

ACN course

Content-Centric Networking (I)

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ACKNOWLEDGEMENT

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

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?

University of Goettingen

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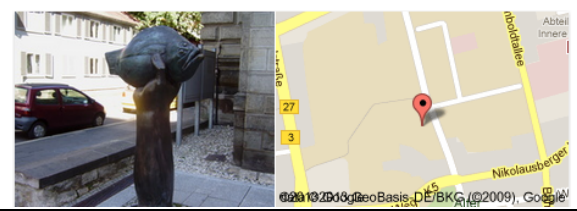
The University of Göttingen, known informally as Georgia Augusta, is a university in the city of Göttingen, Germany. Founded in 1734 by George II, King of Great Britain and Elector of Hanover, it opened for classes in 1737. [Wikipedia](#)

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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**THE UNIVERSITY
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AT A GLANCE**

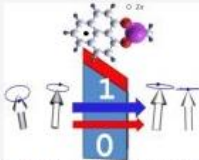
Göttingen University secures 30 million in grant money



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

13.02.2013

▶ Molecular machines in RNA processing, translation and transport

14.02.2013

▶ Molecular machines in RNA processing, translation and transport

15.02.2013

▶ Molecular machines in RNA processing, translation and transport

International

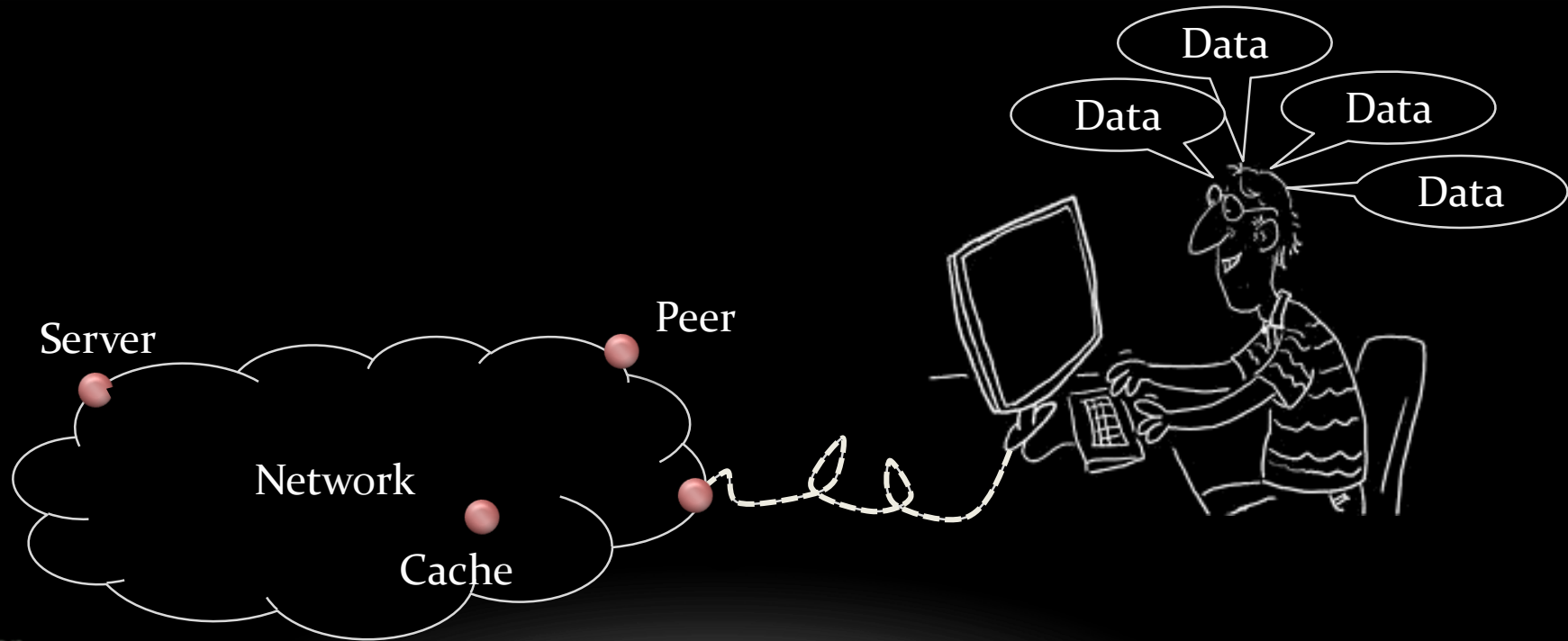
- ▶ General International Information
- ▶ Researching Internationally

LET'S SEE THE FULL PICTURE

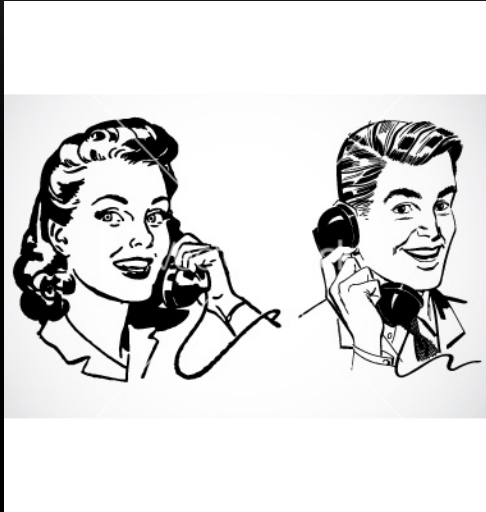


MY PURPOSE OF USING THE NETWORK: GET **DATA!**

- Network should understand my requirement!



WHY CURRENT INTERNET IS NOT DESIGNED IN THIS WAY? IS IT A FLAW IN DESIGN?



TCP/IP was designed when the popular application was “conversations”



Current applications:

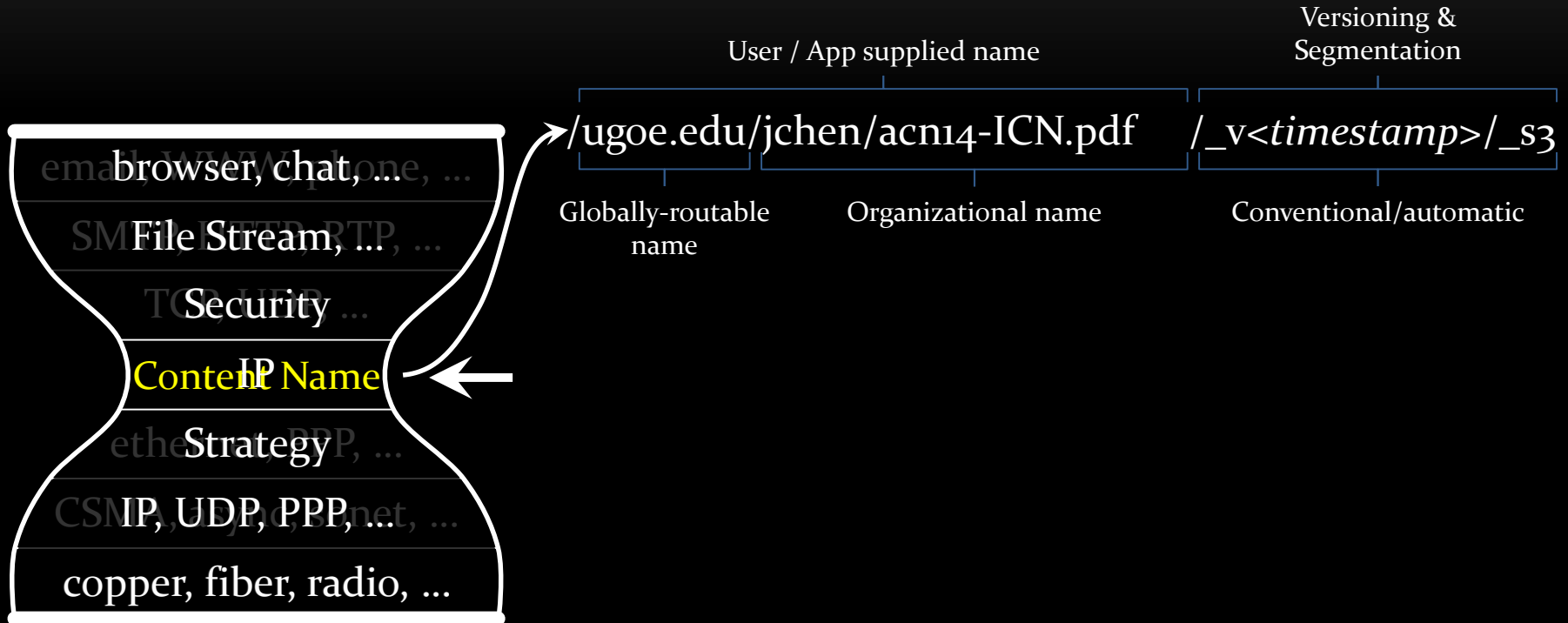
- Users are primarily interested in content (what)
- not where they retrieve the content from
- This fits with current solutions such as CDNs,
- distributed cloud, load-balancing and etc.

