15-744: Computer Networking

L-18 Data-Oriented Networking

Readings

- Required:
  - CCN
  - 2 sections of DONA
  - 2 sections of RE
- Optional reading:
  - DOT

Outline

- DOT
- DONA
- CCN
- RE

Data-Oriented Networking Overview

- In the beginning...
  - First applications strictly focused on host-to-host interprocess communication:
    - Remote login, file transfer, ...
  - Internet was built around this host-to-host model.
  - Architecture is well-suited for communication between pairs of stationary hosts.
- ... while today
  - Vast majority of Internet usage is data retrieval and service access.
  - Users care about the content and are oblivious to location. They are often oblivious as to delivery time:
    - Fetching headlines from CNN, videos from YouTube, TV from Tivo
    - Accessing a bank account at “www.bank.com”.

To the beginning...

- What if you could re-architect the way “bulk” data transfer applications worked
  - HTTP
  - FTP
  - Email
  - etc.
- ... knowing what we know now?

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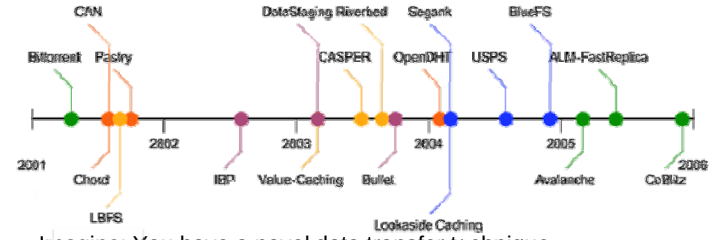
Innovation in Data Transfer is Hard



- Imagine. You have a novel data transfer technique
- How do you deploy?
  - Update HTTP. Talk to IETF. Modify Apache, IIS, Firefox, Netscape, Opera, IE, Lynx, Wget, …
  - Update SMTP. Talk to IETF. Modify Sendmail, Postfix, Outlook…
  - Give up in frustration

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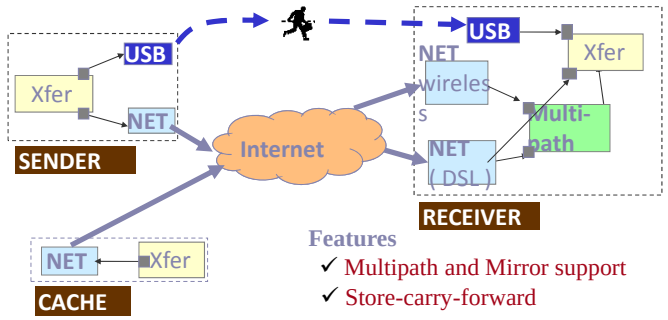
Data-Oriented Network Design



Features
- ✓ Multipath and Mirror support
- ✓ Store-carry-forward

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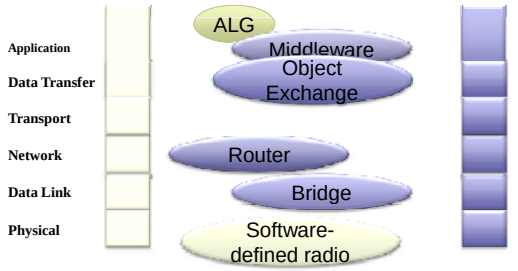
New Approach: Adding to the Protocol Stack



Internet Protocol Layers

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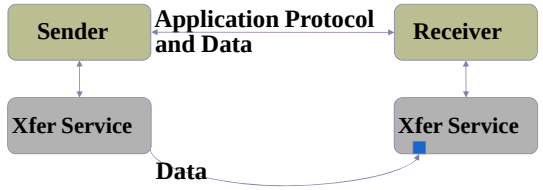
Data Transfer Service



- Transfer Service responsible for finding/transferring data
  - Transfer Service is shared by applications
- How are users, hosts, services, and data named?
- How is data secured and delivered reliably?
- How are legacy systems incorporated?

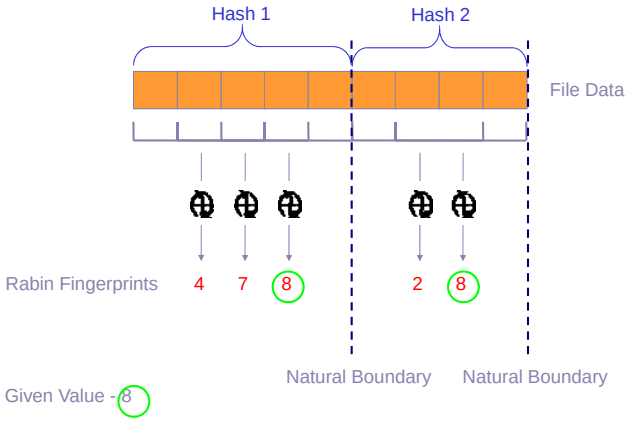
Naming Data (DOT)

- Application defined names are not portable
- Use content-naming for globally unique names
- Objects represented by an OID

- Objects are further sub-divided into “chunks”

- Secure and scalable!

