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Information-Centric Networking

From Point-to-Point Communication To Content Distribution

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Content

- Motivation & Key Components
- Naming Schemes
- Routing & Mobility
- In-Network Caching
- Well-Known Designs
- Service-Centric Networking

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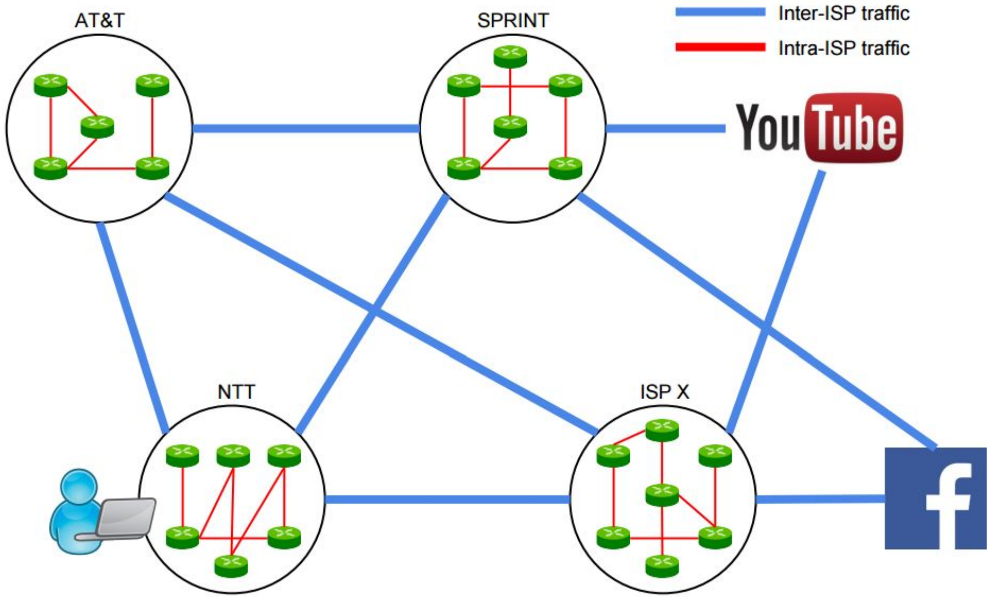
The Big Picture of Today's Internet

A very high-level abstraction of current Internet: ISPs are interconnected with each other, along with big service providers. End-users are attached to various ISP networks.



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Why Content Networking Is Proposed?

- Content distribution is the primary task for today's Internet. E.g., the estimated video traffic will reach 79% of the Internet traffic by 2018.
- Traditional paradigm of communication network is Point-to-Point.
- Point-to-Point paradigm has many drawbacks when dealing with large-scale content distribution - efficiency, security and privacy.

Content consumer only cares what it is instead of where it is from.

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The Key Architectural Components

ICN is a clean-slate redesign of the current Internet infrastructure,

- Content is accessed by name.
- Caching is universal in the network.

ICN tries to solve the problems confronting the current Internet, e.g., content distribution efficiency, security, network congestion and etc.

Meanwhile, ICN also poses new challenges on cache management, content addressing, routing and etc.

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Before We Continue, Remember

- ICN is not a silver bullet.
- There is no one-fits-all solution in system which gives you all the benefits (e.g. efficiency, simplicity, scalability, security, privacy, adaptability, so on and so on).
- We always need to balance different trade-off in engineering.
- System building is both art and science!

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The Quandary Betw. Locator and Identifier

- We need two mappings from Identifier → Locator → Path.
- It's all about "finding a path to what you want", which, we have been doing for thousands of years in different forms …
  - Human society in old days: social knowledge, real map.
  - Telephone system: yellow book, human operator.
  - Internet: DNS, various routing algorithms.

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How Do You Actually Name Content?

Three naming schemes in ICN, two dominate the literature.

