ICN Research Challenges
draft-kutscher-icnrg-challenges-01

Dirk Kutscher, Suyong Eum,
Kostas Pentikousis, Ioannis Psaras,
Daniel Corujo, Damien Saucez,
Thomas Schmidt, Matthias Waehlisch

Document Purpose

- **WHY**
  - Problems and pain points in today's networks

- **HOW** can ICN help
  - Fundamental ICN concepts

- **WHAT** to do in ICNRG
  - Research challenges, important topics

- Possible **RESULTS**
  - Impact on IETF work

Structure

1. Introduction
   - Example pain point, example ICN solution, brief concept overview
2. Problems with information distribution today
   - Inefficiencies, security issues
3. Concepts
   - Receiver-driven communication model based on named data objects (NDOs) as a first-order network service
4. Research Challenges
   - naming, security, routing, name resolution, transport, caching, interconnection, management, mobility management
5. Impact on IETF work
   - Anticipated changes to Internet architecture and protocols, relation to existing work (e.g., CDNI)

Summary of Changes

- Added terminology definitions
  - to be extended in future revisions

- Split naming and security into two sections
  - naming and data authenticity
  - security (network security)

- Extended mobility management
  - listed specific research challenges

Summary of Changes (cont.)

- Extended wireless networking
  - added specific sample scenario
  - added specific research challenges

- Extended transport service
  - clarification on flows in ICNs

- Extended in-network caching
  - discussing deployment cost

- Extended network management

Naming and Data Authenticity

- naming and security (data authenticity) related
  - name-data binding integrity
  - binding to real-world identities
- names can also enable aggregation
  - routing information
- corresponding different approaches
  - hierarchically structured vs flat-ish
- research challenges
  - naming static vs. dynamic objects, requestor privacy, NDO updates, managing accessibility

Security

- Authentication
  - communication channel ends cannot be trusted
    - objects must be authenticated, not channels
    - how robust can authentication be with time and size?
  - currently some overlap with naming section -- to be resolved in next revision
- State and routing
  - if routers keep state (e.g., PIT in CCN), how do we make sure an attacker cannot overload them?
  - if routes are composed of names, how to avoid attackers to inject plethora of names, forwarding entries?
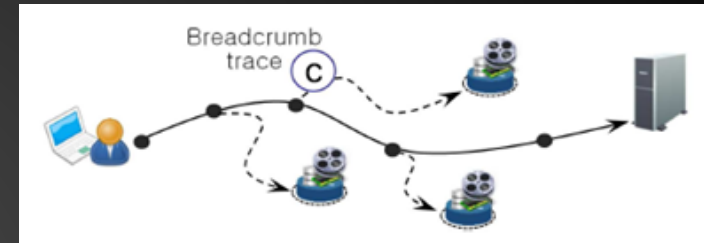- Traffic aggregation and filtering
  - requests can be aggregated, hiding their origin
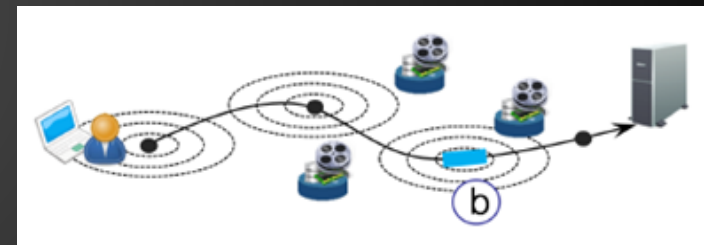   - how to filter traffic? (e.g., source filtering)

Routing

- No changes since the last draft.
- Currently discussing
  - How to deal with caching data objects from a perspective of ICN routing?
    - Caching data objects are a far more and volatile than an original data object in repository.
    - Incorporating the large number of caching data objects into one ICN routing algorithm may
      - cause significant control overhead traffic.
      - make the design of the routing algorithm complicated.
  - E.g., a possible approach?
    - separating an ICN routing into two parts:
      - Main routing algorithm: explicit routing to an originally published data object to guarantee reachability.
      - Subsidiary routing algorithm: implicit routing to caching data objects to achieve availability.
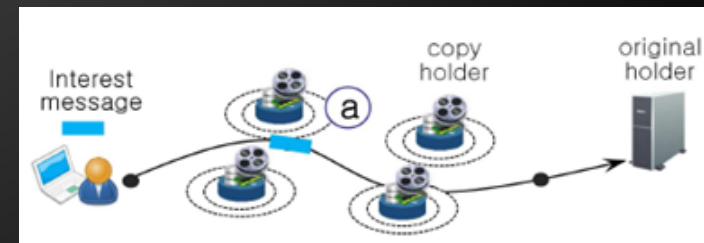
Routing - cont

- Some details... so a user request is always forwarded to an original content holder due to the main routing algorithm, but the request MAY find a copy on the way.

- Currently available approaches are illustrated (righthand side), which use the idea in the first bullet point.

