ICN in the IoT on RIOT

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Outline

1. Problems & Scenarios
2. ICN-IoT Platform: CCN-lite on RIOT
3. Content Dissemination in the IoT: Implementing Pub/Sub

Problem Space (that we look at)

- Constrained systems
  - Memory: scarce kBs
  - Storage: the least constraint (if available)
  - Operations: possibly long sleep cycles
- Communication
  - Event triggers insufficiently supported: want no push on the data plane
  - Data availability: timely at lowest price
- Naming
  - Role of contexts unclear

Typical IoT Network Scenarios

- Sparse deployment (of fixed devices)
- Inhomogeneous node coverage
- Partitioned networks
- Mobility
- Intermittent connectivity
- Selected uplinks into a cloud environment

Opportunities with ICN for IoT

- Mobility
  - Mobile devices are common for the use cases
  - Content counts, not addresses
- Security
  - False alarms may lead to shutdowns
  - Dropped alarms may lead to health risks
- Network management
  - Easy deployment and auto-configuration
  - Reducing total cost of ownership
- Network caches
  - May reduce latency for multiple services
  - Fixed devices anchor network caching

Shortcoming of ICN in the IoT

Routing on Names

- Long names, limited aggregation potentials
- FIBs (too) large, high churn potentials

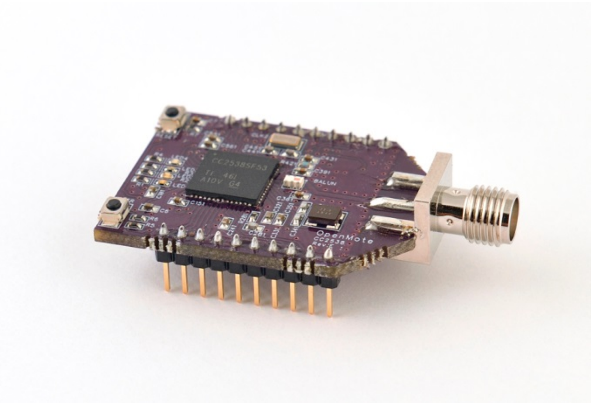
Simplified Link-layer Model

- NDN assumes point-to-point or broadcast

IoT Wireless is a Broadcast Domain

- Lack of L2 mapping moves all packets to the CPU
  - Increases system load and energy consumption
- IoT link layer technologies usually restricted to short MTUs
  - Enhanced susceptibility to interference and loss

Implementing ICN in the IoT: Network Stack



Which ICN implementation?

- CCN/NDN

Which operating system for IoT?

- RIOT

Porting CCN-Lite to RIOT

- 1,000 lines of C code
- Required ROM 16 kBytes
- Required RAM 5 kBytes

More details: Emmanuel Baccelli, Christian Mehlis, Oliver Hahm, Thomas C. Schmidt, Matthias Wählisch, **Information Centric Networking in the IoT: Experiments with NDN in the Wild**, **In:** *Proc. of ACM ICN*, pp. 77--86, New York:ACM, 2014.

CCN-lite on RIOT

- Joint development started in late 2016
- Objective: Maintain CCN-lite as a RIOT package
- Major refactoring started
  - Code reorganization
  - New source structure and include policies
  - Many bug fixes & adaptations (56 PRs closed so far)
  - Features related to IoT platforms
- Dedicated branch in CCN-lite repo: https://github.com/cn-uofbasel/ccn-lite/tree/ccnlv2

New Features

- CCN-Lite runs on a wide range of IoT devices via RIOT (analog to NDN-RIOT)
- LoWPAN support added to CCN-Lite
  - CCN-Lite implements RIOT’s recursive **`netapi`**
  - Inherits support for all protocols/drivers
- Multi-Transceiver /Multi-Stack-Support in RIOT
  - Enables easy gateway functions
  - ICN-MQTT gateway ready
- Two new hooks in CCN-lite
  - **`on interest`**
  - **`on cache full`**

Roadmap & Ongoing Steps

- Building a build system:
  - Modularize code dependencies
  - Produce Makefiles …
- CI similar to RIOT environment – replace Travis?
- Enhance data structures for constrained devices
- Eliminating dynamic memory allocation
  - Provide a fixed size, dynamically usable mem-pool
  - Trade protocol state with cache
  - Limit names by a fixed max length

Content Dissemination

- How to publish data efficiently without continued node presence and huge FIBs?

- draft-gundogan-icnrg-pub-iot-00

Pub/Sub in ICN?