- Hierarchical naming:
  - similar to nowadays DNS,
  - correlates to underlying network topologies.
- Flat naming:
  - usually done by hashing,
  - self-certified.
- Attribute-based naming:
  - more expressive, richer in semantic structures,
  - can combine with previous two naming schemes.

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Which Is the Best Naming Scheme?

- Recall, “No silver bullet in system engineering!”
- Each scheme has its own pros and cons:
    - routing complexity
    - scalability
    - security
    - expressiveness

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How A Request/Interest Is Routed?

- Recall, there are always two basic functionality
  - Name resolution: identifier → locator
  - Routing: locator → path
- How routing is done depends on ICN architectures.
  - Source routing: PURSUIT
  - Hop-by-Hop routing: CCN
  - DHT-like routing: MDHT

How Mobility Is Handled in ICN?

- Receiver mobility is trivial. It is inherently handled by design.
- Publisher (or source) mobility is non-trivial.
- Simultaneous handoff makes life even more complicated!

	Avg. Latency	Handoff Delay	Simultaneous Handoff	Scalability	Single Point of Failure	Complexity
MobiCCN	Medium	Low	Yes	High	No	Medium
Sender-Driven Msg	Low	High	No	High	No	Low
Rendezvous Point	Low	Medium	Yes	Medium	Yes	Low
Indirection Point	High	Medium	Yes	Low	Yes	High
Interest Forwarding	Medium	Low	Yes	Medium	No	High

TABLE III: Comparison of different mobility schemes

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Why In-Network Caching Is Different?

The fundamental difference between a single cache and a cache network:

The topological structure becomes a system parameter in ICN designs.

• Content caching	≠	Content addressing
• Effective capacity	≠	Aggregated cache size
• Local optimum	≠	Global optimum

The whole system should not be treated as a simple "entity", we need examine the internal topological structures of a cache network.

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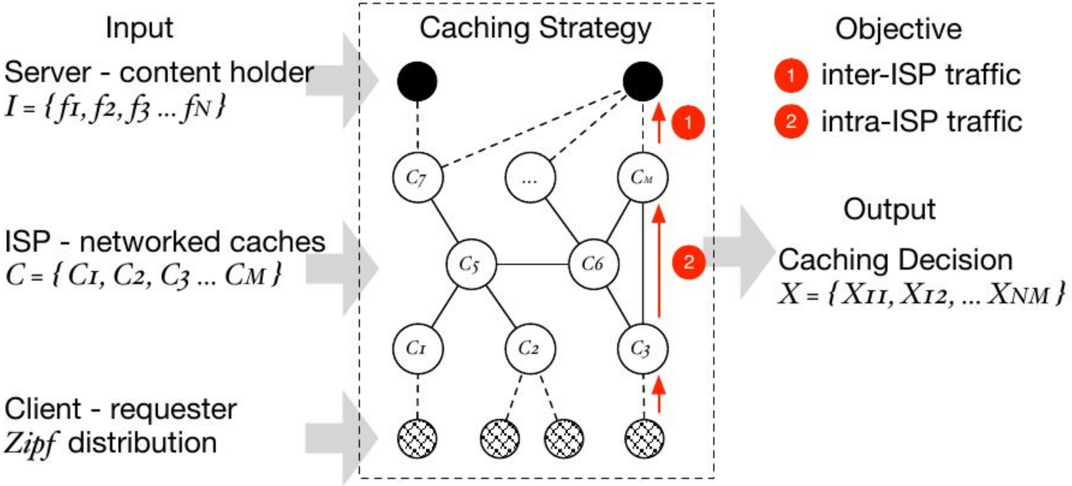
Model of In-Network Caches

Given a group of networked caches, how to utilize them smartly and efficiently in order to push the system to its optimal state?



