

# Advanced Computer Networks

## Content-Centric Networking (I)

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# MOTIVATION

- CCN is a form of Next Generation Network
- What's the problem of the “current generation network”?
- What do we need in CCN?
- What's the benefit of CCN?
- Why CCN is better?
- How does CCN work?

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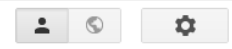
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
# Georg-August University of Göttingen



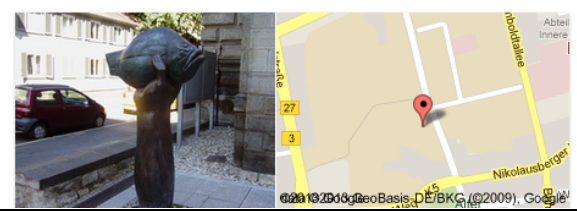
The University of Göttingen, known informally as Georgia Augusta, is a university in the city of Göttingen, Germany. Founded in 1734 by George II, King of Great Britain and Elector of Hanover, it opened for classes in 1737. [Wikipedia](#)

Founded: 1734  
 Founder: [George II of Great Britain](#)

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4. und 5. März 2013

### INFORMATION DAYS FOR PROSPECTIVE STUDENTS



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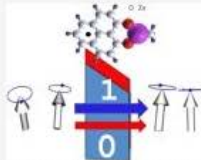
### Göttingen University secures 30 million in grant money



Göttingen University has secured grant money totalling 30 million Euros from the State of Lower Saxony. With this state support for strategic development, the University is able to continue successful projects from the first programme phase of the Excellence Initiative. At the same time, it is

implementing those measures of the new institutional strategy which received positive evaluations in the second phase of the Excellence Initiative. [more...](#)

### Molecular spin memory devices



An international team of researchers affiliated with Göttingen University has found a way to store vast amounts of data - up to one petabyte - per square inch. One petabyte is equivalent to 1,000 terabytes or one million gigabytes. Using information stored in the spin of an electron, the scientists succeeded in storing the information in an organic molecule

and reading it at a temperature close to room temperature. The results were published in the prestigious journal "Nature". [more...](#)

### Events

11.02.2013

- ▶ [Digital Transformations of Knowledge](#)

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- ▶ [Molecular machines in RNA processing, translation and transport](#)

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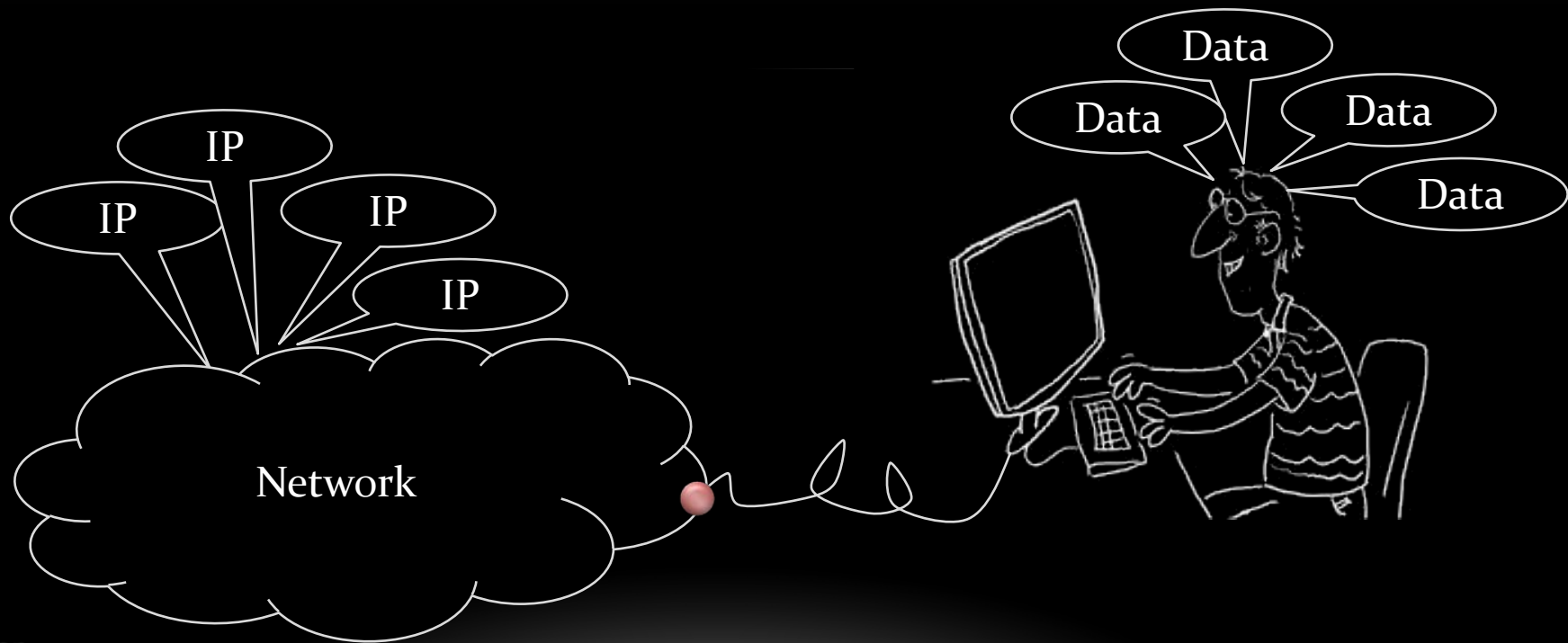
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- ▶ [Molecular machines in RNA processing, translation and transport](#)

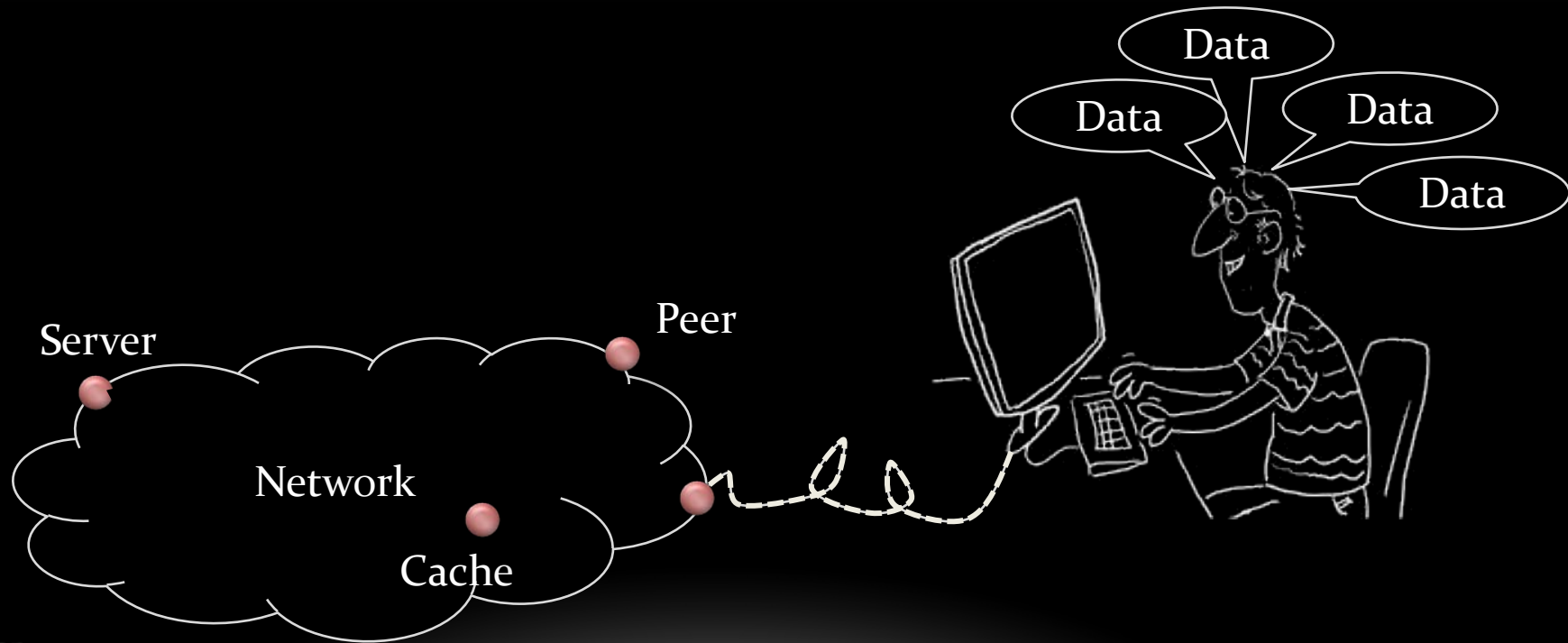


# LET'S SEE THE FULL PICTURE



# MY PURPOSE USING NETWORK: GET **DATA!**

- Network should understand my requirement!
- Why current Internet is not designed in this way?? Is it a flaw in design?