- Common Pub: Push on the data plane
- ICN paradigm contradicts pushing of data – still there is around
  - Unsolicited Push Message
  - Interest Notification
  - Long-Lived Interest
  - Interest polling
- What happens on the control plane?

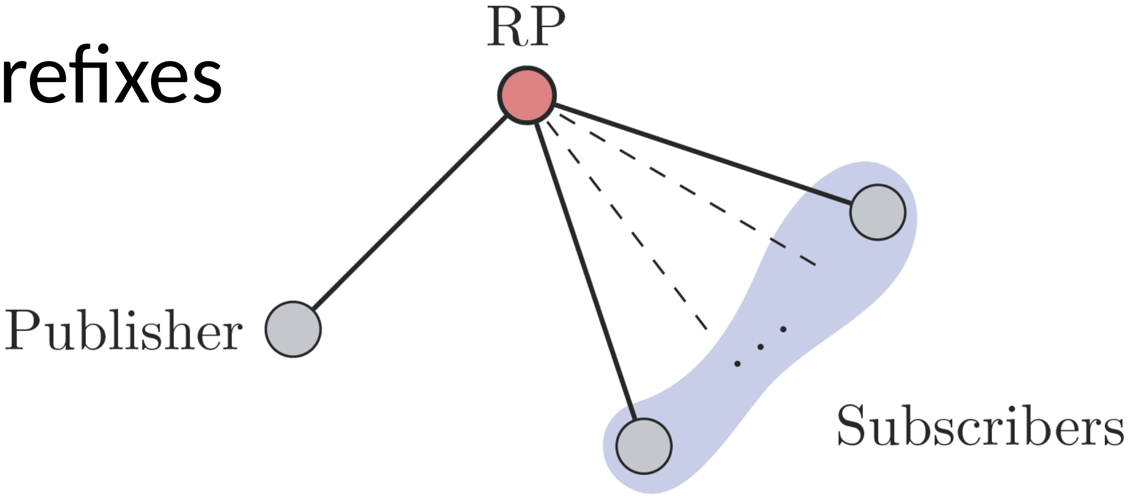
ICN Control Plane

- Distributes routing information
- Fills FIBs → distribute names
  - Originally plain broadcast
  - Flooding according to selected routing protocols
  - Unicast push to Name Collector (PANINI)
  - Request/Response replication (Chronosync)
- Publishing = Making a name available?

More details: Thomas C. Schmidt, Sebastian Wölke, Nora Berg, Matthias Wählisch, **Let's Collect Names: How PANINI Limits FIB Tables in Name Based Routing**, **In:** *Proc. of IFIP Networking*, pp. 458–466, IEEE Press, 2016.

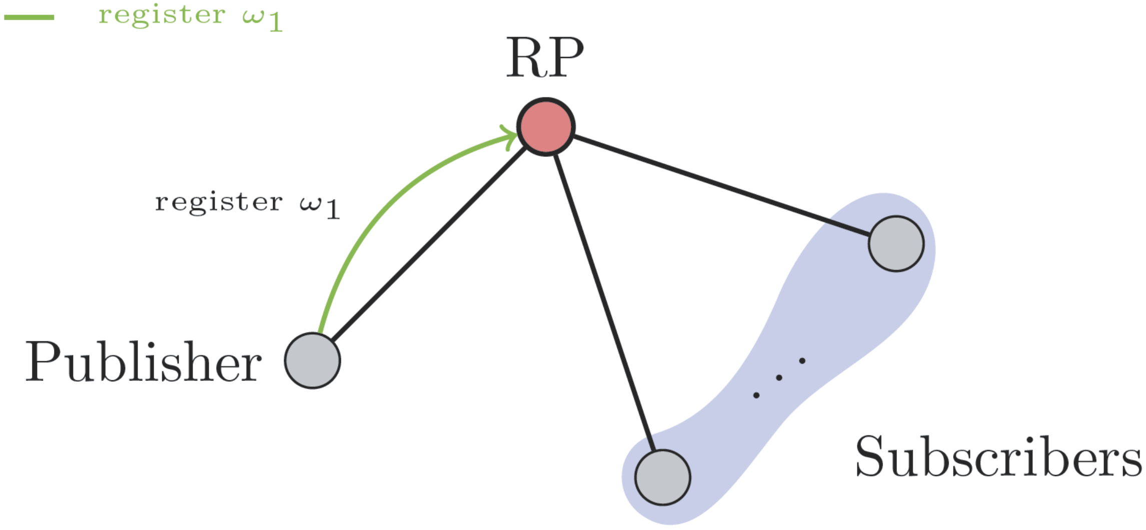
Pub/Sub Approach

- Construct a rendezvous network
- RPs are content nodes
  - Gateways
  - Caches
  - Content stores (CDN replica ...)
- RPs announce prefixes
  - Prefix-specific default routing



