Named Data Networking Based Smart Home Lighting System

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Master Thesis (On going)

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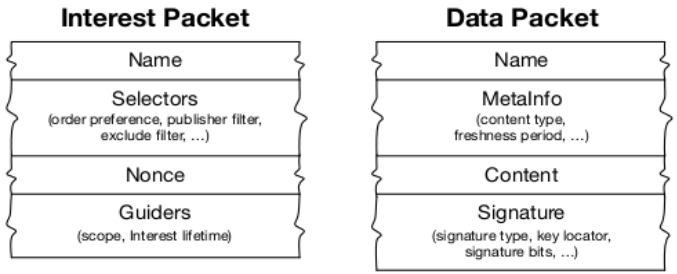
Outline

- 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

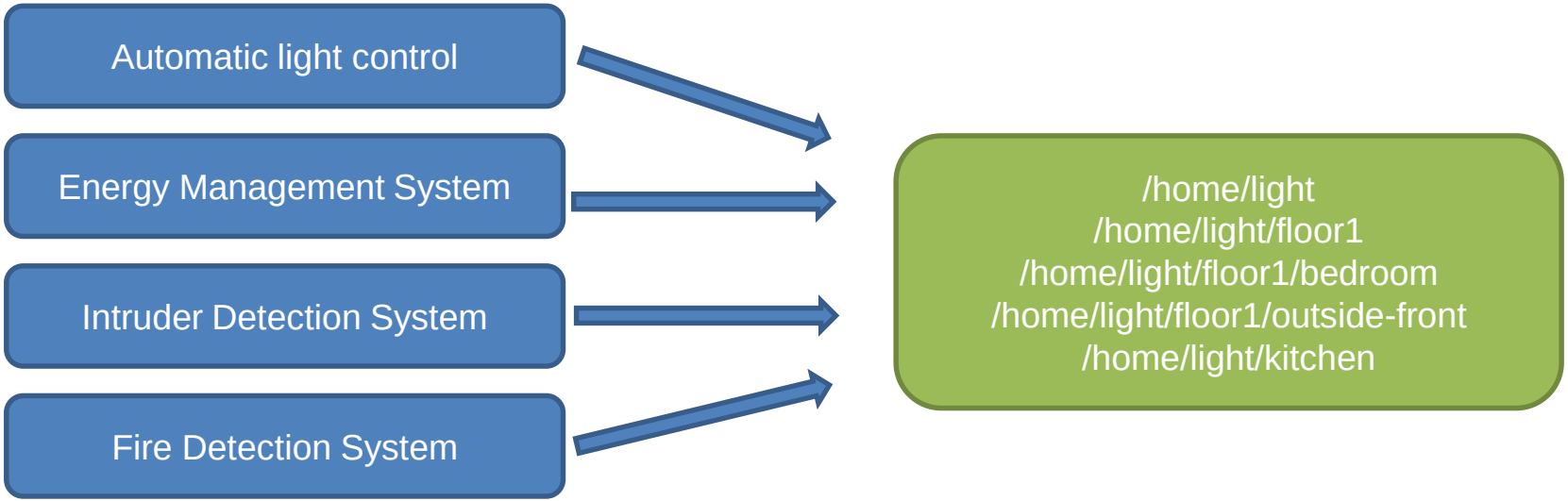
✓ Intruder Detection System

✓ 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.



Solution Overview

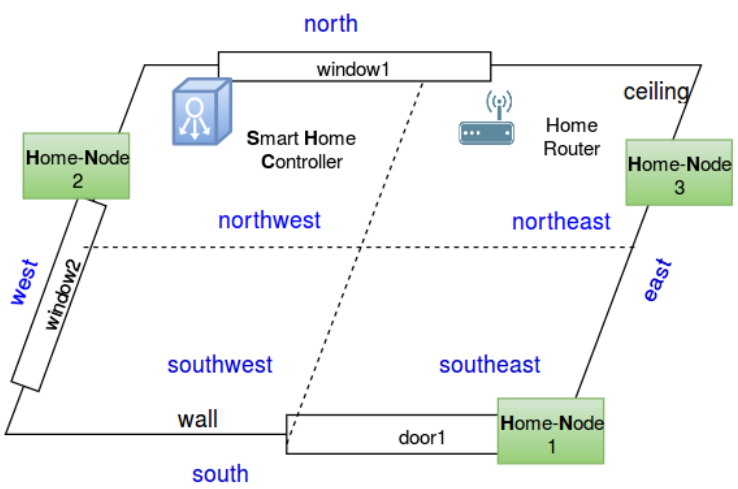
- Goal : Control lights based on occupancy and daylight
- Use NDN
  - easy for developing and configuration