Similar Files: Rabin Fingerprinting



Naming Data (DOT)

- All objects are named based only on their data
- Objects are divided into chunks based only on their data
- Object “A” is named the same
  - Regardless of who sends it
  - Regardless of what application deals with it
- Similar parts of different objects likely to be named the same
  - e.g., PPT slides v1, PPT slides v1 + extra slides
  - First chunks of these objects are same

Self-certifying Names

- A piece of data comes with a public key and a signature.
- Client can verify the data did come from the principal by
  - Checking the public key hashes into P, and
  - Validating that the signature corresponds to the public key.
- Challenge is to resolve the flat names into a location.

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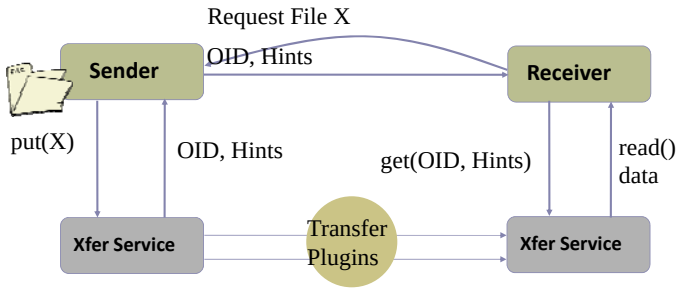
Locating Data (DOT)



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Outline

- DOT
- DONA
  - Slides David Naylor
- CCN
- RE

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Naming Data (DONA)

- Names organized around principals.
- Names are of the form P : L.
  - P is cryptographic hash of principal's public key, and
  - L is a unique label chosen by the principal.
- Granularity of naming left up to principals.
- Names are "flat".

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Name Resolution (DONA)

- Resolution infrastructure consists of Resolution Handlers.
  - Each domain will have one logical RH.
- Two primitives FIND(P:L) and REGISTER(P:L).
  - FIND(P:L) locates the object named P:L.
  - REGISTER messages set up the state necessary for the RHs to route FINDs effectively.

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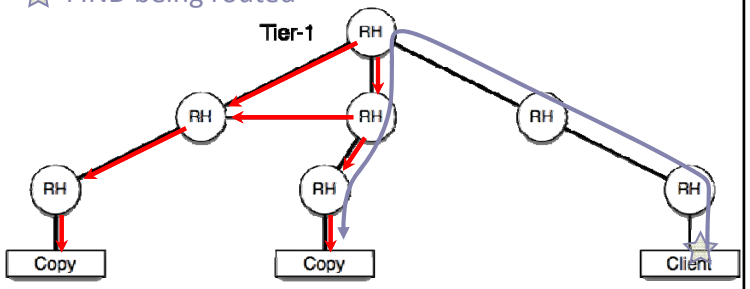
Locating Data (DONA)

REGISTER state

FIND being routed



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Establishing REGISTER state

- Any machine authorized to serve a datum or service with name P:L sends a REGISTER(P:L) to its first-hop RH
- RHs maintain a registration table that maps a name to both next-hop RH and distance (in some metric)
- REGISTERs are forwarded according to interdomain policies.
  - REGISTERs from customers to both peers and providers.
  - REGISTERs from peers optionally to providers/peers.

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Forwarding FIND(P:L)

- When FIND(P:L) arrives to a RH:
  - If there's an entry in the registration table, the FIND is sent to the next-hop RH.
  - If there's no entry, the RH forwards the FIND towards to its provider.
- In case of multiple equal choices, the RH uses its local policy to choose among them.