- Research question:
  - How to take advantage of highly available copies in in-network caches without introducing too much troubles(?) to an ICN routing

Breadcrumb routing

On demand routing

Potential based routing

Mobility Management

- Leverage intrinsic ICN behavior
  - IP mobility management is based on anchors
    - MIP, PMIP, ... 3GPP
    - Distributed mobility management (DMM)
    - The set of DMM requirements also calls for on-demand/dynamic mobility management
  - Do we continue along the same path
    - i.e. use tunnels in information-centric network...
- Mobility impact on
  - Different content requirements/preferences (QoS?)
  - Seamless handover performance
    - Caching reliance
  - Receiver vs. source mobility
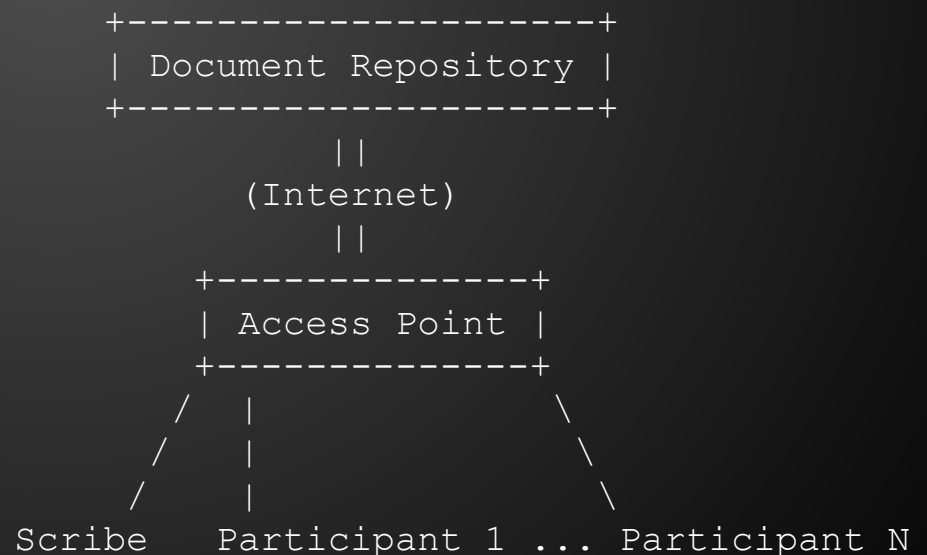
Mobility Management Challenges (1/2)

- How can mobility management take full advantage of native ICN primitives?

- How do we avoid the need for mobility anchors in a network that by design supports multicast, anycast and location-independent information retrieval?

- How can content retrieval mechanisms interface with specific link operations, such as identifying which links are available for certain content?

Mobility Management Challenges (2/2)

- How can mobility be offered as a service, which is only activated when the specific user/content/conditions require it?

- How can mobility management be coordinated between the node and the network for optimization and policing procedures?

- How do we ensure that managing mobility does not introduce scalability issues in ICN?

Wireless Networking

- Principal idea: enable ICN leveraging wireless networks' intrinsic broadcast capabilities
- Wireless vs. mobile
- Example scenario

```
+---------------------+
| Document Repository |
+---------------------+
          ||
      (Internet)
          ||
   +--------------+
   | Access Point |
   +--------------+
   /   |          \
  /    |           \
 /     |            \
Scribe   Participant 1 ... Participant N
```

Wireless Networking Challenges

- Can ICN use wireless resources more frugally
- How can we leverage the broadcast nature of the medium?
- Wireless-oriented ICN protocol stack?
- How about promiscuous operation coupled with opportunistic caching?
- Remember conversational services...
- Network conding? CoMP? MIMO?

Transport Services (no major changes)

- Accessing named data -- not necessarily individual hosts
  - notion of flows changing
  - e.g., ICN multi-source communication will still have flows, but in more dynamic fashion
  - RTT measurements etc. may not be meaningful for a set of requests in a single application/object context
  - out-of-order delivery more common

In-Network Caching (no major changes)

- cache placement
- content placement
- request-to-cache routing

- Added text on cost considerations for caching
  - e.g., ICN caching would enable operators to trade-off CAPEX for caches against traffic localization etc.

Network Management - 1/2

- Beyond FCAPS
  - Empower other mechanisms of the architecture
    - Mobility, Security, Transport, ...
  - Optimize their operation
    - Interchanging information between systems
- Beyond node or link centric
  - Change the way of thinking about mgmt possibilities
  - Figure out how to maintain current mgmt actions
  - Devise new mgmt actions based on ICN
    - Even by employing the support of host-centric protocols
- Concerns
  - Scalability
  - Many ICN Flavours

Network Management - 2/2

- Way to go
  - Expose conceived mechanisms to new scenarios
    - Different ICN deployments
    - Large-scale testing
  - Figure out interaction possibilities
    - Secure Management
    - Management while on the move
    - Management-optimized Transport
- IETF Impact
  - "readiness" of different networking mechanisms towards the future
  - Exposure of existing mechanisms to new scenarios
  - Bring ICN to the forefront of new deployment possibilities

Received Feedback

- Management accessibility (Scott Brim)
  - privacy of communication
  - obtaining an unpublished object, providing requestor authentication and transport encryption
  - Imaginable in a hybrid approach -- how to achieve in pure ICN?

TODO

- Eliminate redundancies for 4.1 (naming and data authentication) and 4.2 (security)
  - probably have a 'naming and security' section and a 'other security' section

- Make this `draft-icnrg-challenges`

More Feedback?

- Questions to ask:
  - level of detail OK?
  - overall selection of topics OK?