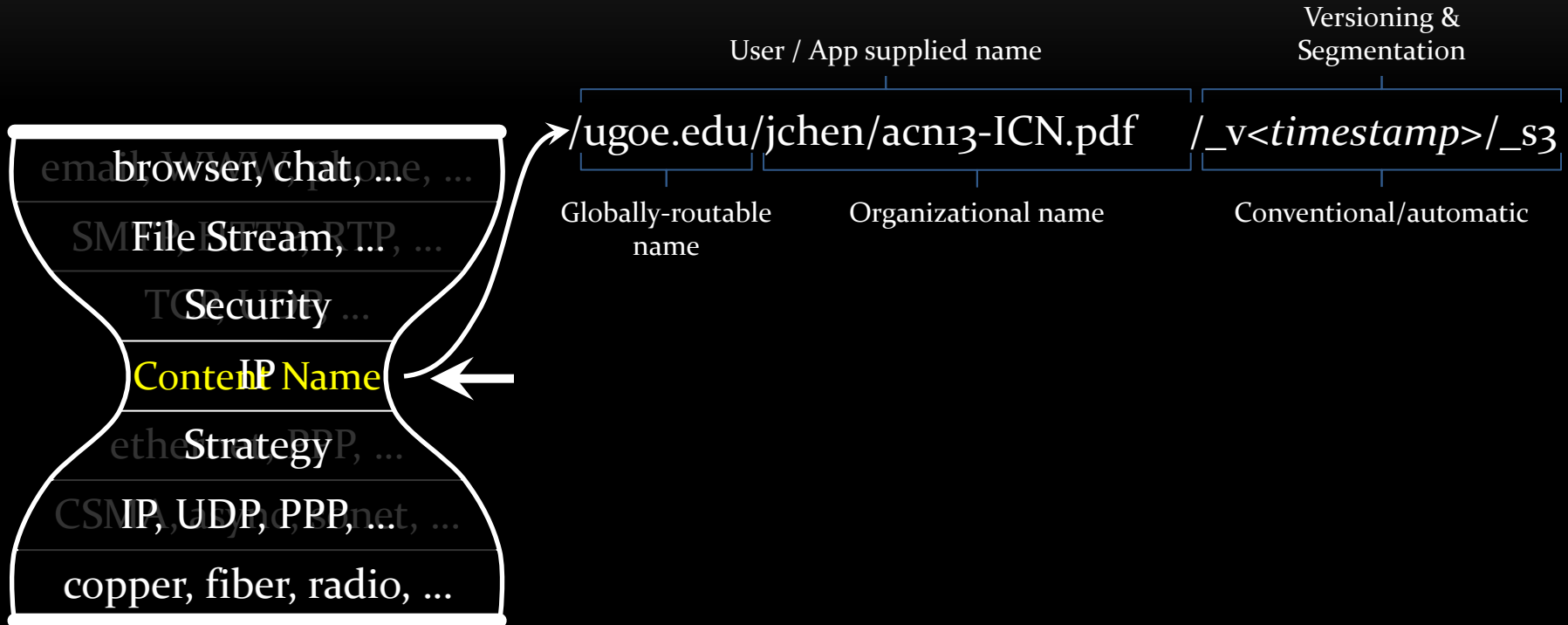
# PROJECTS/PUBLICATIONS RELATED TO CCN

- Document Oriented (and beyond) Network Architecture (**DONA**) [1]
  - Teemu Koponen, *et al.* SIGCOMM'07
- Project: **4WARD** NETINF [2] – **SAIL** NETINF [3]
  - SAIL: Scalable and Adaptive Internet Solutions
- Project: **PSIRP** [4] – **PURSUIT** [5]
  - PSIRP: Publish/Subscribe Internet Routing Paradigm
- **Networking Named Data** [6]
  - Van Jacobson, *et al.* CoNext'09
  - Clean Slate
- Project: **CCNx** [7] – **NDN** [8]
  - NDN: Named Data Networking
- Project: **Green ICN** [9]





# HOW TO ACHIEVE CONTENT-CENTRIC?





# DATA PACKETS

- **Query / Response:**
  - Router forward request to best provider(s)
  - Data follow the request path
  - Data consumes the request
  - Request can be aggregated
  - Data replicated in the network
  - Data can be cached in the network

<b>Content Name</b>
Selector <i>(order preference, publisher filter, scope, ...)</i>
Nonce

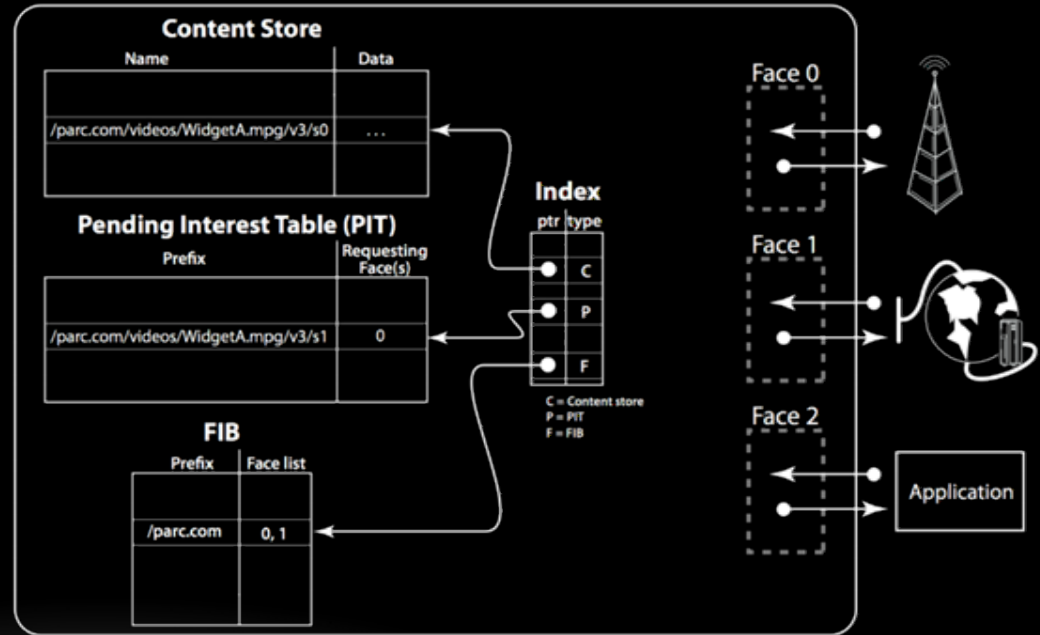
Interest (Request)

<b>Content Name</b>
Content Descriptors
Signature <i>(digest algorithm, witness, ...)</i>
Signed Info <i>(publisher ID, key locator, stale time, ...)</i>
Data

