Enabling Network Identifier (NI) in Information Centric Networks to Support Optimized Forwarding

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# Draft ToC

## Table of Contents

1. Introduction ................................................................. 3
2. Application Identifier (AI) vs. Network Identifier (NI) in ICN ........................................... 3
3. NI based ICN Forwarding .................................................. 6
   3.1. Label based ICN forwarding ....................................... 6
   3.2. Link-object based ICN forwarding ............................... 8
   3.3. Link Object vs. Forwarding Label ............................... 8
4. Name Resolution System Considerations ............................. 9
5. Differences with respect to Existing IP-based Proposals ....... 10
6. References ....................................................................... 10
   6.1. Normative References ............................................... 10
   6.2. Informative References ............................................. 11
Appendix A. Additional Stuff .................................................. 13
Authors' Addresses ............................................................. 13
Draft Motivation

- Here ICN=CCN=NDN
- Over the last few IETFs, we proposed the Forwarding-Label draft. ([https://www.ietf.org/internet-drafts/draft-ravi-icnrg-ccn-forwarding-label-00.txt](https://www.ietf.org/internet-drafts/draft-ravi-icnrg-ccn-forwarding-label-00.txt))
- Forwarding-Label are network identifiers appended to Interest for efficient routing. Proposed as a network service to handle:
  - Edge Computing – replicated Services and Content, Off-Path Caching, Mobility, Routing Scalability.
- An implementation of this idea for producer mobility in CCN, and paper was presented at 5G/ICN workshop at ICN Sigcomm.
  - Demo of this solution was also made in ICN Sigcomm in the context of CCN.
- During recent harmonization discussion, there was discussion comparing Forwarding Labels and Link Objects proposed by NDN.
- FL are similar to Link Objects, but with more flexibility.
- The draft proposes the notion of a Network Identifier as an architectural construct to generalize FL or Link Object in ICN architecture to achieve maximum Interest routing and forwarding efficiency.
Application Identifiers Versus Network Identifiers.

• Application Identifiers
  • Persistent in nature, could name services, content and devices
  • Security and Trust associated with Names
  • Non Topological
  • Managed by Application Provider
  • Two well known formats, Hierarchical and Flat
    • Naming is application defined, hence should include both these formats
  • AI is a ever growing set:
    • New hundreds or millions domain registrations and second level goes to billions [1]
    • Naming IoT content and devices – 10-50B; ICN estimates $10^{15}$ [2]

• Network Identifiers
  • Topological or Mathematical embedding
  • Designed for scalable routing and high speed forwarding
  • Managed by the network provider
  • Names Network Entities (Domains, Routers, PoA and End Points)
  • NI name space grows at much slower rate than the AI space
  • NI name space can be identifiers from other realms e.g. IP, Ethernet etc.

→ Hence if is stability and scalability are ICN design factors, NI based routing and forwarding makes practical sense.

Issues with ICN Routing with AI

- **Mobility**
  - AI based routing is infeasible with mobile producers.
  - Mobility [2] reports that a host changes more than 20% of hosts make more than 10 network address transitions a day.
  - Also each mobility event associated with a device or a popular content may trigger updates on up to 14% of Internet routers.

- **Replication**
  - With Edge Computing and CDN like services replication of content and services will be a norm.
  - [1] estimates that as replication increases from 10% to 200%, FIB size increases $200^X ightarrow 1000^X$.

- **Scalability**
  - AI has no topology aggregation properties, scalability is a challenge.
  - Disaggregated AI name space is a very large set to scale routing.

- **Different Objectives**
  - AI designed for to meet application requirements and not for routing/forwarding optimization.
  - Direct correlation between Naming and Routing/Forwarding Stability and Scalability.
  - This correlation also has other challenges such as name-suffix black holing [1].

