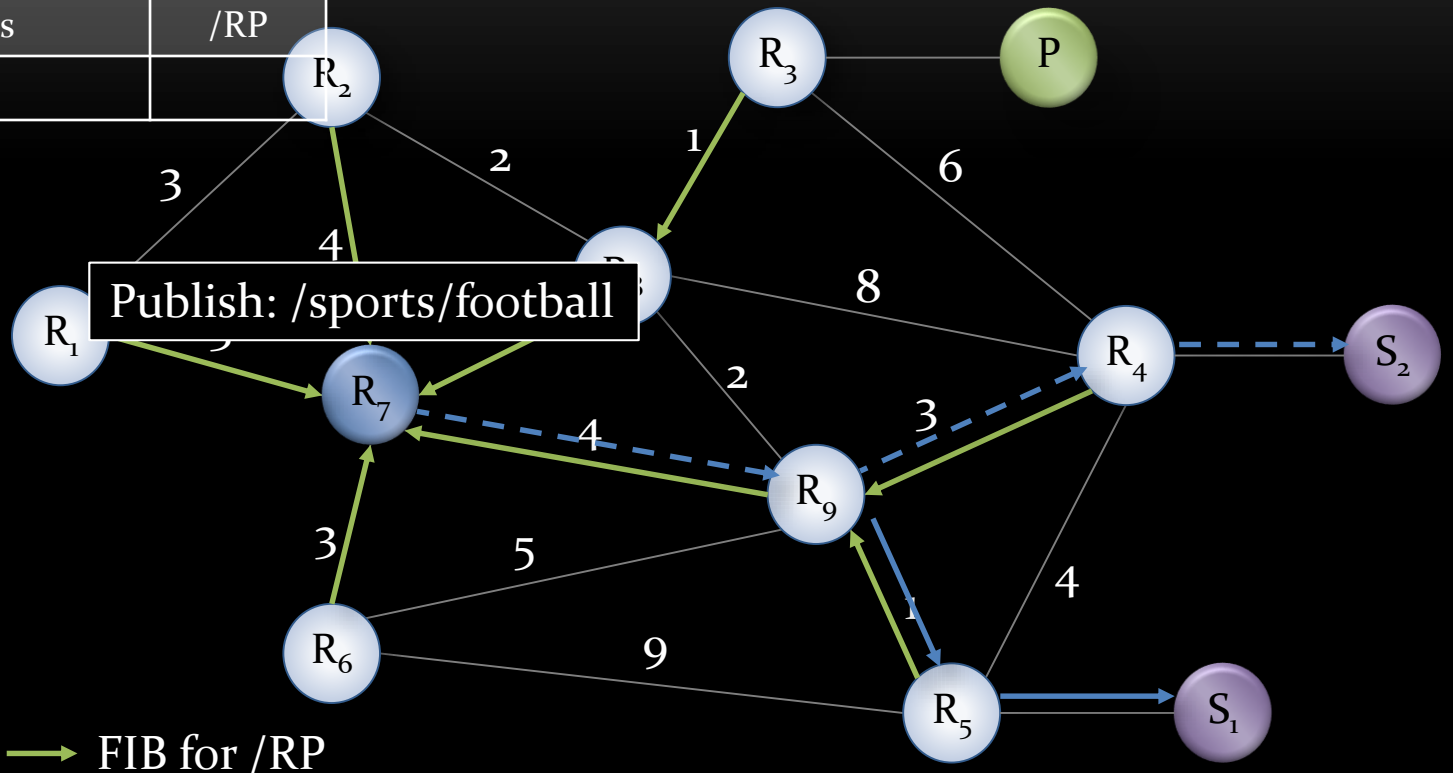
ST for /sports/football

ST for /sports

Data Flow in COPSS – Publication

Global CD-RP Mapping

Prefix	RP
/sports	/RP

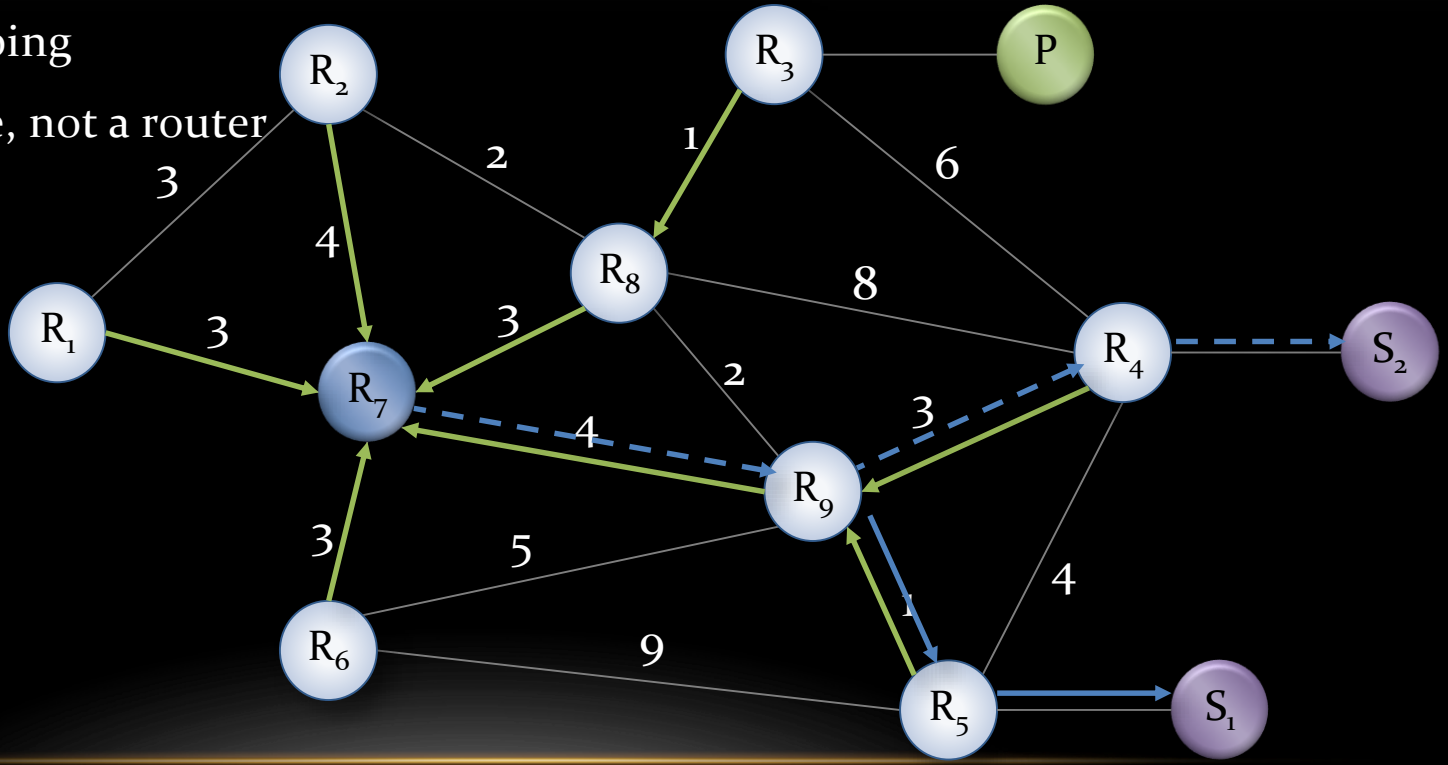


Problem 1: Information Concentration

- Description: Publish packets concentrated at RP(s)
- Solution: Automatic RP balancing
- How?
  - CD-RP mapping
  - RP is a Name, not a router

