Named Data Networking Based Smart Home Lighting System

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Master Thesis (On going)

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Outline

- Named Data Networking
- Smart Lighting Systems
- Solution Implementation
- Benefits of NDN features for the solution
- Future work
Named Data Networking

- In IP, identify end points with IP addresses. DNS Servers are used to convert human readable URLs to IP addresses.
- In NDN, contents are named with human readable names. Consumer directly access content by names, network layer use same names for routing in the network layer.
- So NDN makes content to be the first citizen in the network.
- Anything in the network is identified by hierarchical names
  Piece of content: video, file, music: `/ictp/wirelesslab/school_2016/ndn/demo1`
  An end point: `/ictp/wirelesslab/temperature/front-door`
- Only two types of packets are used: INTERESTs and DATA
  ✓ In network caching
  ✓ Inherent support for multicast communication via Interest aggregation
  ✓ Support for simultaneous multipath forwarding
  ✓ Support Data centric security
Smart Lighting System

Automated light control
✓ Lights are programmable
  Different applications control lights on different requirements.

✓ Automatic Light Control: based on occupancy, daylight
✓ Intruder Detection System
✓ Fire Detection System
✓ Energy Management system
Motivation of using Named Data Networking

- Conventionally, lights are addressed with IP addresses.
- Different group of lights - > Different multicast groups
- With Named Data Networking, we can directly access different light groups based on name hierarchy.

Automatic light control

Energy Management System

Intruder Detection System

Fire Detection System

/home/light
/home/light/floor1
/home/light/floor1/bedroom
/home/light/floor1/outside-front
/home/light/kitchen
Solution Overview

• Goal: Control lights based on occupancy and daylight
• Use NDN
  • easy for developing and configuration

• Out of the shelves Low cost devices
  • Raspberry Pi
  • Home Router
  • Low cost sensor, normal light bulb
• Control via user friendly web interface
System Architecture

**Light node:** Consists with a light, a smart controller, an actuator circuit to switch ON/OFF the light

**Occupancy Detector:** Consists with a smart controller and a motion sensor circuit to track IN/OUT movements to/from the room.

**Luminosity Detector:** Consists with a smart controller and a photo sensor circuit to measure natural light intensity in the room in lux.

**Smart Home Controller:** Smart home application running on a small computing device which can control the lights based on room occupancy and daylight.
NDN Naming Structure

Based on services and physical location hierarchy
3 main operations:

- Luminosity detectors publish light levels and luminosity monitor collects and process them.
- Occupancy detectors publish person movements and occupancy counters collect and process them.
- Light controller control lights based on occupancy and light level in the room.
**Luminosity Detectors**

INTEREST := /home/luminosity/publish/ <detector-full name>/ <lux-reading> / <ts>/ <ma-lux reading>

*ts* - time stamp
*ma-* lux reading - moving average lux reading (window size = 5)
Occupyancy Detectors

INTEREST := /home/occupancy/publish/ <detector-full name>/ <movement> / <ts>

- ts - time stamp
- movement - IN or OUT

Dummy ack Data expected to ensure reliability

Data packet refresh Timer = 4 s
Number of INTEREST retransmission = 3

M:1 data push with ack and without security
Light operation

- **Luminosity monitor** runs in background and collect and store lux data.

- **Occupancy counter** runs in background and keep counting number of persons in the room.

- **Lighting application** switched ON/OFF a set of lights/ all lights based on two thresholds; **Min TH and Max TH**.

- Home user can assign lights into categories (0, 1, 2 etc).

- Lights are operated in groups based on category (ex: home/light/floor1/room1/category-1).

- When lights are needed to switch ON, they are switched ON according to ascending order of available category number.

eg: Home owner can use semantics of the room putting lights into category like assigning a higher order category number to a light near to a window to delay it switching ON. Sametime, he can assign same category number to all lights in the room making all of them to operate together.
INTEREST:= home/light/<floor>/<room>/<category-i>/<command>

DATA := home/light/<floor>/<room>/<category-i>/<command>/<light-id>

1: M Command execution with ack and without security
### Web UI

<table>
<thead>
<tr>
<th>Control Mode</th>
<th>Room</th>
<th>Status</th>
<th>Action</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>occupancy&amp;daylight</td>
<td>testing</td>
<td>idle</td>
<td>Activate</td>
<td></td>
</tr>
<tr>
<td>occupancy&amp;daylight</td>
<td>upeka room</td>
<td>running</td>
<td>Deactivate</td>
<td></td>
</tr>
<tr>
<td>occupancy&amp;daylight</td>
<td>myroom</td>
<td>idle</td>
<td>Activate</td>
<td></td>
</tr>
</tbody>
</table>

Buttons:
- Activate
- Deactivate
- Destroy
- View Operation log

New Light control rule
Benefits of NDN features for the solution

**Naming:**
- Nodes are identified with user friendly names and network layer uses same names on routing. No need to have separate DNS servers.

**Routing and Forwarding:**
- Any number of nodes can register the same name prefix as long as they can provide matching services or data.
- Every light can register same prefix (home/light) and router can send INTEREST message to all light nodes simultaneously.

**Inherent support for multicast feature:**
- Smart controller can send INTERESTS to any group of lights based on hierarchical name components.
  - Eg: all lights in home : home/light
  - all lights in bedroom1 : home/light/floor1/bedroom1
Future work

• Calibration and Performance Evaluation
• Scaling of the solution for large scale deployments
  Exhibition halls, small villages
• Performance comparison with respect to alternative approaches
THANK YOU !
References