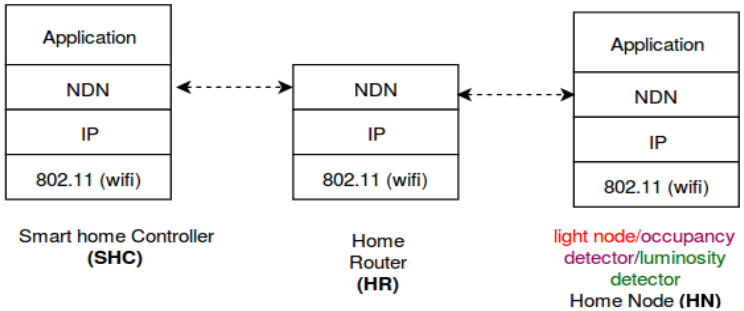
- Out of the shelves Low cost devices
  - Raspberry Pi
  - Home Router
  - Low cost sensor, normal light bulb
- Control via user friendly web interface

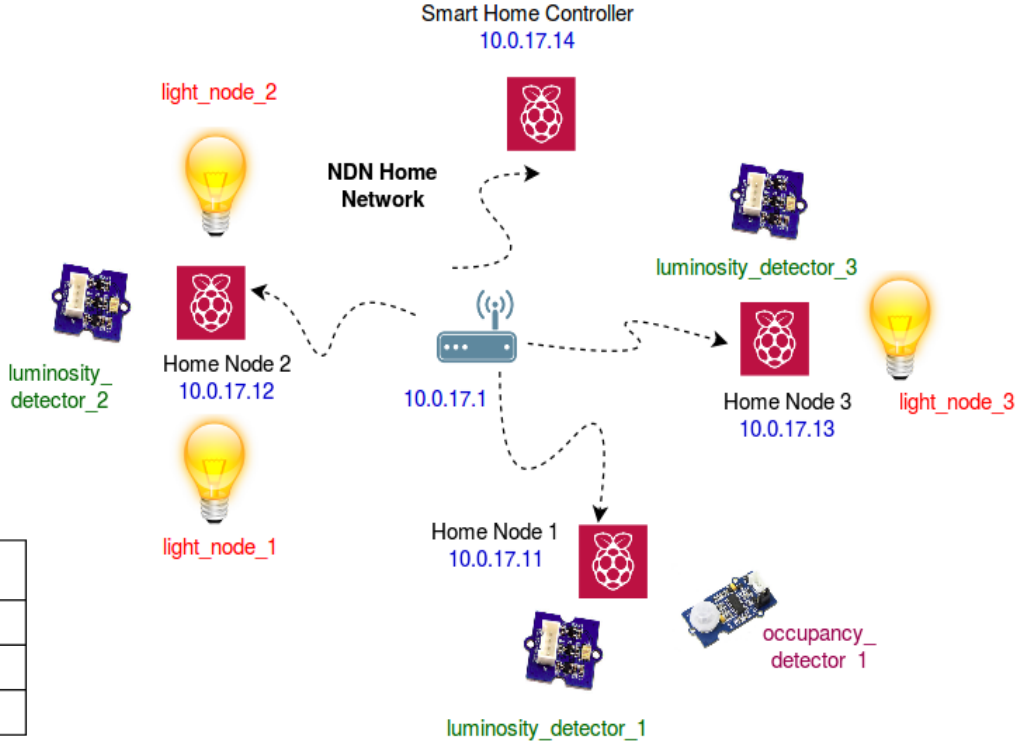




System Architecture