Global CD-RP Mapping

Prefix	RP
/sports	/RP

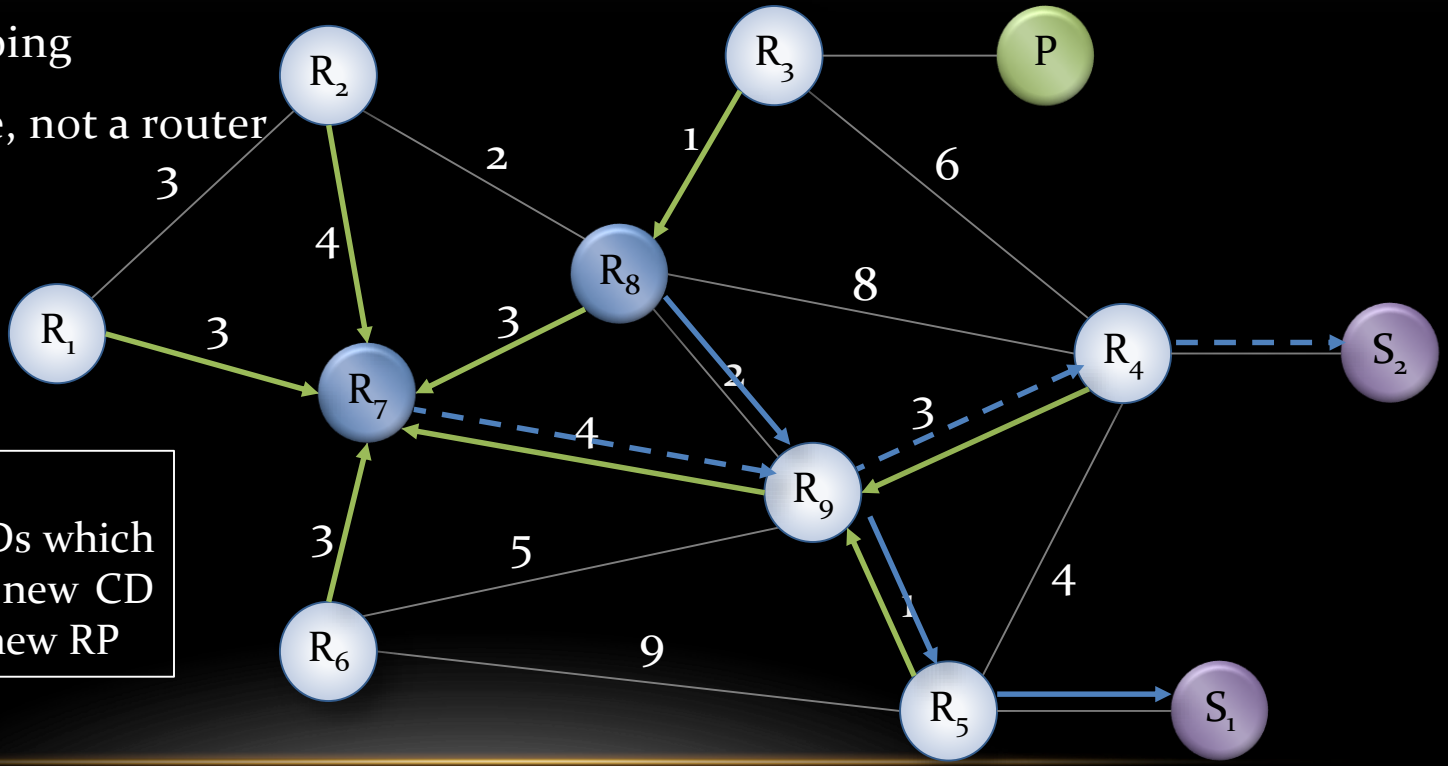


Problem 1: Information Concentration

- Description: Publish packets concentrated at RP(s)
- Solution: Automatic RP balancing
- How?
  - CD-RP mapping
  - RP is a Name, not a router

Global CD-RP Mapping

Prefix	RP
/sports	/RP
/sports/football	/RP2



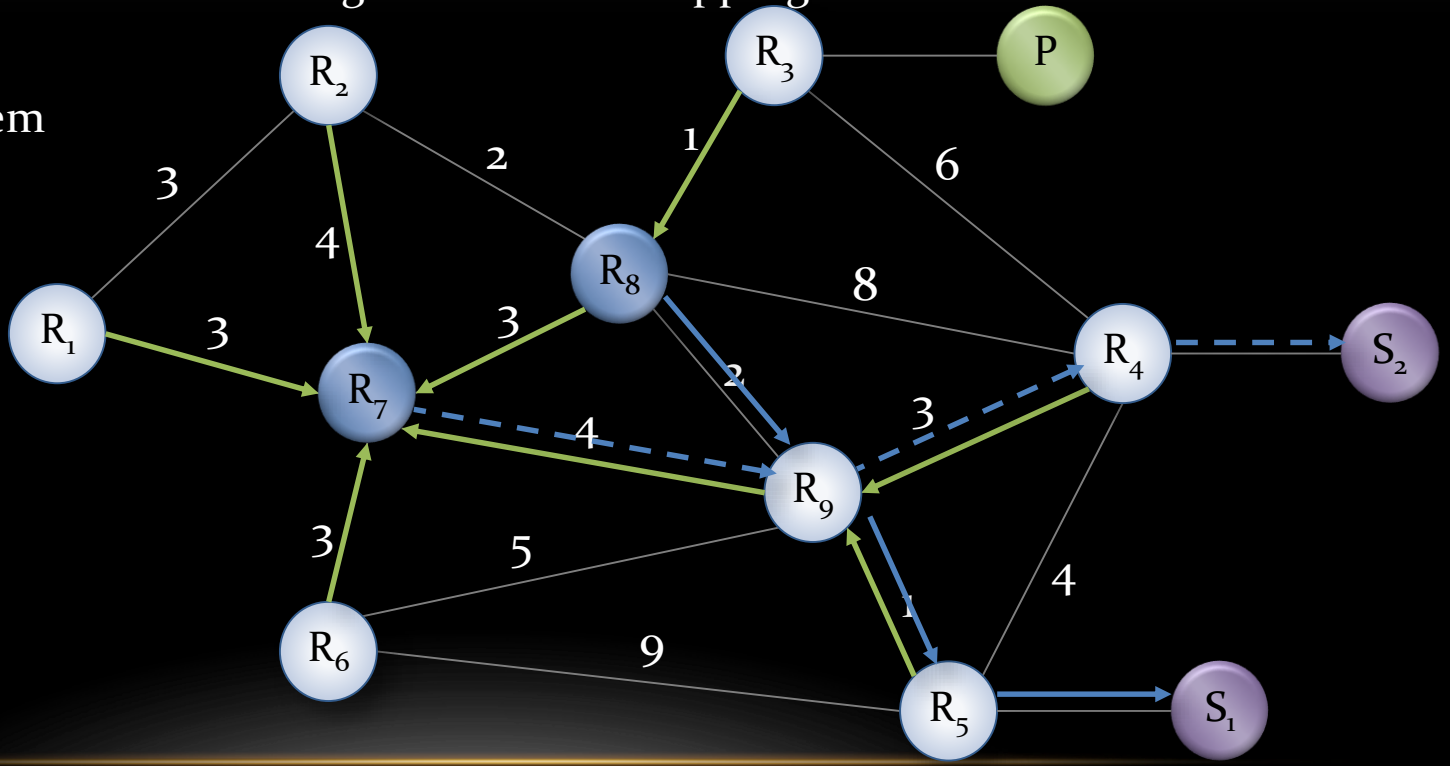
Note:
Any router that has CDs which are the prefix of the new CD shall subscribe to the new RP