PROJECTS/PUBLICATIONS RELATED TO CCN

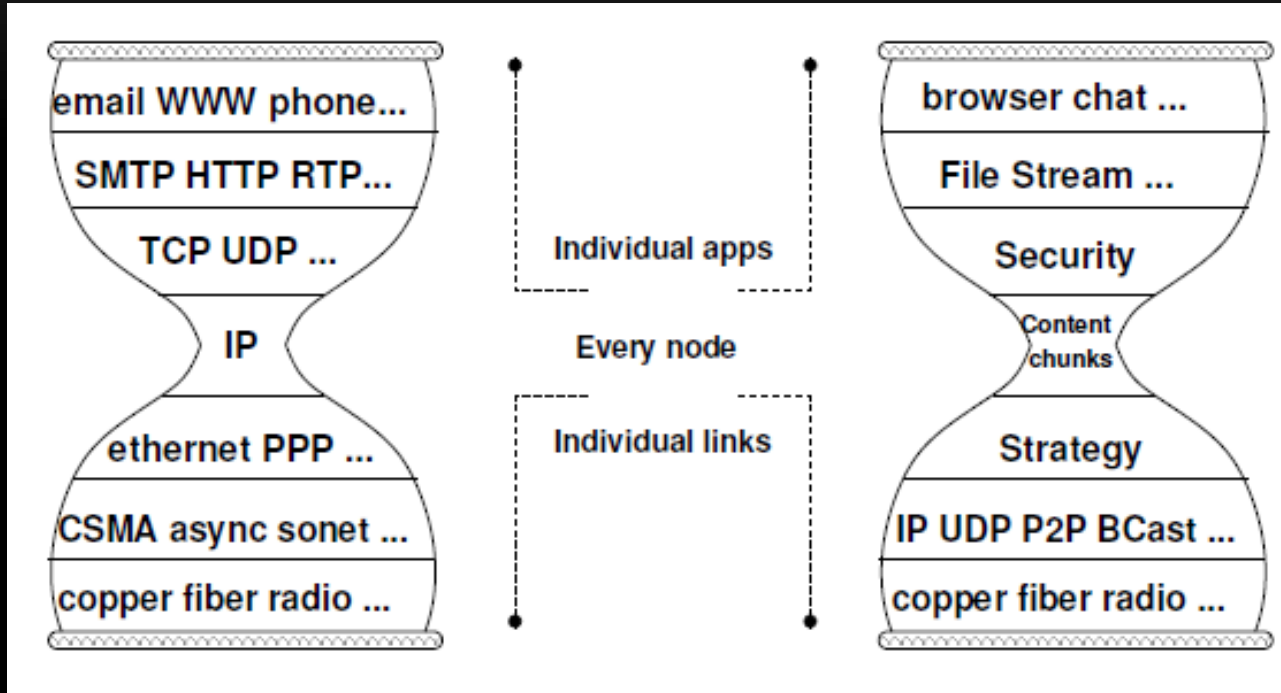
- Document Oriented (and beyond) Network Architecture (**DONA**) [1]
 - Teemu Koponen, *et al.* *SIGCOMM'07*
- Project: **4WARD** NETINF [2] – **SAIL** NETINF [3]
 - **SAIL**: Scalable and Adaptive Internet Solutions
- Project: **PSIRP** [4] – **PURSUIT** [5]
 - **PSIRP**: Publish/Subscribe Internet 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]



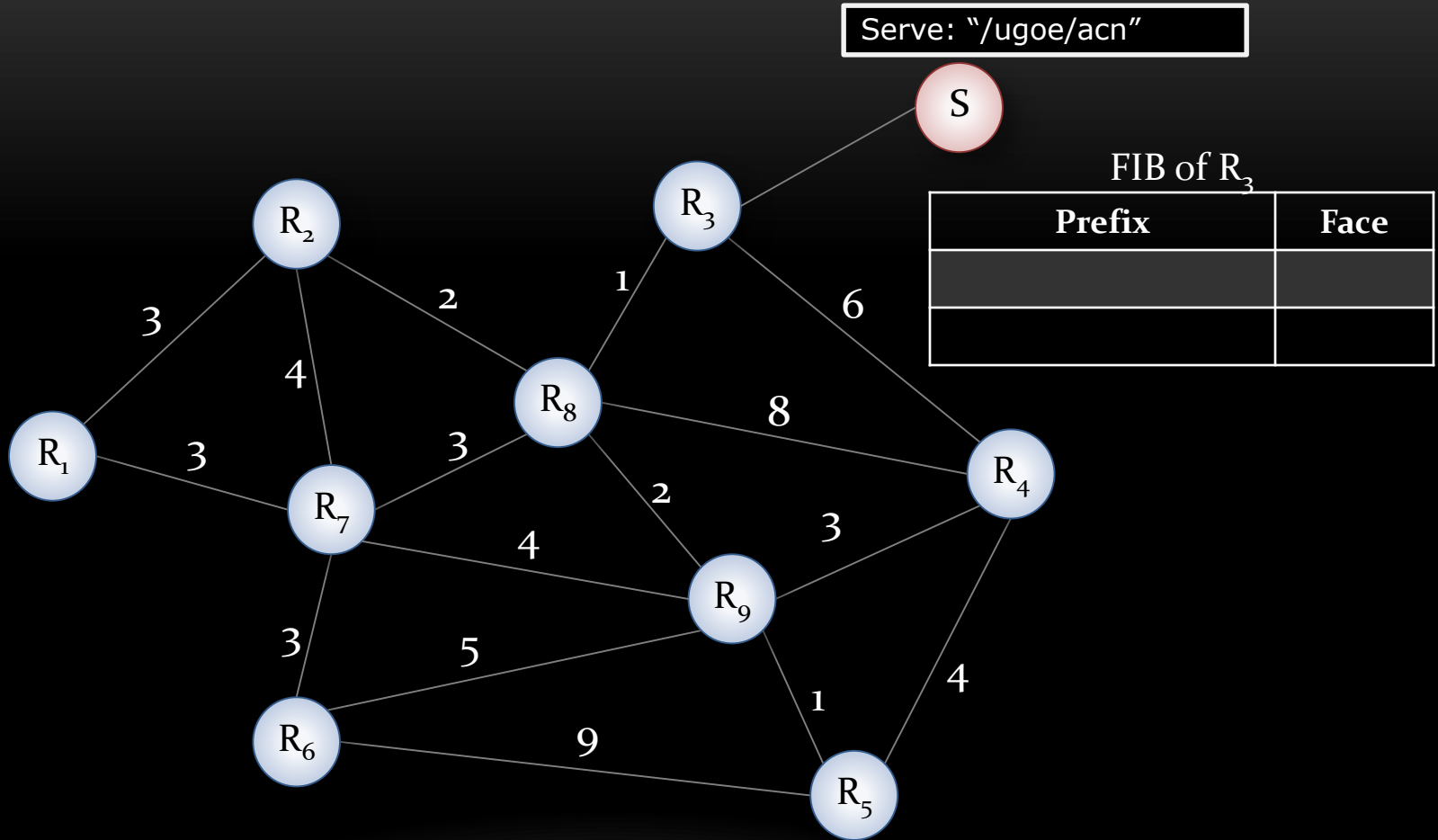
HOW TO ACHIEVE CONTENT-CENTRICITY?



