Content Placement for Reducing FIB Size in NDN Using GA （ICOIN 2025）

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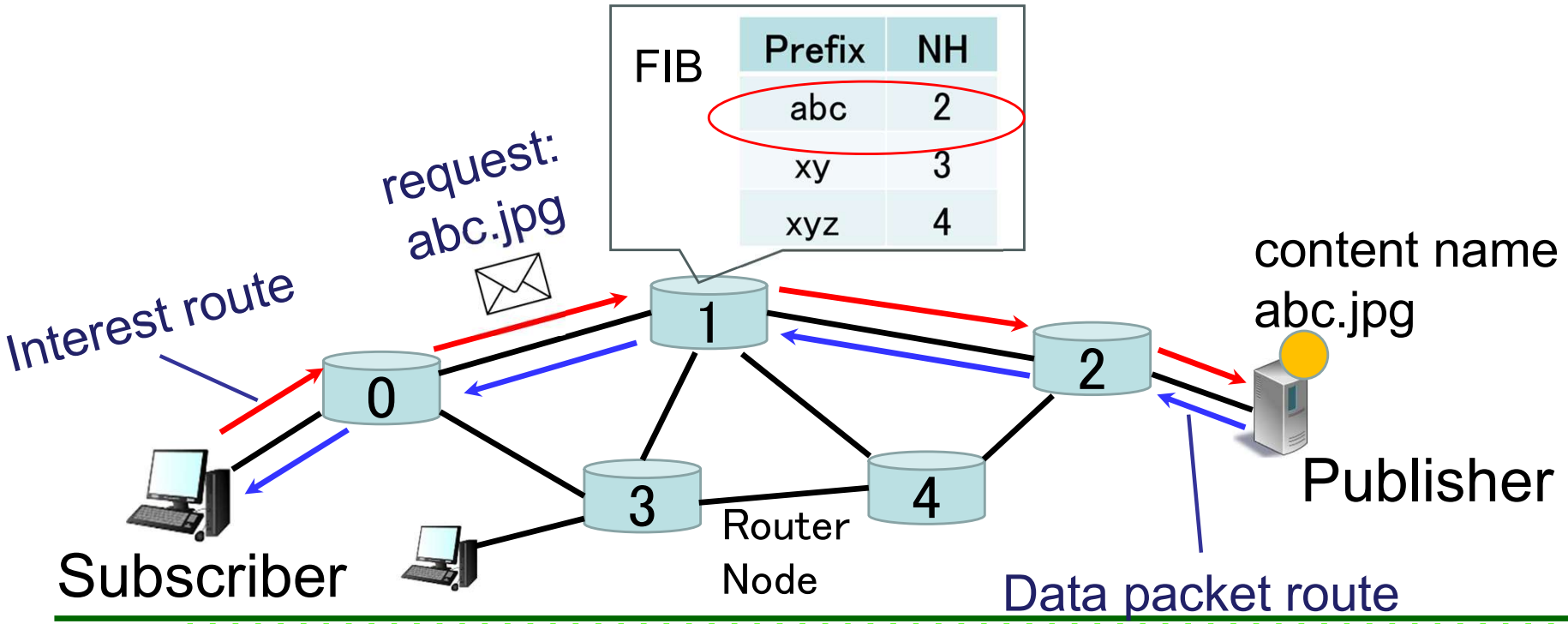
Outline

1. Introduction
2. Propose method
    1. Genetic Algorithm
    2. Proposed method design
    3. Simulation parameter
    4. Result
3. Conclusion/Future work

Information-centric networking

- ICN (Information-centric networking)
  - Interest (request packet): Using content name not IP address
  - How to connect :
  1. Interest are referred FIB (Forwarding Information Base)
  2. Data is send along the reverse route along which the interest pass
  - NDN (named data networking) is popular in ICN



Motivation

- Subject: The Scale of FIB on NDN
  - It is increased the number of Prefixes caused by larger networks
  - It is difficult to aggregate FIB entry due to the lack of locality in local domain names

  ➡we need Large memory size and have much time to search match FIB entry
- Example: when it is considerate only Web contents

  NDN FIB: about 10^9 entry * vs IP FIB: about 10^5 entry

Prefix	NH
abc	0
xy	1
xyz	3

Prefix	NH
223.1.1.1	0
223.2.1.1	1
224.1.1.3	2

NH: next hop

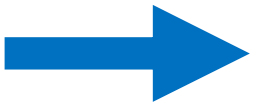
*A. Detti, M. Pomposinim, N. Blefari-Melazzi, and S. Salsano, Supporting the Web with an information centric network that routes by name, Elsevier Computer Networks, Vol. 56, No. 17, pp. 3705–3722, Nov. 2012