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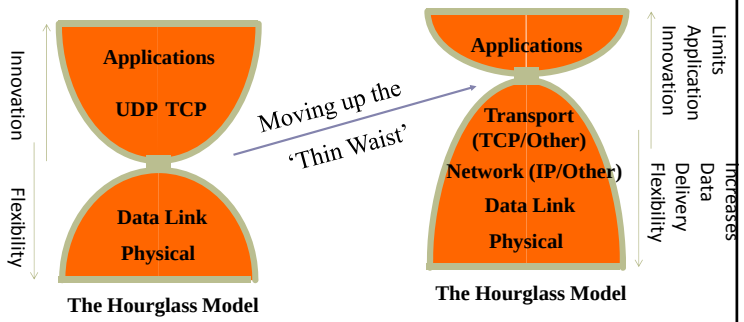
Interoperability: New Tradeoffs



Interoperability: Datagrams vs. Data Blocks

	Datagrams	Data Blocks
What must be standardized ?	IP Addresses Name→Address translation (DNS)	Data Labels Name → Label translation (Google?)
Application Support	Exposes much of underlying network's capability	Practice has shown that this is what applications need
Lower Layer Support	Supports arbitrary links Requires end-to-end connectivity	Supports arbitrary links Supports arbitrary transport Support storage (both in-network and for transport)

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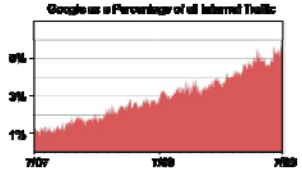
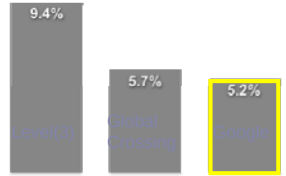
Google…



Biggest content source

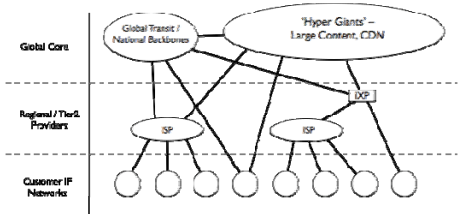
Third largest ISP



source: 'ATLAS' Internet Observatory 2009 Annual Report', C. Labovitz et.al.

1995 - 2007:
Textbook Internet

2009:
Rise of the
Hyper Giants



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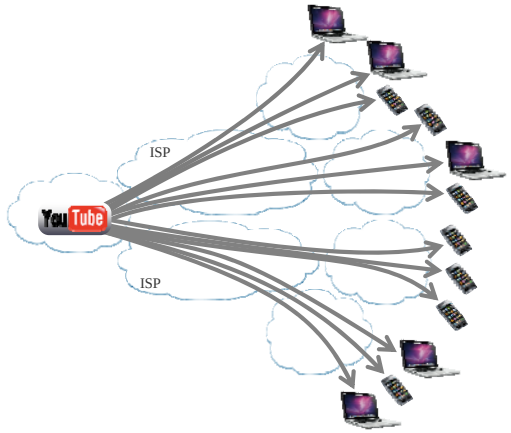
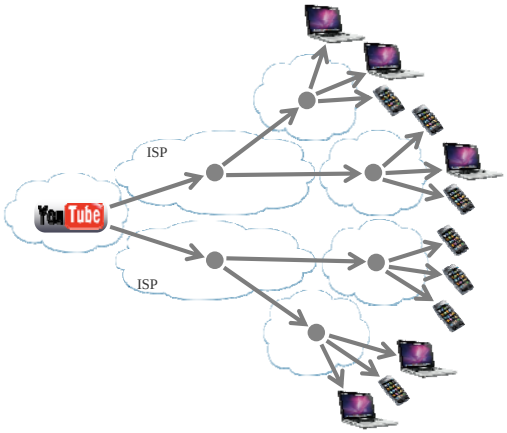
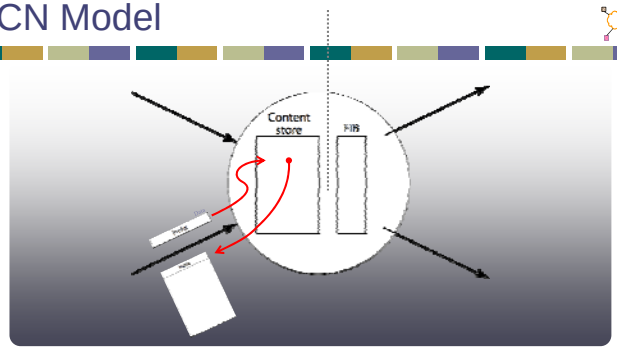
What does the network look like…



What should the network look like…



CCN Model



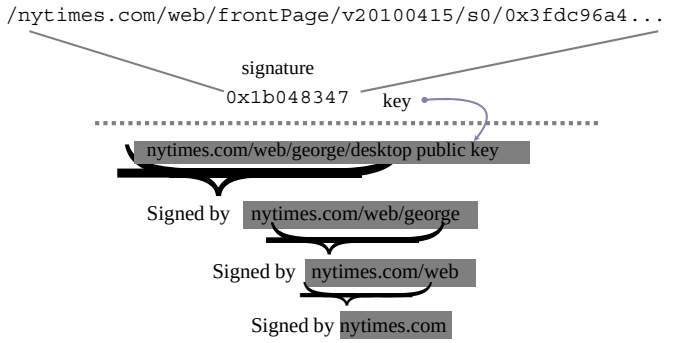
- Packets say 'what' not 'who' (no src or dst)
- communication is to local peer(s)
- upstream performance is measurable
- memory makes loops impossible

Context Awareness?