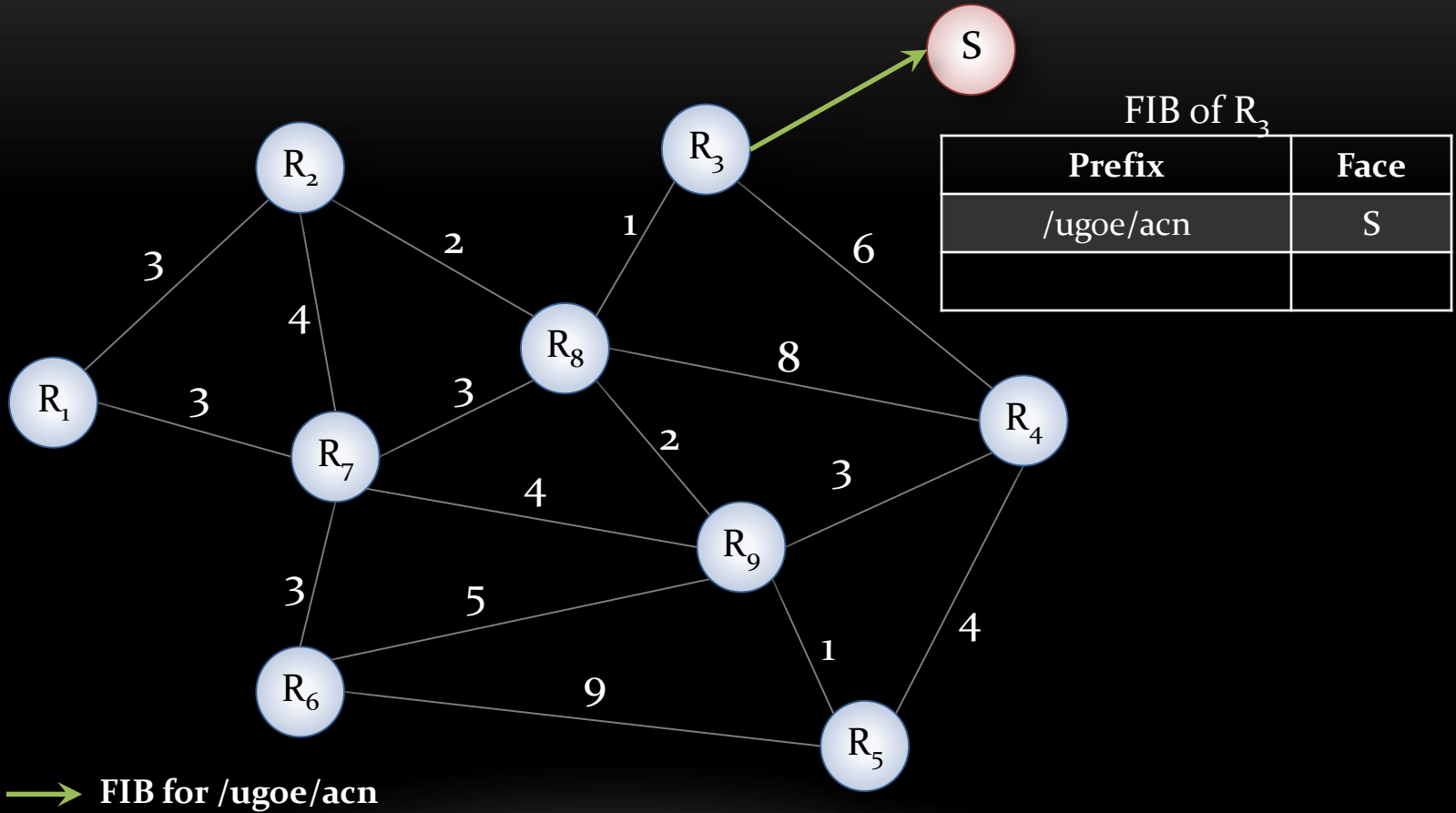
HOURL GLASS SUMMARY



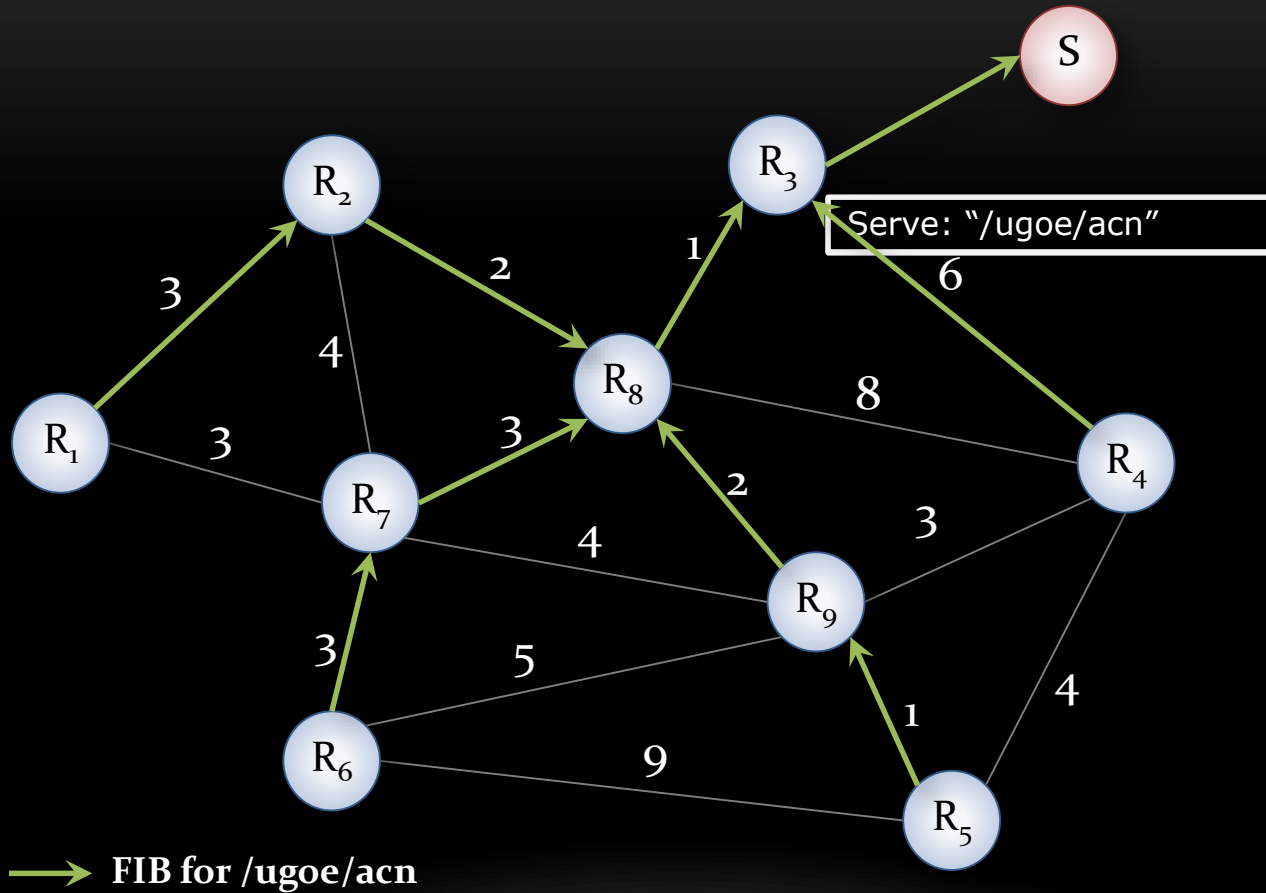
DATA FLOW IN NDN – SERVE A PREFIX



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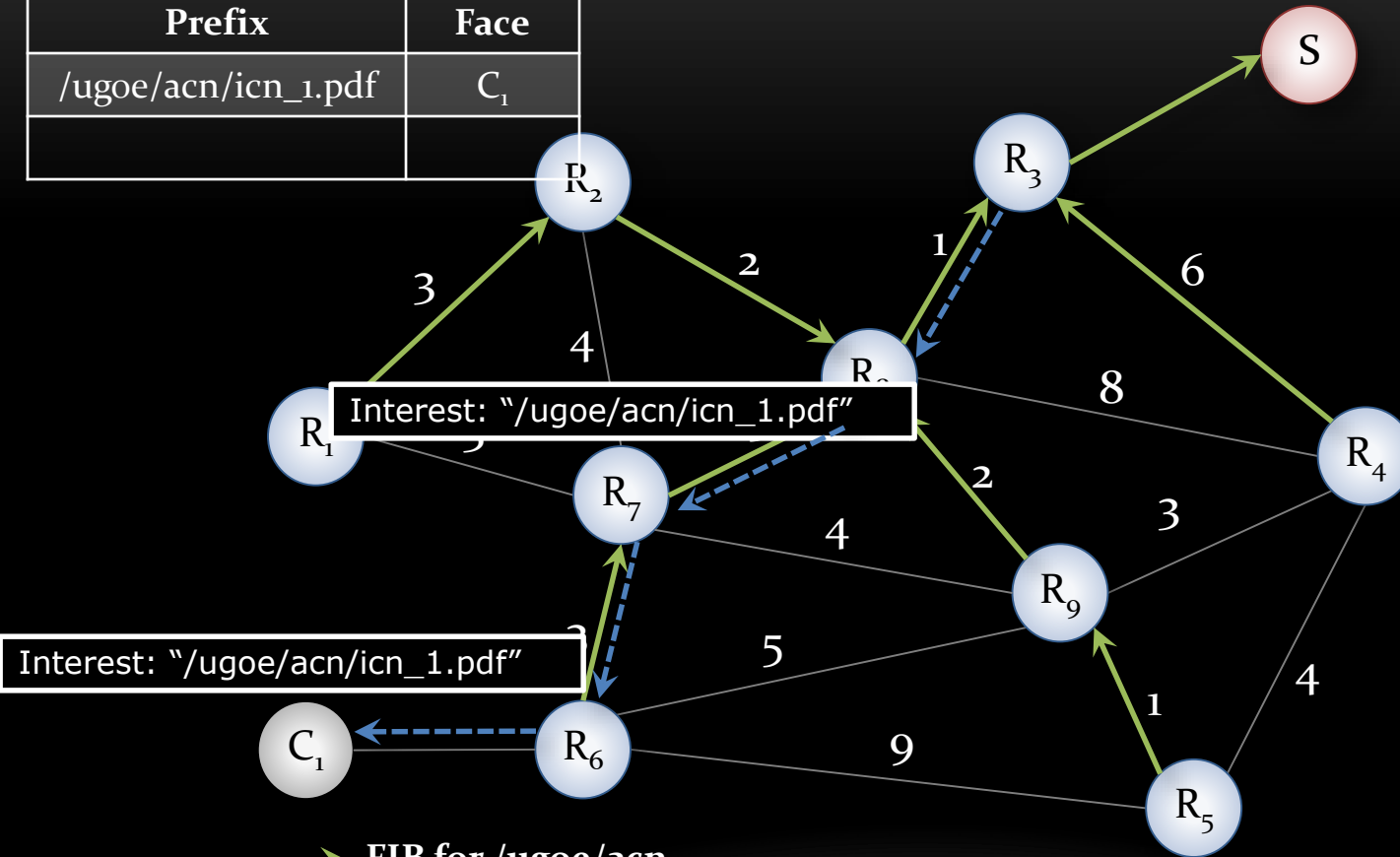
DATA FLOW IN NDN – SERVE A PREFIX



