網内に頒布されたキャッシュコンテンツの探索方式
- Content Hunting Scheme in In-Network Cache -

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Background

➢ Next Generation Network or the Future Internet
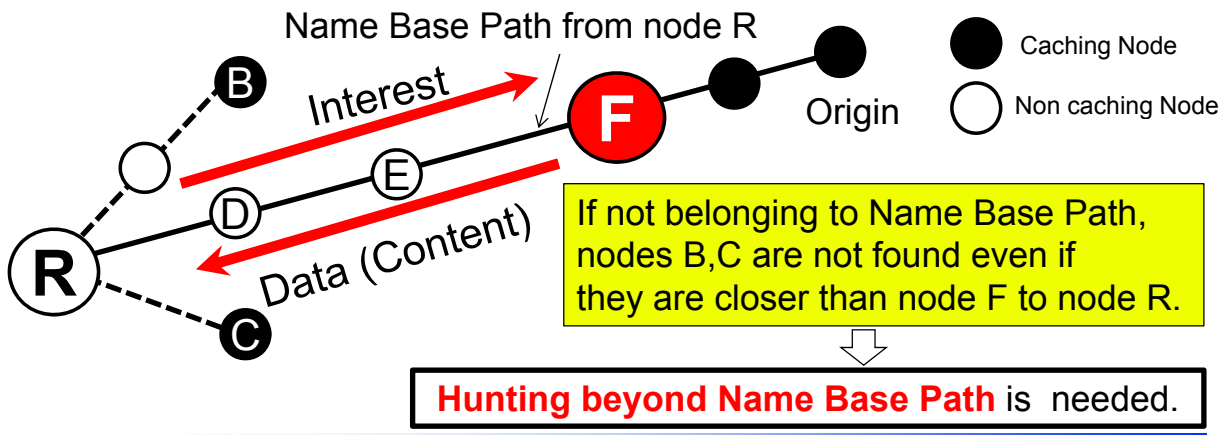　◆Information Centric Network: Content is cached in network nodes.

➢ Information Centric Network (ICN)
　◆ Discovery of the target content disseminated in many caching nodes

➢ Key requirement of network will shift
　 from "How to find the shortest path for the connection"
　 to 　**"How to find the closest cache for the disseminated content"**

Content Centric Network (CCN)

- CCN is a realization system of ICN.
  - Content Name Base Routing
    - Content name with a prefix structure like IP address

> 1. Node R sends Interest through Name Base Path.
> 2. First caching node (node F) which receives it responds.
> 3. Intermediate nodes D and E caches the content.

Name Base Path from node R

Caching Node ●
Non caching Node ○

If not belonging to Name Base Path, nodes B,C are not found even if they are closer than node F to node R.
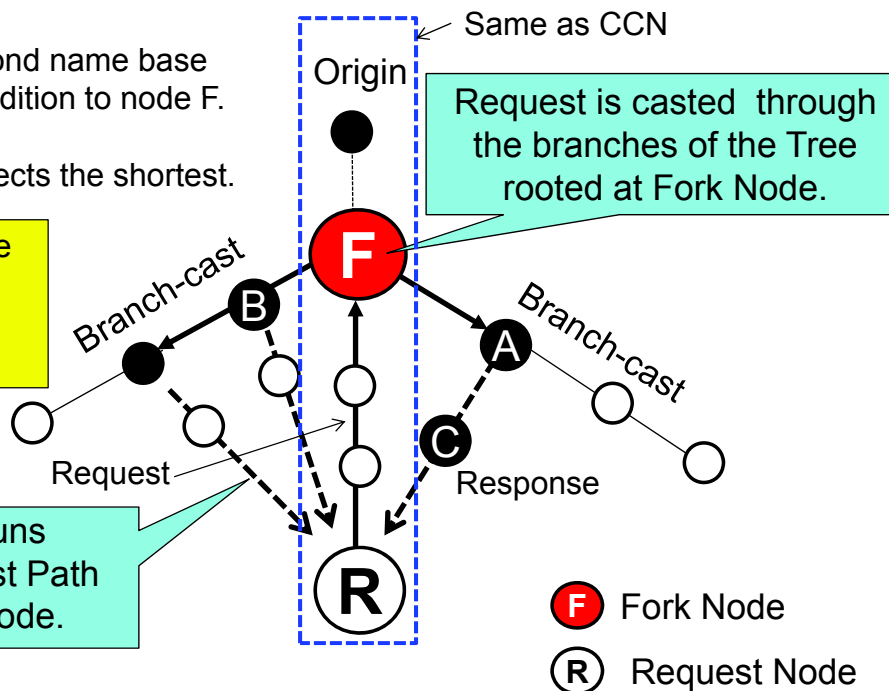
Hunting beyond Name Base Path is needed.