Problem 2: Global CD-RP Mapping

- Description: Maintaining global CD-RP mapping table introduces overhead
- Solution part 1:
  - Only 1st hop routers maintain global CD-RP mapping
- Solution part 2:
  - Lookup system

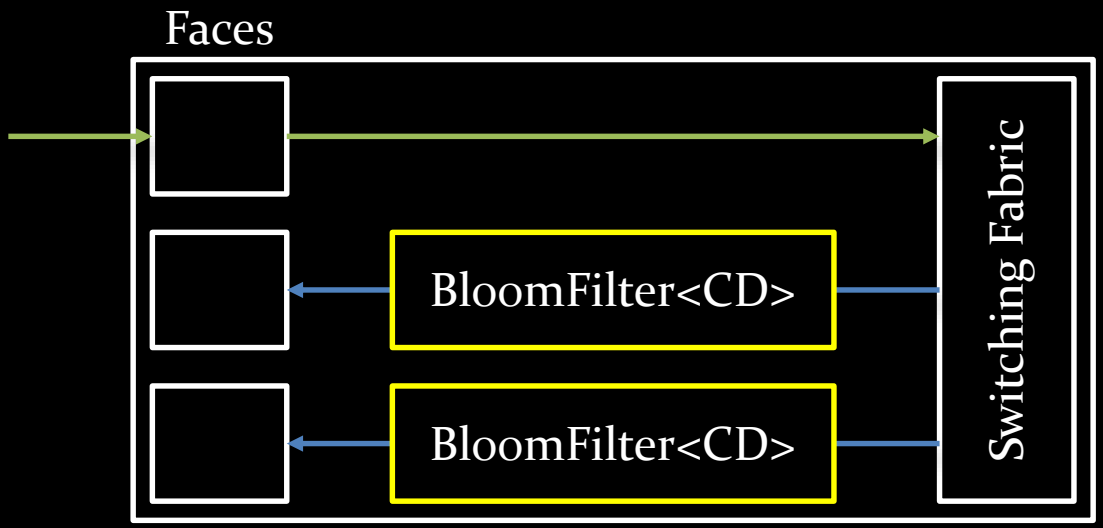
Global CD-RP Mapping

Prefix	RP
/sports	/RP
/sports/football	/RP2



Problem 3: ST Size

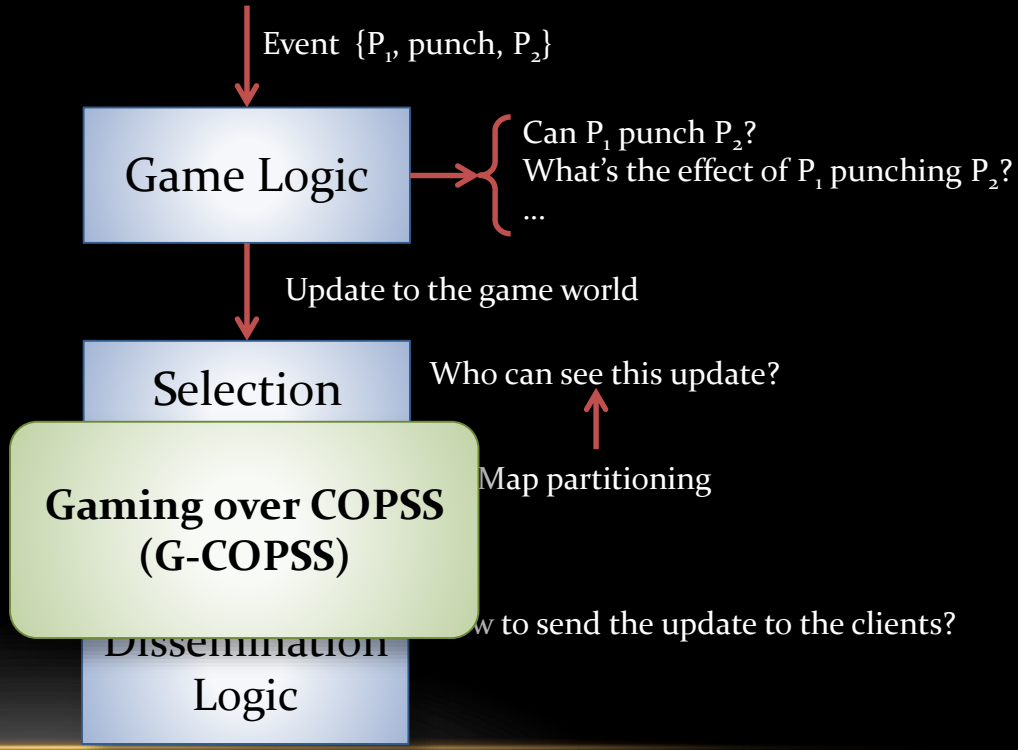
- Description: ST will have too many entries due to the unbounded CD space
- Solution:
  - From CD-Face(s) mapping to Face-BloomFilter<CD> mapping



Router Architecture

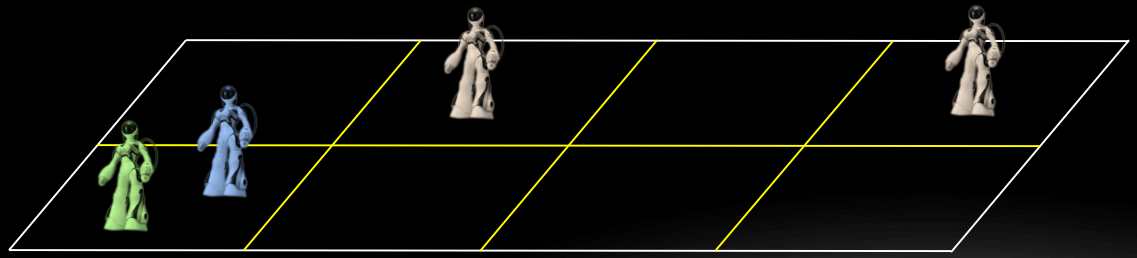
Example 1: Online Gaming

- Gaming is Content-Oriented Pub/Sub??
  - Players ***publish*** updates (actions) ***to an area***, without regard to who's supposed to receive it
  - Players ***subscribe*** to their ***current region***, without knowing who else in the region sending updates