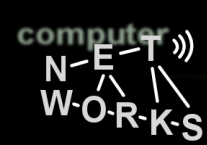
DATA FLOW IN NDN – REQUEST A DATA

PIT of R₆

Prefix	Face
/ugoe/acn/icn_1.pdf	C ₁



- FIB for /ugoe/acn
- PIT for /ugoe/acn/icn_1.pdf

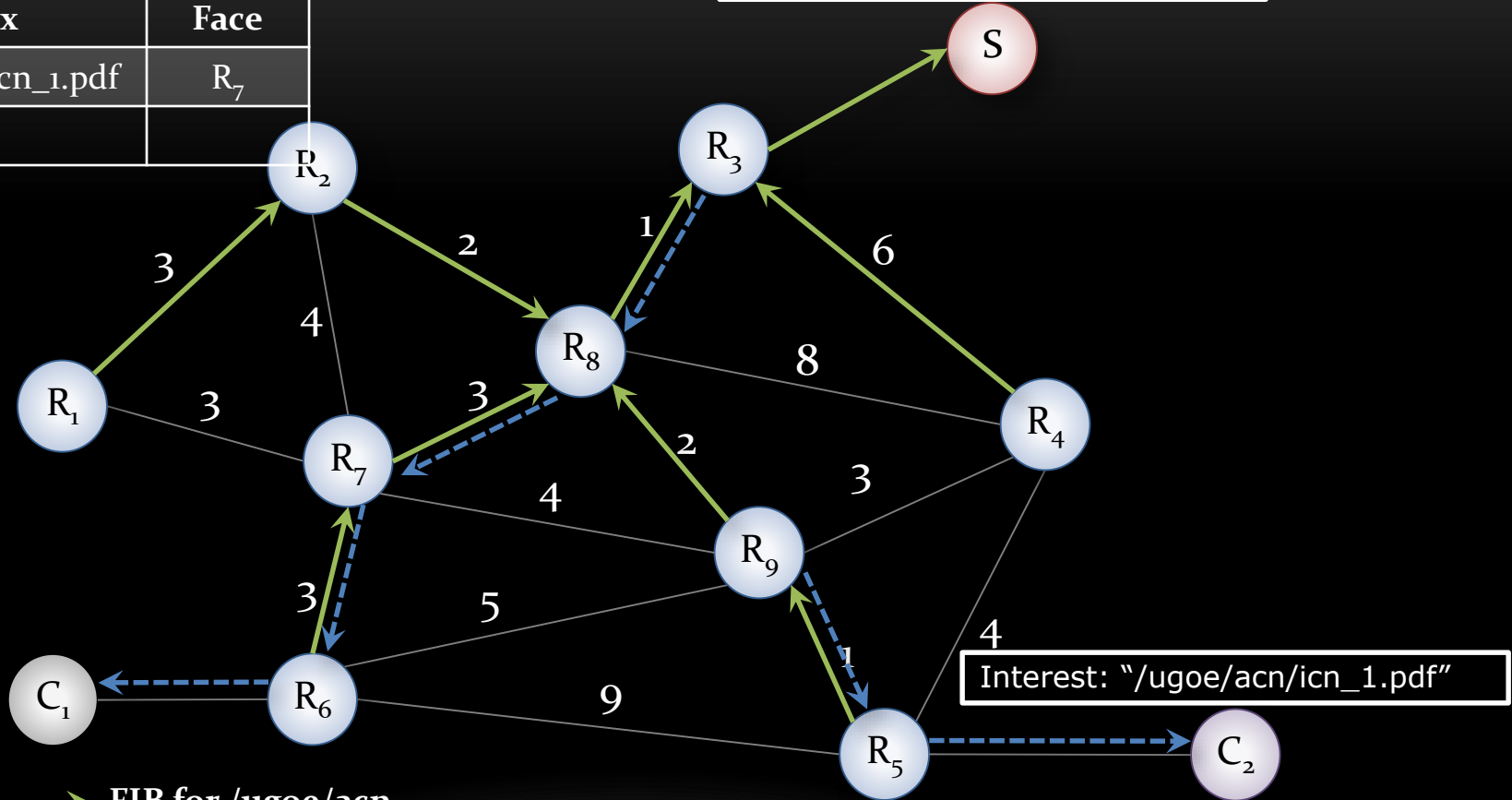


DATA FLOW IN NDN – REQUEST A SAME DATA

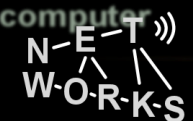
PIT of R₈

Prefix	Face
/ugoe/acn/icn_1.pdf	R ₇

Interest: "/ugoe/acn/icn_1.pdf"



Interest: "/ugoe/acn/icn_1.pdf"

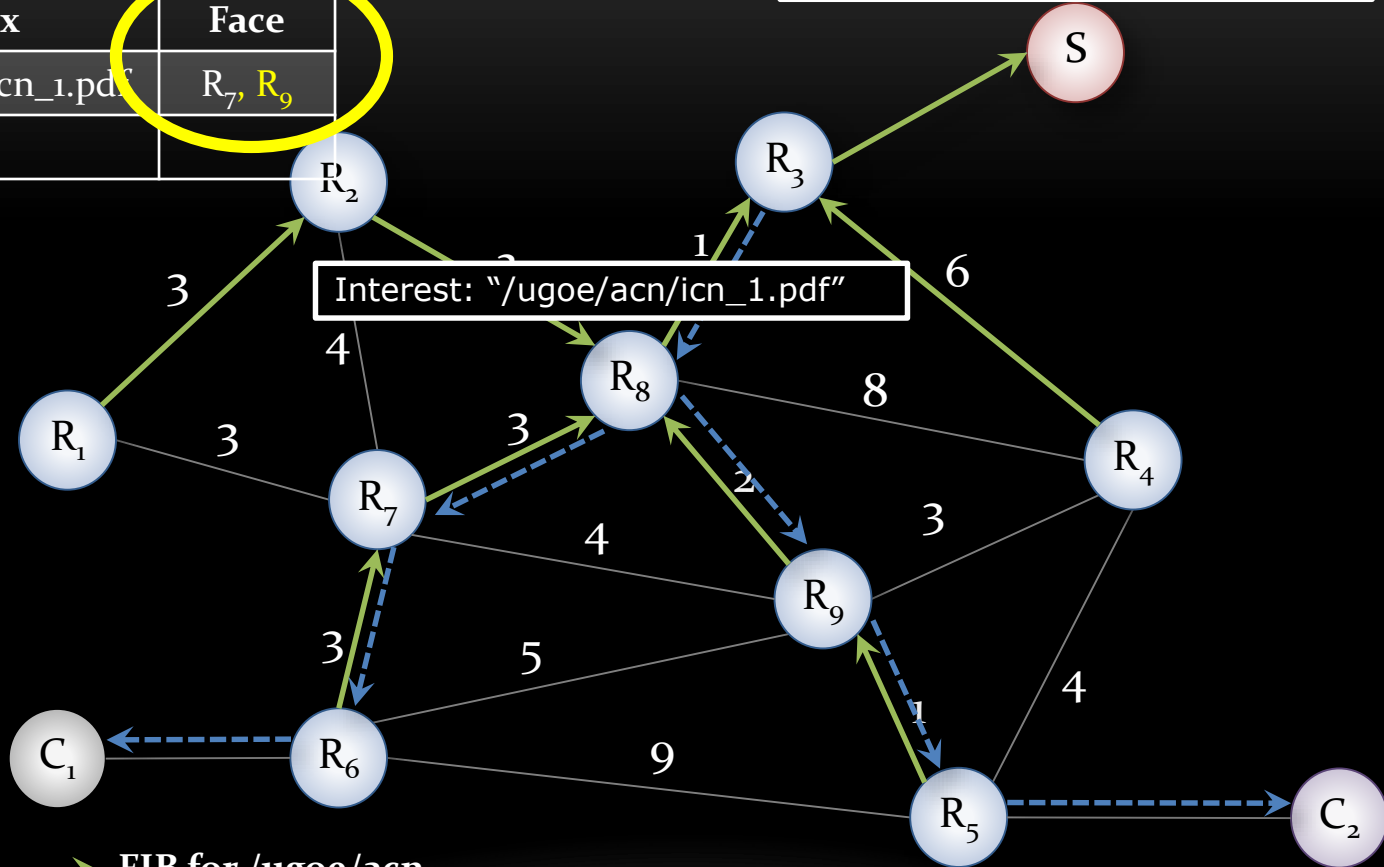


DATA FLOW IN NDN – REQUEST A SAME DATA

PIT of R₈

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

Interest: "/ugoe/acn/icn_1.pdf"