Local Tree Hunting to find almost true closest

1. Nodes A,B,C beyond name base path respond in addition to node F.

2. Request node selects the shortest.

While only one node responds in CCN, multiple nodes respond in LTH.

Same as CCN

Origin

Request is casted through the branches of the Tree rooted at Fork Node.

Branch-cast

Branch-cast

Request

Response

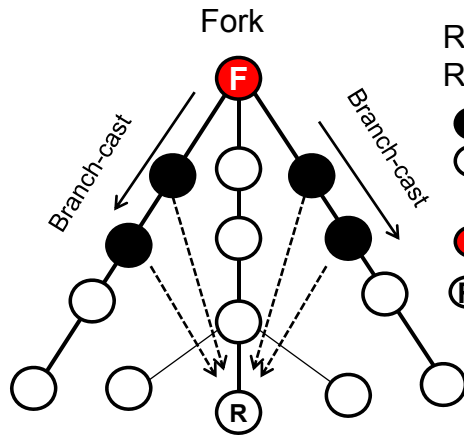Response runs through Shortest Path to Request Node.

F Fork Node

R Request Node

Hunting Area Behavior
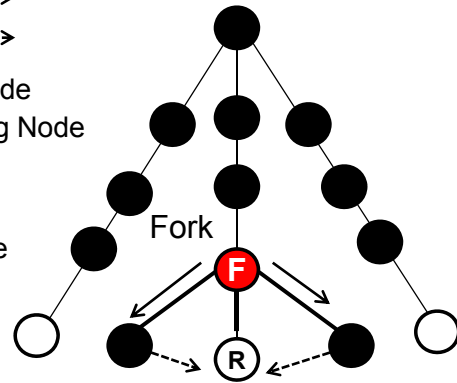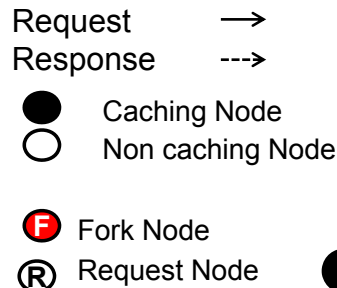
When Small Dissemination,
Wide Range Hunting
(Spares)
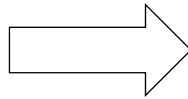
When Large Dissemination,
Small Range Hunting
(Dense)

Fork

Request →
Response --->

● Caching Node
○ Non caching Node

Ⓕ Fork Node
Ⓡ Request Node

Branch-cast

Branch range is wide,
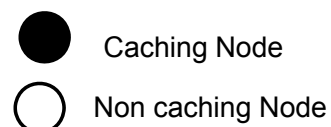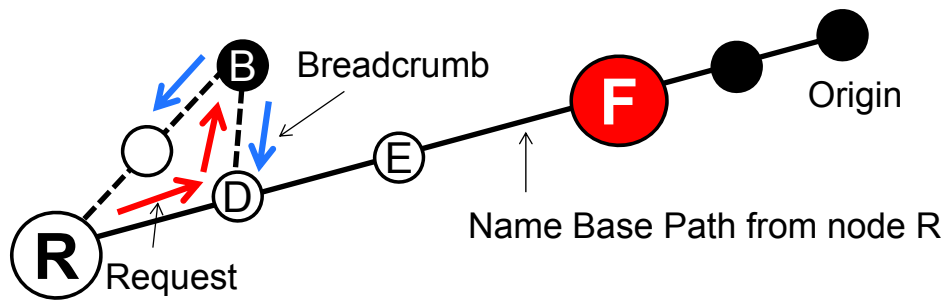but number of caching node is small.

