NDNoT: NDN-IoT Framework – with example application “flow”

Zhehao Wang
zhehao@cs.ucla.edu
Nov 4, 2016
NDNoT: functionalities

- NDNoT (Named data network of things) is an IoT framework featuring functionalities proposed in the IoTDI paper:
  - Naming things, devices, and their data
  - Device bootstrapping and service/capability discovery
  - Schematized trust
  - App-level pub/sub
  - Global internet integration

*Named Data Networking of Things (Invited Paper). IoTDI 2016*
“Flow” application

• Home entertainment application built on top of the framework
  – To be installed at Huawei
  – One step towards providing a whole picture of “what it’s like to use and deploy an NDN application” for users and service providers
Flow application: components

<table>
<thead>
<tr>
<th>Component</th>
<th>Device</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>OpenPTrack</td>
<td>Linux workstation machine</td>
<td>Produces time-series data (location of multiple tracked persons) at 30Hz</td>
</tr>
<tr>
<td>Mobile website</td>
<td>Mobile phone</td>
<td>Produces environment control commands and consumes environment status</td>
</tr>
<tr>
<td>Virtual camera control</td>
<td>RFduino</td>
<td>Produces NDN data from its gyroscope shield, packetize, and send to bluetooth central (RPi) via bluetooth</td>
</tr>
<tr>
<td>Controller</td>
<td>RaspberryPi2</td>
<td>Serve as the trust anchor, and runs as NDN-pi[1] controller</td>
</tr>
<tr>
<td>Unity3D game engine</td>
<td>OSX machine</td>
<td>Consumes opt, phones, and Arduino data; and does visualization</td>
</tr>
</tbody>
</table>

- Each component also runs discovery, and schematized trust
- There may be multiple instances of each component in the system
NDNoT: namespaces

• Each device named from three levels
  – Application level: name the thing
    • An application-specific “label” given by the user
    • Used for application data exchange
  – Device level: name the device in a space
    • Associated with some physical properties of the device to identify the device in a space
    • Used for device control and status feedback
  – Manufacturer level: name given by the manufacturer
    • The name of device given by the manufacturer when produced
    • Used for initial device verification, and manufacturer-based querying
Flow: namespace as in NDNoT framework

/  

- com/RF-digital/  
  - manufacturer name

- my-home/living-room  
  - root prefix (the room)

- RFduino/serial-1234

- devices
  - discovery
    - gateway/90
      - cmd
        - add
          - ts_1
    - Arduinos/serial-1234
      - ID-CERT
    - digest_1
      - _meta
        - _manufacturer
        - _capabilities

- flow1
  - Arduino1
    - _meta
    - gyroscope
      - _meta
        - _device
        - _status
        - seq_1
  - opt1
    - start_ts_1
      - tracks
        - track_1
        - seq_1
      - track_hint
        - ts_1
      - app data
        - instance

Manufacturer namespace  

IoT framework: device namespace  

Flow: application namespace
Flow: namespace example

• As an example of the different namespaces, for a Samsung phone “flow-123” labeled “phone-A”, its names on different levels could be

<table>
<thead>
<tr>
<th>Application</th>
<th>/my-home/living-room/flow-123/phone-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>/my-home/living-room/devices/12345678</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>/com/samsung/IMEI/12345678</td>
</tr>
</tbody>
</table>
Flow: application trust schema

- Flow trust schema defines the following relationship:

```
/my-home/living-room/devices/gateway/1234/  gateway identity certificate: trust anchor
```

```
/my-home/living-room/devices/Arduinos/serial-5678/  device identity in home
```

```
/my-home/living-room/flow1/Arduino1/gyroscope/#seq  application data produced by that device
```
NDNoT: bootstrapping trust

• Follows the bootstrap process introduced in NDN-pi [1]
  – Bootstrap trust between a controller and a device via a shared secret established offline (e.g. NFC scan, manual input PIN)
Flow: discovery

- Flows runs distributed (digest exchanged based) discovery (NdnCon discovery)
  - Multicast namespace:
    
    /my-home/living-room/devices/discovery/<digest>
  - Digest is a hash of names of devices currently known by the data’s producer; Data content is the list of names known by the data’s producer
  - Each device, upon being certified, will add its own device name to this list and reply to interests for the old digest
  - Each device, upon receiving data, will issue device metadata interest using names in the list to know if the device’s in, and what data-type it’s publishing
Flow: constrained devices

- RFduinos (not treated differently by the framework)
  - work with a more powerful device, “helper” (like a Raspberry Pi)
  - bootstrap trust using a shared secret with helper, and also negotiate a symmetric key (encrypted by public key of the helper)
  - generate data and packetize as NDN data packet, attach an HMAC created using the symmetric key
  - helper verifies data and serves interest
NDNoT and Flow: implementation

• [https://github.com/remap/ndn-flow](https://github.com/remap/ndn-flow)

• Current framework code / API documentation (evolving):
Thanks

Combining IoT efforts?