➔ FIB for /ugoe/acn
- - -> PIT for /ugoe/acn/icn_1.pdf

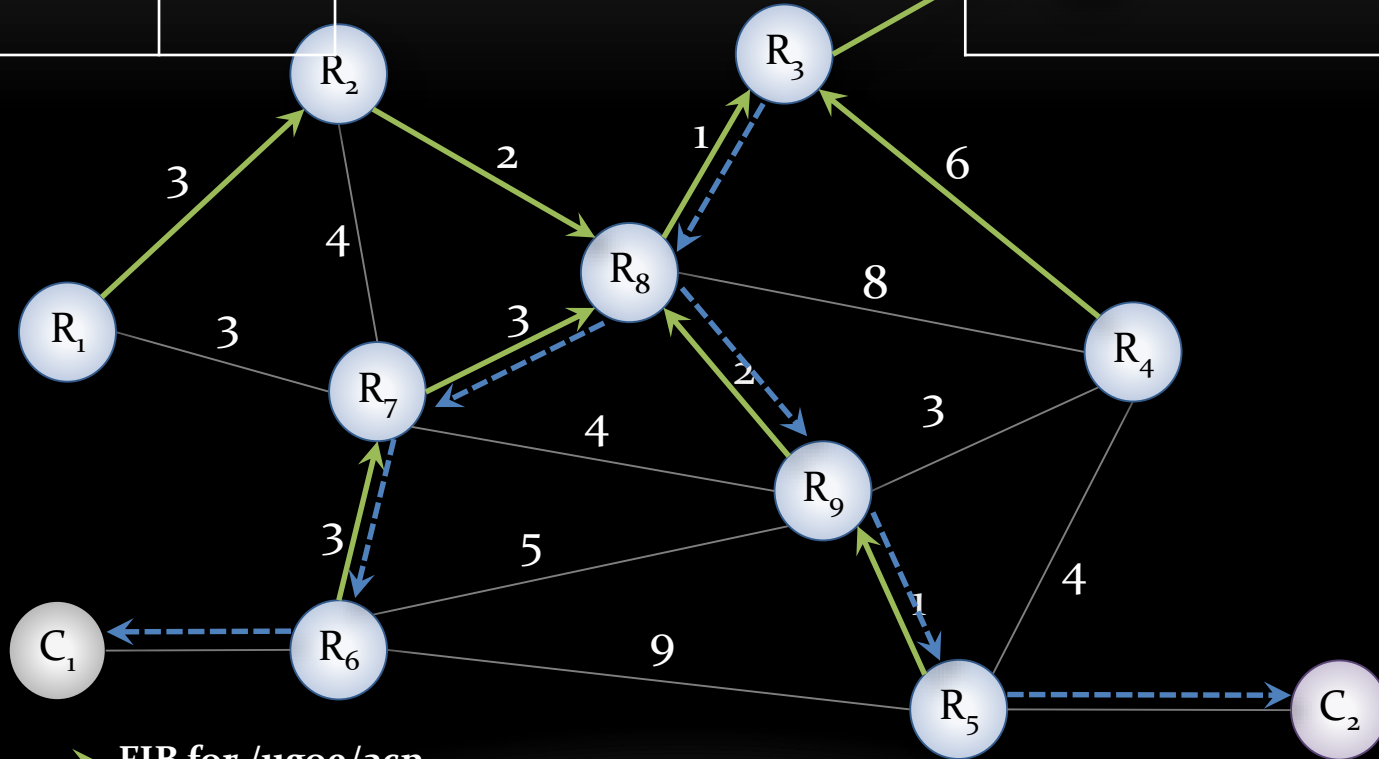
DATA FLOW IN NDN – RESPOND A DATA

PIT of R_3

Prefix	Face
/ugoe/acn/icn_1.pdf	R_8

Content Store of R_3

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



DATA FLOW IN NDN – RESPOND A DATA

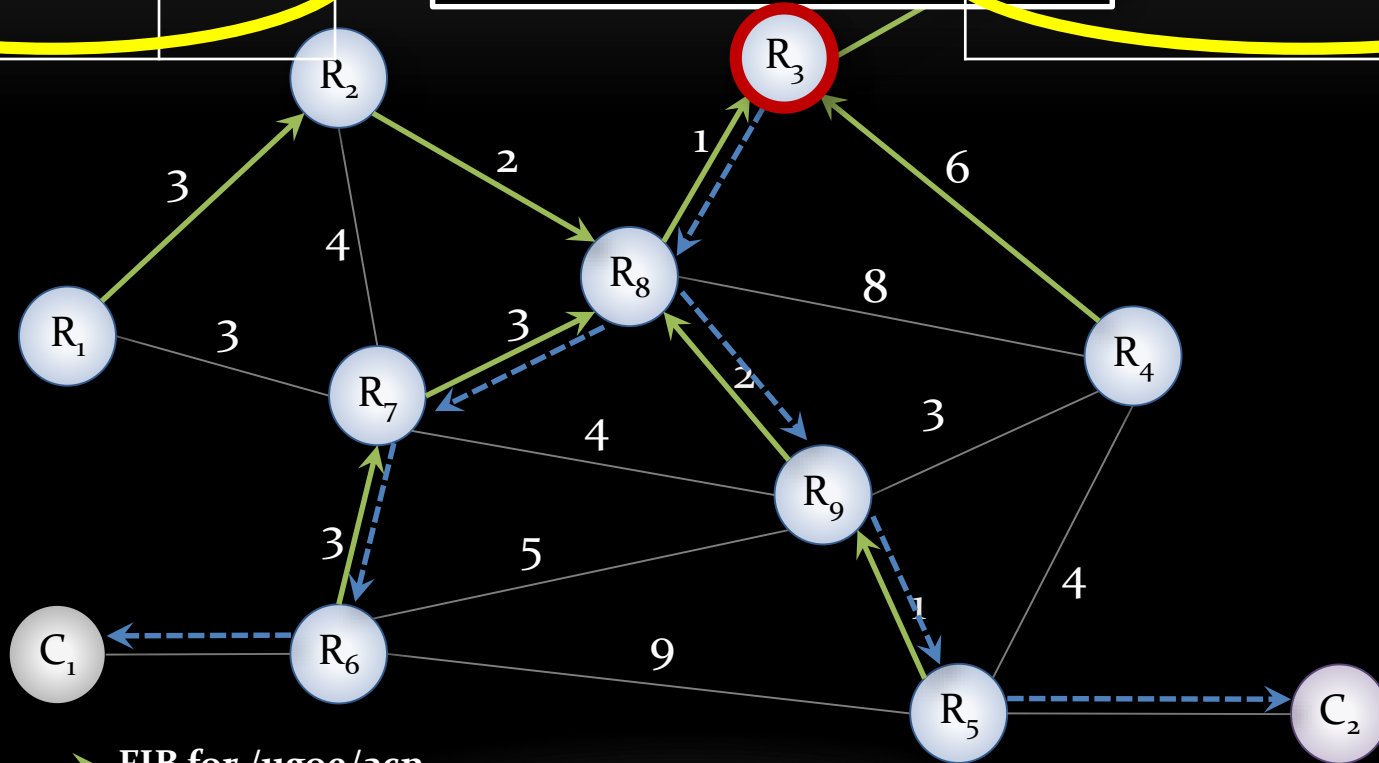
PIT of R₃

Prefix	Face
/ugoe/acn/icn_1.pdf	R ₈

Content Store of R₃

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

Data: "/ugoe/acn/icn_1.pdf/_v1/_s1"