System Architecture

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

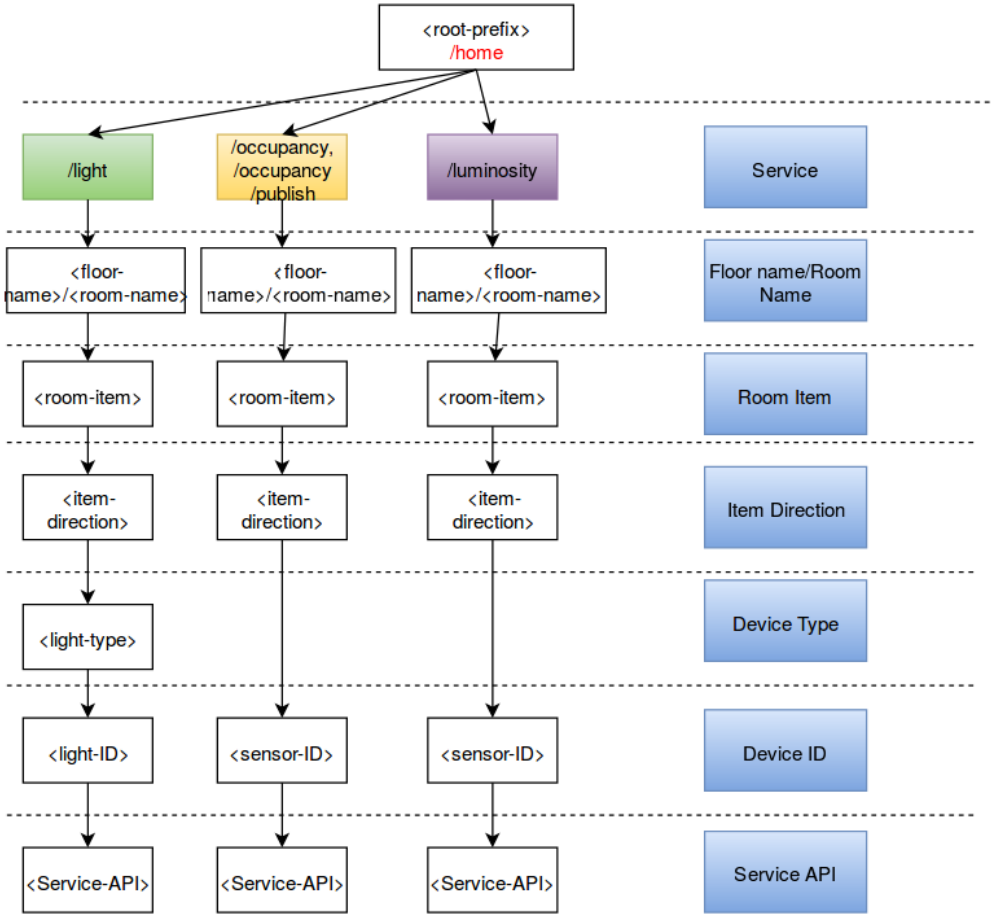
Occupancy Detector: Consists with a smart controller and a motion sensor circuit to track IN/OUT movements to/from the room.