Previously Study* -1

- The FIB entry aggregate method
  - LPM (Longest prefix matching)
  - Components : each part separated by “period”
  - The aggregate method
    - Sort URLs in reverse order
    - When both component and NH are same, their entries can aggregate

Before aggregation

	Prefix	NH
①	jp/post/zib	R3
②	jp/post/abs	R3
③	jp/post/ac	R4
④	com/google	R5



After aggregation

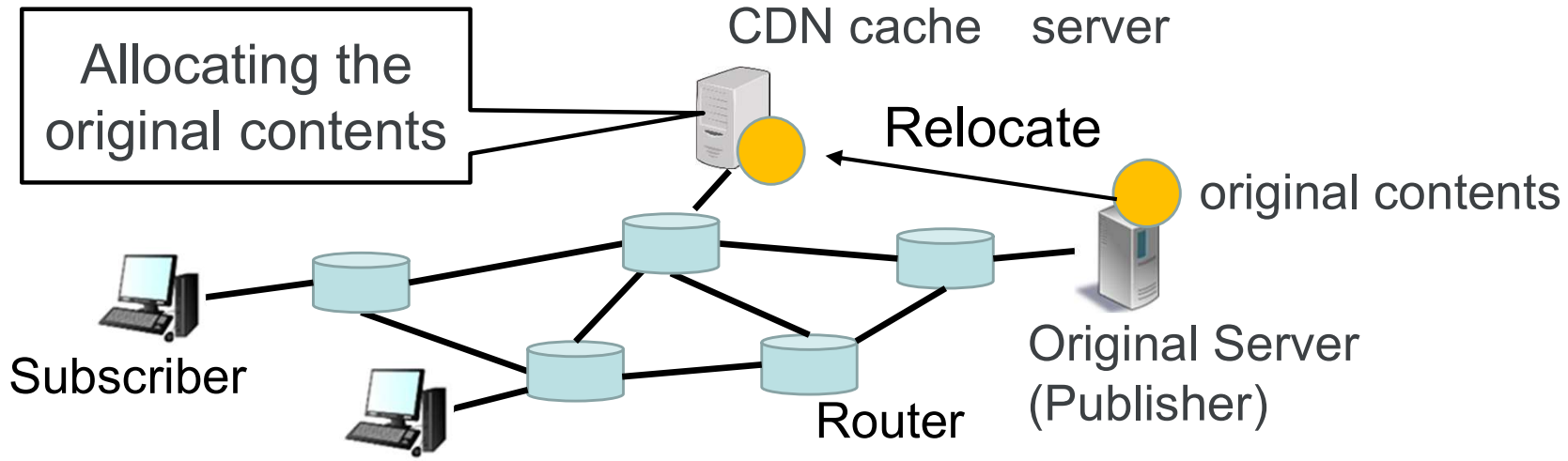
	Prefix	NH
①	jp/post/*	R3
③	jp/post/ac	R4
④	com/google	R5

* Y. Sasaki, et al., Designing Content Placement of CDN for Improving Aggregation Effect of ICN FIBs,

Previously Study* -2

- Allocating the original contents by using CDN (Content Delivery Networking)
  - CDN can
    - advertise Prefixes of cached content to the network.
    - be hosted by publisher.

➞ By allocating content with the same TLD or SLD to the same CDN cache server, we have effective aggregation of FIB entries



* Y. Sasaki, et al., Designing Content Placement of CDN for Improving Aggregation Effect of ICN FIBs, ICOIN 2020.

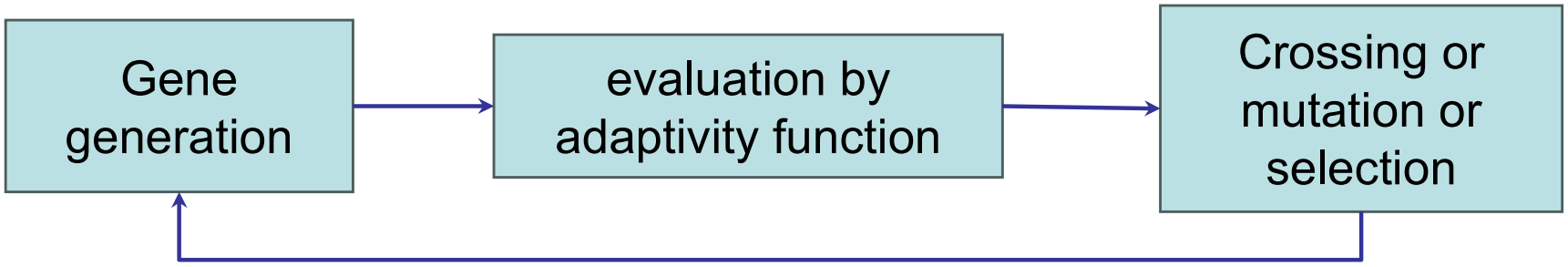
Aim

- However, content placement has influence in network quality
  - In terms of FIB size, it is desirable that contents with the same name are allocated on the same node
  - On the other hand, it is not desirable load concentration
  - The content placement is NP hard in heuristic method