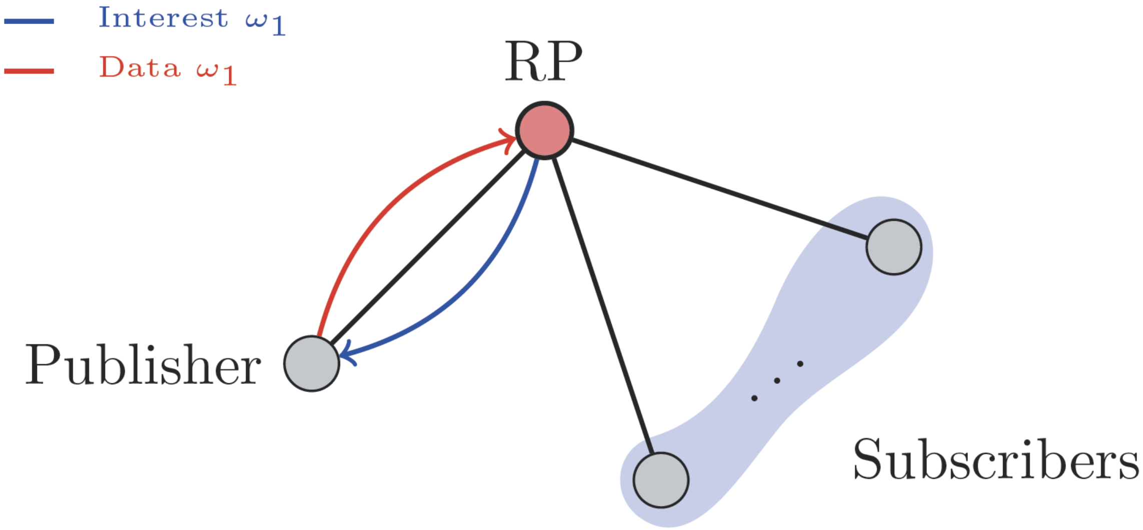
Publishing Names

- A content producer ‚tells‘ the new name to the content node
  - Name advertisement along default route (Panini NAM)
    - Pushing the name, not the content



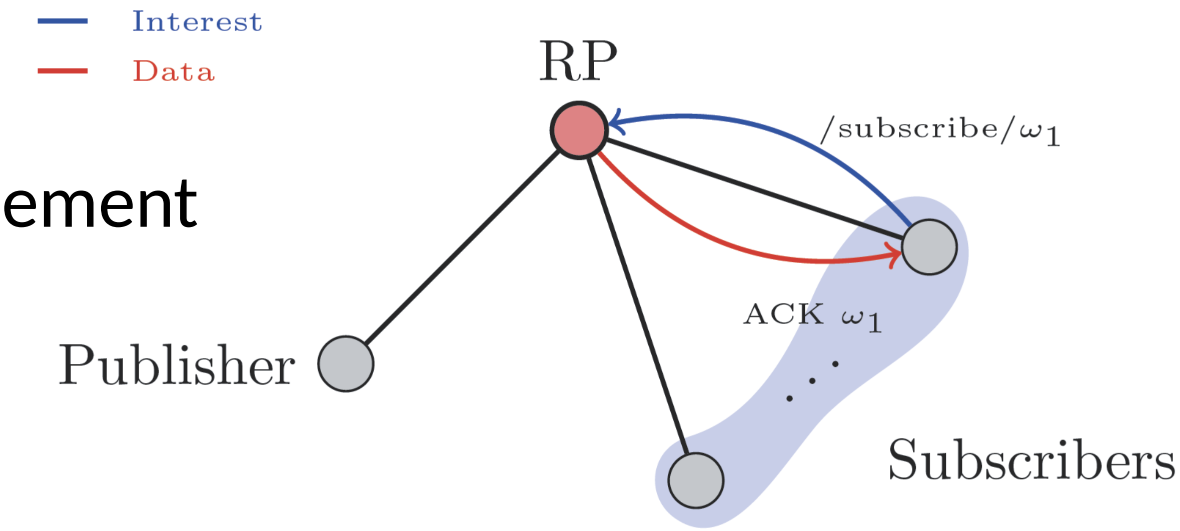
Publishing Content

- The content node may request data
  - Replication to caches/deputy nodes
  - Data follows Interest