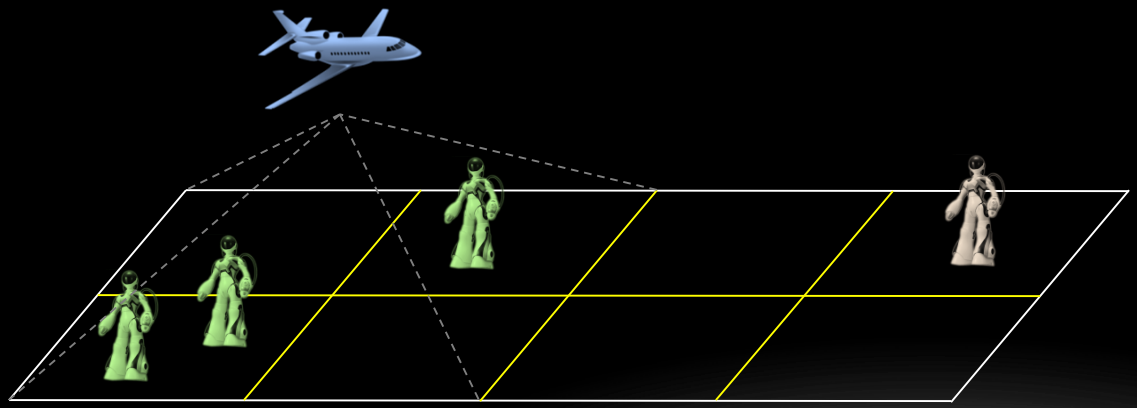
Example 1: Online Gaming

- Hierarchical Map Partitioning



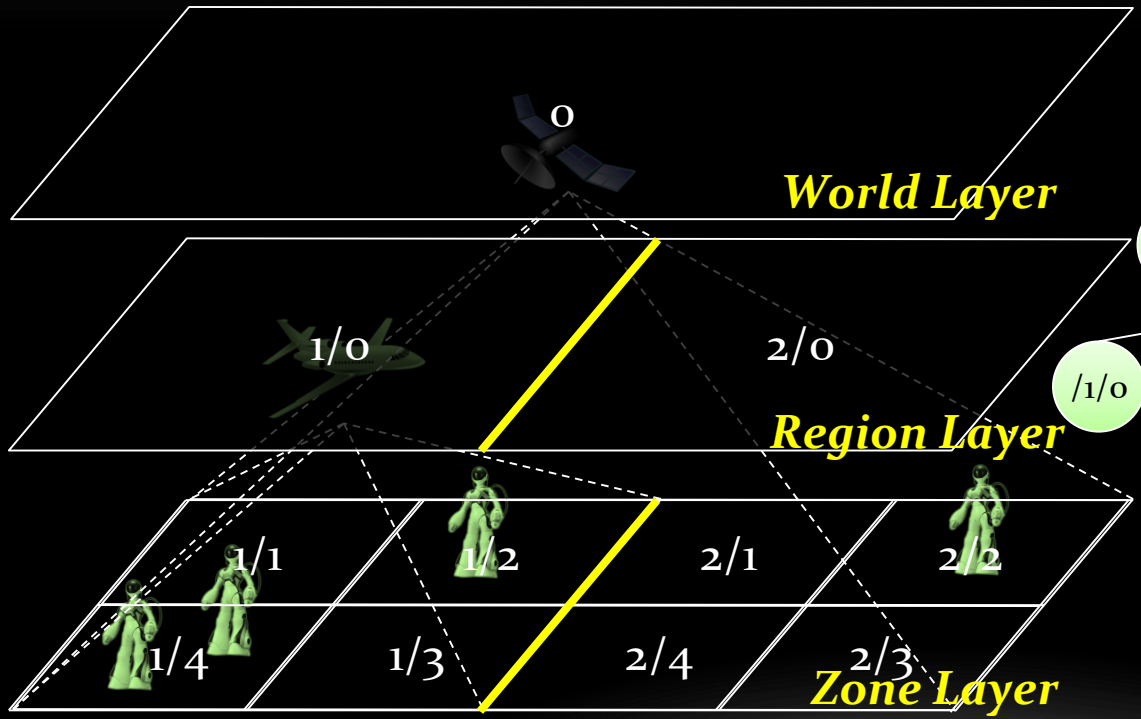
Example 1: Online Gaming

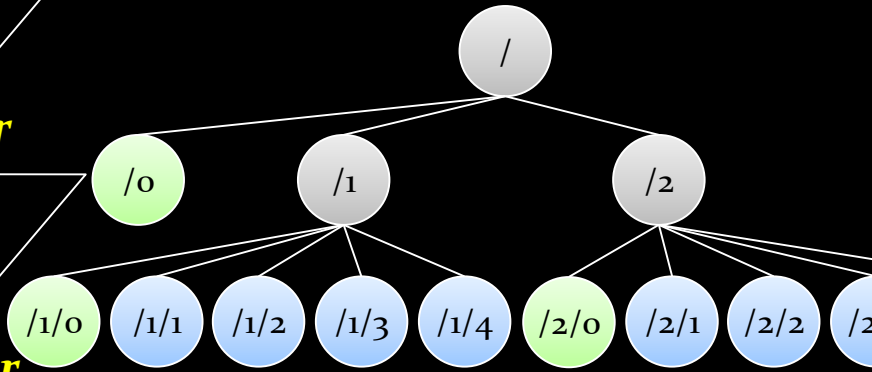
- Hierarchical Map Partitioning



Example 1: Online Gaming

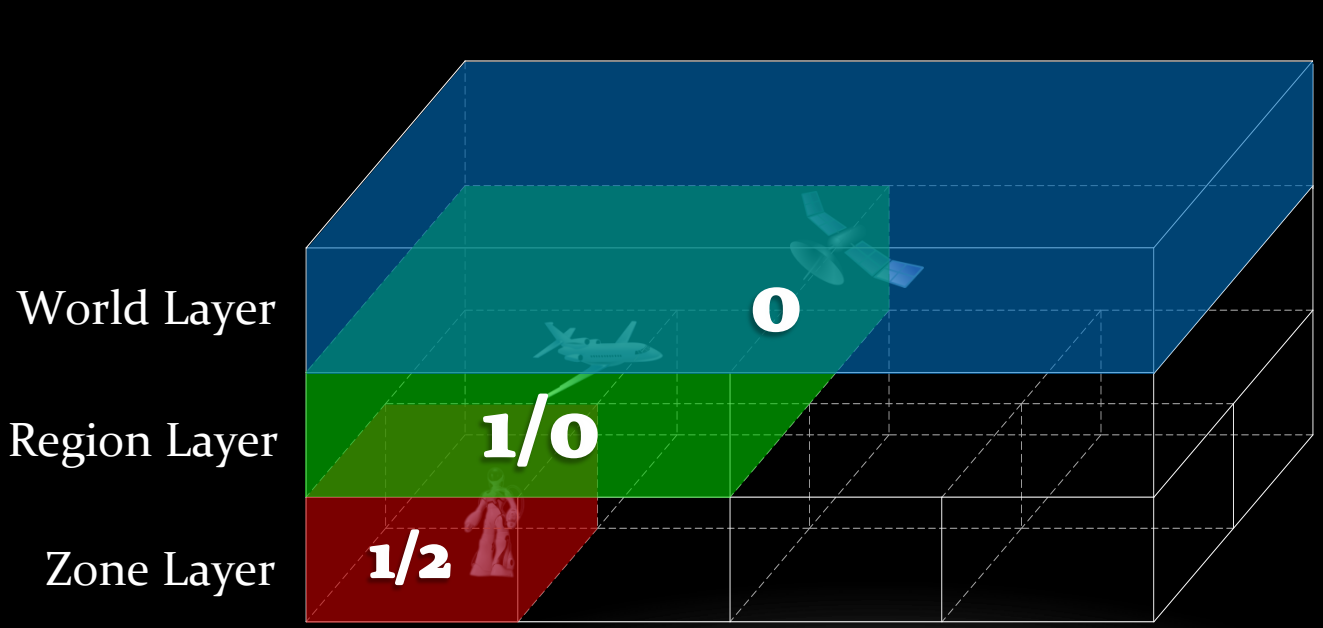
- Hierarchical Map Partitioning
  - Hierarchical CDs