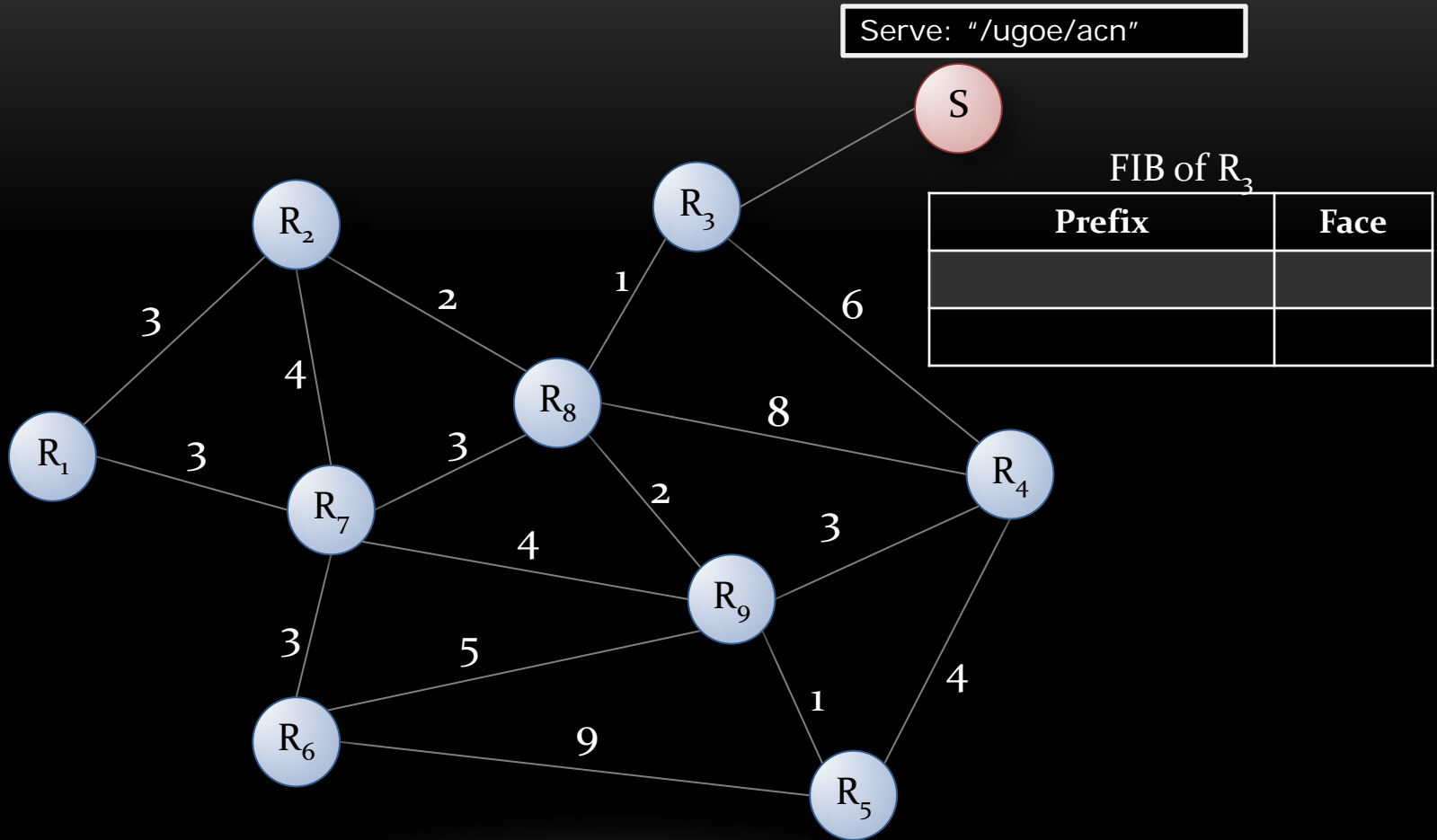
Data (Response)

# FORWARDING ENGINE

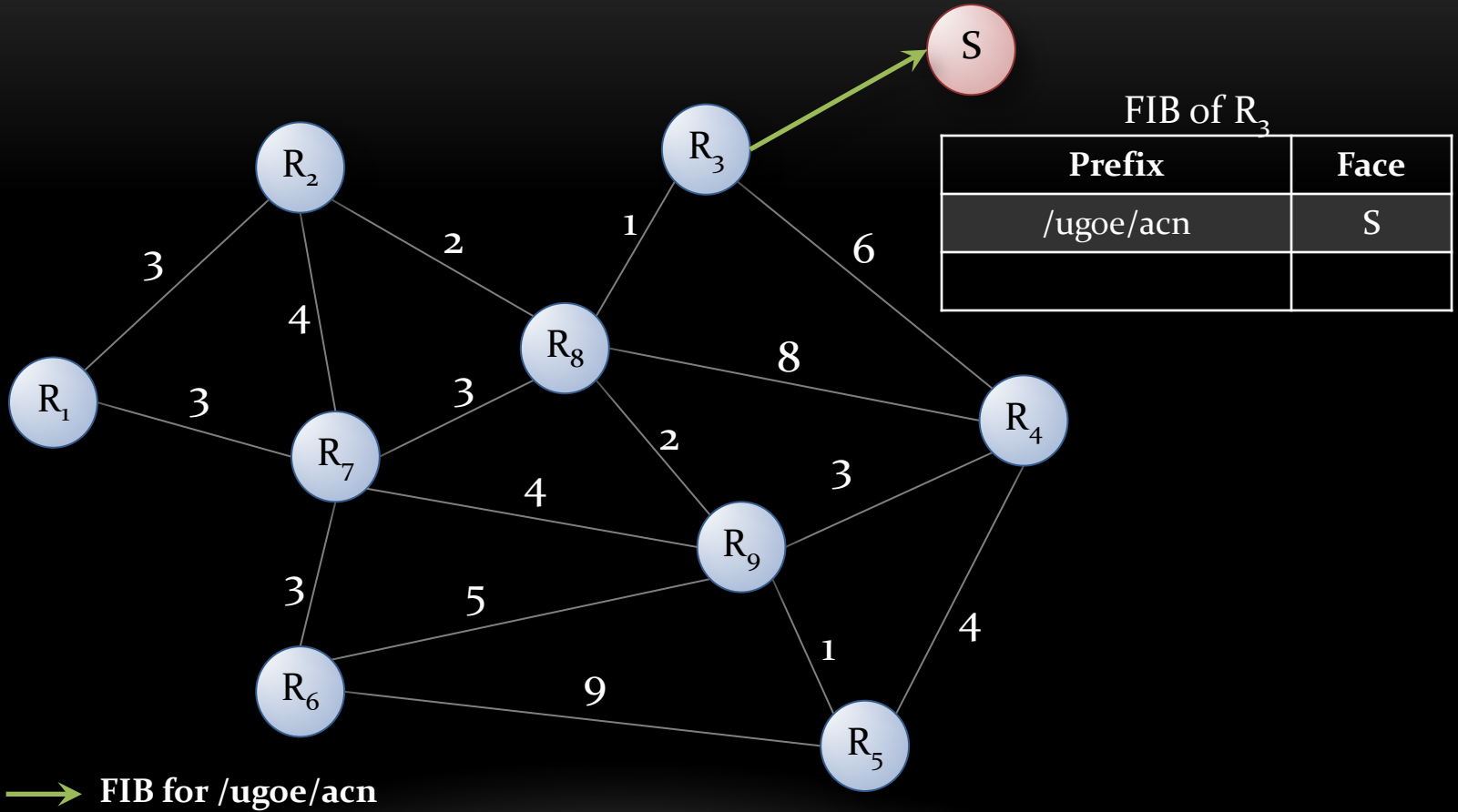
- Forwarding Information Base (**FIB**)
  - Stores the information about where to forward the request to.
  - Prefix → Face
- Pending Interest Table (**PIT**)
  - Stores the unsatisfied requests
  - Interest → Face
- **Content Store**
  - In-router cache
  - Content Name → Data