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

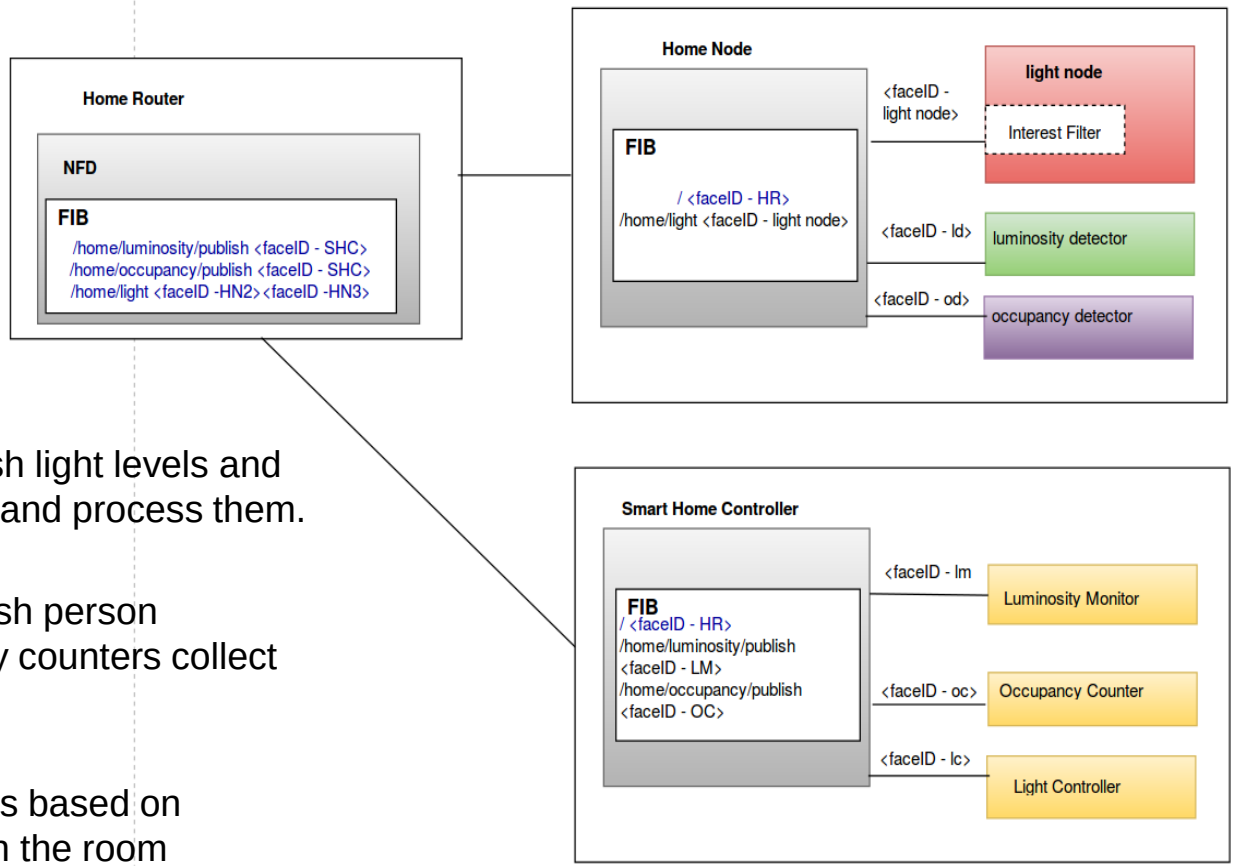
Smart Home Controller: Smart home application running on a small computing device which can control the lights based on room occupancy and daylight.

