Named data networking

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CMPSCI 691– Content-oriented Networking (Spring 2014)
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(based on Van Jacobson’s and Lixia Zhang)
Outline

- Motivation
  Why the Internet model is now inadequate
- Named Data Networking
  Architecture, packet forwarding, security, etc
- Experiments and results
- Pros and Cons
- Discussion
How do we use the Internet today?

Major fraction of traffic is

- Video streaming (e.g., Netflix, YouTube)
- File sharing (P2P networks)
Communication model is based on the past

- 60’s/70’s: resources were scarce; connected to a server shared by many terminals
- User access a server to use a resource

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Current model is “inadequate”

- Users want to access **content**
  - Yet the Internet talks in terms of “locations”
  - Users and servers can move

  **Content as first-class citizen**

- Some content are extremely popular
  - As Internet sees pairwise connections, it is oblivious to the content that traverses it

  **No longer point-to-point delivery**

- Security mechanisms are “cumbersome”

**Built-in security**
Named data networking

- Proposal for an alternative paradigm to the current Internet architecture
- Initially developed at PARC by Van Jacobson
- Key ideas:

CONTENT DISTRIBUTION
CCN requires pieces of content to be requested explicitly. Pub/Sub model has been proposed as enhancement.
CCN overview

Data:
/umass/videos/
CCN-lect01.mp4
[content]

I have
/umass/videos

Interest:
/umass/videos/
CCN-lect01.mp4

Interest:
/umass/videos/
CCN-lect01.mp4

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How large forwarding tables would be in practice?
CCN packet types

Content-Centric Networking

CCN Packets:

- Consumers send **interest packets** to content identified by name; nodes that have it reply w/ **data packet**

- **Hierarchical** and **Context-dependent** name prefixes (e.g., /local/Friends)

- **Nonces** (random numbers) to prevent interests from looping
How does a CCN router decide to route packets?
**Forwarding in CCN (Jacobson)**

### Content Storage

<table>
<thead>
<tr>
<th>Name</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>/youtu.be/bailey.mpg/v3</td>
<td>data</td>
</tr>
</tbody>
</table>

### Pending Search Table

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Port</th>
</tr>
</thead>
<tbody>
<tr>
<td>/youtu.be/bailey.mpg/v3</td>
<td>0 2</td>
</tr>
</tbody>
</table>

### Forwarding Table

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Port</th>
</tr>
</thead>
<tbody>
<tr>
<td>/youtu.be/</td>
<td>0,1</td>
</tr>
</tbody>
</table>

### Diagram

- **Port 0**: Get /youtu.be/bailey.mpg/v3
- **Port 1**: Data
- **Port 2**: Get /youtu.be/bailey.mpg/v3

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Web Cache (Proxy caching)

content storage

<table>
<thead>
<tr>
<th>Destination/file</th>
<th>content</th>
</tr>
</thead>
<tbody>
<tr>
<td>/youtu.be/bailey.mpg</td>
<td>data</td>
</tr>
</tbody>
</table>

pending search table

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</thead>
<tbody>
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<td>0</td>
</tr>
</tbody>
</table>

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Pending search table and “bread crumbs”

- What happens if A and B have the content? If interest sent through both faces, only 1st data packet is returned; is the bandwidth wasted?
- Why no interest loops can occur?
Quick review of last slides

- **Stateful** routers
- **Interest** is *routed*, not **data** (breadcrumbs)
- **Duplicate** data packets are **discarded**
- **Nonces** (random numbers) prevent interest packets from looping
- Multiple faces can be used in parallel to retrieve data to multiple requesters
CCN supports/has TCP-like features

Reliability:
- Application resends requests, more flexible
  E.g., app needs reliable communication (libraries)
- Similar to TCP SACK

Flow Control:
- At most one data packet per interest packet
- TCP window advertisements -> Interest packets
Other layers

*Strategy layer* (program in Forwarding Table describing how to use faces)

- Multiple faces in a “forward entry”
  - sendToAll (broadcast), sendToBest (opportunistic routing)

*Routing:*

- Any routing scheme that works well for IP
  - IP and CCN forwarding are based on prefixes
- Multi-sources, multi-destinations
- Compatible with IP-based routers (CCN route announcements discarded)
CCN Security Model

**IP Networking**
- Point-to-point
- Secure the channel

**Content-Centric Networking**
- Name associated to key
- Sign data at creation time
- Asymmetric keys
Ad hoc networking, mobility

- Two mobile nodes communicate as soon as they can physically reach each other

- CCN can provide streaming to nodes on the move
What if the “content” moves?

Forwarding tables of some routers must be updated

- How does it affect forwarding table sizes?
- How long does it take?
- How many routers get affected?

It depends on the old/new locations, network topology and aggregatability of the prefix.

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Experiments

- **Experiment 1:**
  - How does it compare to TCP for unicast?

- **Experiment 2:**
  - What about multiple simultaneous transmissions?

- **Experiment 3:**
  - How well do voice calls work if client moving?
Experiment 1: “unicast” performance

- Performance of CCNd vs. ttcp for different amounts of pipelining

- Asymptotically comparable
- Gap due to headers
Experiment 2: “multicast” performance

Implicit assumption?
Clients are synchronized

Increasing number of clients, little increase in time
Problem with IP routing

OK, but we know that ISPs cache YouTube videos!

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Pros and Cons

- CCN is a clean-slate architecture to content-based network service
- Built-in security, multicast and multipath
- Facilitates mobility, ad hoc and DTN
- Preliminary experiments
- Not clear where the improvements come from
- Many open questions regarding feasibility
Discussion

- Do “performance improvements” justify deployment? What about mobility and security features?
- Incrementally deployable, but nodes in “bridged” CCN-capable ISPs will not see benefits
- What has to be changed in current routers?
- Forwarding tables can be huge – estimated 100M prefixes. Is it possible to build memories large and fast enough?
- How expensive?
  - Edge routers. Current: $300, CCN: +$31K (minimally +$4K)
  - Core routers. Current: $130K, CCN: +$130K
- Who is to regulate name choices?
- Is it ever going to take off?

See www.ccnx.org for prototype and more info

Three things to remember

- CCN is an alternative to today’s Internet architecture
Addressing Scheme

- Hierarchical names (components)
- Sequencing

How long does a cache look-up can take?
Interest flooding attack

Flooding: Generate a large number of interest packets to overwhelm content source’s

Defenses:
• Nodes can monitor how many interest pkts of the same prefix were successfully resolved
• Domain can ask downstream routers to throttle the number of interests they forward of the same prefix