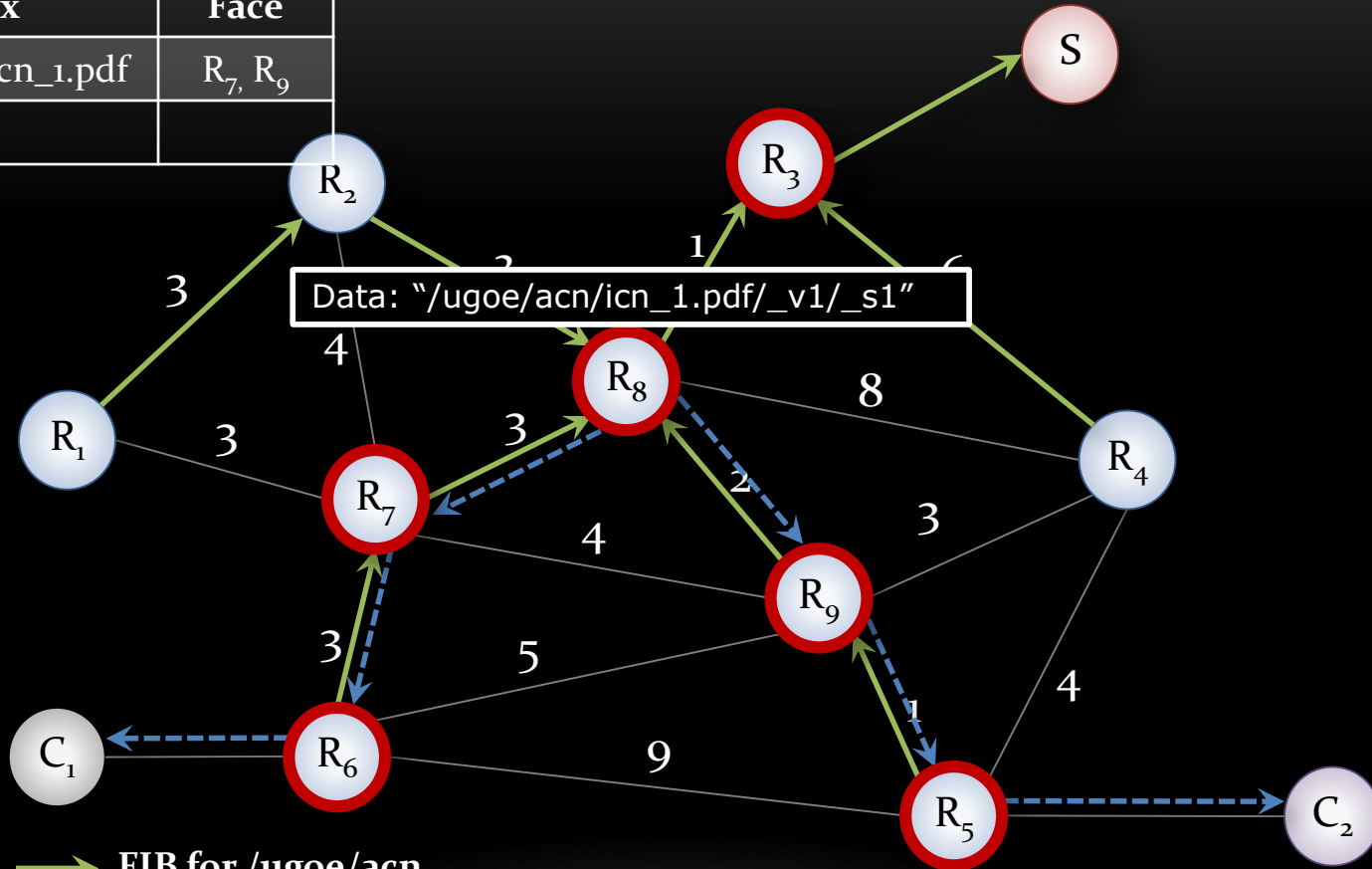


- FIB for /ugoe/acn
- - -> PIT for /ugoe/acn/icn_1.pdf

DATA FLOW IN NDN – RESPOND A DATA

PIT of R_8

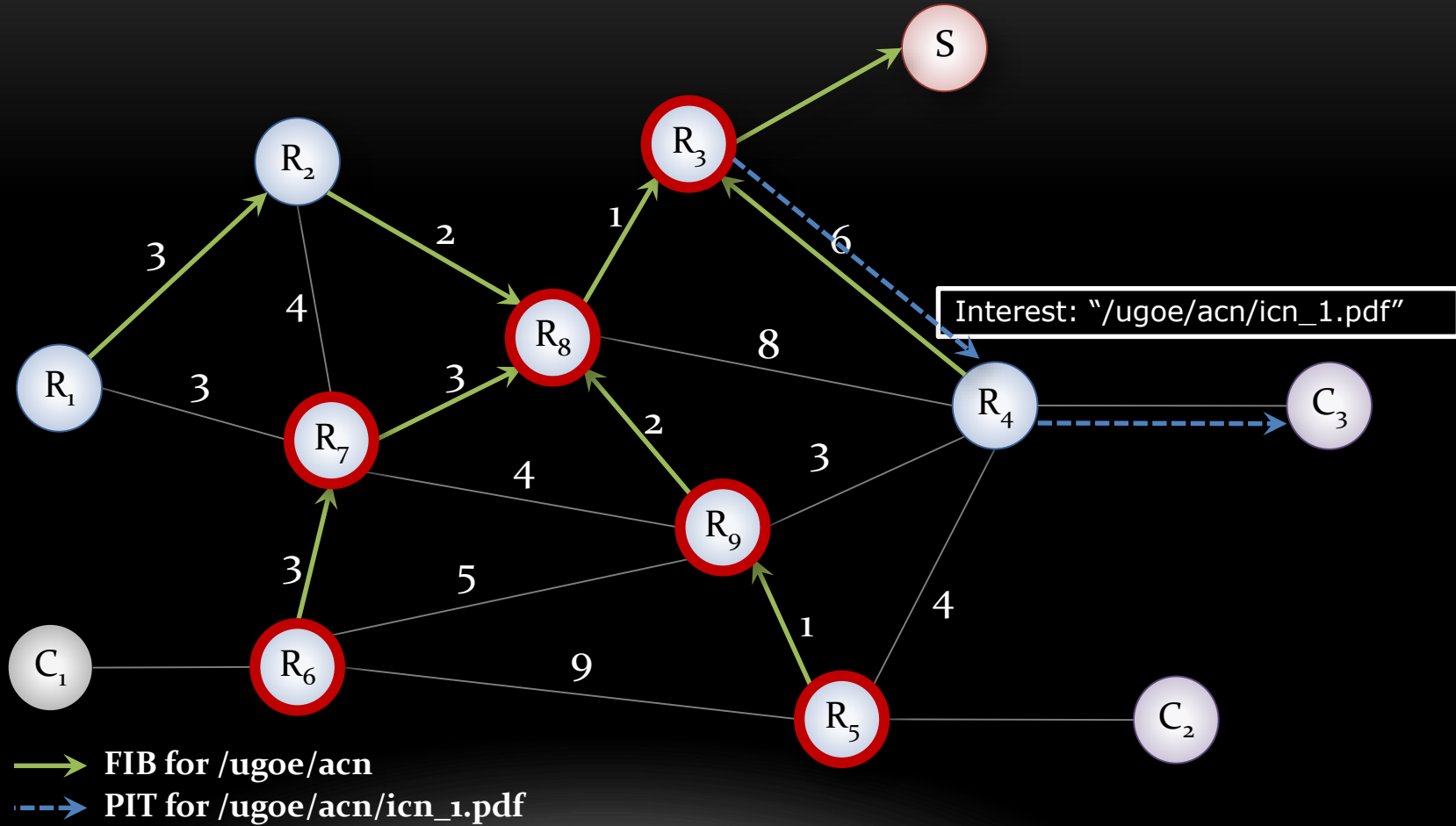
Prefix	Face
/ugoe/acn/icn_1.pdf	R_7, R_9



