



**OpenFlow-based Content-Centric Networking
Architecture and Router Implementation**



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Outline

- Research area
 - Content-Centric Networking (CCN)
- Objectives
 - Resolve Implementation and Deployment Issues
- Research Approach
 - OpenFlow-based CCN
- Major Outcomes
- Conclusion

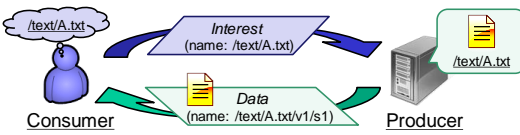





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Content-Centric Networking (CCN)


- Content-based addressing with "name"
- Transmission using *Interest* and *Data* packets
- Natively supported mechanisms to disseminate contents
 - Interest aggregation, data multicasting, In-network caching

➔ Realization of CCN is a big challenge



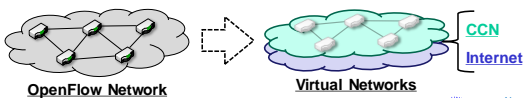
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Objective and Approach

- Objective: Realization of CCN
 - Implementation of CCN forwarding
 - Deployment of CCN


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- Approach: Implement **OpenFlow-based CCN**
 - Allows to easily implement new protocols
 - Allows multiple systems to share one network



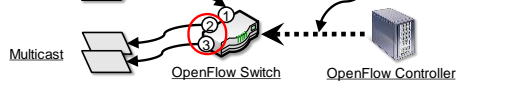





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Design of OpenFlow-based CCN


- Fast Processing based on name address
 - Convert name to hash value (that is hierarchically structured)
 - Write the hash in IPv4 address field
- Multicast using multiple actions

Name: /text/A.txt → Hash: 0x12340000 → IPv4 Addr: 18.52.0.0	<table border="1"> <tr> <td>Match Field</td> <td>• DST IPv4 Addr = 18.52.0.0/16</td> </tr> <tr> <td>Action</td> <td>• Packet-out port 2 • Packet-out port 3</td> </tr> </table>	Match Field	• DST IPv4 Addr = 18.52.0.0/16	Action	• Packet-out port 2 • Packet-out port 3
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Major Outcomes

- Hierarchically structured hash value
 - Support active name
- Analysis of hash collision probability
 - Explore the trade-off
- Implementation of the program for OpenFlow controller
 - Show the demonstration

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Hierarchically Hashed Name

- Assign 4 bits to each component
 - Ex. /text/A.txt/v1/s1
 - "text" = 2, "A.txt" = 1, "v1" = 4, "s1" = 2
 - IP address: 33.66.0.0/16 (= 0x21420000)
- Trade-off between B and C
 - B: number of bits assigned to component
 - C: number of components that can be hashed

Protocol	C = number of components			
	B = 4	B = 8	B = 16	B = 32
IPv4 (32 bit)	8	4	2	1
MAC (48 bit)	12	6	3	2
IPv6 (128 bit)	32	16	8	4

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Support Active Name

- Resolve a mismatch caused by flatly hashing^[1]

[1] N. Biefan-Melazzi, A. Detti, G. Mazza, G. Morabito, S. Sakano, L. Veltri, "An OpenFlow-based Testbed for Information Centric Networking," in Proceedings of Future Network & Mobile Summit 2012, 4 – 6 July 2012, Berlin, Germany

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Hash Collision Probability

- $$p_4^{\text{Protocol}} = \left(1 - \prod_{i=1}^N \frac{(2^B - 1) - i}{2^B - 1} \right)^{\frac{\text{len}}{B}}$$
- B: number of bits assigned to component
- N: number of names
- len: bit-length of the address in the protocol

Protocol	N(p = 0.1) / N(p = 0.9)		
	B = 4	B = 8	B = 16
IPv4 (32 bit)	6 / 11	21 / 43	224 / 624
MAC (48 bit)	7 / 11	27 / 47	287 / 664
IPv6 (128 bit)	9 / 12	32 / 50	427 / 753

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Program Demonstration

Demo Environment

Screenshot of Demo

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Program Demonstration

```

===== datapath_id: 1 =====
===== cs =====
===== pit =====
===== fib =====
=====
Received ARP_REQUEST from IP[192.168.0.22]
Interest(ESwitchManager)
name: /text/A.txt
===== datapath_id: 1 =====
===== cs =====
===== pit =====
/text/A.txt => 1
===== fib =====
=====
Received ARP_REQUEST from IP[192.168.0.11]
Interest(PIIT)
name: /text/A.txt
    
```

```

# ruby interest.rb /text/A.txt
/text/A.txt
waiting for a packet...

# ruby interest.rb /text/A.txt
/text/A.txt
waiting for a packet...

# ruby data.rb /text/A.txt/v1/s1
/text/A.txt/v1/s1
waiting for a packet...

*** 10% has been finished. ***
*** 20% has been finished. ***
*** 30% has been finished. ***
*** 40% has been finished. ***
*** 50% has been finished. ***
    
```

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Conclusion and Future Work

- Conclusion
 - Feasibility of OpenFlow-based CCN
 - Provides the implementation of CCN forwarding on OpenFlow
 - Support active name
 - Analyze hash collision probability
- Future work
 - Implement lacking mechanisms
 - Routing, hardware caching
 - Explore scalability
 - Hash collision probability, flow entries
 - Evaluate performance using hardware

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