ICN Research Challenges

draft-kutscher-icnrg-challenges-01
Wednesday Presentation

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

Outcome of Sunday Meeting (1/2)

- In general
  - ICN opportunities vs. challenges
- Restructure naming & security section
  - eliminate redundancies
  - section on naming and naming-related security
  - section on system and network security
- Mobility
  - want to say more on how ICN supports mobility
  - requestor vs. publisher mobility
  - long-term vs. short term options and challenges
  - do not unnecessarily constrain ICN mobility to existing mechanisms

Outcome of Sunday Meeting (2/2)

- Wireless
  - focus more on challenges related to broadcast, network coding
  - notion of de-centralizing networks: where to put that?

- New challenges
  - interactive services -- challenge or non-feature?
  - name life cycle
    - retaining control of published objects
    - re-naming, updating, versioning

Plan for
Naming and Data Authenticity Section

1. What do we want to name (e.g., objects, chunks)?
2. Challenges for naming different types of objects
   - static objects
   - dynamic objects
3. Requestor privacy
4. Name life cycle management
   - updates
   - versioning

Plan for Security Section

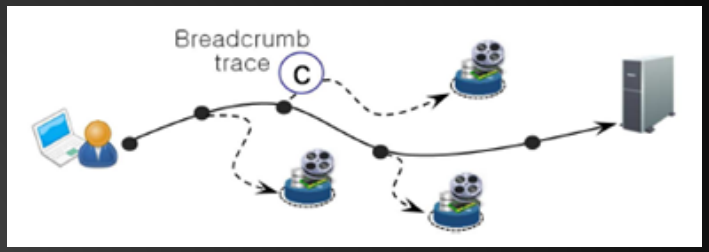
1. Binding NDOs to real-world identities
2. Access and distribution control
   - who is requesting (e.g., access list) ?
   - how to keep control of published objects?
3. State overloading on network elements
4. Routing/Forwarding robustness against attacks
5. Cryptography robustness

Routing

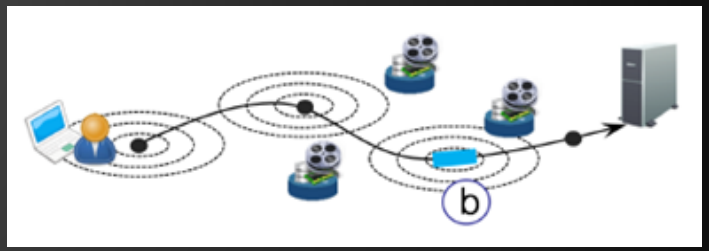
- No changes since the last draft.
- Currently discussing
  - How to deal with caching data objects from a perspective of ICN routing?
    - Caching data objects are a far more and volatile than an original data object in repository.
    - Incorporating the large number of caching data objects into one 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

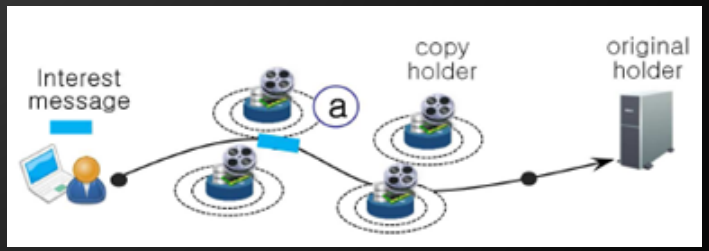
- Some details... so a user request is always forwarded to an original content holder due to the main routing algorithm, but the request MAY find a copy on the way.
- Currently available approaches are illustrated (righthand side), which use the idea in the first bullet point.
- Research question:
  - 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

Plan for Routing Section

1. Incorporation of the challenge described previous slides into the ongoing document somewhere in
   - Section 4.3: routing and resolution system
   - or Section 4.7: in-network caching
     - Any suggestion?
2. Robustness in Name Resolution System (NRS).
   - Robustness (e.g., tolerate up to # nodes failures??) is as important as other design goals, e.g., scalability.. etc.
   - Can we achieve robustness without sacrificing efficiency (e.g., low stretch)?

Other Challenges that came up

Fragmentation

- Ideally, we don’t want to be bothered
- In real life, we have MTUs, challenged networks or links
- Seems to be a general concern (independent of ICN approach)
- For example, NetInf:
  - fragmentation and reassembly on Convergence Layer (hop-by-hop) link
  - not visible to ICN layer

Next steps for this draft

- Collect more feedback
- Implement changes as described
  - new version before Hong Kong
- make this `draft-icnrg-challenges`

Slides from Sunday

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)

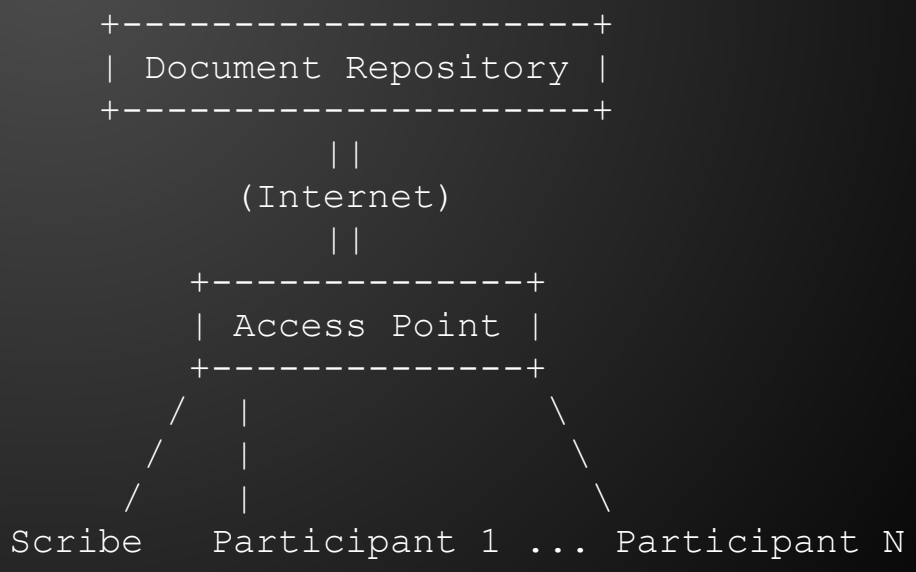
- How can mobility be offered as a service, which is only activated when the specific user/content/conditions require it?

- 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



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?