Towards Evaluating Named Data Networking for the IoT: A Framework for OMNeT++

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Pisa – Italy – September 05-07 2018
Outline

1. Named Data Networking & IoT
2. NDN-OMNeT design
3. Use case example
Current IP stack

- Most apps are content-based (e.g. facebook, youtube, skype, etc.)
- DNS, P2P, CDN to support content-based applications
- The applications view DNS names as their namespace
- The network layer views IP addresses as its namespace
- Need name resolution
- Need middleware
Paradigm shift

Focus on delivering packets

Focus on retrieving content

Host-based Networking

Information Centric Networking (ICN)
Named Data Networking

- **Hierarchical** names (e.g. /UniPisa/campusA/room1/temperature)
- **Packet routing/forwarding directly on names**
- **Two packet types: Interest & Data**
- **Content, name and producer bind with crypto-signature**

<table>
<thead>
<tr>
<th>Interest</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Name</td>
</tr>
<tr>
<td>Request parameters</td>
<td>Content</td>
</tr>
<tr>
<td></td>
<td>Security info. &amp; Signature</td>
</tr>
</tbody>
</table>
**NDN communication**

**Interest**
- **Name**: /UniPisa/campusA/room1/temp
- **Nonce**: 47fa2d0c
- **HopLimit**: 5

**Data**
- **Name**: /UniPisa/campusA/room1/temp/3pm
- **Content**: 22°C
- **Signature**: ECDSA
- **SignatureT**: 0A...65

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**r1’s FIB**
- **prefix**: ../room1/*
- **face**: 1, 2

**R1’s PIT**
- **Interest**: /UniPisa/...
  - **face**: 0

**r1’s CS**
- **Data**: /UniPisa/...
Opportunity for the IoT

NDN provides a native support for IoT

- **Security**
  Secure IoT data directly.

- **Mechanism**
  Mobility support, asynchronous, natural names (close to CoAP)

- **Lightness**
  Implementations (e.g. NDN-RIOT) show that NDN can be lighter than 6LoWPAN on IoT devices.

- **Projects**
  NDN Building Automation System, Home automation, etc.
NDN for low-end IoT: challenges

Considering a low rate/power wireless technology (e.g. IEEE 802.15.4)

- **Wireless forwarding**
  Native NDN (over L2), reduced overhead, feasibility with current IoT devices.

- **Constrained devices**
  Packet processing/size (small MTU).

- **Naming**
  Name size/processing & semantics, FIB management, etc.

- **Device management**
  Trust model, bootstrapping, service discovery.
Evaluating NDN-IoT solutions

ndnSIM (ns-3) is widely used, but...

- **Visualization**
  For understanding and teaching purposes
- **Not only networking**
  Need to evaluate memory consumption, etc.
- **Quick simulations**
  Need to test features with minimal coding
- **OMNeT++/INET**
  Simulate system/network interactions, NDN data structures, etc.
NDN-OMNeT design
NDN core

- NDN as an L3 protocol (*NdnL3*)
- Based on INET 3.5
- Compound module that includes
  - Pending Interest Table (*IPit, PitBase*)
  - Forwarding Information Base (*IFib, FibBase*)
  - Content Store (*ICs, CsBase*)
  - eXperimental Unit (*IXu*)
  - Forwarding strategy (*IForwarding, IForwardingBase*)
- Communication by module access or messages
Hosts

- A typical wireless IoT device (*NdnWirelessHostBase*)
  - Basic NDN host
  - Includes NDN core as a network layer
  - Ready to act as relay node
- A typical IoT end-device (*NdnWirelessHost*)
  - Extension of the basic NDN host
  - Consumer and/or producer apps
  - Ready to act as end-device (e.g. sensor)
Applications

- Consumer app (*ConsumerAppBase*)
  - Sends Interests under a given prefix
  - Parameters: prefix, #Interests, lifetime, sendInterval, length, etc.
- Producer app (*ProducerAppBase*)
  - Responds to incoming Interests with a Data packet under a given prefix
  - Parameters: prefix, length, freshness, etc.
Packets

- NDN uses TLV packet representation
- NDN-OMNeT supports
  - Straightforward packet definition (i.e. extension of cPacket)
  - TLV representation and size computation (for packet processing evaluations)
  - Non-NDN fields are used for evaluation purposes
Use case example
NDN wireless forwarding

Basic approach (related work)

- First Interest is broadcasted (flooding)
- Nodes keep/update temporary FIB entry after getting Data
  - In the FIB: NDN prefixes mapped to MAC addresses
- Flooding triggered by consumer after Interest timeout
- Delayed retransmissions
  - To reduce useless broadcasts
  - If a node overhears packet with the same prefix, the delayed reTx is canceled
- Different NDN-to-MAC mapping: (parameter in Forwarding module)
  - IUDU: Interest Unicast Data Unicast
  - IBDB: Interest Broadcast Data Broadcast
  - IBDU: Interest Broadcast Data Unicast
  - IUDB: Interest Unicast Data Broadcast
Simulation

Topology

 Metric

- Collisions number
- Satisfaction rate
- Interest-Data RTT
- Total transmitted frames
- PIT size/lookups
- ...

...
Results (1)
Results (2)
## Conclusion & Future work

| NDN-OMNeT | Extend OMNeT with ICN paradigm  
<table>
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<th>A tool for evaluating NDN-IoT solutions</th>
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| Forwarding| Other strategies already included  
|           | Need a fully-customizable forwarding module |
| Future features | Support NDN TLV packet processing  
|               | Memory/processing models for NDN data structures |
| Compatibility| Deal with OMNeT/INET versions  
|             | Other integration/compatibility suggestions... |
This work is part of:

A realistic NDN integration in the IoT
Thank you!

Repo:
https://github.com/amar-ox/NDNOMNeT

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