- Therefore, we propose placing original contents that uses genetic algorithm (GA) to consider four evaluation criteria

Genetic algorithm(GA)

- meta-heuristic algorithms
- generated up until a pre-defined condition
  - Iteration of gene (=solution) generation and evaluation by adaptivity function
  - Leave highly adapted genes to the next generation



Proposed GA Design

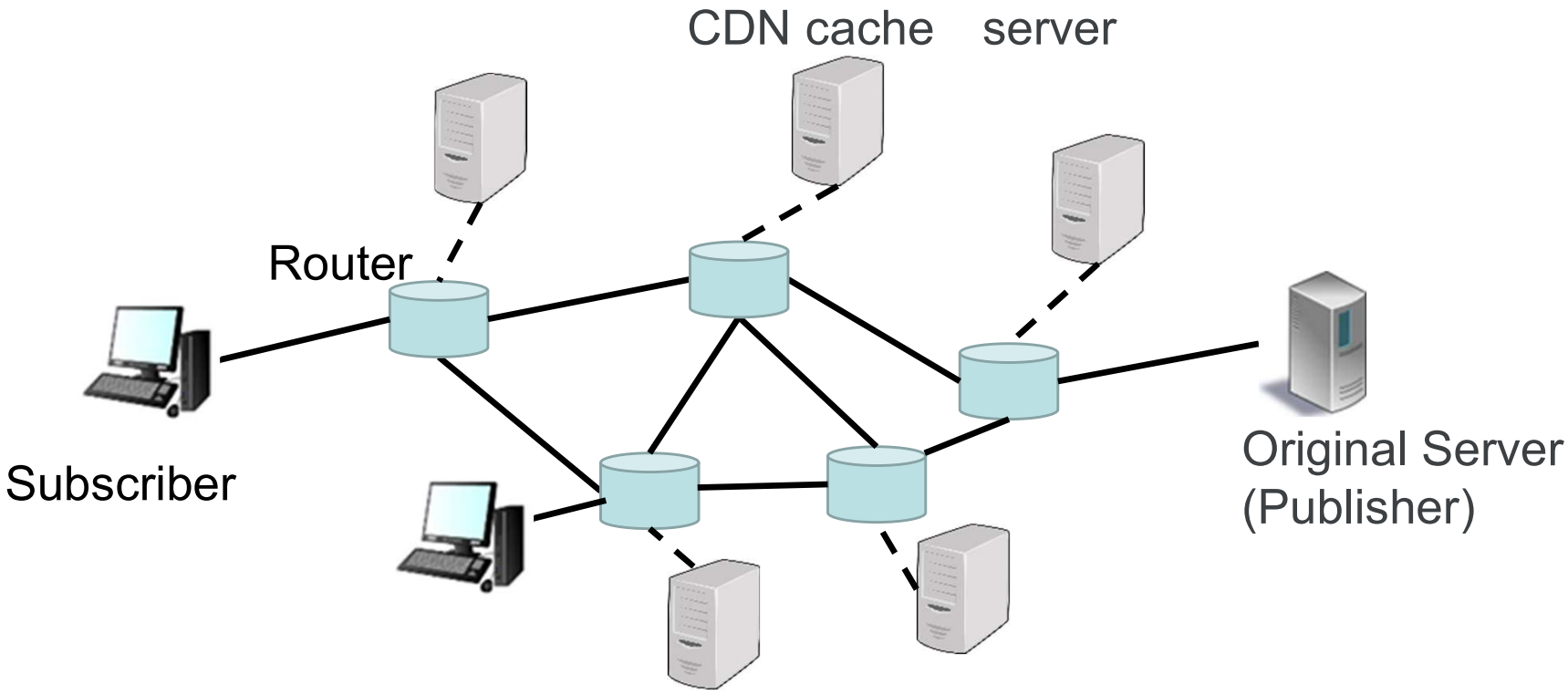
- Gene g_k: The result of content placement
- Unit of content on GA:
  - TLD contents set (except TLD “com” and “net”)
  - SLD contents set (only TLD “com” and “net”)
- Fitness function

$$A(g) = w_1(1 - E'_a) + w_2(1 - L'_a) + w_3(1 - C'_L) + w_4(1 - R'_c)$$

  - E_a : Average FIB entry size
  - L_a : Average Link Load
  - C_L : Coefficient of variation of link load
  - R_c : Loss of Availability
    - Normalization by generation ⇒ $E'_a,\ L'_a,\ C'_L,\ R'_c$
  - weight : w_1, w_2, w_3, w_4