# DATA FLOW IN NDN – SERVE A PREFIX

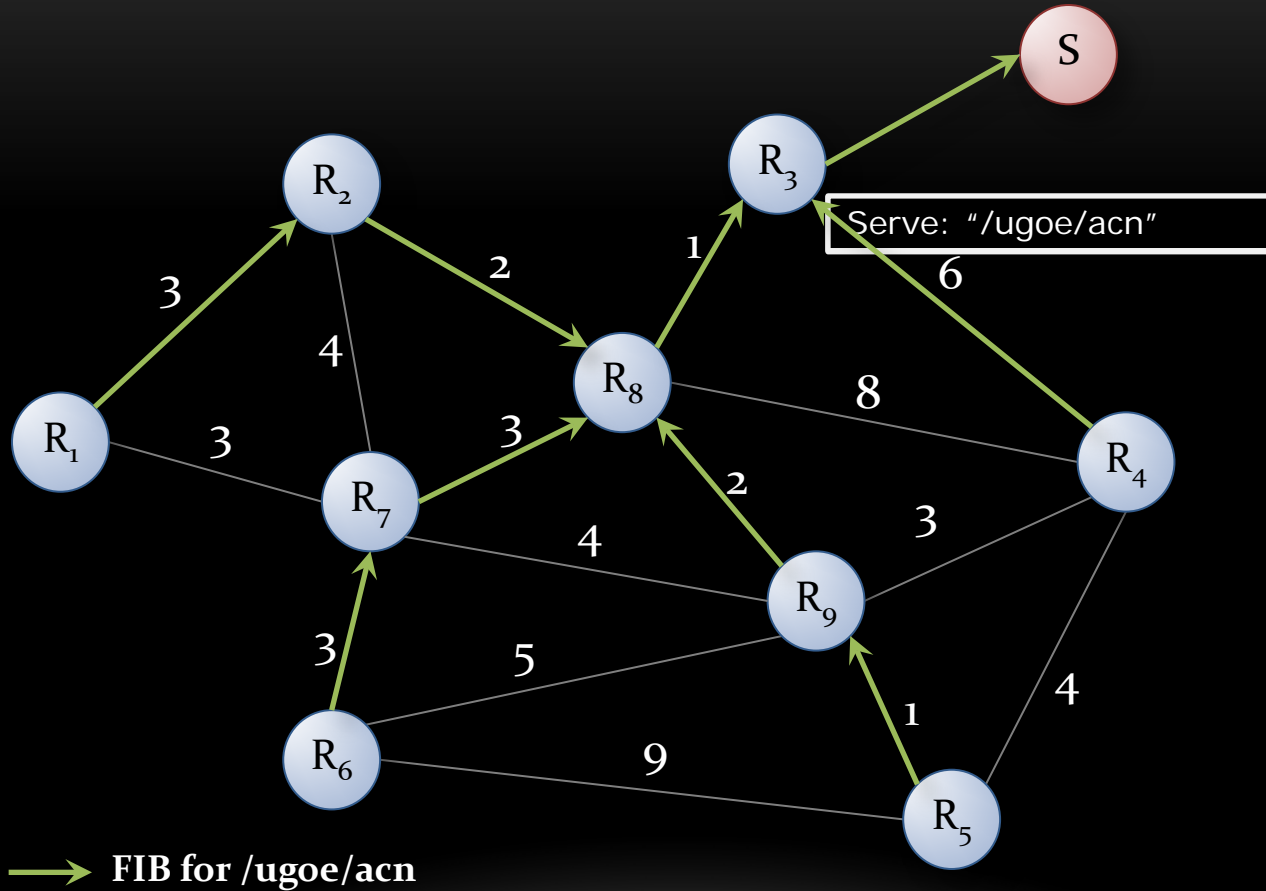


# DATA FLOW IN NDN – SERVE A PREFIX



→ FIB for /ugoe/acn

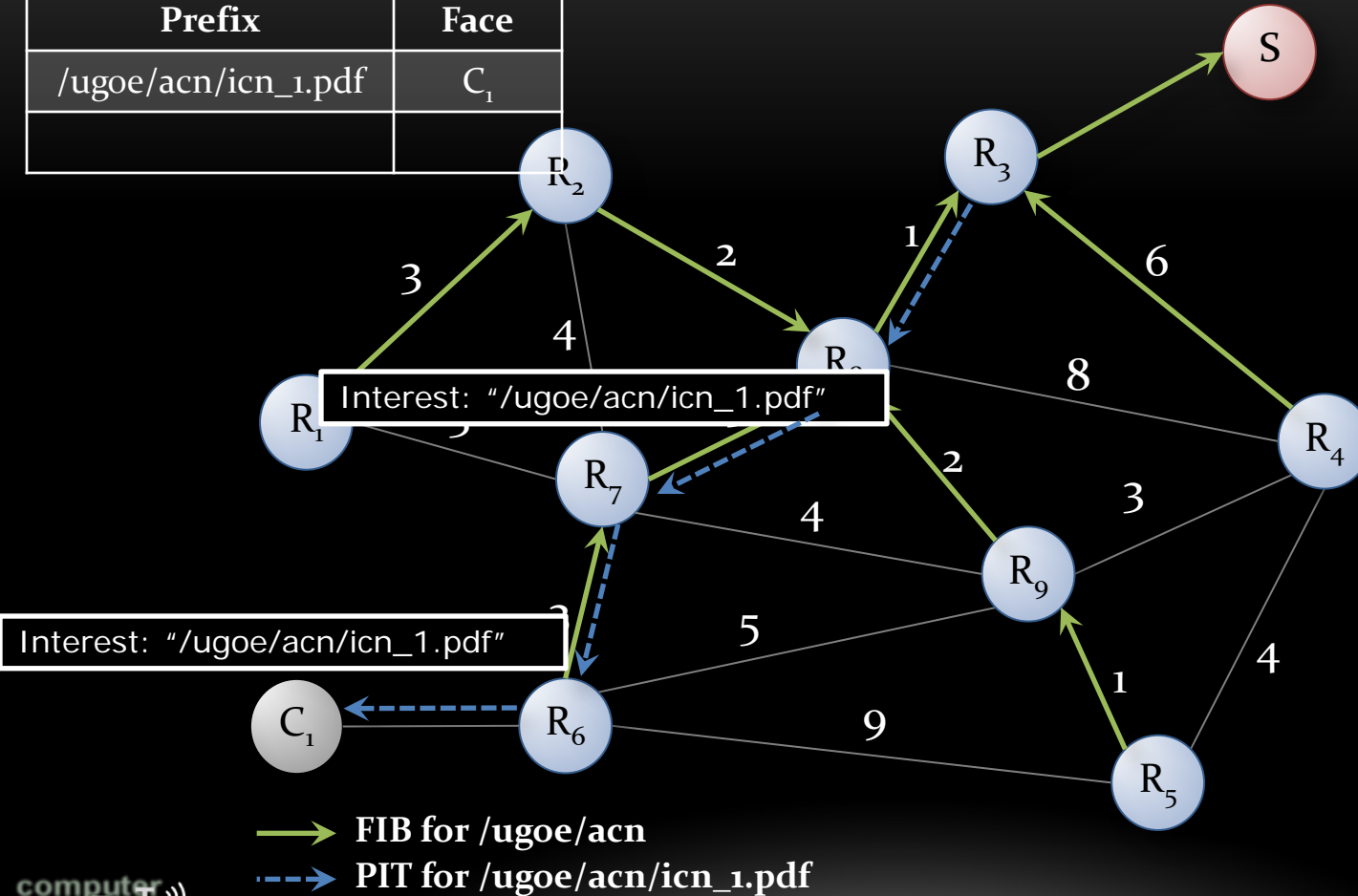
# DATA FLOW IN NDN – SERVE A PREFIX



# DATA FLOW IN NDN – REQUEST A DATA

PIT of R<sub>6</sub>

Prefix	Face
/ugoe/acn/icn_1.pdf	C <sub>1</sub>



→ FIB for /ugoe/acn

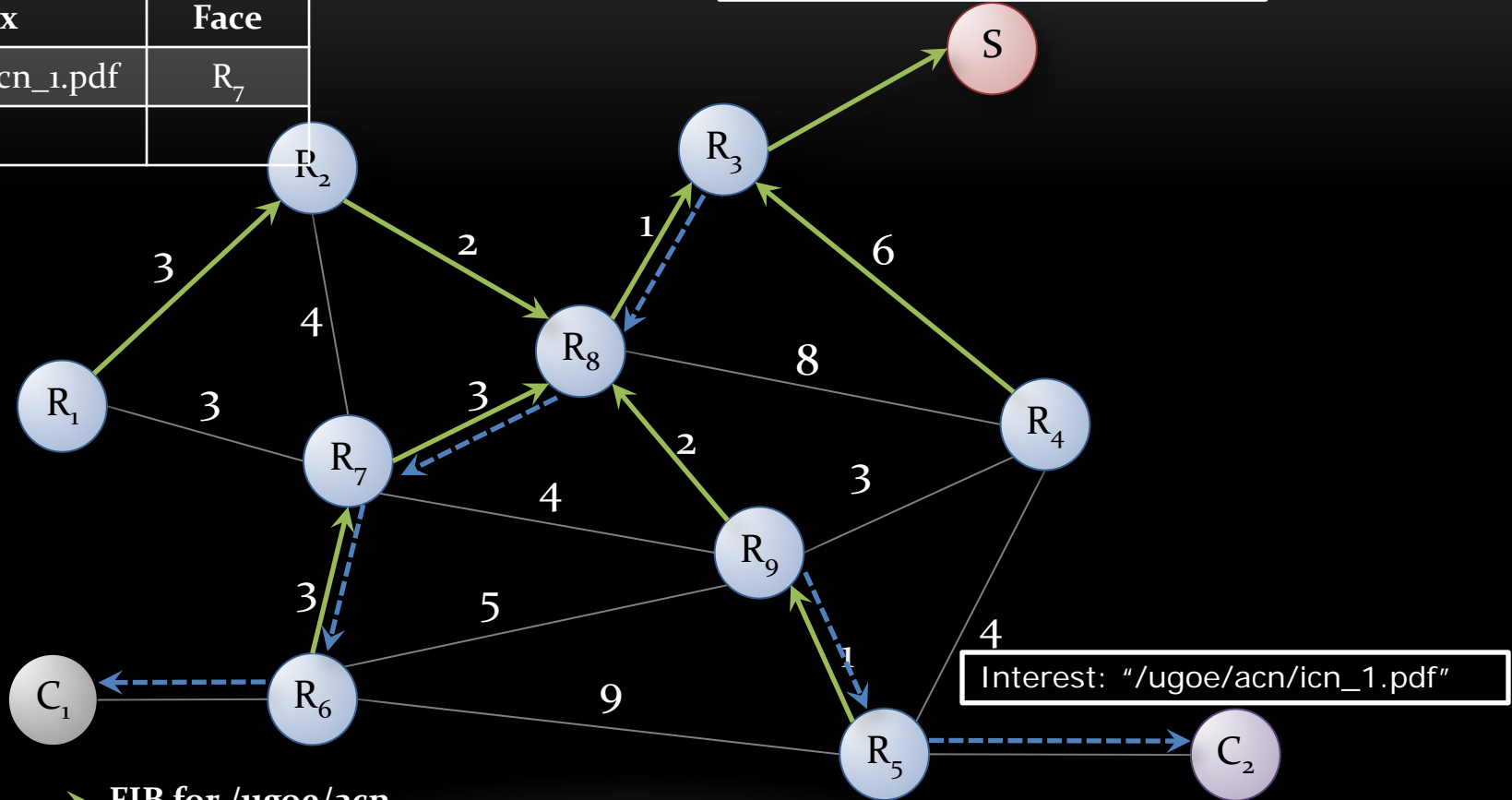
---> PIT for /ugoe/acn/icn\_1.pdf

# DATA FLOW IN NDN – REQUEST A SAME DATA

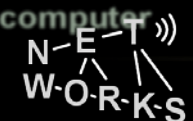
PIT of R<sub>8</sub>

Prefix	Face
/ugoe/acn/icn_1.pdf	R <sub>7</sub>

Interest: "/ugoe/acn/icn\_1.pdf"