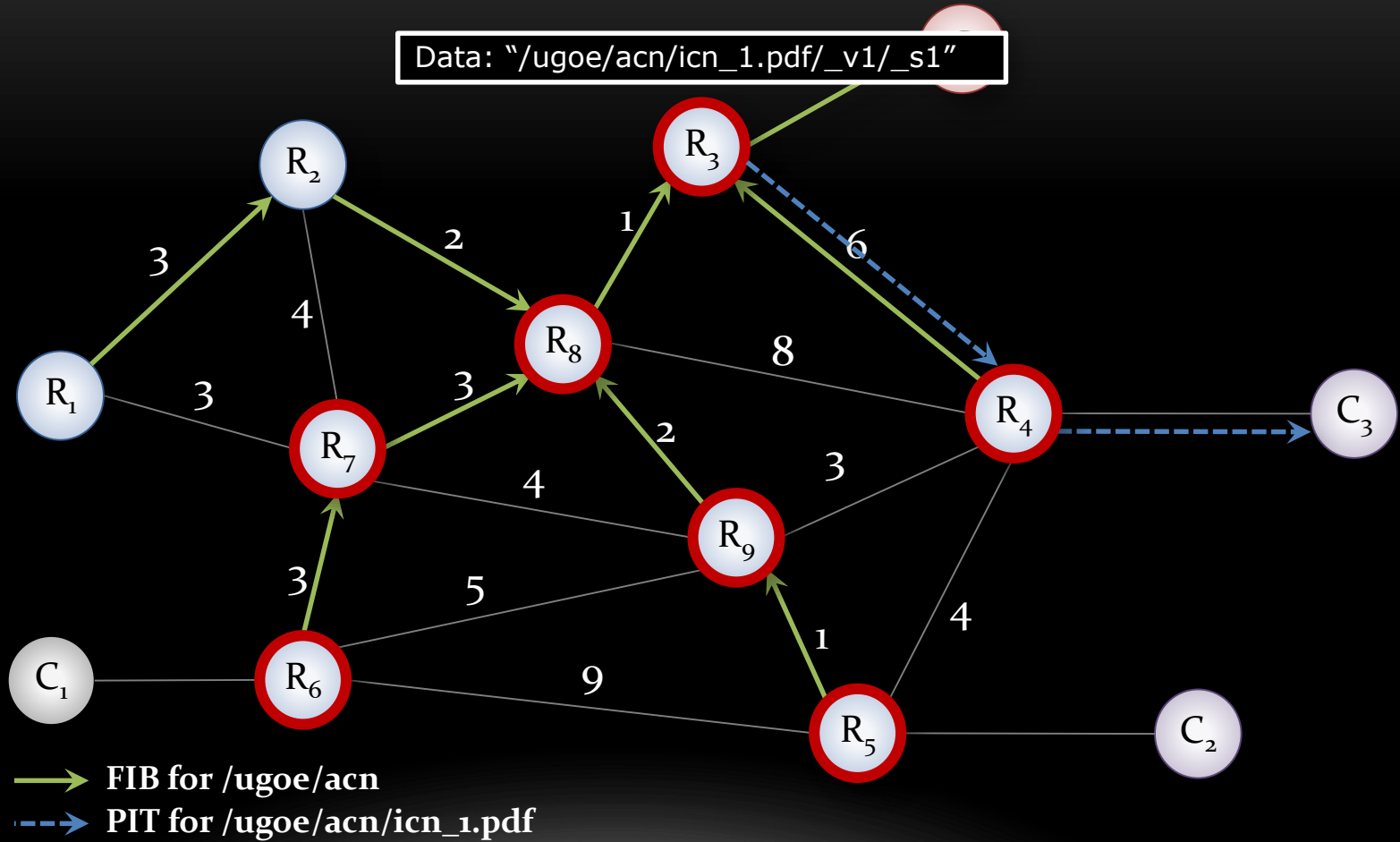
→ FIB for /ugoe/acn

---> PIT for /ugoe/acn/icn_1.pdf

DATA FLOW IN NDN – FURTHER REQUESTS



DATA FLOW IN NDN – FURTHER REQUESTS



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

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

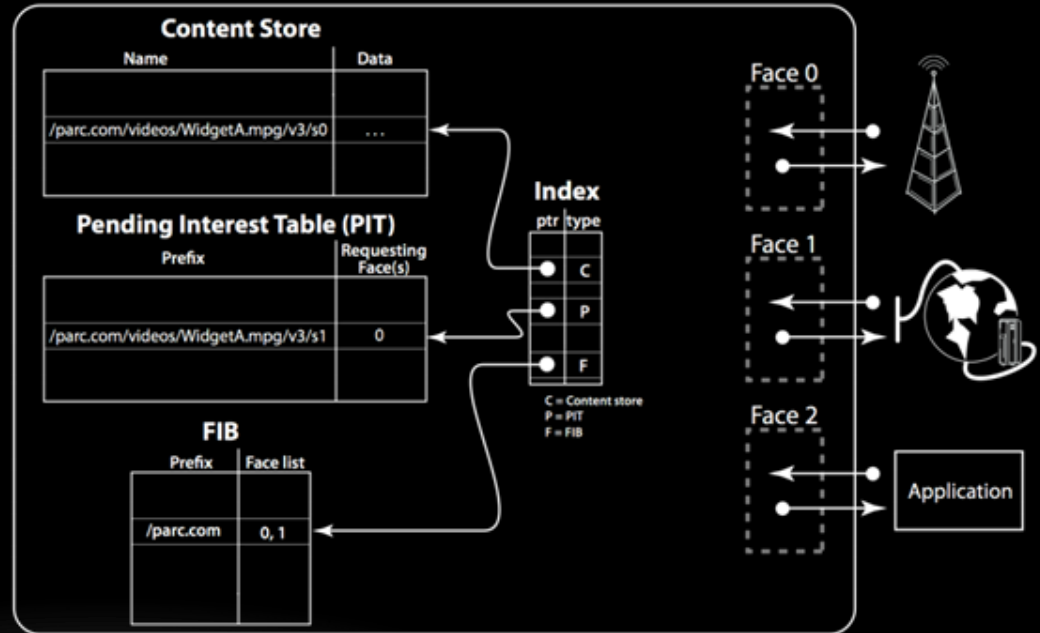
Interest (Request)

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

Data (Response)

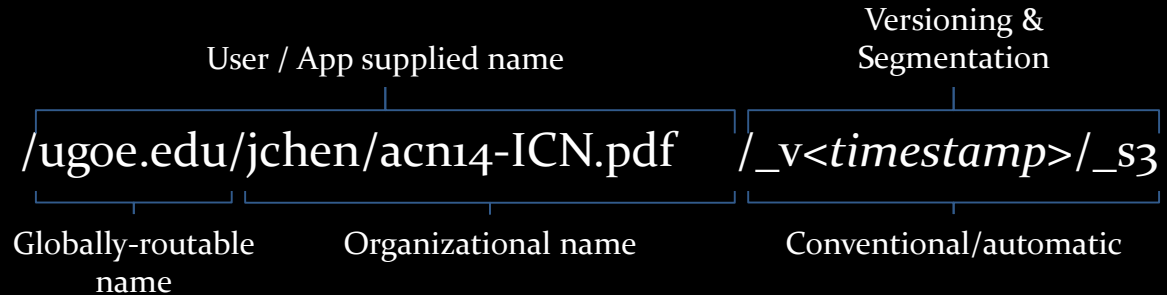
FORWARDING ENGINE

- 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



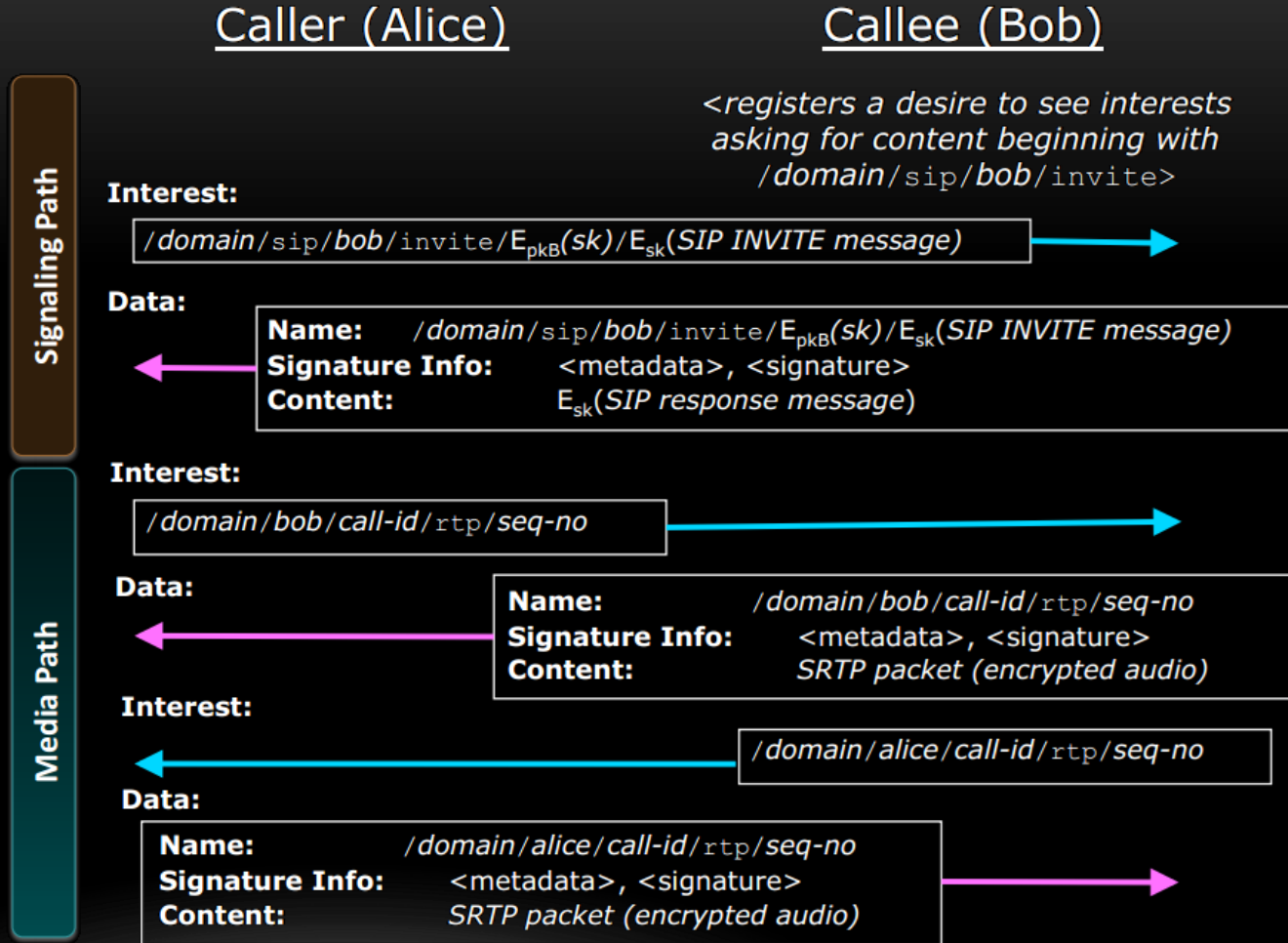
DISCUSSION 1: FLOW CONTROL

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



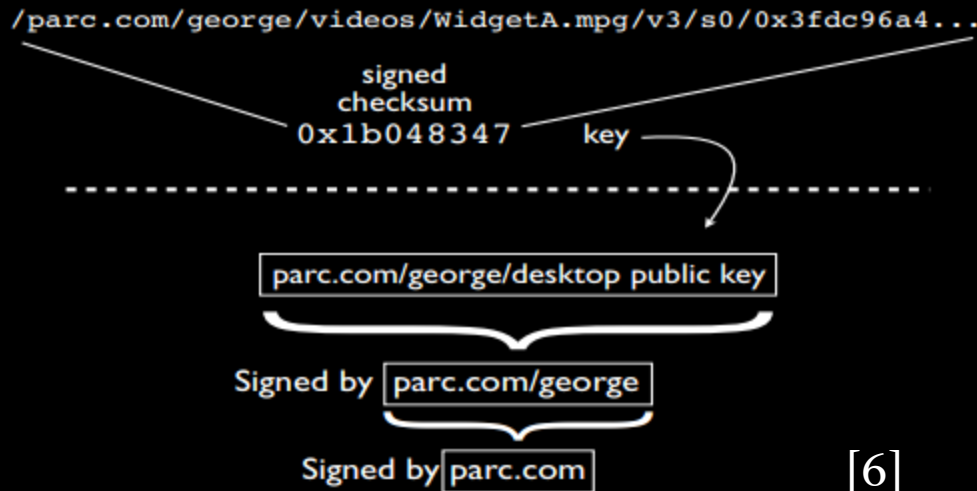
DISCUSSION 1: FLOW CONTROL

- Example: VoCCN [11]