Example 1: Online Gaming

- Hierarchical Map Partitioning
  - Pub/Sub rules



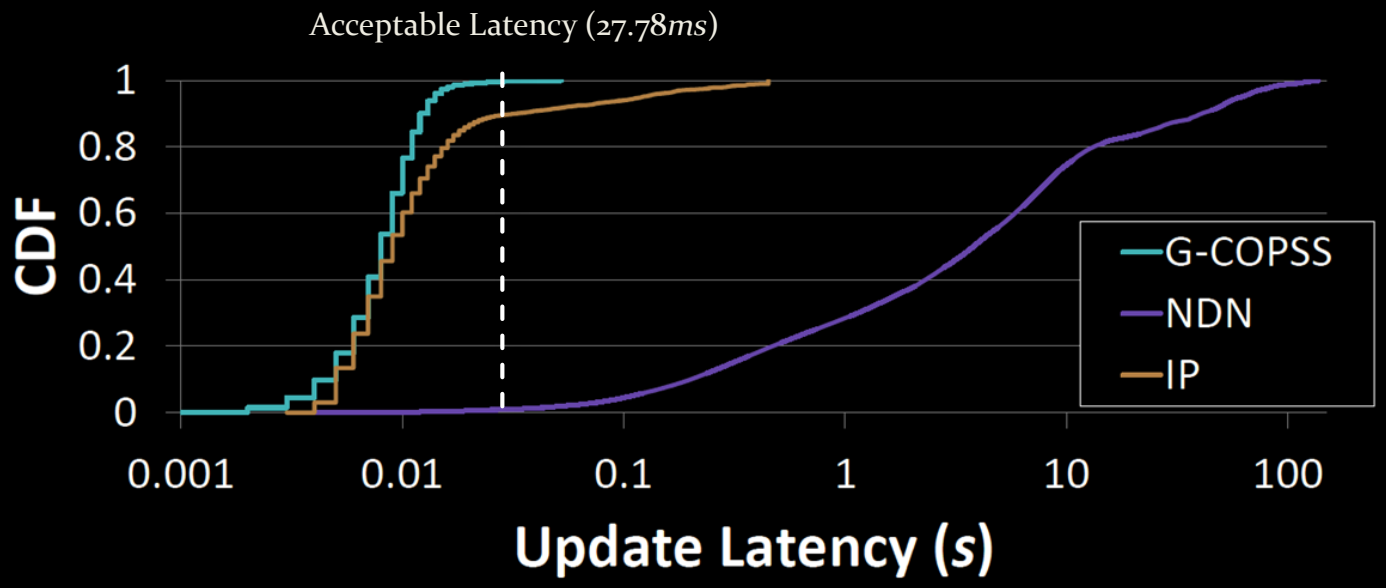
Satellite:
- Location: 0
- Pub: /0
- **Sub: /**

Plane:
- Location: 1/0
- Pub: /1/0
- **Sub: /1, /0**

Soldier:
- Location: 1/2
- Pub: /1/2
- **Sub: /1/2, /1/0, /0**

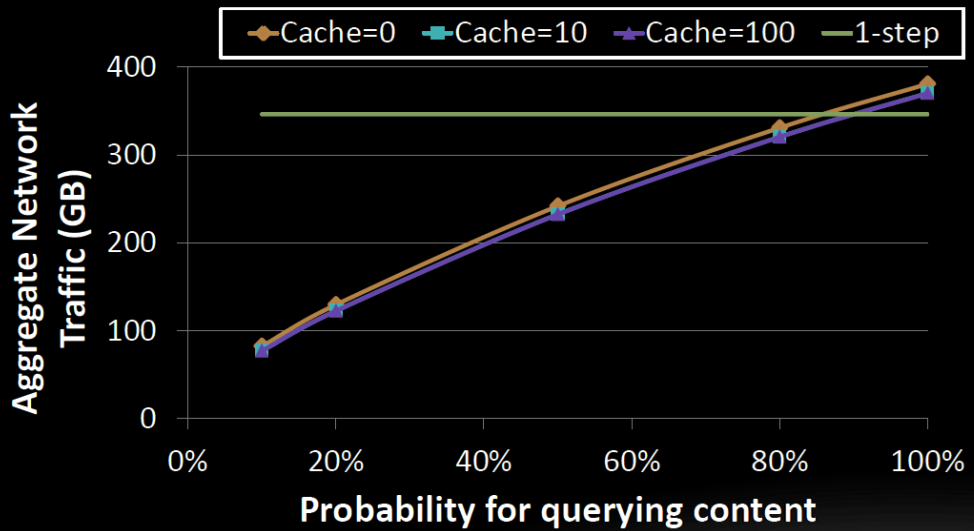
Example 1: Online Gaming

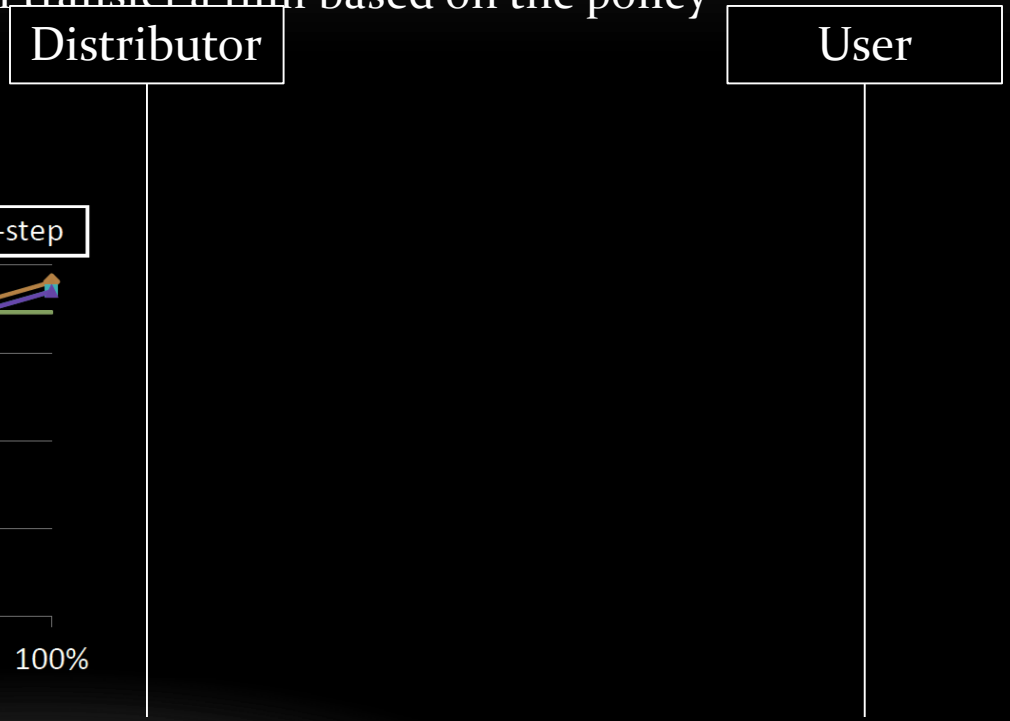
- Performance Comparison



Example 2: Film Delivery System

- Requirement:
  - Distributors notify users as soon as they get a new film
  - Users can choose if they are going to download a specific film
  - Distributors can choose if they will transfer a film based on the policy
- Solution:
  - 2-step dissemination
    - Snippet

