A Keyword-based ICN-IoT Platform

Hierarchical Part  
/a/b/c/  

Function tag  
f:tag  

Hashtags  
#tag1, #tag2  

Domain location  

Network function  

IoT information

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IoT Status Quo: Isolation of Things

- Difficult to manage
- Long RTTs
- Lots of Messages
Problem Statement

• Facts
  – IoT data sets can become huge over time
  – IoT data items are produced at the edge
  – IoT data need processing
  – IoT data may be useful to many applications

• Goals
  – Bring processing close to the data
  – Allow applications to share data and results
Naming IoT Data

- Hierarchical approach to naming is too rigid!
- Picture a Building Management System
  - Data can be named on a location basis
    • /building/floor/room/...
  - Data can be named on a data-type basis
    • /temperature/building/floor/...
- How to accommodate different applications?
  - How to ease data/result sharing?
Sketch of Keyword-Based IoT

- Flexible IoT Data Naming based on Keywords
- Local Processing based on Named Functions
- Data Sharing & Reuse
- Subset of Filtered Data sent to cloud

Impossible to do with IP!
Keyword-based IoT: Overview

- Virtual split: IoT domain vs. Internet domain
  - Realised by an IoT domain border gateway
- IoT domain: data named by keywords
  - \{temperature, building, room, \ldots\}
  - Keywords encoded by hashing
  - Names encoded as Bloom filters
- Internet domain: domains named hierarchically
  - /fub/campus/cs
Keyword-based IoT: Name structure

<table>
<thead>
<tr>
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- Domain location
- Network function
- IoT information

- **Functionality**
  - *Hierarchical Part*: Locate IoT domain across Internet
  - *Function Tag*: Express processing (if needed)
  - *Hashtags*: Identify data values within IoT domain

- **Example**
  - `/fub/campus/cs ⊕ f: average ⊕ #temperature,#foyer`
Keyword-based IoT: Operation

• *Outside IoT domain*: ignore Function & Hashtags
• *Inside IoT domain*: ignore Hierarchical Part
• Logical IoT topology is a tree
  – Physically or via spanning tree algorithm
• Propagate and replicate Interest downstream
  – As in TagNet, but reversing the rules
• Execute function to merge result upstream
  – If no matching data: NACK sent back
Function Placement – Naïve

BR

Result

#area1 #bldng1 #flr1 #avg_temp

#area1

LC

#bldng1

#flr1 #flr2

#area1 #bldng1 #flr1 #rm1 #rm2

Data GW

Campus

Area

Building

Floor

Room
Function Placement – Minimum Transfer

- #area1 #bldng1
- #flr1 #avg_temp

Diagram showing placement of data and sensors.
Function Placement – Least Congested

#area1 #bldng1 #flr1 #avg_temp

Result

#area1

#bldng1

#flr1

#avg_temp

Campus

Area

Building

Floor

Room

Data

#rm1

#rm2

GW

GW

GW

GW

GW

GW

GW
Simulations

- Regular tree: height: 3, branching: 10
  - E.g., 10 floors, 10 areas, 10 devices: 1111 nodes
- More cores as we move towards root
- 100 apps simulated
  - Each app asks data from up to five random nodes
  - CPU time is random (mean 100 ms) but fixed per app
  - All data items are of the same size
  - Each link has 3 ms propagation delay
  - Requests generated so as to not overload root
Preliminary Results

Number of function executions

Level 0 | Level 1 | Level 2 | Level 3
---|---|---|---
1.6x10^6 | 1.4x10^6 | 1.2x10^6 | 1x10^6

Min. transfer | Least congested | Naive

Overhead (number of hops)

Min. transfer | Least congested | Naive
---|---|---
2.5 | 3 |

Average completion time (msec)

Min. transfer | Least congested | Naive
---|---|---
200 | 100 | 500
Issues for Discussion

• IoT Domain Size
  – Too large domains will make Bloom filters saturate

• Routing Scheme Limitations
  – TagNet routing would allow execution not on the tree

• Expressing Time Constraints
  – Information Time Tags to select Data (and Results)

• Security and Privacy
  – Combine with Proxy Re-encryption (Fotiou et al.)
Summary

• Flexible naming/processing for ICN-IoT
  – CCN/NDN names across the Internet
  – Keyword-based names inside IoT domain
  – Function tags to locally aggregate data

• TagNet inspired matching to locate data
  – Single tree and reverse matching rule

• NFN inspired execution to aggregate data
  – Tree-based execution placement strategies