

Hash-routing Schemes For Information Centric Networking

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Information Centric Networking (ICN)

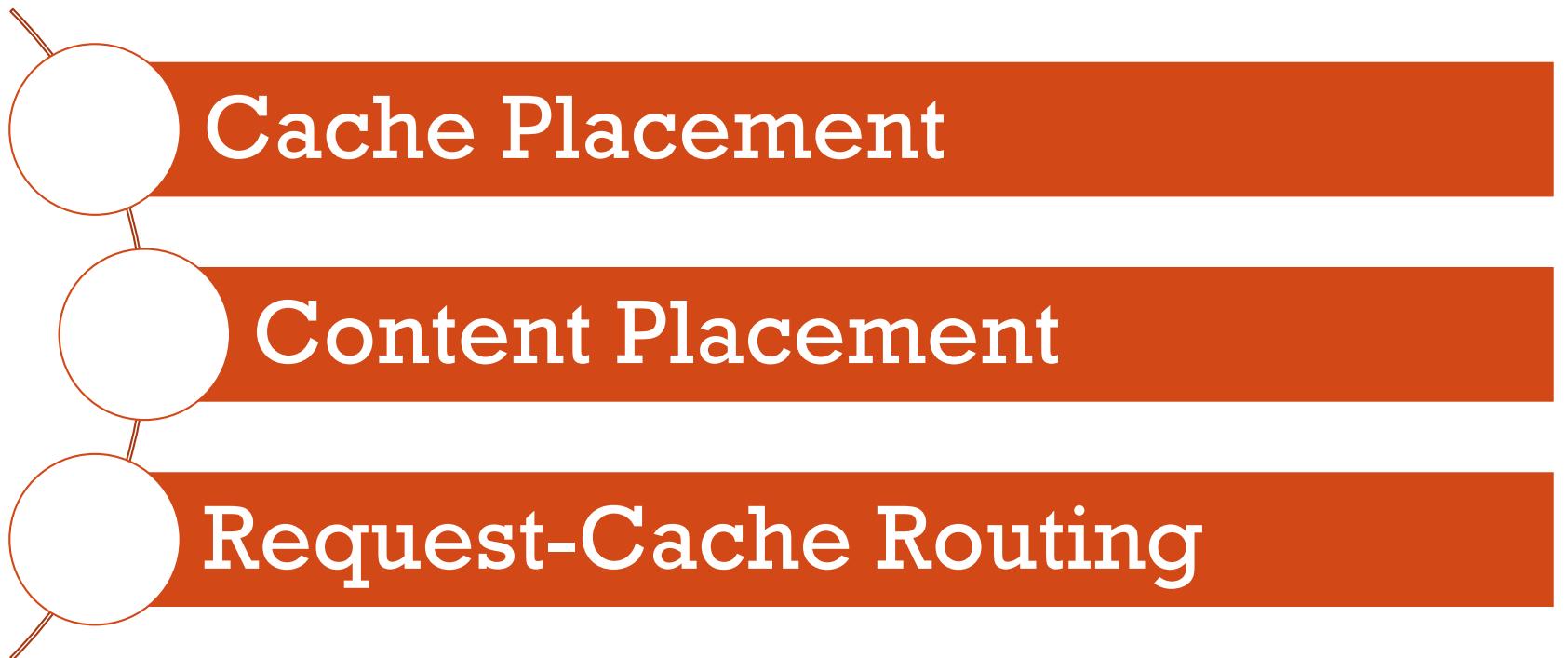
- We are looking for information; not compute or storage nodes
- ICN schemes focus on finding information
- Network hardware, like routers, can cache information closer to the user who needs it
- Similar in concept to Content Delivery Network (CDN)

Content Delivery Network (CDN)



- Place content closer to the user
- Akamai pioneered the technology
- Most popular Netflix content exists in local ISP distribution centers (Netflix Open Connect)