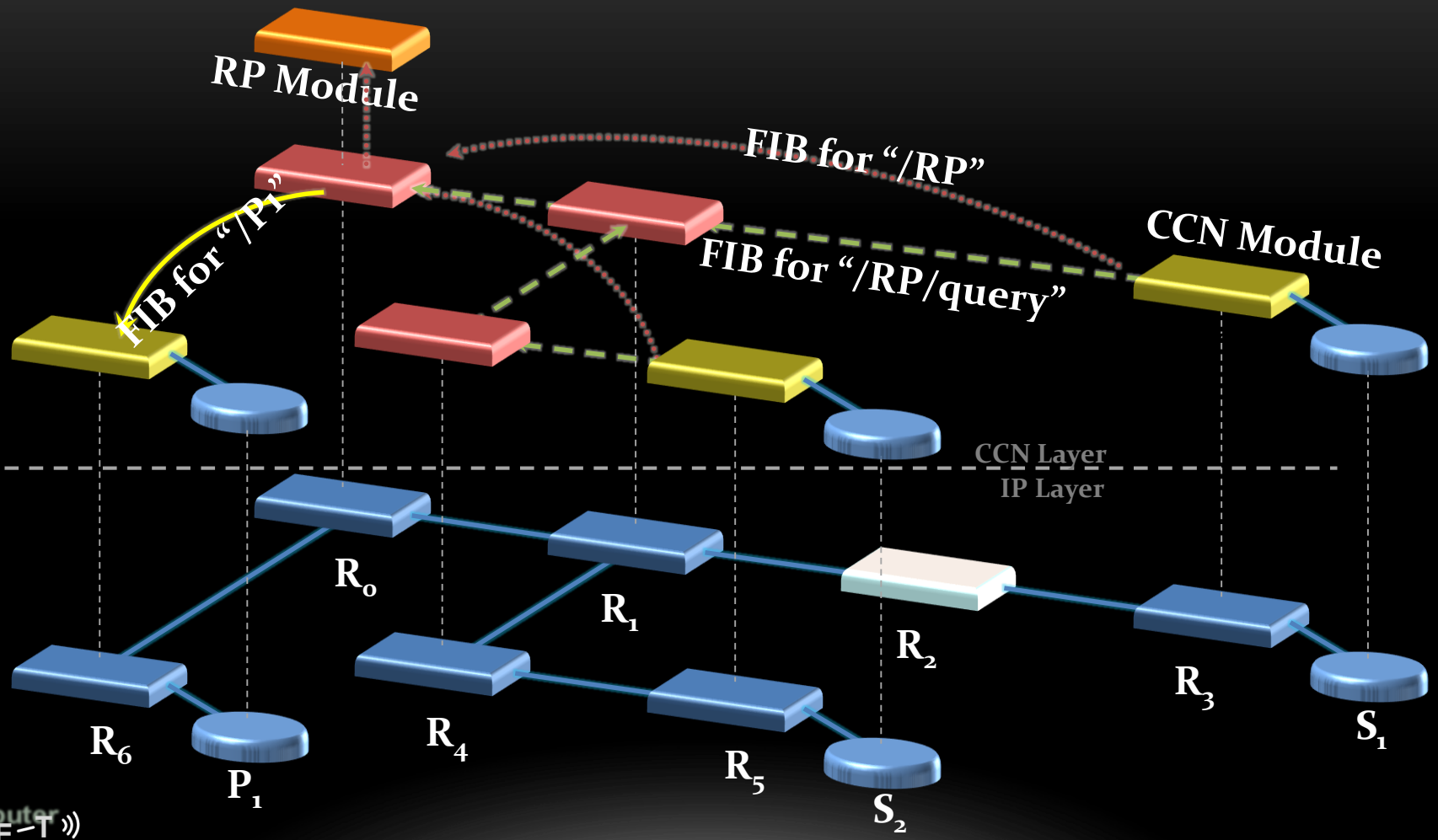




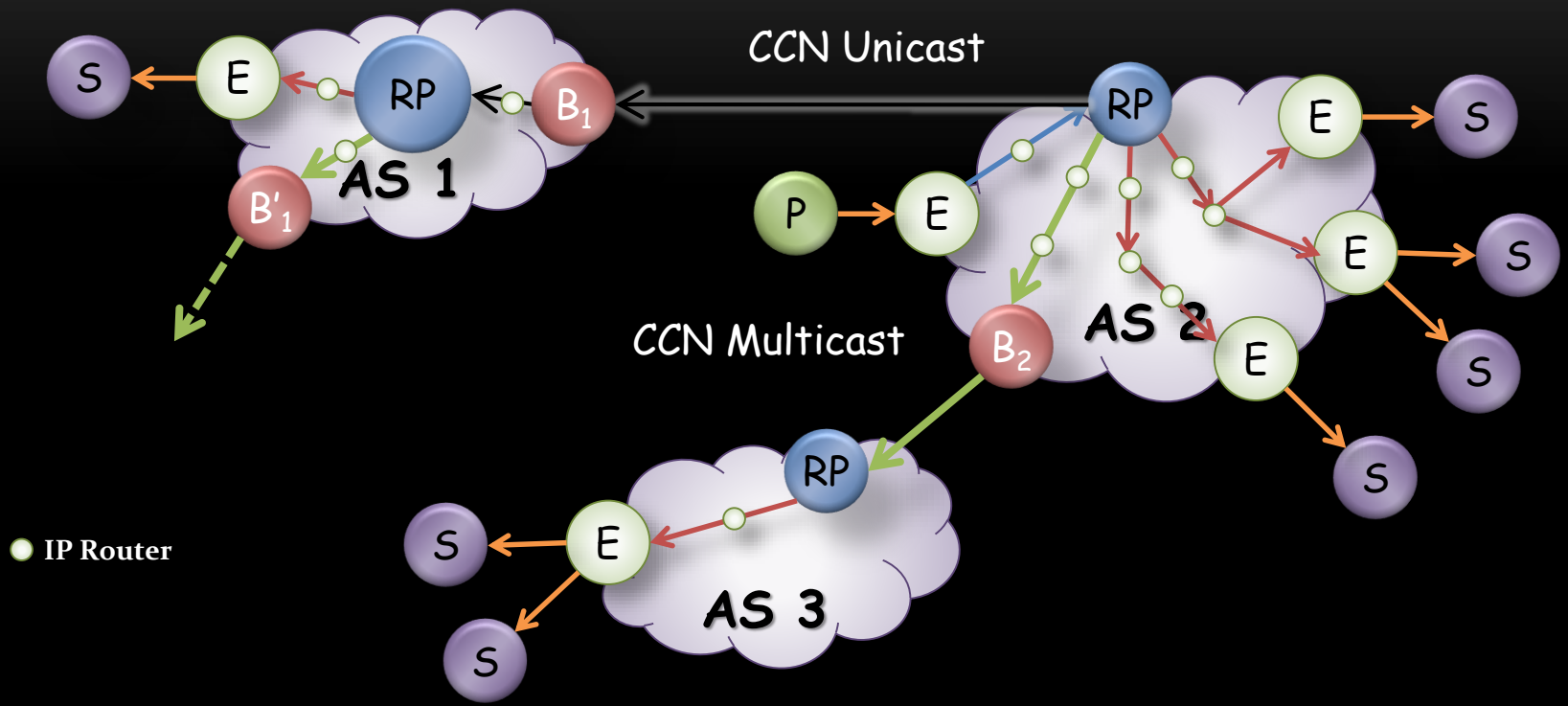
Incremental Deployment

- Incremental deployment is desirable for infrastructure change
- How can CCN be enabled in the network at ***large scale***? And ***efficient***?
  - A ***reasonable number*** of nodes that are able to provide CCN functionality
  - The other nodes provide ***high-speed***, ***efficient*** forwarding
  - As we go forward, we can have more nodes CCN enabled for ***scalability*** and ***performance***.
- Our target:
  - **Evolve**: IP infrastructure → content-oriented network
    - Co-exist with the IP network throughout the evolution
    - An approach tightly integrated with IP network (using IP multicast)
  - **Efficiency**: Identify the key points
    - Content-centric forwarding ***at key points*** while using hash-based forwarding (IP) at the other nodes
    - Cache content ***at key points***

