Osaka University

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# *Retrieving Information with Autonomously-Flying Routers in ICN*

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Osaka University 1

## Outline

- Background
- CCN Architecture with Flying Routers
- Demo Movie of Prototype
- Summary and Future Work

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Osaka University 2

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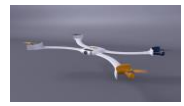
Osaka University 3

## Drone

A small aircraft

Programmable

Battery-driven



Active movement

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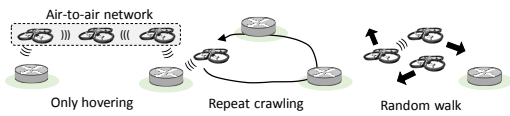
## Networking with drones in previous work

- DTN (Delay-Tolerant Networking) [1][2]
  - Use drones as intermittent **data links**
  - **Not** support **packet-driven movement**
  - e.g., hovering, fixed movement, randomness




Effective movement of drones is not considered so much.

**[1]** Y. Zhou, et al., "Multi-uav-aided networks: Aerial-ground cooperative vehicular networking architecture", *Vehicular Technology Magazine, IEEE*, vol. 10, no. 4, 2015.
**[2]** N. Uchida, et al., "Resilient Network with Autonomous Flight Wireless Nodes based on Delay Tolerant Networks", *IT Convergence Practice*, vol. 2, no. 3, Sep 2014.

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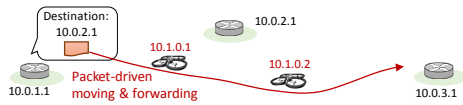
## Our proposal

- Flying Router (FR)
  - Use a drone as a **moving router**
  - **Enable** realizing **packet-driven movement**


- Benefits by **packet-driven movement**
  - Deliver packets toward destination
  - Control drone's behavior by packets



## Problems of FRs

- **Host-oriented networking (e.g., IP)** is not suitable.
  - Drone topology may change because drones move.
  - Drones are frequently replaced due to battery charge.

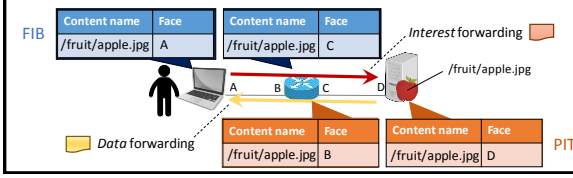
It is difficult to manage node addresses of FRs.
**Cooperation of multiple FRs is also difficult.**

- We apply **content-oriented networking** to FRs.
  - Every node has no address.
  - Content ID is used as routing information.
  - It is called **ICN (Information Centric Networking).**



## ICN (Information Centric Networking)

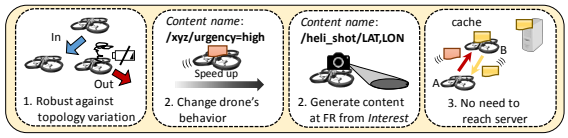
- Addressing with "***name***" of content
- An ICN realization: **CCN (Content Centric Networking)**
- Two message types and two routing tables in CCN
  - ***Interest* message**: Request content
  - ***Data* message**: Response corresponding to *Interest*
  - **FIB (Forwarding Information Base)** : Forward *Interest*
  - **PIT (Pending Interest Table) :** Forward *Data*






## Main advantages of using ICN on FRs

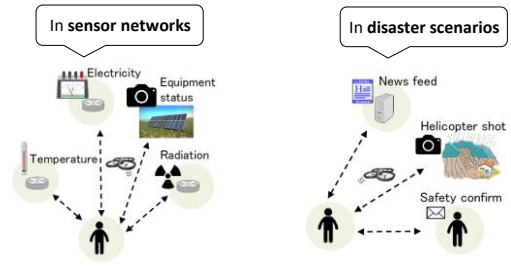
1. Robust against movement and interruption of FRs
   - Because FR does not have node address unlike IP
2. Flexible content-driven operation of FRs
   - Change movement speed depending on content *name*
   - Dynamic generation of contents (e.g., helicopter shot)
3. High performance due to in-network cache
   - Shorten moving distance of FRs






## Application examples of FRs

- There are a variety of applications of FRs.
  - Provide connectivity between dis-joint networks effectively using the advantages from routers and ICN.



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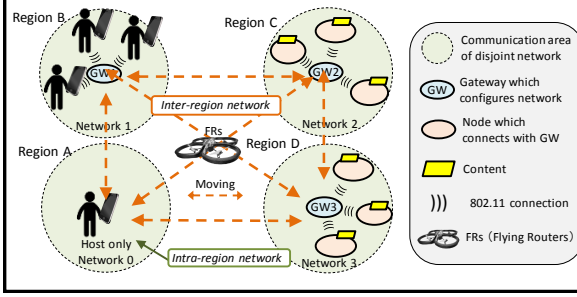
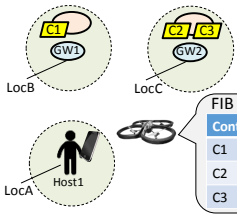
## An operation scenario

- *Intra-region network* is constructed by a gateway of a host.
- **Multiple FRs** construct *inter-region network*.



## How introducing movement of an FR into CCN

- Interface Table is proposed to map between faces and locations.
- FR can move to gateways associated with requested contents by referring to FIB/PIT and Interface Table.