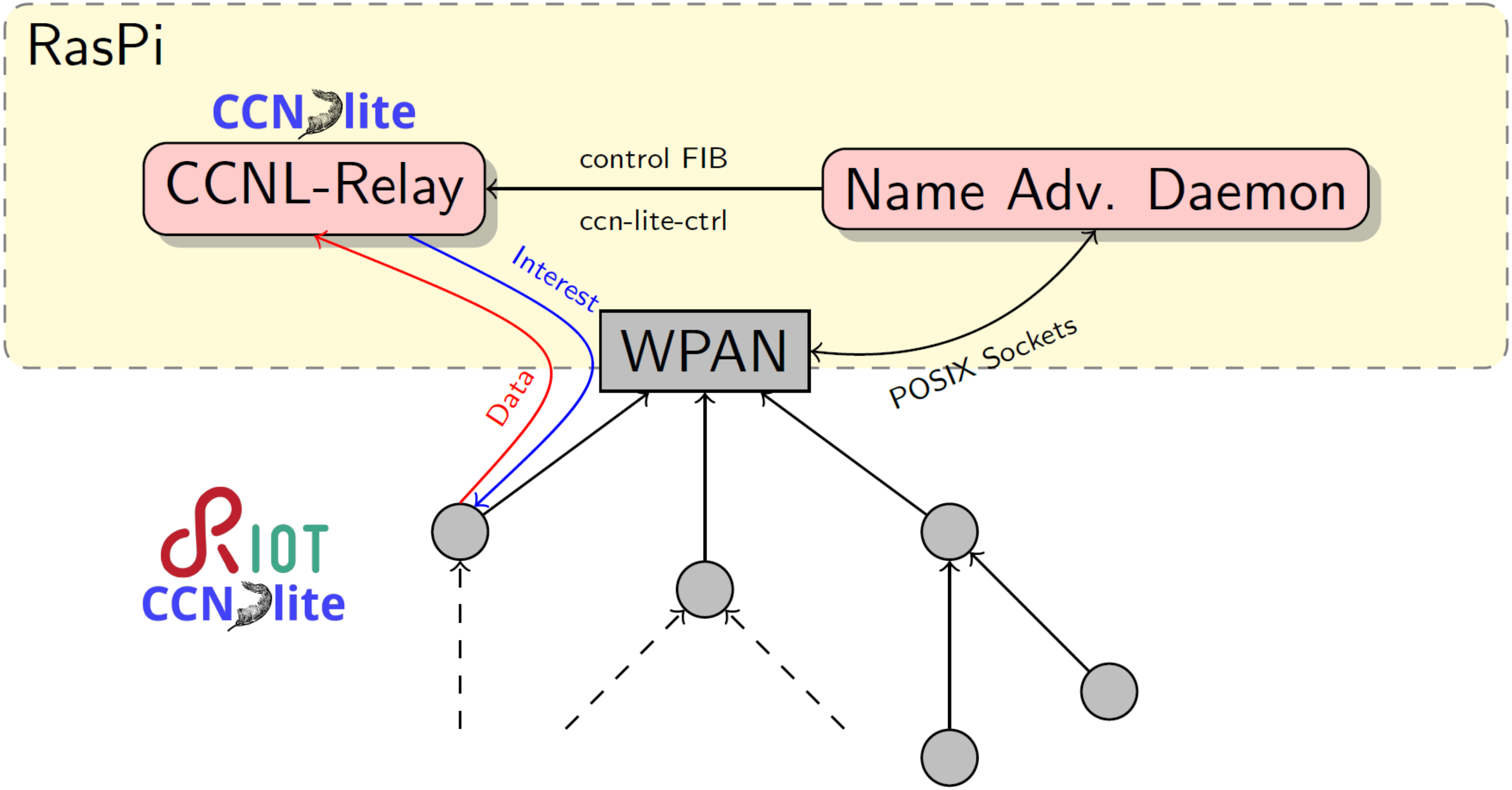


Subscribing to Content in the IoT

- Interest - following default route
  - Returns a unique content item
  - May carry a „sub“-indicator for future alerts
- Name advertisement
  - Meta table (polling)
  - NAM advertisement (broadcast/ multicast)



Implementation



Questions & Discussion?

http://ccn-lite.net/

http://riot-os.org/