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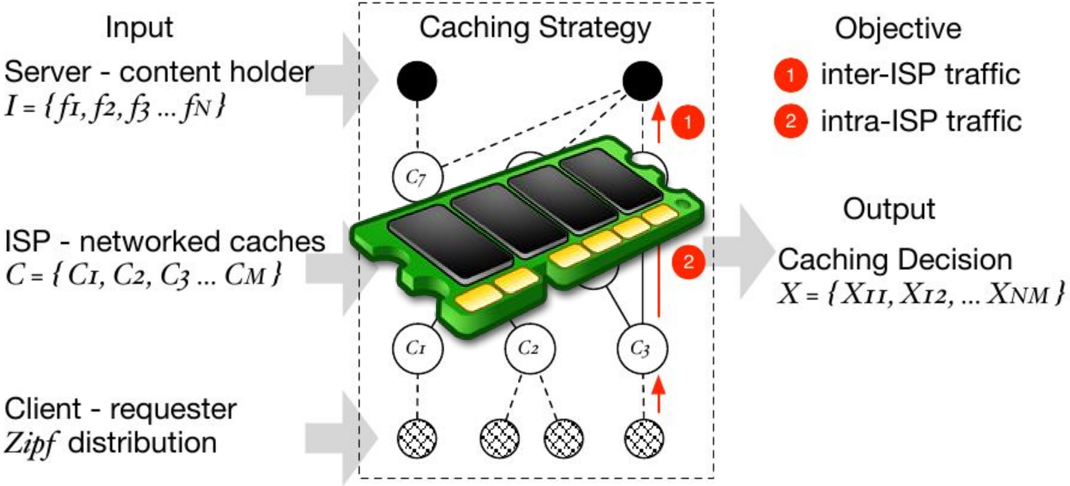


Collaborative In-Network Caching

What is purpose of collaboration?

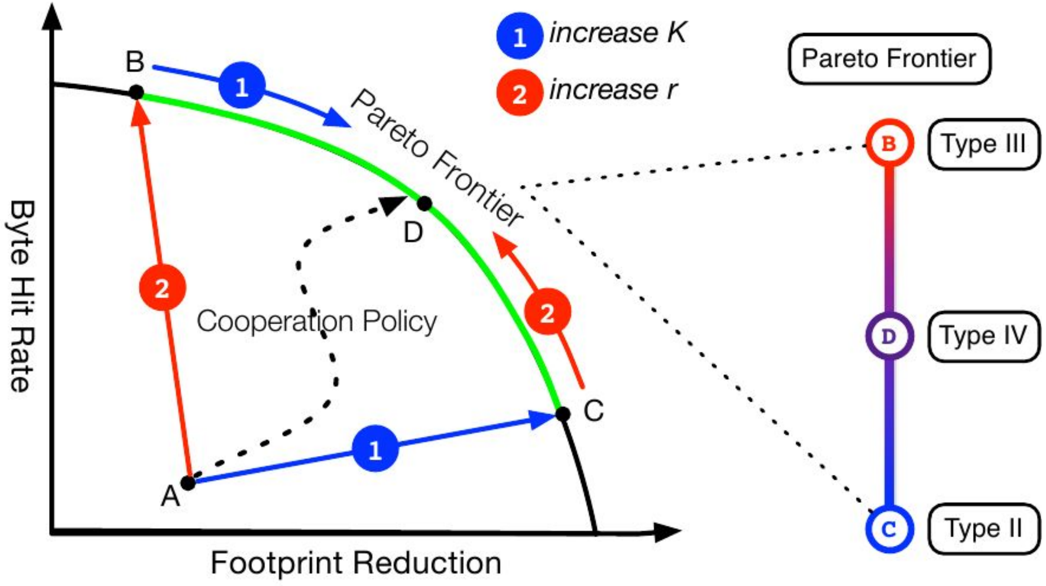
- Discovering content;
- Reducing duplicates.

How expensive is the collaboration?

- For global optimal solution;
- For off-path collaboration.

How effective is the collaboration?

- Filtering effect.