Fork

Branch range is small, but caching
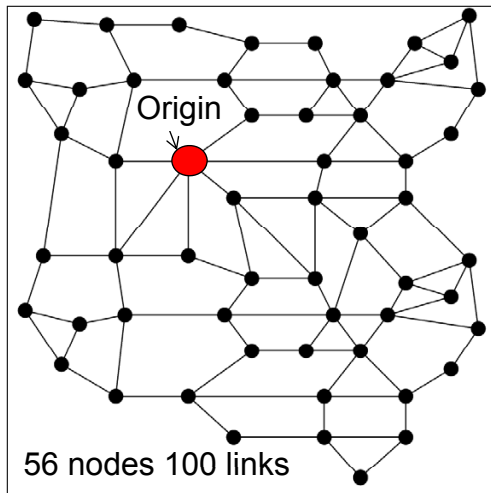nodes enough close are hunted.

Proactive Breadcrumb for Neighbor Nodes

Optional scheme

1. When caching content, node B notifies of Breadcrumb to neighbors.

2. Neighbor node D records the Breadcrumb.

3. Intermediate node D switches the request following to Breadcrumb.

B — Breadcrumb

F — Origin

E

R — Request

Name Base Path from node R

● Caching Node
○ Non caching Node

Simulation Model

Origin

56 nodes 100 links

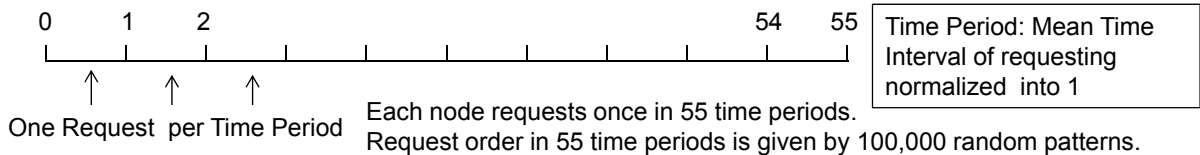**Schemes to be evaluated**
1) CCN: Response Node is always One
2) True Closest Hunting (Whole Tree Hunting)
     Origin node always does branch-cast.
3) LTH: Local Tree Hunting
     Fork node does branch-cast.
4) LTH+BC (One Hop Breadcrumb)

Evaluation Metrics:
1) Hop-count for downloading &
                 Number of caching nodes
2) Hit waiting Time
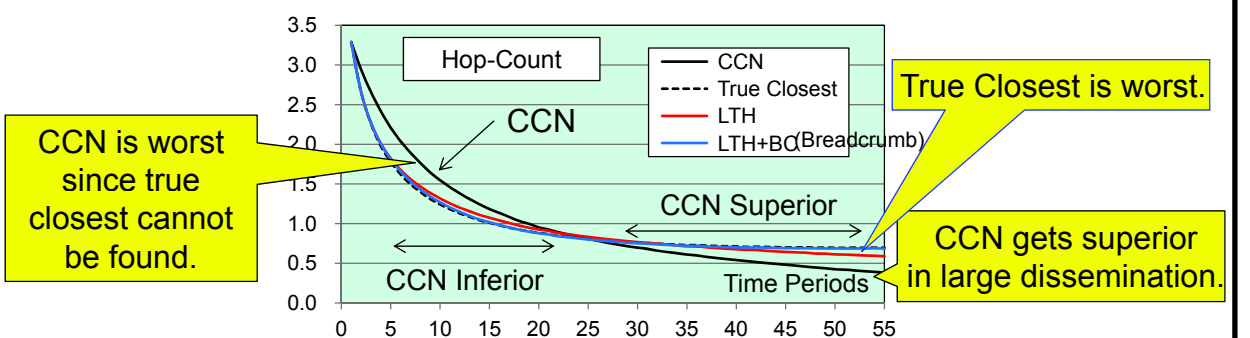3) Number of response nodes
                 as Hunting overhead

Access Model

0   1   2   54   55

↑   ↑   ↑

One Request per Time Period

Each node requests once in 55 time periods.
Request order in 55 time periods is given by 100,000 random patterns.