Incremental Deployment



Inter-Domain Multicast



Conclusion

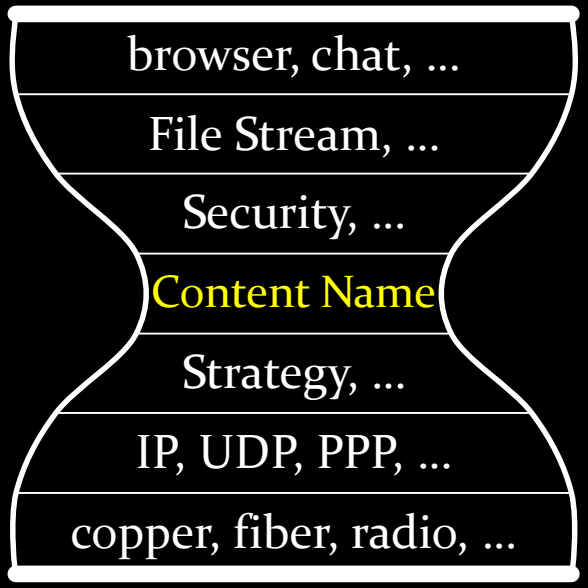
- Why COPSS?
  - Temporal separation between providers (publishers) and consumers (subscribers)
- How does COPSS work?
  - Content Descriptor (CD)
  - Subscription and Publish packet
  - Subscription Table (ST)
- Optimizations in COPSS?
  - Automatic RP balancing
  - CD-RP Mapping
  - BloomFilter-based ST
- Hierarchical Map Partitioning
- 2-step Dissemination
  - Subscriber Interest
  - Policy Control
- Incremental Deployment
  - Using IP as underlay
  - Using IP multicast
- Inter-domain multicast

Review

- **Why COPSS?**
  - Temporal separation between providers (publishers) and consumers (subscribers)
  - NDN cannot achieve this via pure query/response model
  - The add-on systems to mitigate the mismatch also introduces overhead

REVIEW

- Why COPSS?
- **How does COPSS achieve Content-Centric Pub/Sub? (protocol level)**



Content Name:

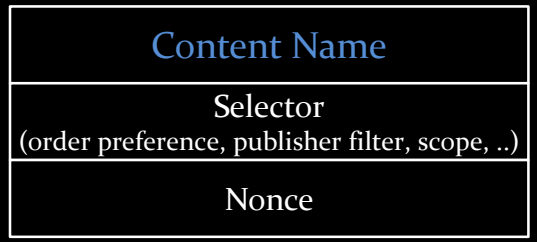
/ugoe.edu/jchen/acn14-ICN.pdf/_v1/_s1

Content Descriptors:

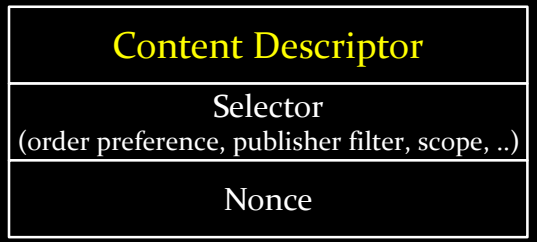
/networking/ICN
/ugoe.edu/acn/2014
/ugoe.edu/jchen

Review

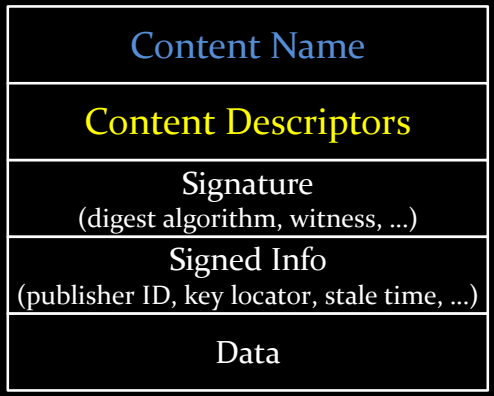
- Why COPSS?
- How does COPSS achieve Content-Centric Pub/Sub? (protocol level)
- **What are the 2 new packet types in COPSS?**



Interest (Request)



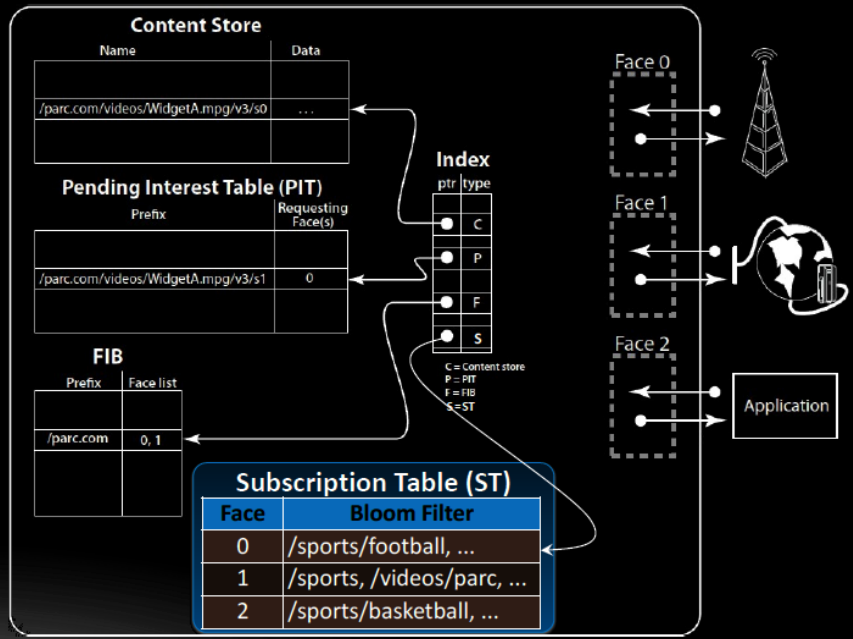
Subscription



Data (Response)
or
Publish

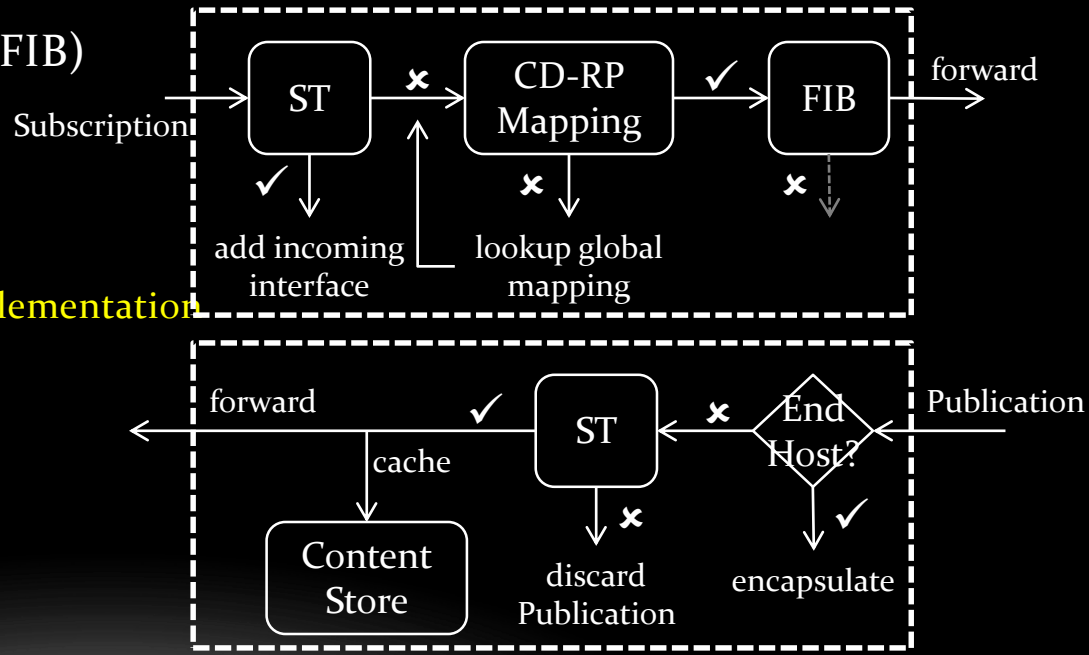
Review

- Why COPSS?
- How does COPSS achieve Content-Centric Pub/Sub? (protocol level)
- What are the 2 new packet types in COPSS?
- **What are the data structures in a COPSS forwarding engine? And functions?**
  - Forwarding Information Base (FIB)
  - Pending Interest Table (PIT)
  - Subscription Table (ST)
  - Content Store