NDN Naming Structure

Based on services and physical location hierarchy



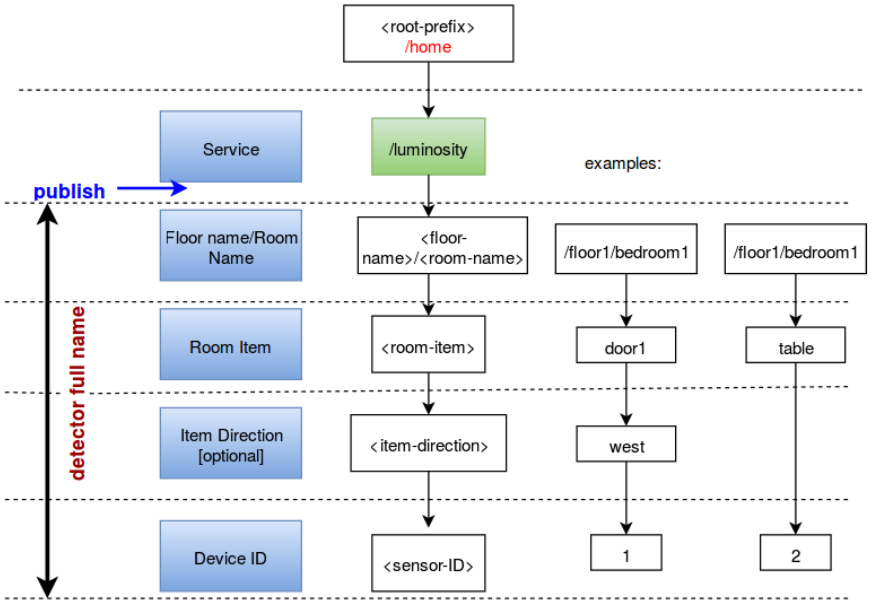
NDN Routing

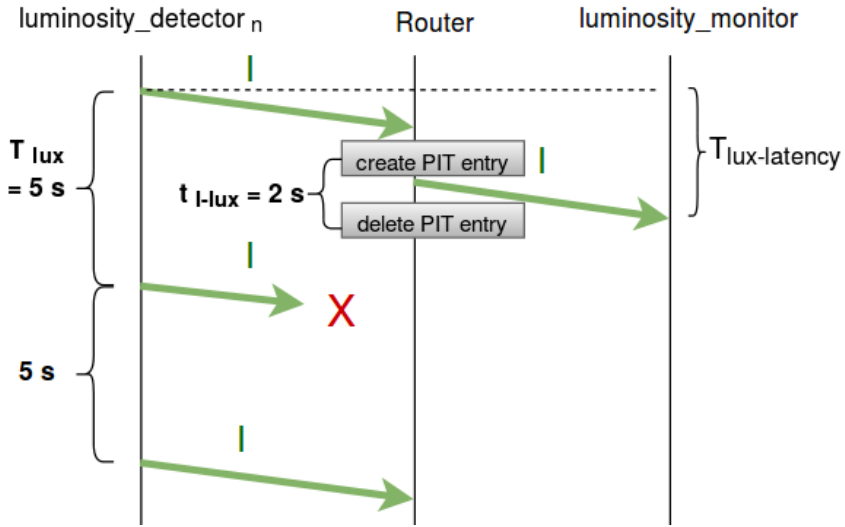


3 main operations:

- ✓ 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





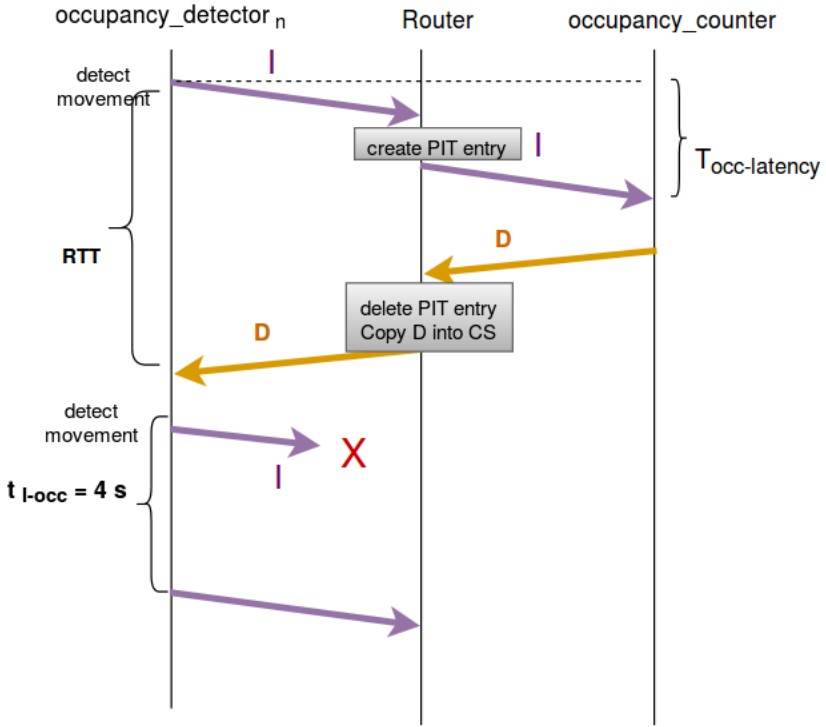
M:1 data pushing **without ack,** without security

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)