Interest: "/ugoe/acn/icn\_1.pdf"



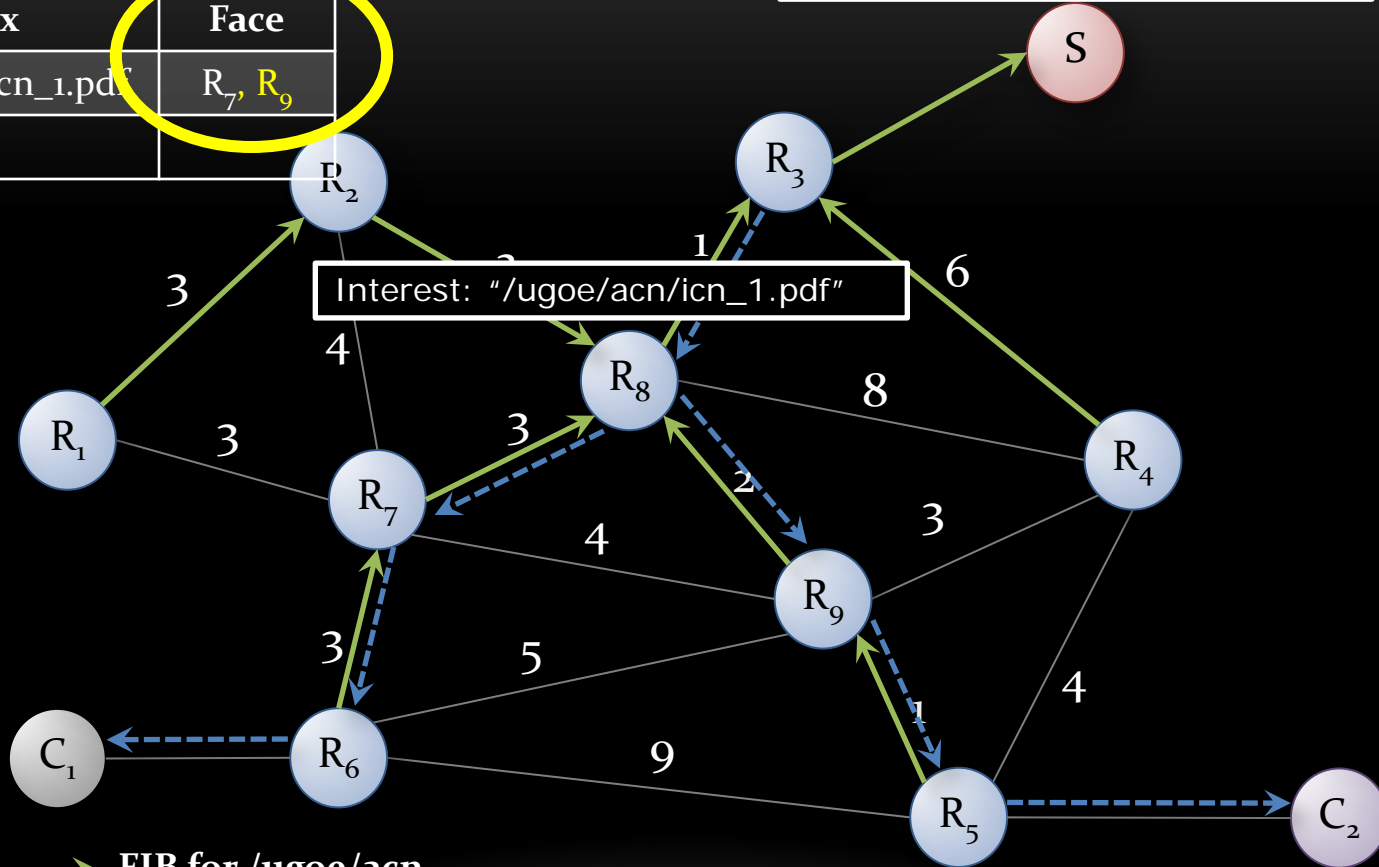


# DATA FLOW IN NDN – REQUEST A SAME DATA

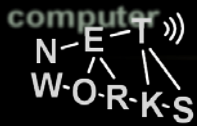
PIT of R<sub>8</sub>

Prefix	Face
/ugoe/acn/icn_1.pdf	R <sub>7</sub> , R <sub>9</sub>

Interest: "/ugoe/acn/icn\_1.pdf"