Routing tables of FR

FIB

| Content name | Face |
|---|---|
| C1 | GW1 |
| C2 | GW2 |
| C3 | GW2 |

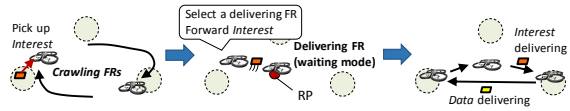
Interface Table

| Face | Location |
|---|---|
| Host1 | LocA |
| GW1 | LocB |
| GW2 | LocC |



## How delivering messages by FRs cooperatively

- **FRs in crawling mode (Crawling FRs)**
  - Crawl along intra-region networks
  - Collect and advertise routing information (lists of contents)
  - Pick up *Interest* and forward it to a delivering FR
- **FRs in delivering mode (Delivering FRs)**
  - Wait at Rendezvous Point (RP), which is central position of an inter-region network firstly (waiting mode)
  - Deliver *Interest* and *Data*
  - Back to waiting mode after delivering



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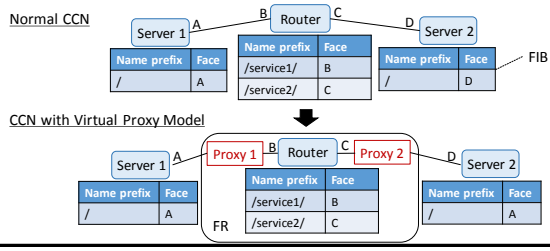
## Functions of prototype

- A prototype of FR is developed, which has **only delivering mode** to confirm the feasibility of this proposal easily.
- The prototype can only realize the following functions.
  1. Wait until an *Interest* is received
  2. Forwarding the *Interest* to the server including movement
  3. Wait until the *Data* is received
  4. Forwarding the *Data* to the requester including movement




## How realizing Interface Table on CCN

- Virtual Proxy Model is proposed to realize Interface Table.
  - There are as many intra-region networks as proxies on an FR.
  - Proxies are applied to Face of FIB/PIT.
  - A proxy has a function to move an FR to one place.



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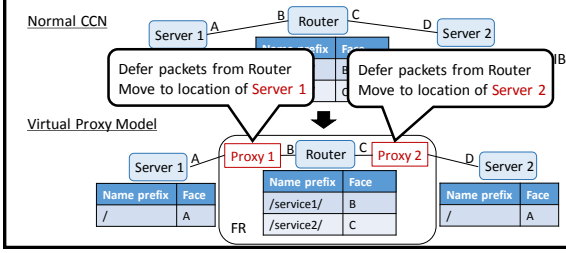
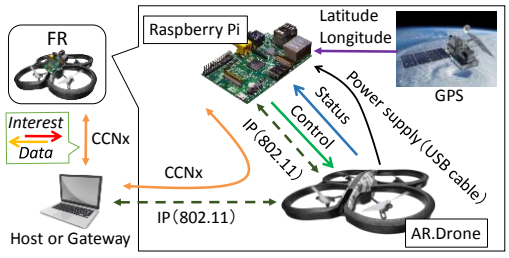


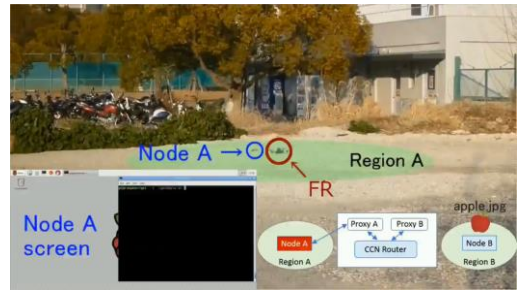
## Prototype operation

- **Raspberry Pi** is used as CCN router.
- **AR.Drone** is used as drone.
- **CCNx 0.8.2** is used as implementation of CCN.






## Demo movie



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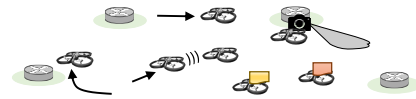
## Summary and future work

- Summary
  - Flying Router (FR) is proposed by introducing Interface Table in CCN protocol stacks.
  - How FRs cooperate to deliver contents is discussed.
  - A prototype of FR is developed, and its operation (only delivering mode) is demonstrated.
- Future work
  - Investigation on the feasibility of multiple drones operation
  - e.g., scheduling, movement strategy, security, and so on



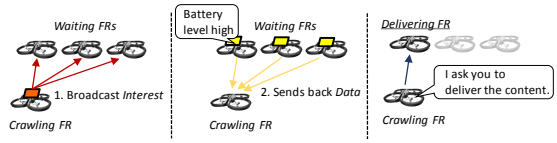


For questions



## *Signaling* : how to select a delivering FR

- A crawling FR selects a delivering FR from waiting FRs.
- Signaling is performed by exchange of CCN message.
  1. A crawling FR broadcasts an *Interest* to waiting FRs
  2. Each waiting FR sends back a *Data* including
     - whether local cache of the content is hit
     - destination of messages which the waiting FR already has
     - specifications of the waiting FR (e.g., battery, speed)
  3. The crawling FR selects one appropriate delivering FR



## An example of our cooperative routing

Routing tables of FRs

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| Content name | Face |
|---|---|
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| C2 | GW2 |
| C3 | GW2 |

PIT

| Content name | Face |
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| C2 | Host1 |

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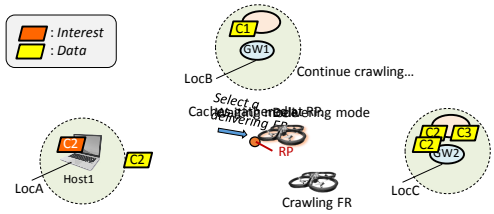




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