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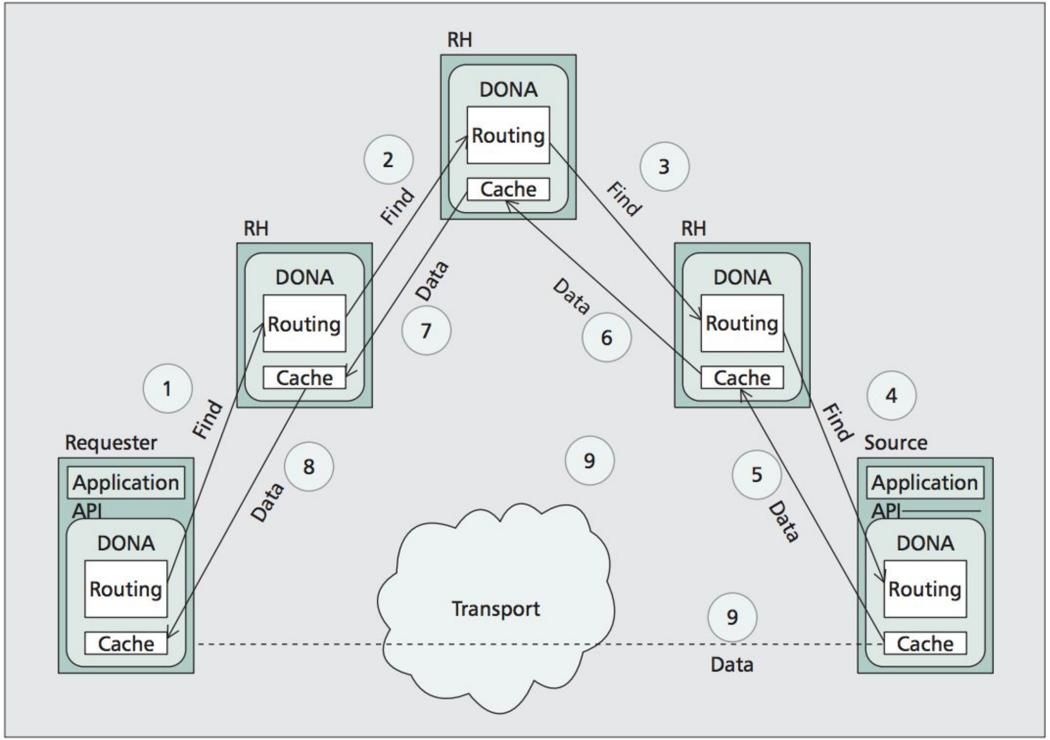
Well-Known Designs - DONA



Ahlgren, Bengt, et al. "A survey of information-centric networking."*Communications Magazine, IEEE* 50.7 (2012): 26-36.