- FIB for /ugoe/acn
- PIT for /ugoe/acn/icn\_1.pdf



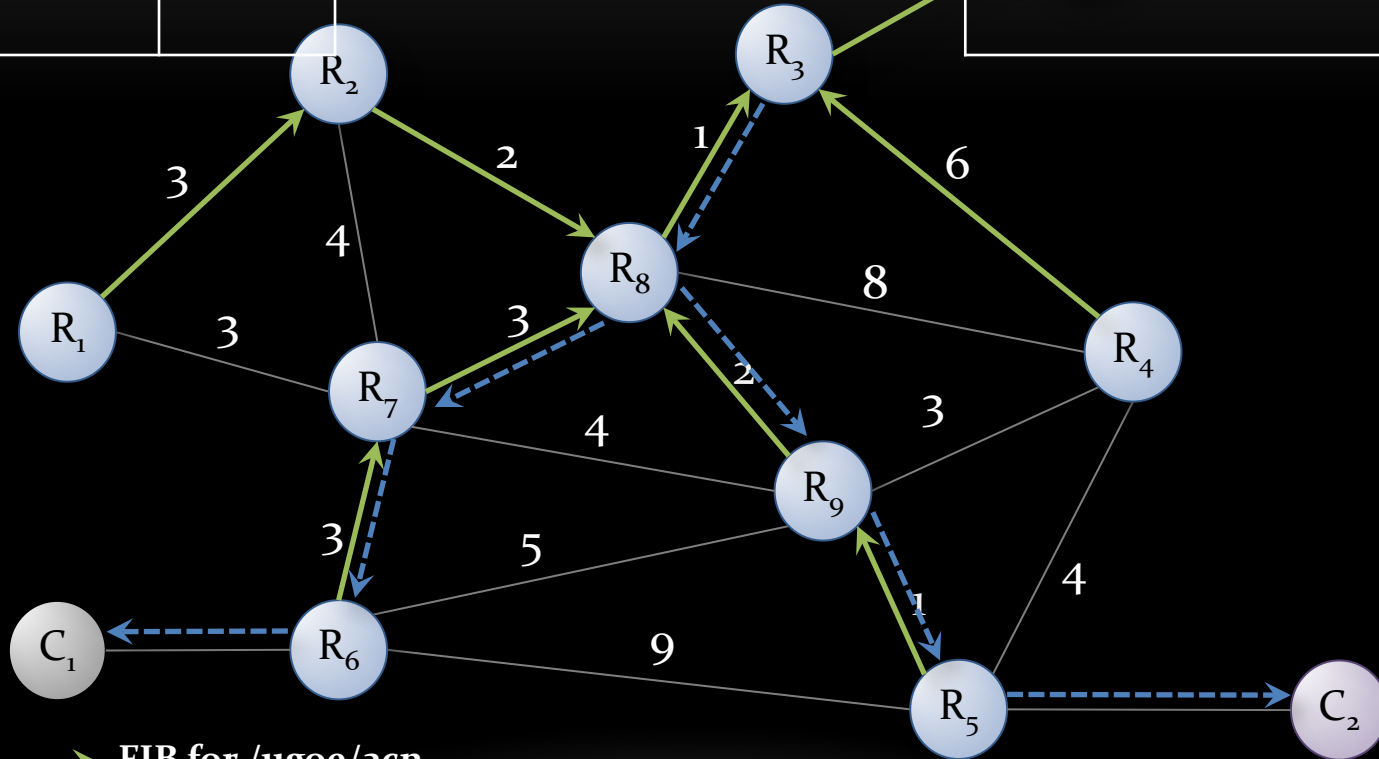
# DATA FLOW IN NDN – RESPOND A DATA

PIT of R<sub>3</sub>

Prefix	Face
/ugoe/acn/icn_1.pdf	R <sub>8</sub>

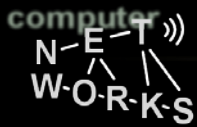
Content Store of R<sub>3</sub>

Name	Data
/ugoe/acn/icn_1.pdf/_v1/_s1	S



→ FIB for /ugoe/acn

- - - - - PIT for /ugoe/acn/icn\_1.pdf



# DATA FLOW IN NDN – RESPOND A DATA

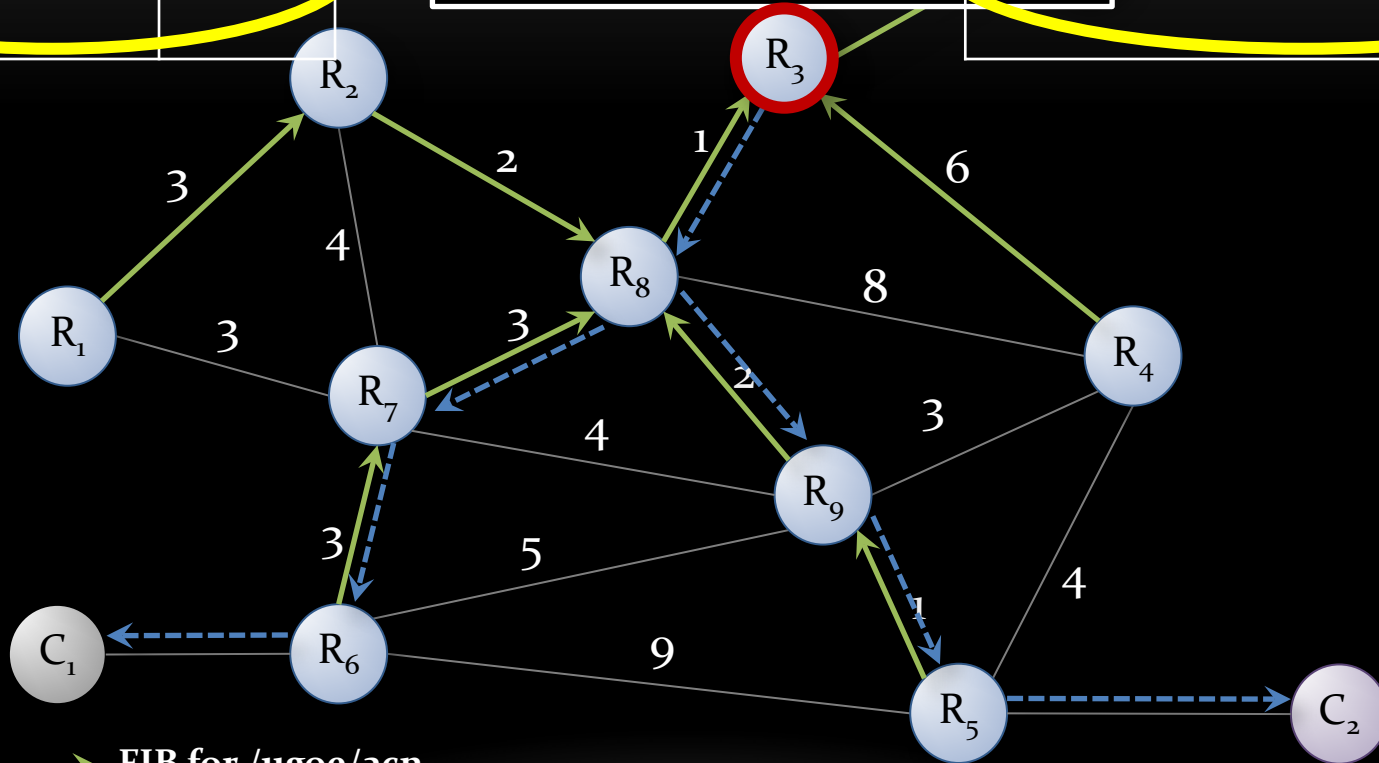
PIT of R<sub>3</sub>

Prefix	Face
/ugoe/acn/icn_1.pdf	R <sub>8</sub>

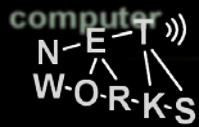
Content Store of R<sub>3</sub>

Name	Data
/ugoe/acn/icn_1.pdf/_v1/_s1	...

Data: "/ugoe/acn/icn\_1.pdf/\_v1/\_s1"



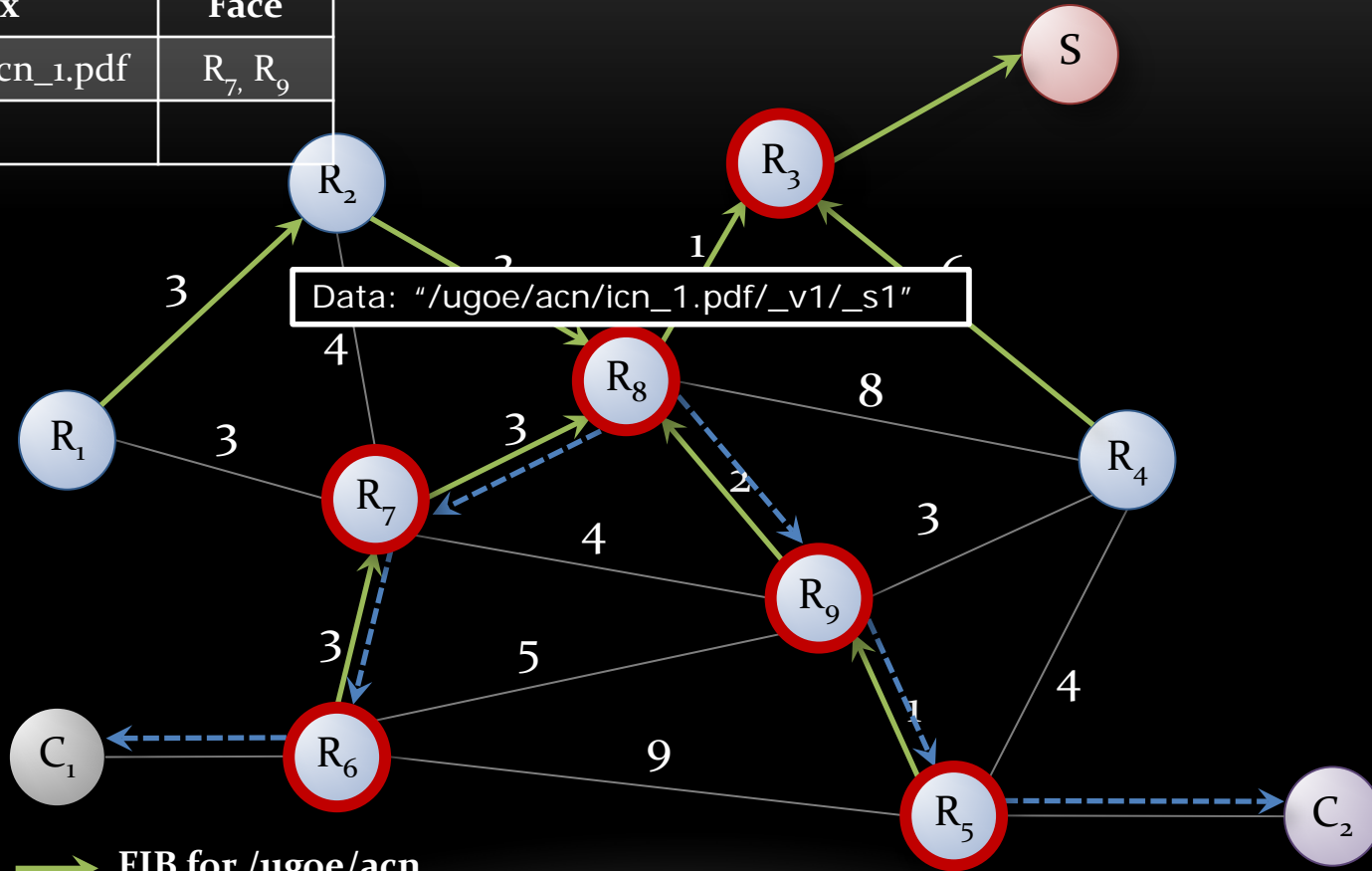
- FIB for /ugoe/acn
- PIT for /ugoe/acn/icn\_1.pdf