Review

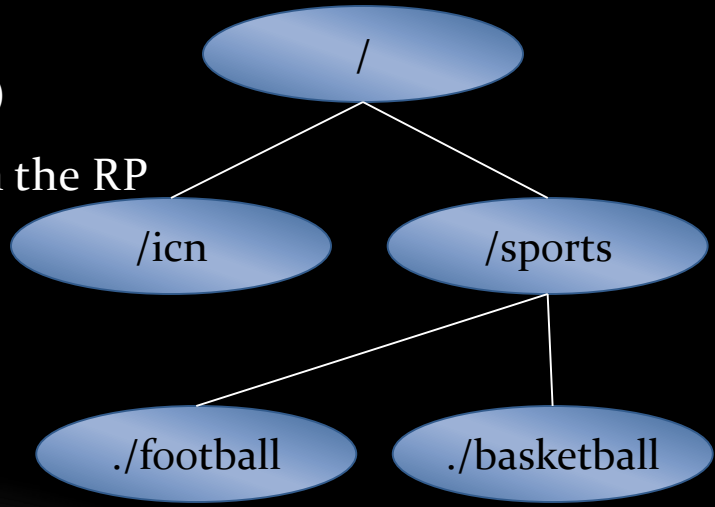
- Why COPSS?
- How does COPSS achieve Content-Centric Pub/Sub? (protocol level)
- What are the 2 new packet types in COPSS?
- **What are the data structures in a COPSS forwarding engine? And functions?**
  - Forwarding Information Base (FIB)
  - Pending Interest Table (PIT)
  - Subscription Table (ST)
  - Content Store
  - * You can separate RP module in implementation



Review

- Why COPSS?
- How does COPSS achieve Content-Centric Pub/Sub? (protocol level)
- What are the 2 new packet types in COPSS?
- What are the data structures in a COPSS forwarding engine? And functions?
- **What is Rendezvous-Point (RP) based communication? How to avoid information concentration?**
  - An RP serves
  - All the public
  - Automatic RP
  - Note: RP is ju

Prefix	RP Name
/	/RP1
/icn	/RP2
/sports	/RP3
/sports/football	/RP4
/sports/basketball	/RP5



Review

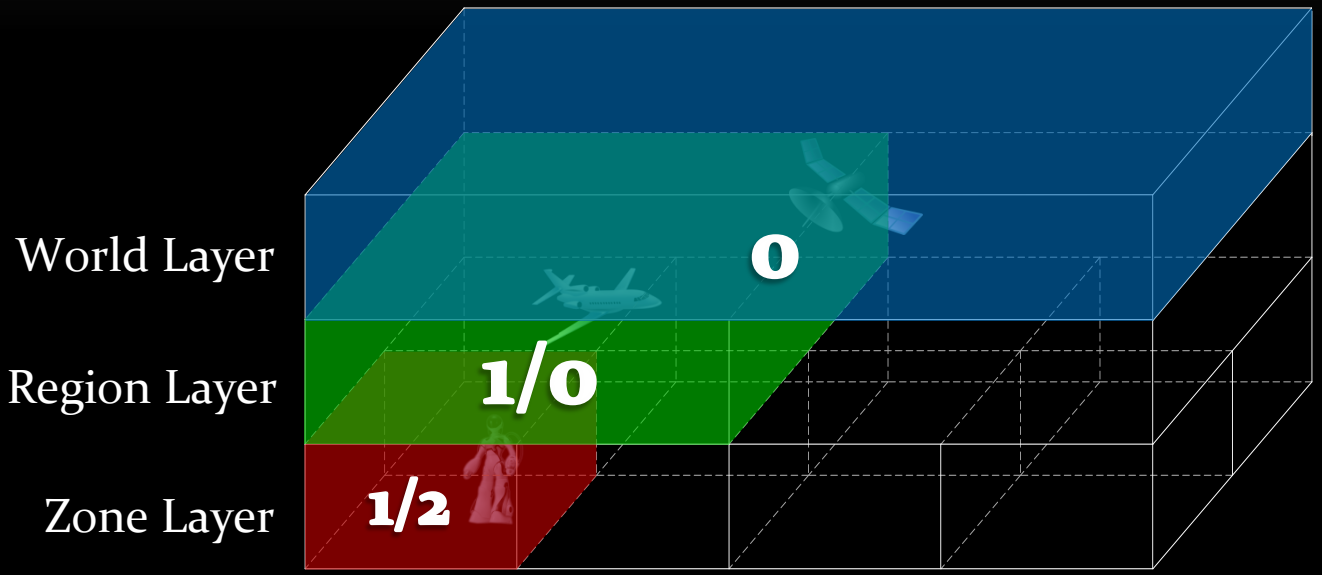
- Why COPSS?
- How does COPSS achieve Content-Centric Pub/Sub? (protocol level)
- What are the 2 new packet types in COPSS?
- What are the data structures in a COPSS forwarding engine? And functions?
- What is Rendezvous-Point (RP) based communication? How to avoid information concentration?
- **How to control CD-RP Map size and ST size for scalability?**
  - CD-RP lookup like DNS
  - Bloom-Filter ST

Review

- Why COPSS?
- How does COPSS achieve Content-Centric Pub/Sub? (protocol level)
- What are the 2 new packet types in COPSS?
- What are the data structures in a COPSS forwarding engine? And functions?
- What is Rendezvous-Point (RP) based communication? How to avoid information concentration?
- How to control CD-RP Map size and ST size for scalability?
- **Why gaming is related to COPSS?**
  - Online gaming needs a communication infrastructure
  - Gaming is content-centric
  - Gaming is pub/sub

Review

- Why COPSS?
- How does COPSS achieve Content-Centric Pub/Sub? (protocol level)



Satellite:
- Location: 0
- Pub: /0
- **Sub: /**

Plane:
- Location: 1/0
- Pub: /1/0
- **Sub: /1, /0**

Soldier:
- Location: 1/2
- Pub: /1/2
- **Sub: /1/2, /1/0, /0**

Review

- Why COPSS?
- How does COPSS achieve Content-Centric Pub/Sub? (protocol level)
- What are the 2 new packet types in COPSS?
- What are the data structures in a COPSS forwarding engine? And functions?
- What is Rendezvous-Point (RP) based communication? How to avoid information concentration?
- How to control CD-RP Map size and ST size for scalability?
- Why gaming is related to COPSS?
- Hierarchical map partitioning → Hierarchical CD structure?
- **Two-step communication?**
  - Subscriber interest
  - Policy control

References

1. Yi, Cheng, *et al*. "*A case for stateful forwarding plane*." Computer Communications 36.7 (2013): 779-791.
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Acknowledgment

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