Time Period: Mean Time Interval of requesting normalized into 1

Hop Count and Number of Caching Nodes

In any scheme, final number of caching nodes = Number of nodes excluding Origin (=55).

CCN is worst since true closest cannot be found.

True Closest is worst.

CCN gets superior in large dissemination.

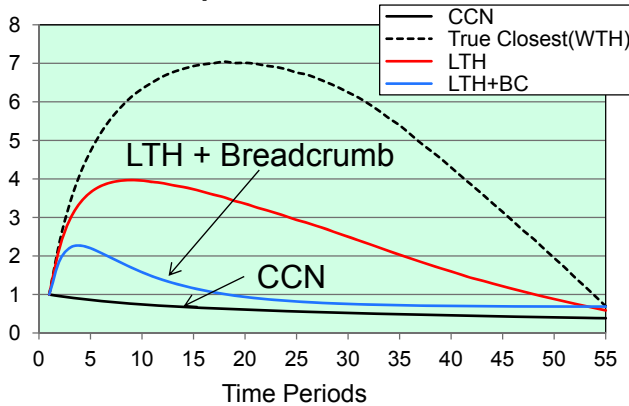Performance gap between CCN and True Closest

Since accumulated number of hop-count is number of caching nodes,
it contributes to save both of link and storage resources to find true closest.
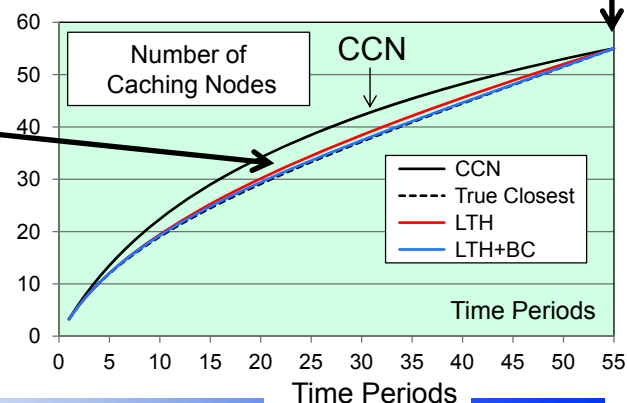
Number of Response Nodes

Number of Response Nodes

This is measured as
overhead of content discovery.
(When the request node has already cached,
this is counted as zero. Hence,
the mean values may become less than one.)

For the reduction of the response nodes,
when finding the request is neighbor,
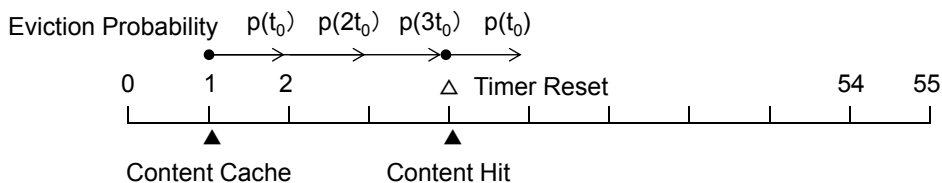branch-cast is not initiated for reducing
the number of response nodes.

◆ CCN provides the best performance since only one node responds to the request.

◆ Breadcrumb operation contributes to reduce the overhead
within around twice of CCN.