DISCUSSION 2: TRUST

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



[6]

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

Data (Response)

REVIEW

- **Why CCN?**
 - User behavior is already Content-Centric
 - But Network is still Location based
 - The add-on systems to mitigate the mismatch also introduces overhead

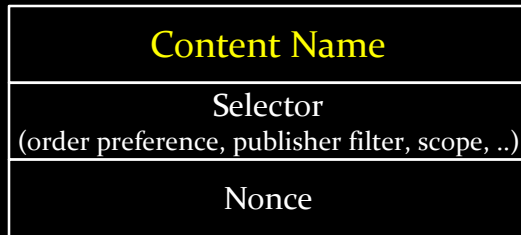
REVIEW

- Why CCN?
- **How does NDN achieve Content-Centric? (protocol level)**

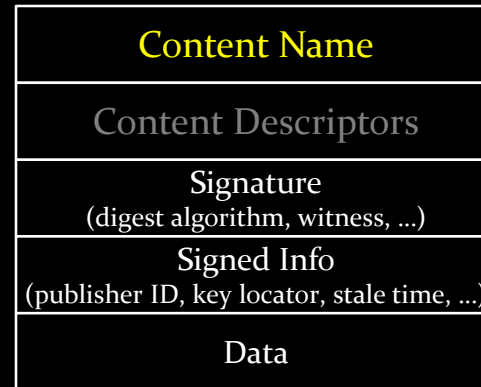


REVIEW

- Why CCN?
- How does NDN achieve Content-Centric? (protocol level)
- **What are the 2 packet types in NDN? Why NDN is inherit query/response?**



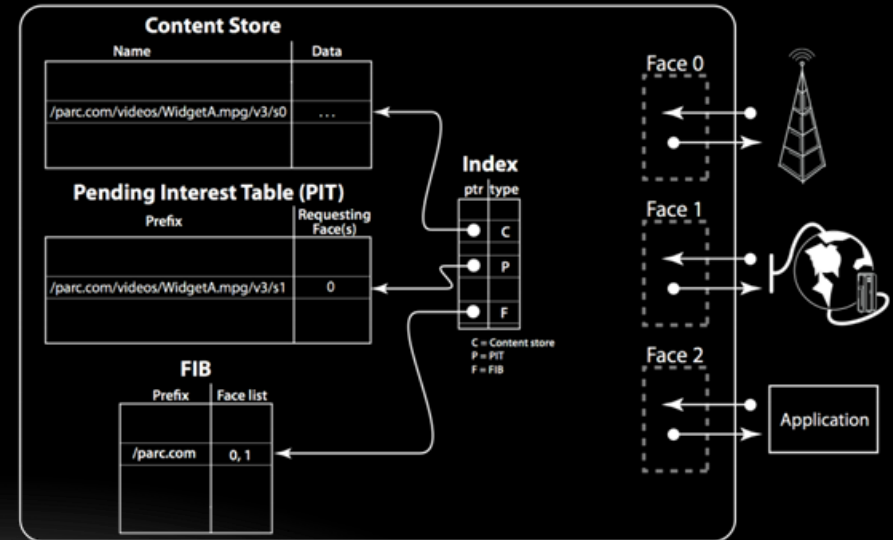
Interest (Request)



Data (Response)

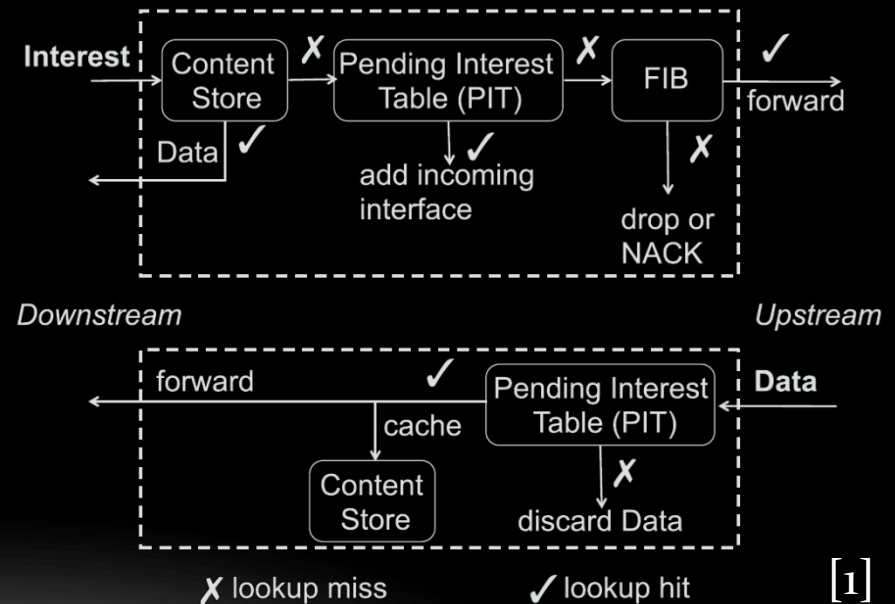
REVIEW

- Why CCN?
- How does NDN achieve Content-Centric? (protocol level)
- What are the 2 packet types in NDN? Why NDN is inherit query/response?
- **What are the data structures in a NDN forwarding engine? And functions?**
 - Forwarding Information Base (FIB)
 - Pending Interest Table (PIT)
 - Content Store



REVIEW

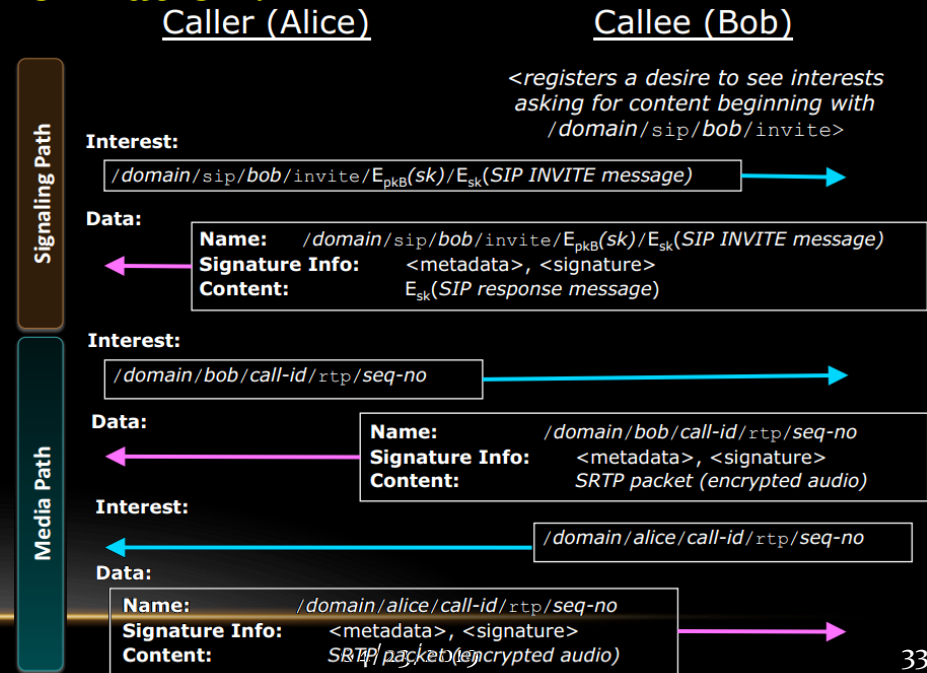
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[1]

REVIEW

- Why CCN?
- How does NDN achieve Content-Centric? (protocol level)
- What are the 2 packet types in NDN? Why NDN is inherit query/response?
- What are the data structures in a NDN forwarding engine? And functions?
- **Can NDN transfer live audio/video information?**
 - Yes, VoCCN does it.



REVIEW

- Why CCN?
- How does NDN achieve Content-Centric? (protocol level)
- What are the 2 packet types in NDN? Why NDN is inherit query/response?
- What are the data structures in a NDN forwarding engine? And functions?
- Can NDN transfer live audio/video information?
- **Is query/response enough for Internet use?**

REFERENCES

1. Koponen, Teemu, et al. “A data-oriented (and beyond) network architecture.” *ACM SIGCOMM Computer Communication Review*. Vol. 37. No. 4. ACM, 2007.
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.