# DATA FLOW IN NDN – RESPOND A DATA

PIT of R<sub>8</sub>

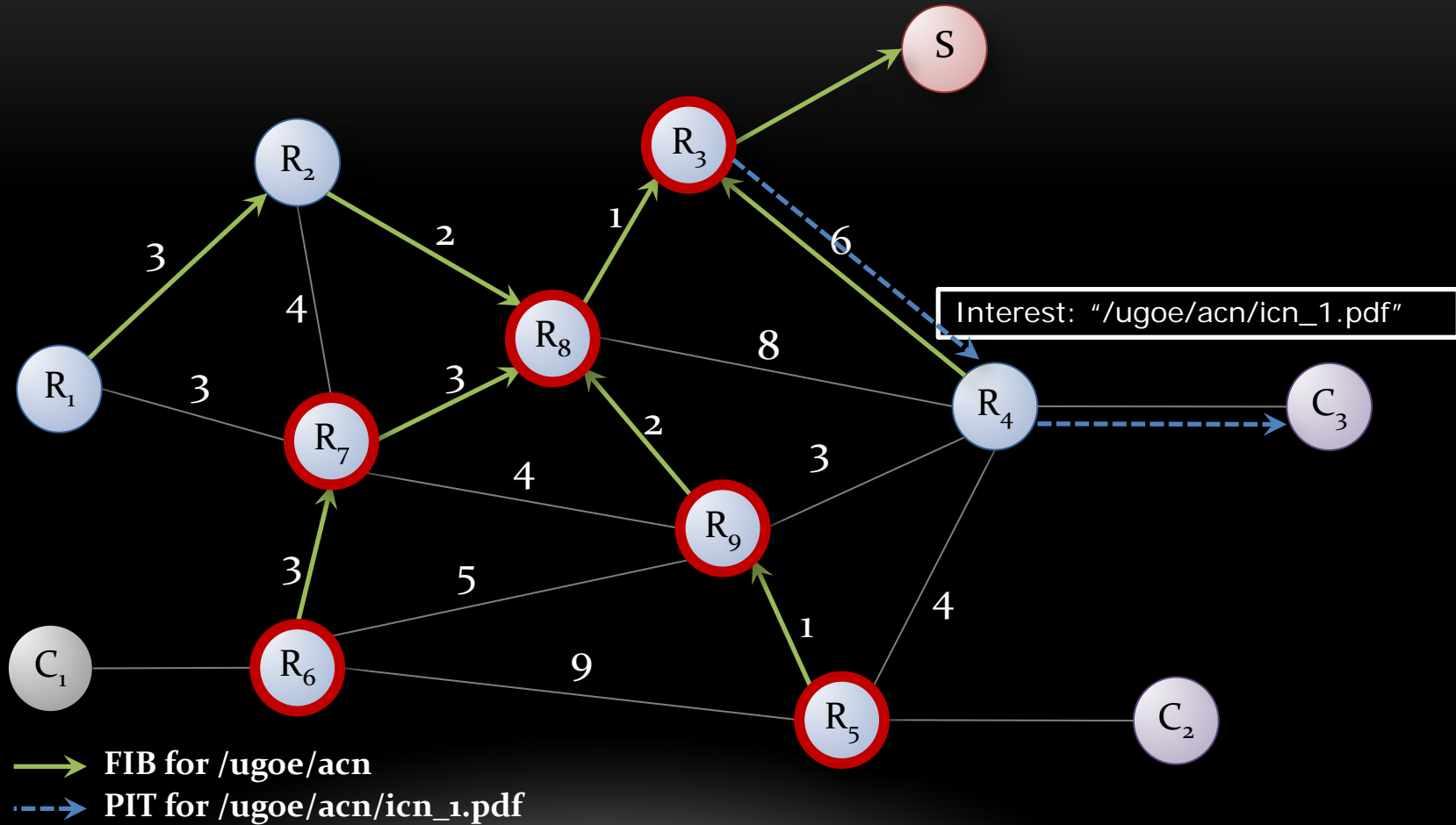
Prefix	Face
/ugoe/acn/icn_1.pdf	R <sub>7</sub> , R <sub>9</sub>



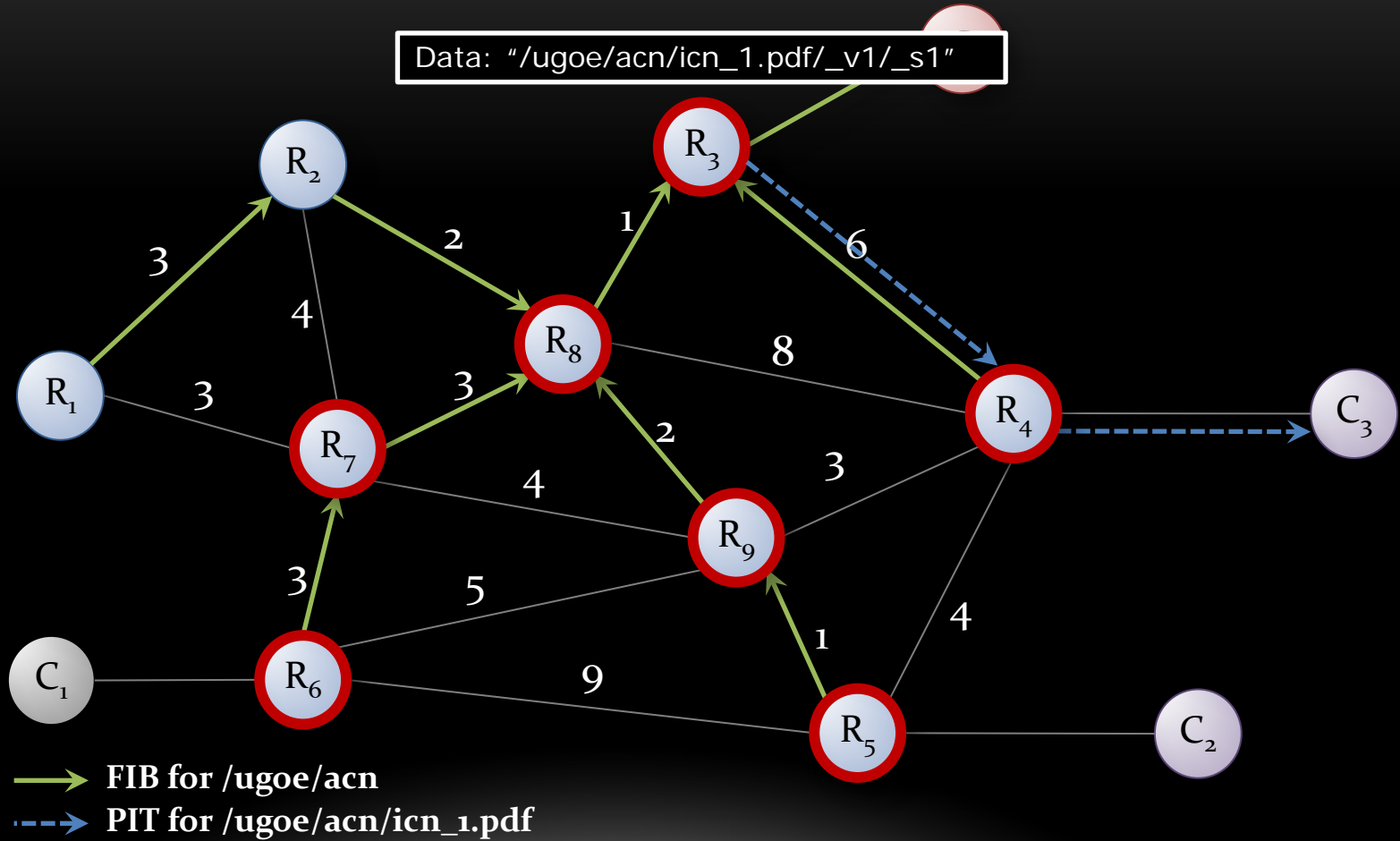
→ FIB for /ugoe/acn

---> PIT for /ugoe/acn/icn\_1.pdf

# DATA FLOW IN NDN – FURTHER REQUESTS

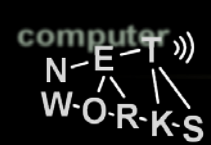
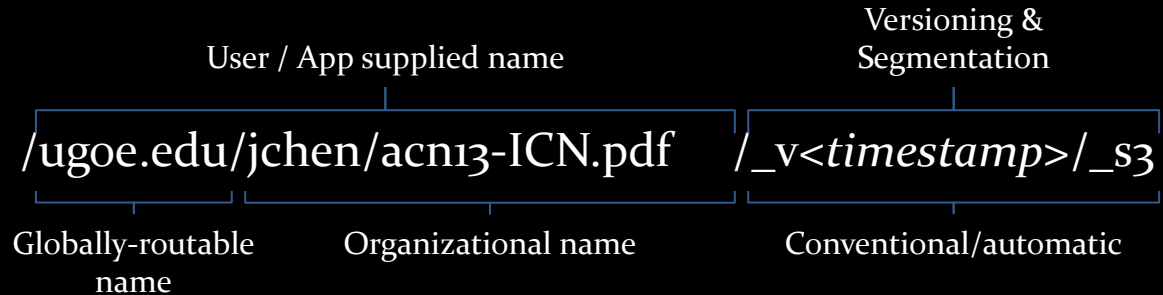