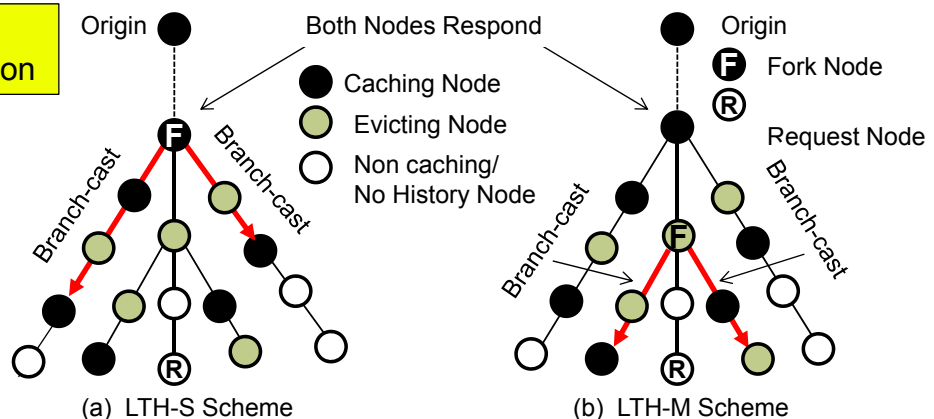# LTH Modification for Content Eviction

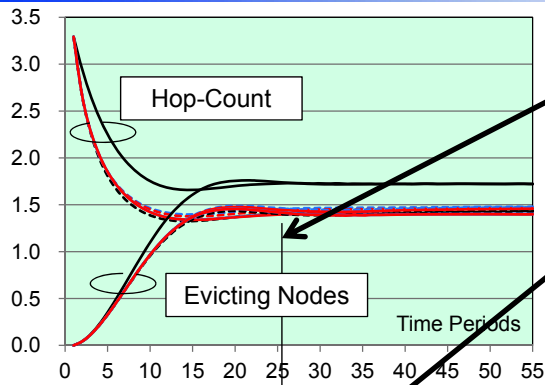Eviction Model： Eviction rate is proportion to the caching time duration.

Eviction Probability $p(t) = \alpha \int (1-p(t))\, dt$ *Hence,* $p(t) = 1 - \exp(-\alpha t)$
Here, α is given by the value such as $p(55t_0) = 50\%$ after 55 time period duration.

Eviction Probability $p(t_0)$ $p(2t_0)$ $p(3t_0)$ $p(t_0)$

0   1   2   △ Timer Reset   54   55

Content Cache   Content Hit

**Modified LTH
in Content Eviction**

Origin   Both Nodes Respond   Origin
● Caching Node   F Fork Node
● Evicting Node   ® Request Node
○ Non caching/
No History Node   Request Node

Branch-cast   Branch-cast

(a) LTH-S Scheme   (b) LTH-M Scheme
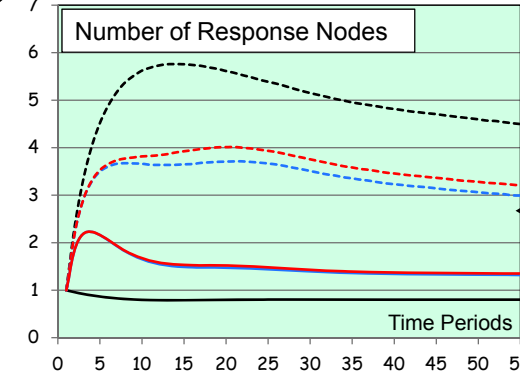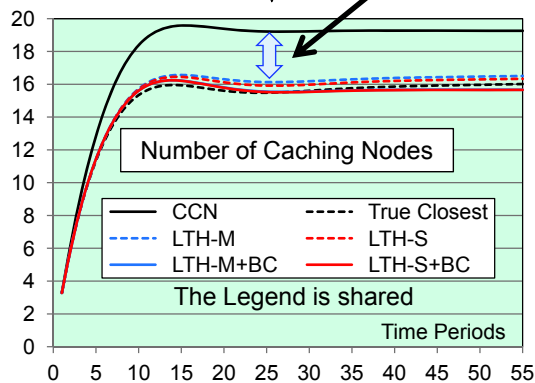
Performances at 50% Eviction Rate after 55 time periods

By eviction, dissemination degree stays in low.

Performance gap between CCN and True Closest is held in large.

Hop-Count

Evicting Nodes

Time Periods

Number of Response Nodes

Number of Caching Nodes

CCN	True Closest
LTH-M	LTH-S
LTH-M+BC	LTH-S+BC

The Legend is shared

Time Periods

Time Periods

Although there is no particular deference of left-side performances among LTH family, LTH-M is superior in number of response nodes.

Conclusion

1. By finding the true closet caching node from the request node, hop count in small dissemination, number of caching nodes and hit waiting time can be reduced.

2. Under content eviction, performance gap between true closest and CCN is held in large since content dissemination stays in small.

3. Proposed LTH scheme offers the almost the same performances as those of true closest hunting with suppressing the number of response nodes.

4. Breadcrumb option largely contributes to reduce number of response nodes.

5. In a topology with small branch size such as Star-Hub topology, LTH effectiveness will be limited.

References

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