Network Modeling

- CDN is placed all the node in network
- The router caching is not considered in this research



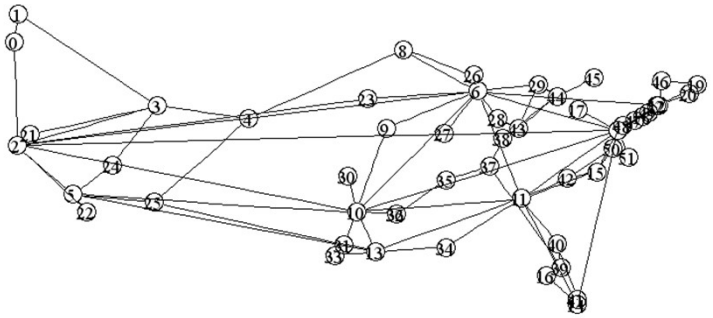
Content request

- Link Load
  - $L = \sum_{f_{sd} \in F_l} D(s)p(d)$
    - f_{sd} : network flow between start node s and destination node d
    - F_l : Set of flows through link l
    - $D(s)$: Access ratio of content request destination node s
    - $p(d)$: Population ratio of requesting node d
- This research used 12,010 web objects for which distribution servers exist in the United States.
  - Each content has request rate
  - Calculate link load when requests appear from all nodes to each data at one time

Alexa webpage, https://www.alexa.com/siteinfo

Simulation parameter

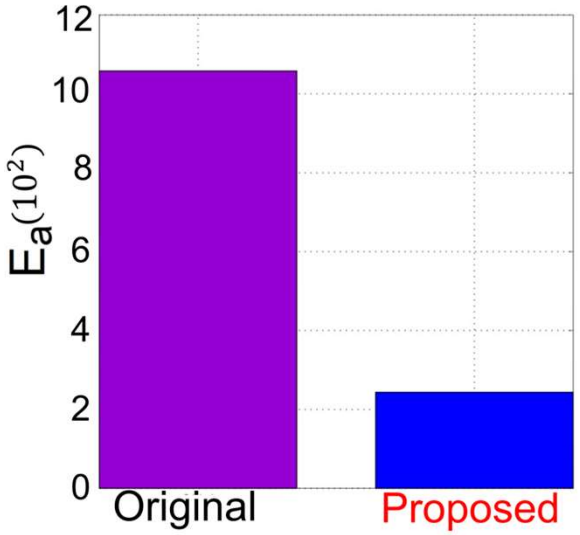
- The number of generation
  - $G = 10$
- The number of gene per one generation
  - $I = 250$
- The weight of fitness
  - w_1, w_2, w_3, w_4 = 0.25
- Topology : Allegiance Telecom
  - static configuration



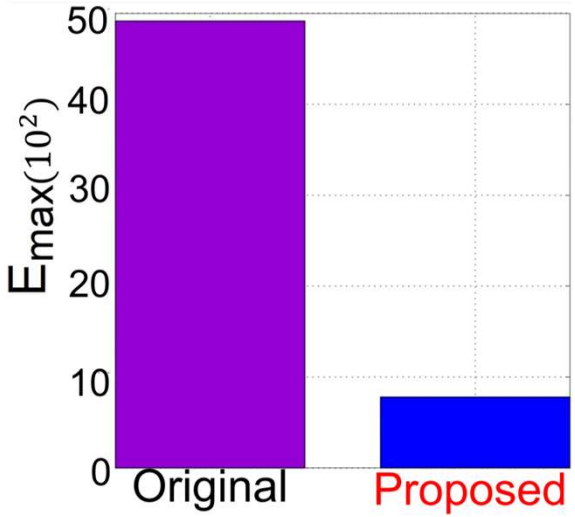
- Evaluated by six evaluation criteria
  - Average FIB size
  - Coefficient of variation of link load
  - Loss of Availability
  - Average link load
  - Max FIB size
  - Max Link load