# DATA FLOW IN NDN – FURTHER REQUESTS



# DISCUSSION 1: FLOW CONTROL

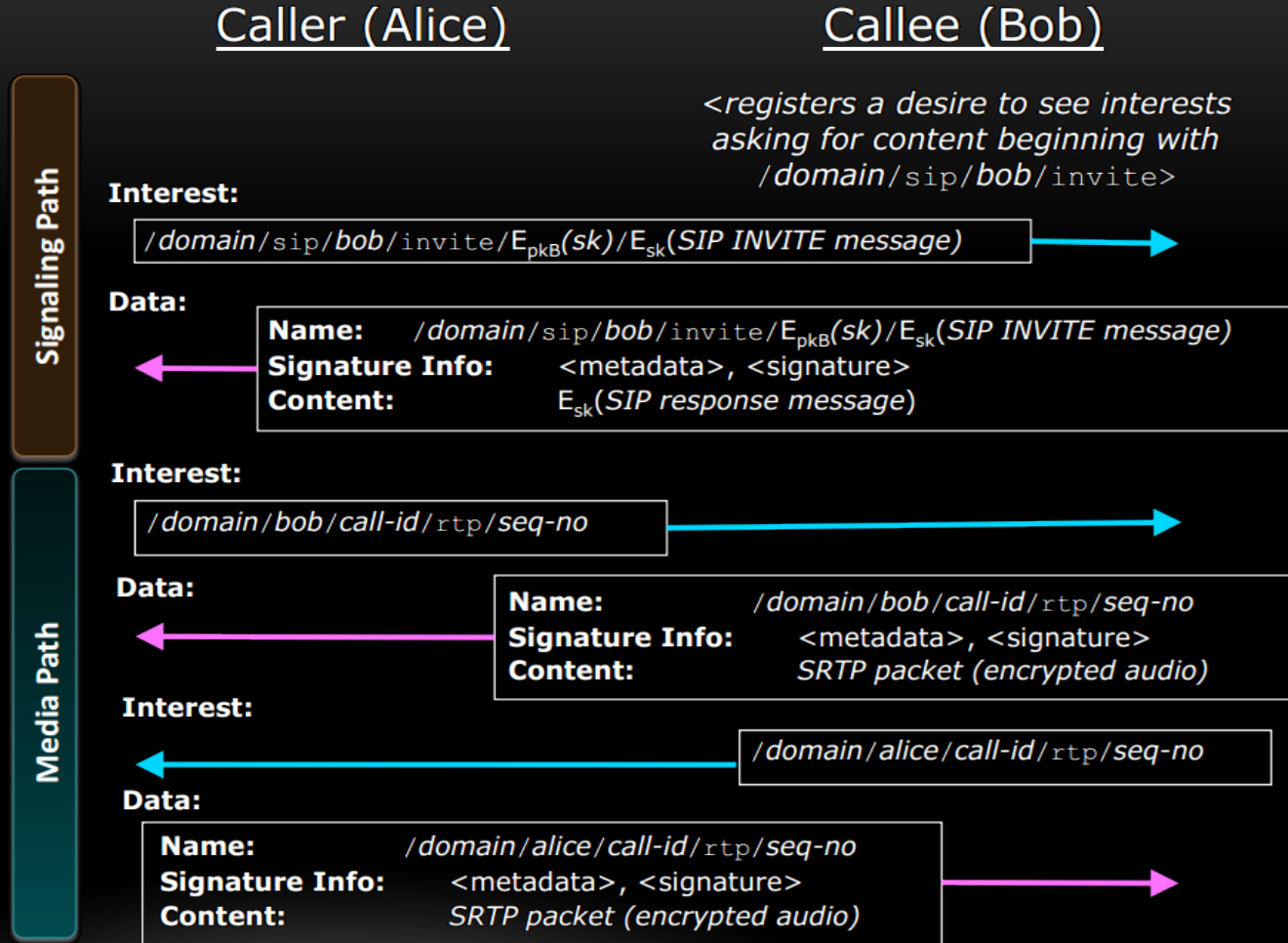
- Pipelining:
  - Receiver send multiple Interests before he receives Data
- Receiver-driven Flow & Congestion Control <sup>[10]</sup>
  - Sequence number
  - TCP-like window control (AIMD)
  - Problem??





# DISCUSSION 1: FLOW CONTROL

- Example: VoCCN [11]



*<registers a desire to see interests asking for content beginning with /domain/sip/bob/invite>*

`/domain/sip/bob/invite/EpkB(sk)/Esk(SIP INVITE message)`

**Data:**

**Name:** `/domain/sip/bob/invite/EpkB(sk)/Esk(SIP INVITE message)`  
**Signature Info:** `<metadata>, <signature>`  
**Content:** `Esk(SIP response message)`

**Interest:**

`/domain/bob/call-id/rtp/seq-no`

**Data:**

**Name:** `/domain/bob/call-id/rtp/seq-no`  
**Signature Info:** `<metadata>, <signature>`  
**Content:** `SRTP packet (encrypted audio)`

**Interest:**

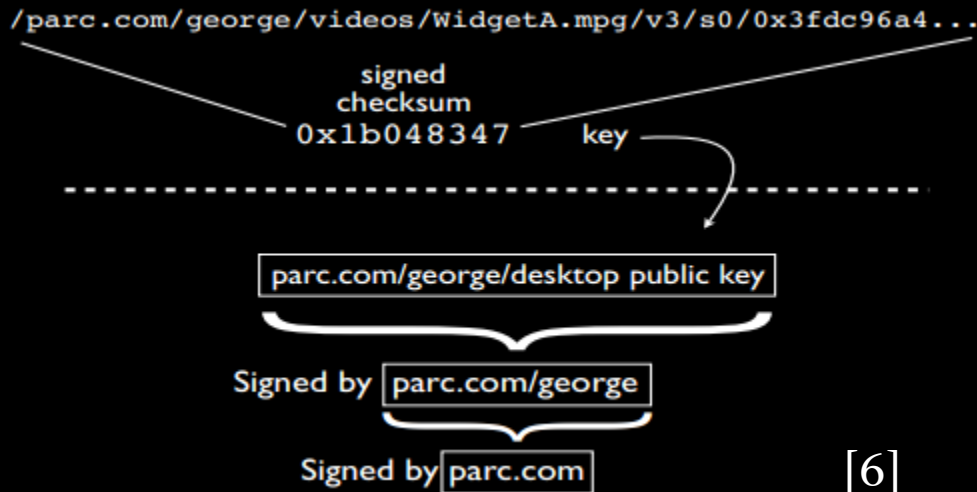
`/domain/alice/call-id/rtp/seq-no`

**Data:**

**Name:** `/domain/alice/call-id/rtp/seq-no`  
**Signature Info:** `<metadata>, <signature>`  
**Content:** `SRTP packet (encrypted audio)`

# DISCUSSION 2: TRUST

- Inherit trust support:
  - Signature in Data packet
  - Hierarchical publisher-key establishment



Content Name
Content Descriptors
<b>Signature</b> (digest algorithm, witness, ...)
Signed Info (publisher ID, key locator, stale time, ...)
Data

Data (Response)

[6]

# DISCUSSION 3: PROBLEMS?

- Scalability:
  - FIB size? (Unbounded name space)
- Efficiency:
  - PIT locking?
  - Cache aware routing?
  - Cache hit rate?
- Security:
  - Interest flooding attack?
- Incremental Deployment?
- Functionality:
  - Users will be limited to query/response?

*Till Next Week!*



# REFERENCES

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2. FP-7 EU Project “4WARD.” <http://www.4ward-project.eu/>
3. FP-7 EU Project “SAIL.” <http://www.sail-project.eu/>
4. Project “PSIRP.” <http://www.psirp.org/>
5. FP-7 EU Project “Pursuit.” <http://www.fp7-pursuit.eu/>
6. Jacobson, Van, et al. “Networking named content.” *CoNext*, 2009.
7. Project “CCNx.” <http://www.ccnx.org/>
8. Zhang, Lixia, et al. “Named Data Networking (NDN) project.” *Relatório Técnico NDN-0001, Xerox Palo Alto Research Center-PARC* (2010). <http://www.named-data.net/>
9. FP-7 EU Project: “Green ICN.” <http://www.greenicn.org/>
10. Carofiglio, Giovanna, et al. “Icp: Design and evaluation of an interest control protocol for content-centric networking.” *ICN*, 2012.
11. Jacobson, Van, et al. “VoCCN: voice-over content-centric networks.” *ReArch*, 2009.