- Like IP, CCN imposes no semantics on names.
- 'Meaning' comes from application, institution and global conventions:

/parc.com/people/van/presentations/CCN
/parc.com/people/van/calendar/freeTimeForMeeting
/thisRoom/projector
/thisMeeting/documents
/nearBy/available/parking
/thisHouse/demandReduction/2KW

CCN Names/Security

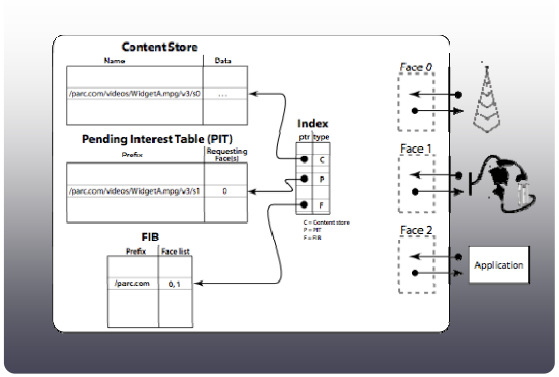


- Per-packet signatures using public key
  - Packet also contain link to public key

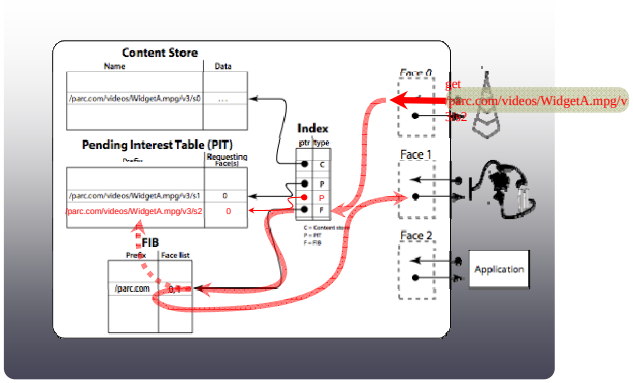
Names Route Interests

- FIB lookups are longest match (like IP prefix lookups) which helps guarantee log(n) state scaling for globally accessible data.
- Although CCN names are longer than IP identifiers, their explicit structure allows lookups as efficient as IP's.
- Since nothing can loop, state can be approximate (e.g., bloom filters).

CCN node model



CCN node model

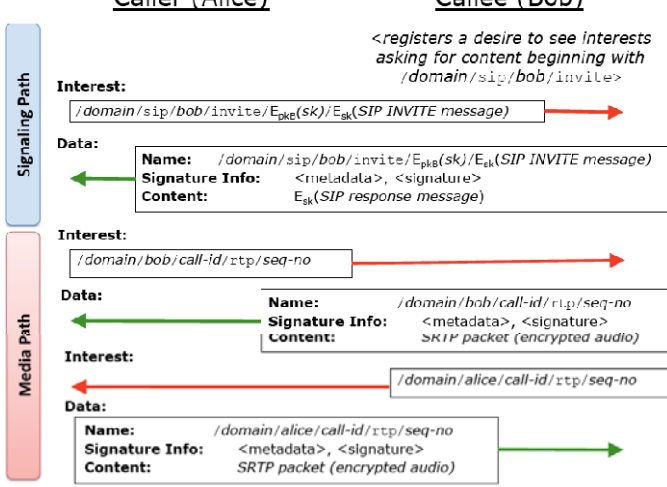


Flow/Congestion Control

- One Interest pkt → one data packet
- All xfers are done hop-by-hop – so no need for congestion control
- Sequence numbers are part of the name space

What about connections/VoIP?

- Key challenge - rendezvous
- Need to support requesting ability to request content that has not yet been published
- E.g., route request to potential publishers, and have them create the desired content in response



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  - See slides Favonia

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“But ...

- “this doesn’t handle conversations or realtime.
  - Yes it does - see ReArch VoCCN paper.
- “this is just Google.
  - This is IP-for-content. We don’t search for data, we route to it.
- “this will never scale.
  - Hierarchically structured names give same log(n) scaling as IP but CCN tables can be much smaller since multi-source model allows inexact state (e.g., Bloom filter).