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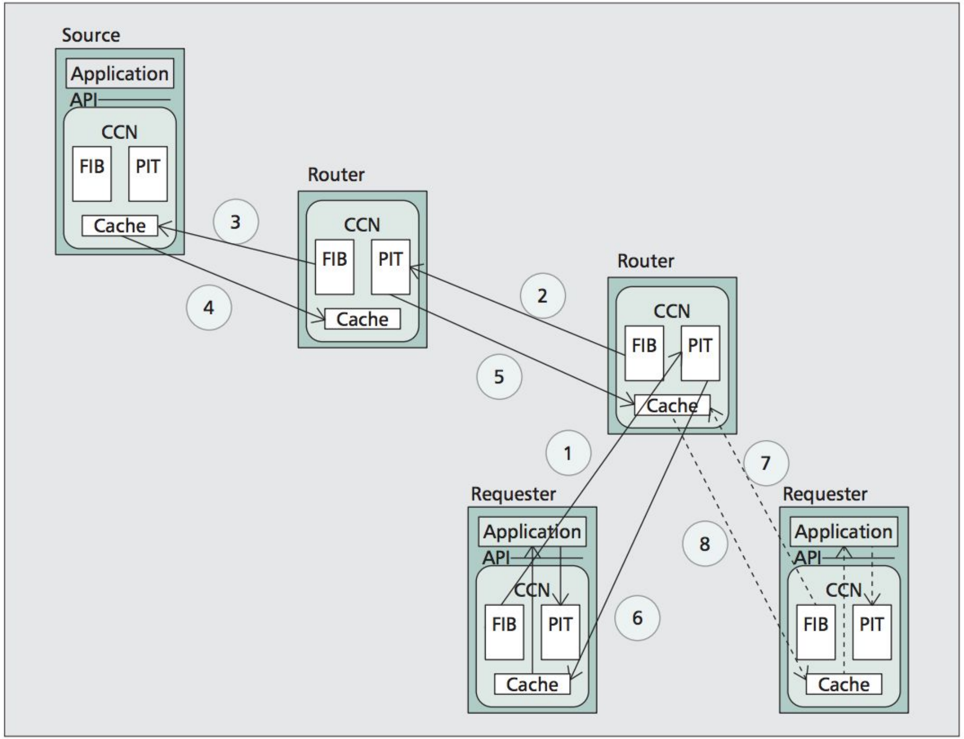
Well-Known Designs - CCN



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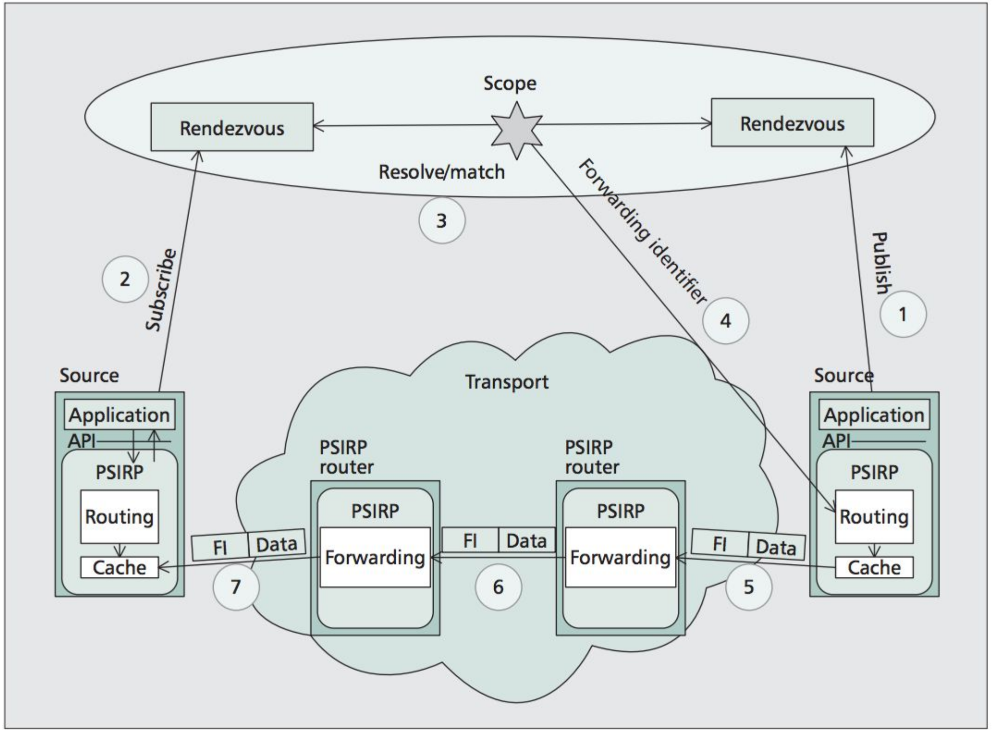
Well-Known Designs - PSIRP



