Some Technical/Architectural Issues

Overview

- Update and discussion of some ongoing work
  - Packet format, system design, tech memos.
    - LINK, ENCAP, NACK
    - Routing scalability
    - Name discovery, selectors.
    - Variable-length header
    - Hop-by-hop fragmentation/reassembly
    - Implicit digest
    - Naming conventions
- Suggestions on new topics.

LINK

- LINK is a data packet whose payload contains multiple names that point to the same content.
- Example:
  - Files are published under /net/ndnsim,
  - but hosted by ATT, /att/user/alex/net/ndnsim
  - Consumers need to use the latter name to retrieve the content across the Internet.

LINK

Name of the link object (**/net/ndnsim/LINK**)
MetaInfo: **ContentType=LINK**, ….
Content**:** **alias 1, pref (/att/user/alex/net/ndnsim, 100)** **alias 2, pref**
Signed by the publisher of the LINK

- LINK is defined as a new ContentType.
  - Allow multiple aliases.
  - Support preference/weight for each alias.

ENCAP

- A general mechanism to encapsulate one or more packets under a different name.
  - A new ContentType
  - Each enclosed object is a complete packet on its own.
  - The outer signature covers the outer name and signatures of all the enclosed objects.

Name
MetaInfo: **ContentType=ENCAP**, …
Content: • **Object 1, Object 2, …**
Signature

ENCAP

- Example:
  - Return a chain of certificates in response to a key retrieval request.
- Example:
  - Interest /att/user/alex/net/ndnsim/a.cpp
  - Return an encapsulated packet that contains
    - Original data object (/net/ndnsim/a.cpp), and
    - The LINK object (/net/ndnsim <- /att/user/alex/net/ndnsim)
    - Under an outer name like
      - /att/user/alex/net/ndnsim/a.cpp/encap

Application NACK

- “Content doesn’t exist yet”
  - Published by the content producer
  - A new ContentType
    - Routers process it as a regular data packet.
      - Satisfy PIT, cache it, etc.
      - No need to explore alternative paths.
    - Consumer apps need to handle this NACK.
  - Meant to be used at time scale much longer than regular interest/data exchange.
    - App NACK vs. retx/refresh.

Application NACK

Name of this NACK object
MetaInfo: **ContentType=NACK**, ….
Content: • **Name (prefix) of non-existent content** • **A code of why the content is not available** • **Expiration time of this NACK**
Signed by the publisher

- Applications may add/remove what's in the content part. Need more experimentation.

Application NACK Example

- A NACK is published for a prefix
  - /ndnsim/src
- But an Interest asks for a specific piece of data
  - /ndnsim/src/a.cpp
- Need to encapsulate the NACK object in order to match the interest name.

Name /ndnsim/src/a.cpp/nack
MetaInfo: **ContentType=ENCAP**, …
Content: • **NACK (name=/ndnsim/src/nack, content, sig)**
signature

Network NACK

- Non-authoritative, generated by routers, repos, server replica, etc.
  - “cannot get the content, because of X”.
  - Downstream node should explore other paths upon receiving this NACK.
    - NACK only when exhausted all local options.
  - The reason “X” is important for downstream to react appropriately. For examples:
    - Link failure: don’t send future interests upstream.
    - Congestion: send to upstream with reduced rate.
    - Loop/duplicate: try an interest with different nonce.

Per-packet Network NACK

- Return the Interest packet to the downstream as a NACK
- Include the error code in the shim layer (layer 2.5)
- In-band, fine-grained feedback.

Layer 2.5: NACK and error code
Interest Name
Other fields
signature

Aggregated Network NACK

- Upstream and downstream neighbors run a control plane app, e.g., /localhop/feedback/…
- Send NACK information as regular interest/data exchange between the control processes.
- Provide out-of-band, aggregated feedback.
  - E.g., when the outgoing link at the upstream node fails, it can send this NACK to the downstream node to stop incoming traffic.
- Closely related to routing decisions and forwarding strategy.

Routing Scalability

- The problem: what if core routers can no longer hold all the content prefixes.
- The solution: map-and-encap
  - Only a subset of prefixes are allowed in DFZ routers. They're globally routable prefixes.
  - A distributed mapping system that given a content prefix will return one or multiple routable prefixes belong to ISPs hosting the content.
  - Interest is sent using the ISP/routable prefix to reach and retrieve the content. Returned data is encapsulated.

Data Encapsulation Approach

- Consumer app: /net/ndnsim/a.cpp
  - Should not be bothered with anything below.
- Consumer library/serivce/…
  - Look up the mapping system, get a LINK
    - /att/user/alex/net/ndnsim -> /net/ndnsim
  - Send interest with a routable prefix
    - /att/users/alex/net/ndnsim/a.cpp
    - Which prefix to use if multiple? Who makes the decision?
- Producer reply with encapsulated data
  - Need to know the ISP prefixes and register.
  - Think about a corporate network multihomed to several ISPs.
- How would selectors such as Exclude work if we modify the names?

Forwarding Hint Approach

- Keep the name intact: /net/ndnsim/a.cpp
- Consumer library/service …
  - Look up the mapping system, get a LINK
    - /att/user/alex/net/ndnsim -> /net/ndnsim
  - Send interest with original name
    - Attach the LINK object to the Interest.
- Routers lookup /att prefix if no route to /net/ndnsim.
  - Better routing decision in the network
- Producer reply with original data
  - No change to the logic, no encapsulation.
  - Better caching, multicast, etc.
- Colluded content poisoning?