Occupancy Detectors



M:1 data push **with ack** and without security

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

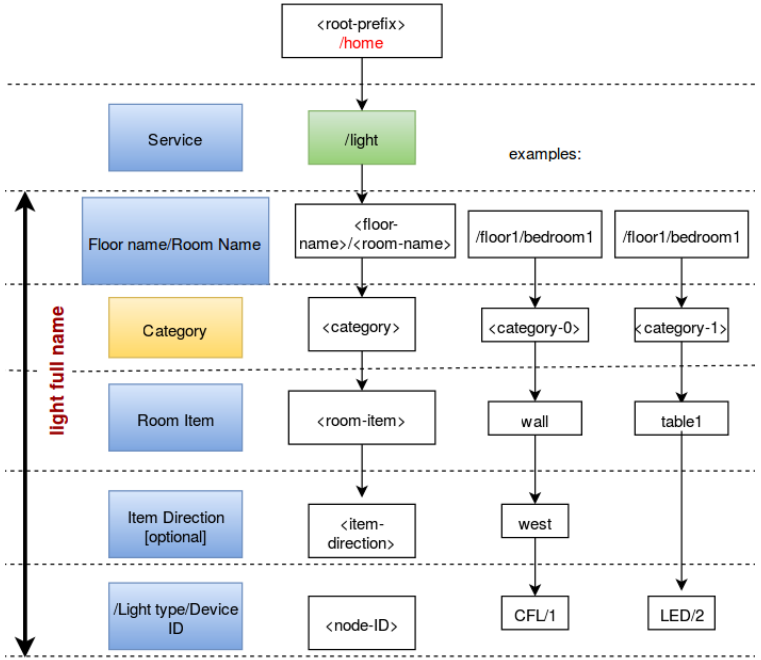
ts - time stamp
movement - IN or OUT

Dummy ack Data expected to ensure reliability

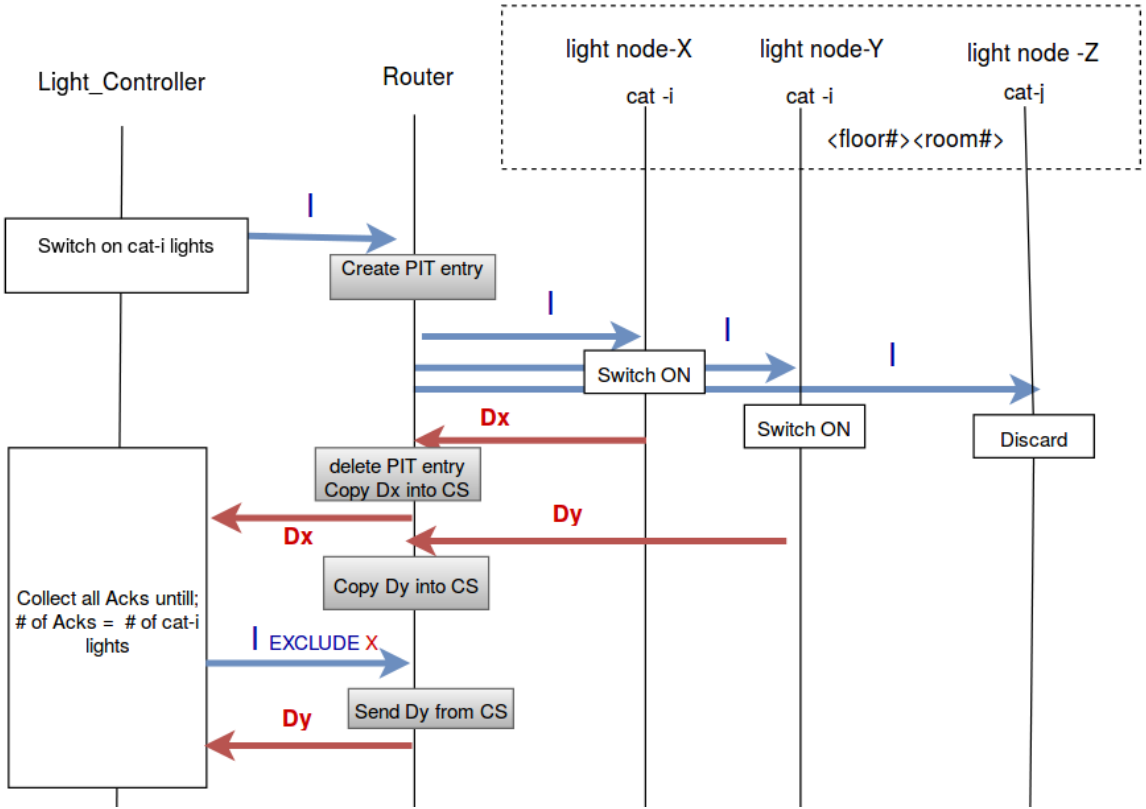
Data packet refresh Timer = 4 s
Number of INTEREST retransmission = 3

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.