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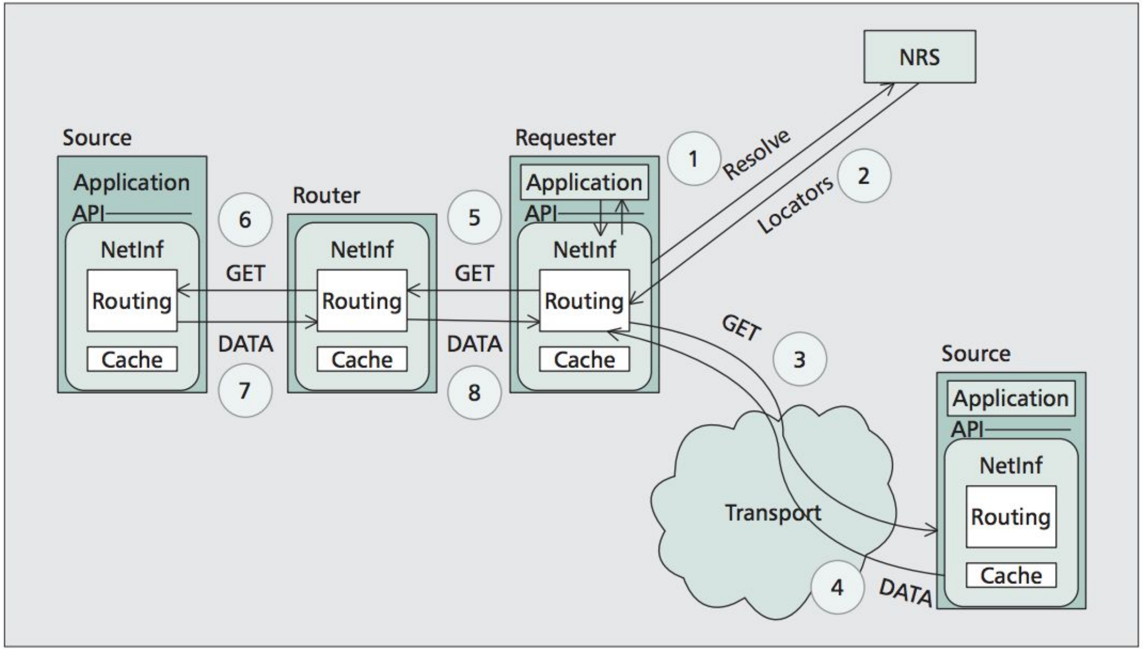
Well-Known Designs - NetInf



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Architectural Comparison

	DONA	CCN	PSIRP	NetInf
Namespace	Flat with structure	Hierarchical	Flat with structure	Flat with structure
Name-data integrity	Signature, PKI independent	Signature, external trust source	Signature, PKI independent	Signature or content hash, PKI indep.
Human-readable names	No	Possible	No	No
Information abstraction model	No	No	No	Yes
NDO granularity	Objects	Packets	Objects	Objects
Routing aggregation	Publisher/explicit	Publisher	Scope / explicit	Publisher
Routing of NDO request	Name-based (via RHs)	Name-based	NRS (rendezvous)	Hybrid NRS and name-based
Routing of NDO	Reverse request path or direct IP connection	Reverse request path using router state	Source routing using Bloom filter	Reverse request path or direct IP connection
API	Synchronous get	Synchronous get	Publish/subscribe	Synchronous get
Transport	IP	Many including IP	IP/PSIRP	Many including IP

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From Static Content to Dynamic Service

- Information should **not** only refer to static content.
- Recursive definition: Information = f(Information).
- f is a service which filters, edits, combines existing information to provide new information.

What Are the Benefits of Service Caching?

- Better localised communication: latency, bandwidth, availability …
- Better control on sharing conventional static content.
- Flexible policy configuration but with simpler architecture.
- Key services in emergency and disaster scenarios.
- Efficient access to popular Internet cloud-based services.

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A Glimpse on Service-Centric Networking

Thank you. Questions?

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Conclusion