Name Discovery

- If a consumer supplies the complete name, we only need exact match between interest/data.
- Name discovery problem: how to find out the complete name?
- A complete name usually contains components that need to be dynamically discovered.
  - E.g, Version, local context.
- Can we accomplish the discovery at the app layer rather than the network layer?
  - So the network layer only needs to support exact match.

Example: discovering versions

- When an app doesn't know the exact version number
  - E.g., the latest version of /nytimes.com/frontpage.

NDN's approach

- Allow the consumer to ask a vague question, i.e., an incomplete name.
  - E.g., /nytimes.com/frontpage/latest
- Any answer with a longer name will do.
  - E.g., /nytimes.com/frontpage/latest/v6
- Consumer uses selectors to narrow down to the data that it wants.

Alternatives

- Manifest
  - Publish manifest file that contains the complete names of all versions of /nytimes.com/frontpage. Retrieve the manifest first, then request desired page using complete name.
  - However, the manifest itself is just another piece of data, how to discover the latest version of the manifest?
- Can I request /nytimes.com/frontpage/latest and get the current latest page in return with the exact same name?
  - Then the page you got today and yesterday have different contents but share the same name.
- How about each node (cache) runs a service that periodically announces what contents it offers over the network?
  - Need to run this directory service
  - Doesn't work in wide-area network due to broadcast.

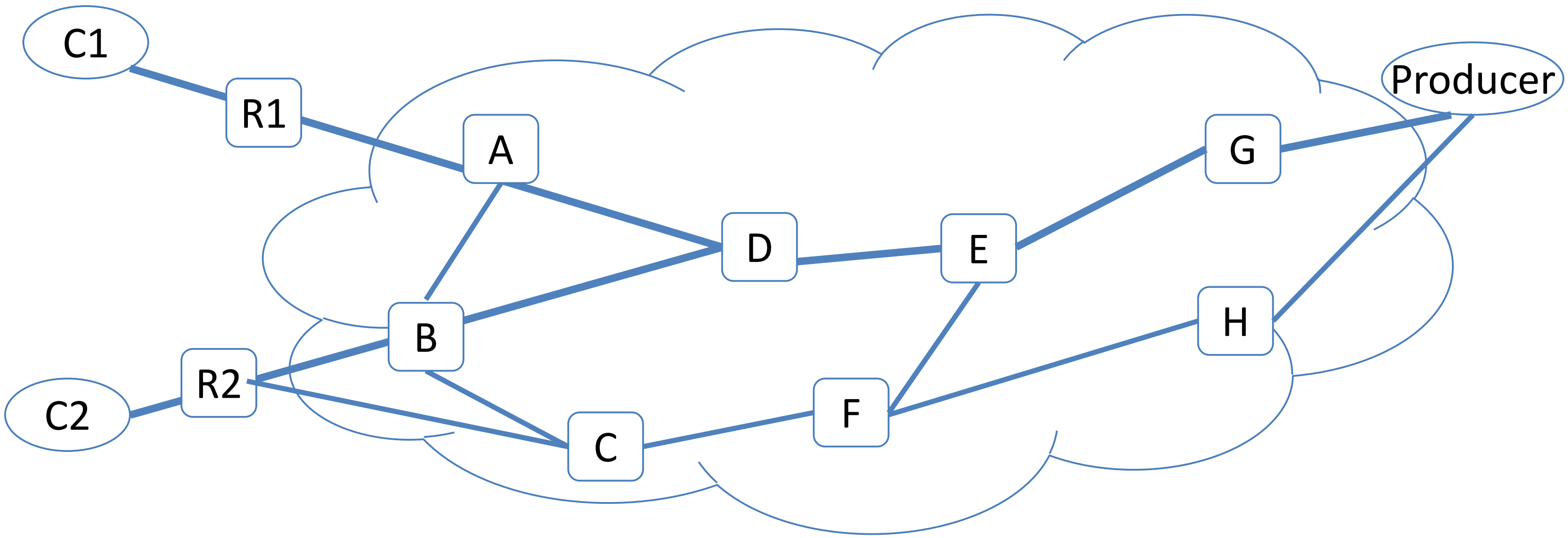
What can we do?

- Apps: minimize the use of name discovery.
  - E.g., limit it to manifest. The bulk retrieval is done using complete names.
- Routers
  - Can core routers ignore selectors?
- Architecture: examine existing selectors
  - Do we need them? Any better way to achieve the functionality?

Can core routers ignore selectors?

- Approach One
  - Core routers skip selector processing, skip CS for these packets, forward *all* interests carrying selectors without interest aggregation.
  - Edge routers and producers will still evaluate selectors.
  - May increase bandwidth use, and consumer delay, but should not impact system correctness.
- It works most of the time, but has a problem under certain conditions.

Selectors at core routers



- C1 and C2 are sending interests with the same name but different selectors.
- C2 could get starved under certain circumstances.

Can core routers ignore selectors?

- Approach Two
  - Consumer appends the hash (H) of the selector field to the interest name (N) to make it /N/H.
  - Router processing has no change.
  - Producer sends data /N/x back by encapsulating it under name /N/H/x.
- No need to change the forwarding behavior, but consumers/producers need to agree on the naming convention.

Next step

- Write these up
- Implement and experiment
- Add a ContentType for encrypted data?
- Mobility support, especially producer mobility.
- The shim layer
  - Hop-by-hop fragmentation/reassembly
  - Detect loss on a link, retransmission.
  - Carry network NACK