Binding between AI and NI

• AI based routing and forwarding is feasible within local domains
  • Scalability is not a concern and when dynamism is minimal
  • Using hierarchical or even flat names in local domain context
  • Useful in Ad Hoc scenarios, where AI is not pre-known, but requires suffix name filters

• AI and NI binding required for multi-domain connectivity when scalability and dynamism is involved

• Hence this binding is optional in the sense that - Interest may be routed based on AI, NI or both based on the network segment
  • Most requests crosses local domains, hence support for NI becomes crucial

• Introducing NI in ICN doesn’t affect any current properties: Location Independence, Consumer Mobility, Symmetric Routing, Multi-Homing or Multi-Path Routing.

• Rather it enables : Off-Path Caching, Producer Mobility, Conversational session requirements.
Two proposals of Network Identifier (NI)

• Forwarding Label Object [1]
  • Towards more Routing Flexibility. FL identifies domains, routers, PoA etc.
  • Appended to the Interest by the Network based on service requirements.
  • Part of the fixed header
  • FL is mutable – it can be swapped or removed by network elements
    • Enables Late Binding feature
  • FL Object has the NI and an optional security object to bind AI to the NI.
  • Allows network service metadata to allow FL management based on its use case scenario
  • FL takes precedence over AI in the Interest
  • One can route on AI in one domain and then swap with FL in another domain.
  • AI to FL mapping is managed by a cache table in the edge routers

Proposals for NI

• Link Object [1]
  • Towards Routing Scalability. Identifies Zones or Domains.
  • Serves as an hint to the forwarder, so is used only if name based routing fails
  • Part of the Application Payload
  • Resolved by the Consumer – an Application level construct
  • Immutable, hence cannot change during forwarding
    • Similar to Early binding
  • Contains a link header and signed by the Producer for authentication
  • May contain multiple Links which the forwarder can choose to forward on
  • A delegation header is used to represent the link choice by the previous forwarder, hence is changeable

## Side-by-Side Comparison

<table>
<thead>
<tr>
<th>Feature</th>
<th>Forwarding Label Object</th>
<th>Link Object</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Requirement</strong></td>
<td>Routing Flexibility and Scalability</td>
<td>Routing Scalability</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>Network Scope</td>
<td>Application Scope</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>Network and End Points</td>
<td>End points</td>
</tr>
<tr>
<td><strong>Mutability</strong></td>
<td>Mutable (Late binding)</td>
<td>Immutable (Early Binding)</td>
</tr>
<tr>
<td><strong>Security Binding</strong></td>
<td>Binding Optional</td>
<td>Binding is Mandatory</td>
</tr>
<tr>
<td><strong>Priority</strong></td>
<td>Prioritized over AI</td>
<td>Names Before Link Object always</td>
</tr>
</tbody>
</table>
Name Resolution System Design Choices

- **Hierarchical System**
  - AI/NI mapping is managed by Application Providers
  - Follows DNS hierarchical architecture
  - NDNS is an example of such a system
  - Good for static named resources rather than dynamic entities
  - Has to scale to a large set of named resource, beyond just the set of host names

- **Network Integrated Flat System**
  - Flat Architecture
  - Routers uses a part of its compute and storage to enable this as a network service
  - The Integration allows multiple ways of designing an NRS
  - Good scalability and proven handling of dynamic updates
  - MobilityFirst’s GNRS is an example of this

- **Distributed System**
  - A distributed domain based NRS
  - Exploits the context in name to map the resources to their home controller
    - E.g. /company/content-id maps to /company/resolver-id.
  - Home Controllers further doesn’t sync with any higher controllers
  - Scalable and can handle dynamic updates
AI/NI in ICN versus ID/Locator Systems

• Here we are compare with HIP/ILNP/LISP proposals
• They address the problem of routing scalability, multihoming, mobility, security challenges preserving IP’s host-centric communication model.
• ICN focusses on a network layer where name based routing, caching, mobility, multihoming are integral features
Conclusions

• Considering Link Object, Forwarding Label, Locators in Nameless Objects proposals – suggest to formalize the notion of AI/NI in ICN
• Make it part of the terminology document
• Next steps would be understand its incorporation into the ICN protocol architecture
• FL and Link Objects are two proposals, harmonize this to afford maximum flexibility towards ICN routing and forwarding.
• More comments?