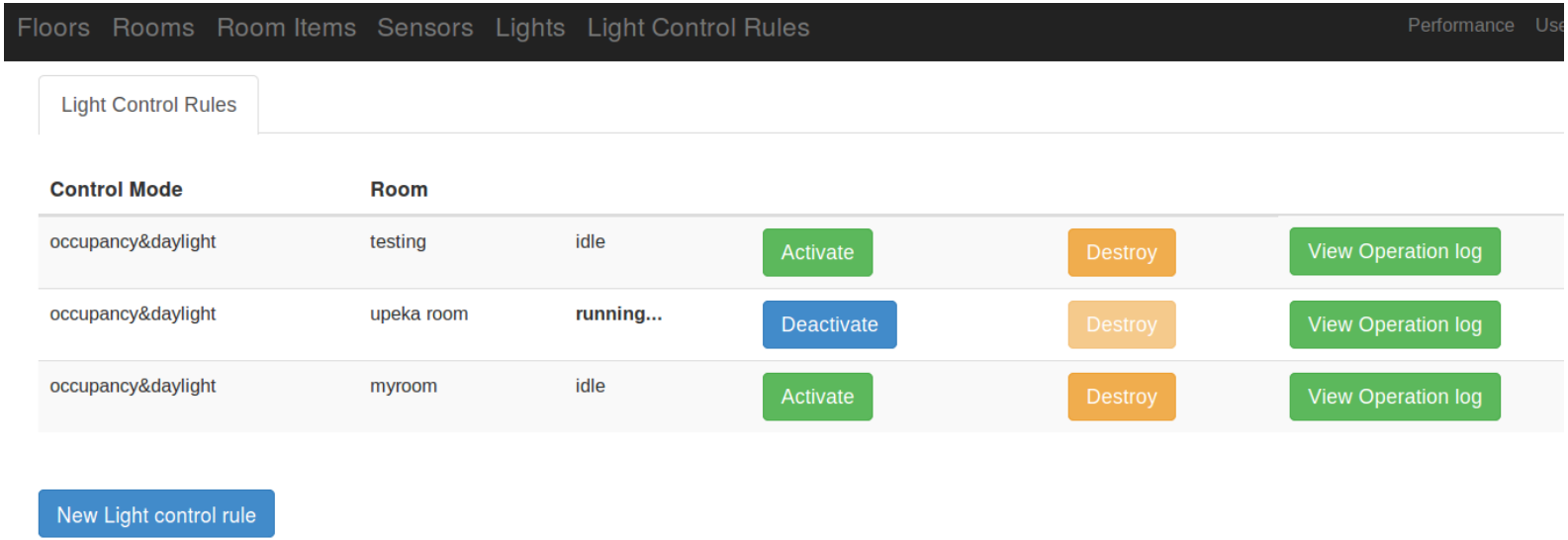


INTEREST:=
home/light/**<floor>/<room>**/<category-i>/**<command>**

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

1: M Command execution with ack and without security

Web UI


Floors
Rooms
Room Items
Sensors
Lights
Light Control Rules
Performance
Use
Light Control Rules
Control Mode
Room
occupancy&daylight
testing
idle
Activate
Destroy
View Operation log
occupancy&daylight
upeka room
running...
Deactivate
Destroy
View Operation log
occupancy&daylight
myroom
idle
Activate
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

[1] Named Data Networking Project, named-data.net.

[2] J. Fran ̧cois, T. Cholez, and T. Engel, “CCN Traffic Optimization for IoT,” in The 4th International Conf. on Network of the Future (NoF), 2013.

[3] F. Wahl, M. Milenkovic, O. Amft - ACTLab, Signal Processing Systems, TU Eindhoven, “ A distributed PIR-based approach for estimating people count in office environments” , IEEE 15th International Conference on Computational Science and Engineering, 2012.

[4]Alexander Afanasyev et.al, NFD Developer’s Guide,NDN, Technical Report NDN-0021,2015