Result -1

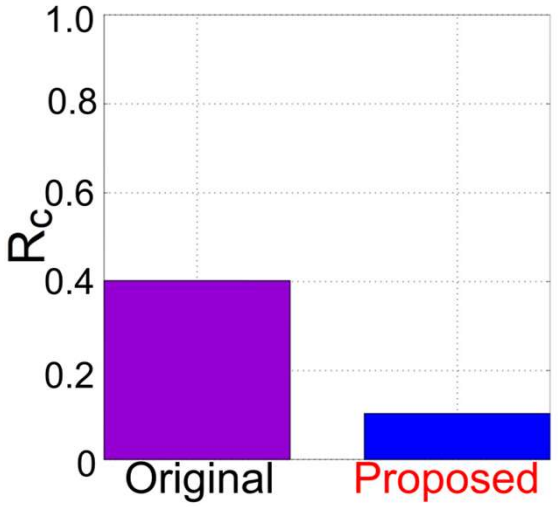
- Reduces FIB size and content availability
  - The proposed method suppresses the increase in FIB entries while distributing content throughout the network



Average FIB size



Max FIB size



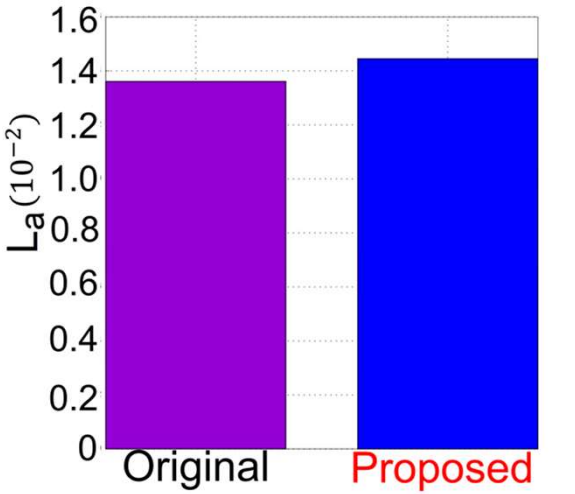
Loss of Availability

Original: content is delivered from the publisher's host

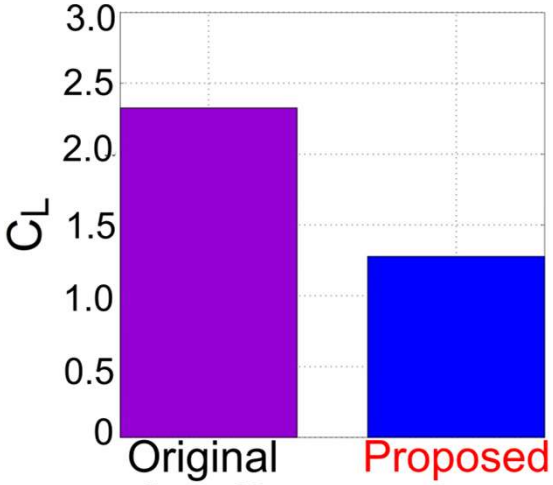
Proposed : relocate contents placement by GA

Result -2

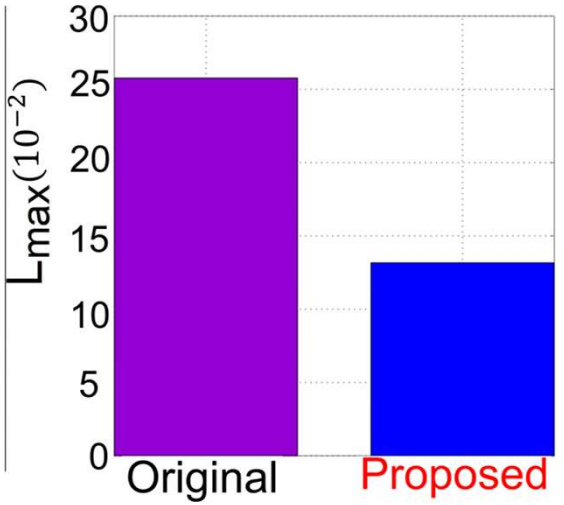
- Reduces link load coefficient of variation and maximum link load
- Average link load increased
  - Content is now allocating across the network, increasing the number of hops required to obtain content



Average Link Load



Coefficient of variation of link load



Max Link Load

Original: content is delivered from the publisher's host

Proposed : relocate contents placement by GA

Conclusion/Future work

- We proposed using genetic algorithm to allocate content by TLD and SLD and reduce FIB size for NDN
- It can distribute placement of content and reduce FIB size
- Average link load increases with equal weights
  - Can be reduced by setting larger weights on L_a

- Future Work
  - When we allocate contents, we are going to considerate contents moving cost.
  - This is static replace method, so we need to consider active replacement method.