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
Note:

- Originally titled "Problem Statement"
- Discussion whether this is useful
- General consensus: rather describe expected challenges, i.e., topics to be worked on
- Want to add
  - some motivation (what are the critical issues, why do we do this)
  - explanation: what is the general idea (concepts)
- Hence the following structure...
Structure

1. Introduction
   ○ example pain point, example ICN solution, brief concept overview

2. Problems with information distribution today
   ○ Inefficiencies, security issues

3. Concepts
   ○ Requesting named-data 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)
Problems with Information Distribution Today

- Today's overlay approaches to CDN, M2M vs. accessing named data on network layer
- Sub-optimal routing
- Difficulties in leveraging multicast/broadcast capabilities
- Difficulties in establishing direct communication
- Application-specific approaches to caching, replication
ICN Concepts

- Accessing named data objects as a first-order network service
- Name-content binding validation and other features
- Leveraging ubiquitous storage
- New options for transport
Naming and Security

- Currently describing hierarchically structured and flat names
- Describing static and dynamic object naming challenges
- Requestor privacy
- Updating and versioning
- Managing object accessibility
Transport Services

Research challenges:

● Several possible path between a sender and a receiver
  ○ How to utilize multiple sources?
  ○ How to control data rate on multiple paths?

● Requests can be aggregated by routers
  ○ How to make the distinction between retransmissions or new requests?
  ○ How can a source determine the number of requesters?

● Receiver-driven communication or Router-driven communication?
In-Network Caching (1/2)

Three main challenges:

- **Cache Placement**
  - On-path vs off-path
  - Is on-path on-shortest(-BGP)-path?
  - Off-(shortest-)path has been investigated a lot
  - On-path is more challenging

- **Content Placement - Content-to-Cache Distribution**
  - What is to be cached and who decides?
  - What are the criteria/metrics to decide where to cache what?
    - Popularity, traffic characteristics?
  - How big should caches be?
In-Network Caching (2/2)

- **Request-to-Cache Routing**
  - Relates to name-based routing
  - Relates to collaboration between the data and control places
  - Do we allow for cache-aware routing? And who is "aware"?
    - Cache-aware routing introduces complexity, but
    - Cache-unaware routing reduces chances of cache hits
  - Affects traffic dynamics through request redirection
Routing and Resolution System Scalability [1/2]

<table>
<thead>
<tr>
<th>Numbers</th>
<th>Comments &amp; reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of BGP</td>
<td>Now, an up-to-date BGP router is working with this number. [bgp.potaroo.net]</td>
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<tr>
<td>routing table</td>
<td></td>
</tr>
<tr>
<td>4.5*10^5</td>
<td></td>
</tr>
<tr>
<td>Technically</td>
<td>Back in 2007, that number of data objects could be supported technically - DONA.</td>
</tr>
<tr>
<td>speaking</td>
<td></td>
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<tr>
<td>10^11</td>
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<tr>
<td>Domains</td>
<td>Routing with domain names? [<a href="http://www.domainworldwide.com">www.domainworldwide.com</a>]</td>
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<tr>
<td>4.6*10^7</td>
<td></td>
</tr>
<tr>
<td>Indexed web</td>
<td>Google’s indexed web pages [<a href="http://www.worldwidewebsize.com/">www.worldwidewebsize.com/</a>]</td>
</tr>
<tr>
<td>pages</td>
<td></td>
</tr>
<tr>
<td>5*10^10</td>
<td></td>
</tr>
<tr>
<td>Indexed URLs</td>
<td>Google’s indexed URLs back in 2008 [<a href="http://www.pcworld.com">www.pcworld.com</a>]</td>
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<tr>
<td>10^12</td>
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<tr>
<td>Do we expect</td>
<td>Updated or version up data object, a group of data objects, or more and more.</td>
</tr>
<tr>
<td>more?</td>
<td></td>
</tr>
<tr>
<td>10^22</td>
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</table>
# Routing and Resolution System

## Scalability [2/2]

<table>
<thead>
<tr>
<th>Operation</th>
<th>Route-By-Name Routing (RBNR)</th>
<th>Lookup-By-Name Routing (LBNR)</th>
<th>Hybrid Routing (HR)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operation</strong></td>
<td>Discovery - Delivery</td>
<td>Resolution - Discovery - Delivery</td>
<td>RBNR + LBNR</td>
</tr>
<tr>
<td><strong>Challenges</strong></td>
<td>How to aggregate the names of data objects to reduce the number of routing entries?</td>
<td><strong>Fast lookup</strong>: mapping the name of data object to its locators (copies as well?)</td>
<td>How to design a scalable mapping system, which given the name of data object, it should return a destination domain locator so that a user request can be encapsulated and forwarded to the domain?</td>
</tr>
<tr>
<td></td>
<td>How does user learn the name which is designed for aggregation by provider?</td>
<td><strong>Fast update</strong>: location of data object is expected to change frequently. Multiple data objects may change their location simultaneously, e.g. data objects in a laptop?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Can we still achieve a scalable routing without name aggregation? e.g., compact routing, random walk, greedy routing, etc?</td>
<td></td>
<td>How to incorporate copies of a data object in in-network caches in these routing schemes?</td>
</tr>
</tbody>
</table>
Mobility Management [1/2]

- Different ICN deployments provide intrinsic mobility support
- However, such support is not optimized
  - Seamless handover for real-time multimedia?
  - Network resources negotiation and activation
- Moreover, client-mobility and source-mobility are different
  - How the intrinsic caching and forwarding will be impacted?
- Finally, with the different access technologies available today, how will their unique mechanisms impact an optimized mobility-supported scenario?
Mobility Management [2/2]

Research Challenges:

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

- How to make mobility as a service that is only activated when the specific user/content/conditions require it?

- How to coordinate mobility management between the node and the network for optimization and policing procedures?
Network Management [1/2]

- Current management support tools (ranging from SNMP to full-fledged AAA and policing infrastructures) are currently host-centric or end-to-end oriented
- In ICN, not only content becomes the core aspect for management requirements
  - it also sees network management leveraging intrinsic ICN mechanisms
- On one hand, such mechanisms need to be used to address common network management procedures
  - How to identify nodes, networks, segments using ICN naming?
- On the other hand, native ICN aspects can open up new scenarios and considerations for network management as a concept
  - E.g., content-oriented management and caching
Network Management [2/2]

Research Challenges:

- Manage and control content reception at the destination
- Coordination of management information exchange and control between ICN nodes and ICN network control points
- Identification of management and controlling actions and items through information naming
- Relationship between NDOs and host identities identification
Status and Next Steps

● Section about "Problems today": rather talk about goals
● Align level of detail for sections
● Separate Naming and security sections
  ○ have more detailed TODO list for those
● "Other challenges"
  ○ want to at least other related challenges not discussed here: business models
● Got volunteers for additional input
  ○ Thomas/Matthias: mobility/security
  ○ Damien: security
● Plan is to update this after IETF-86
Feedback?