In-network Caching Challenge



Terminology



Edge node – a network router calculates hash function

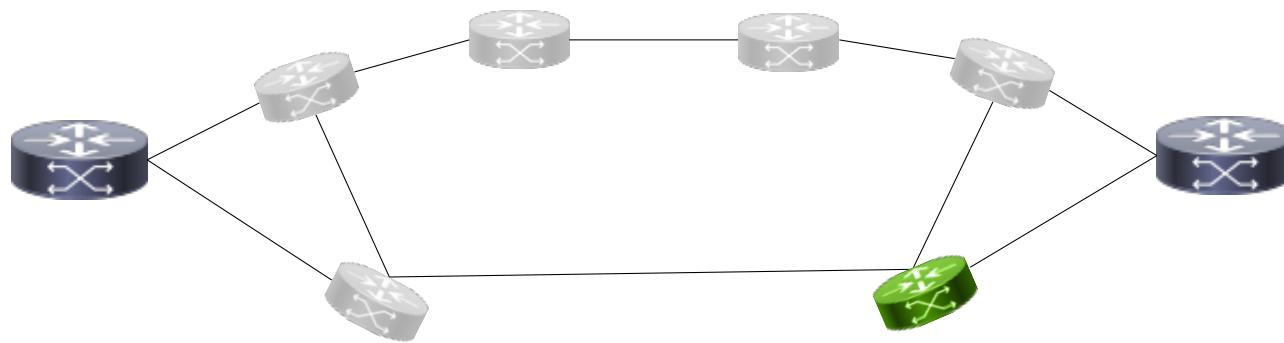


Intradomain network switch/router



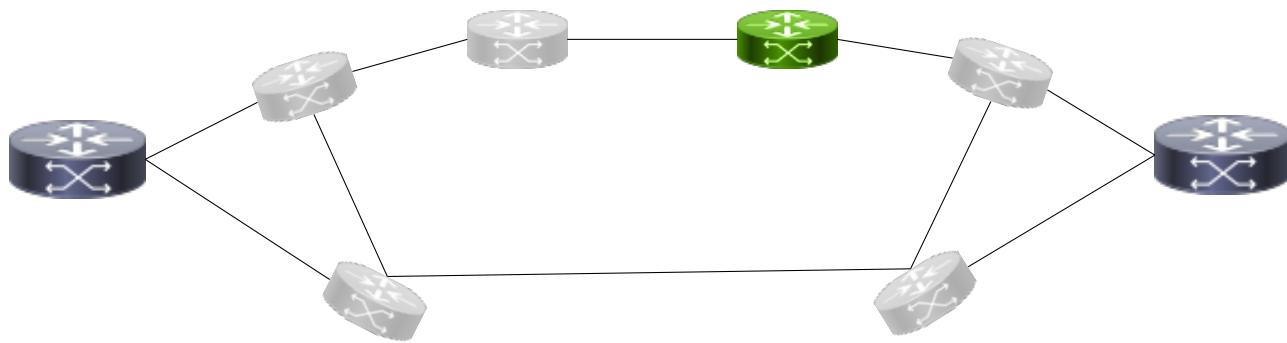
Cache node - Intradomain network switch/router that also caches some content

On-Path Caching



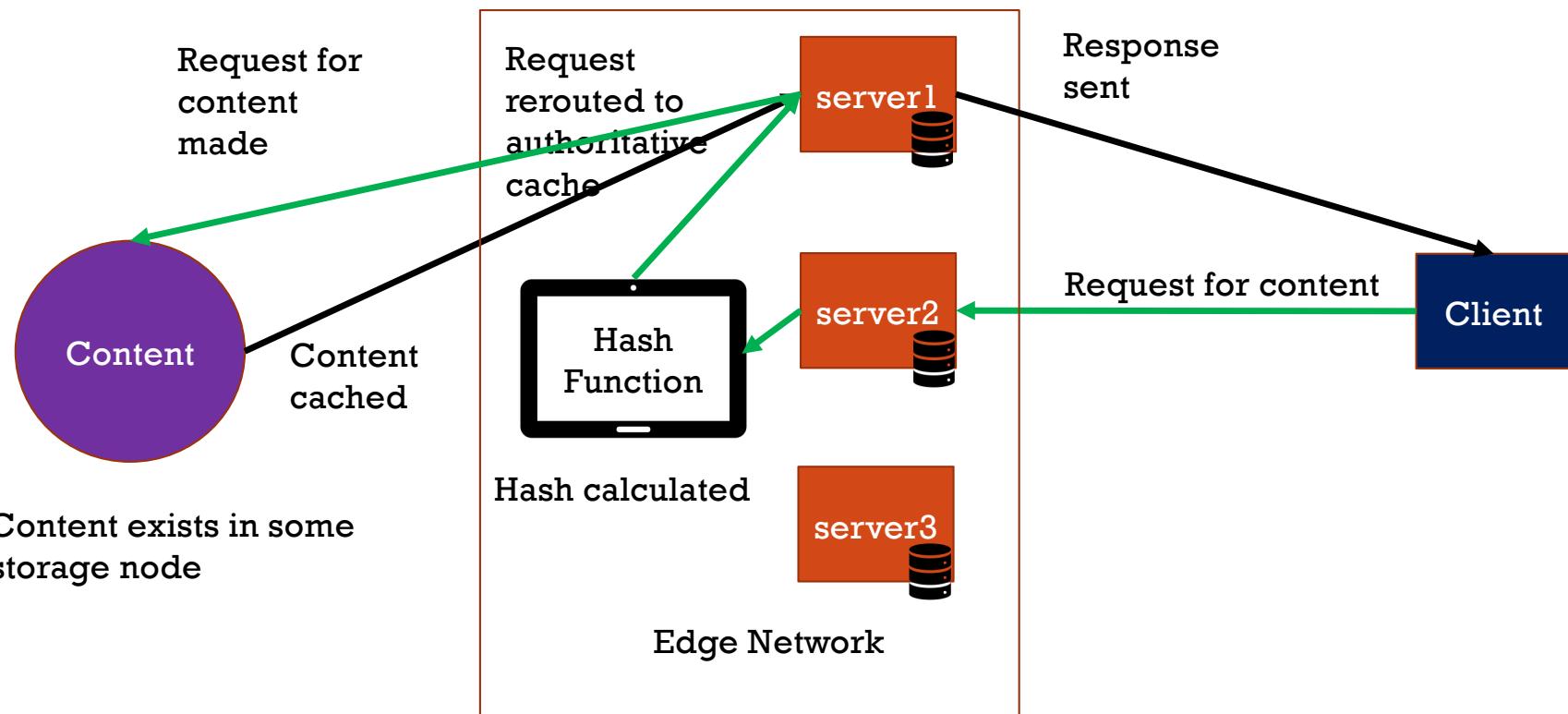
- Scalable but limited cache hits due to redundant caching
(same content at too many places)

Off-path Caching



- Better cache utilization and hit ratio but needs to maintain state
- Not scalable

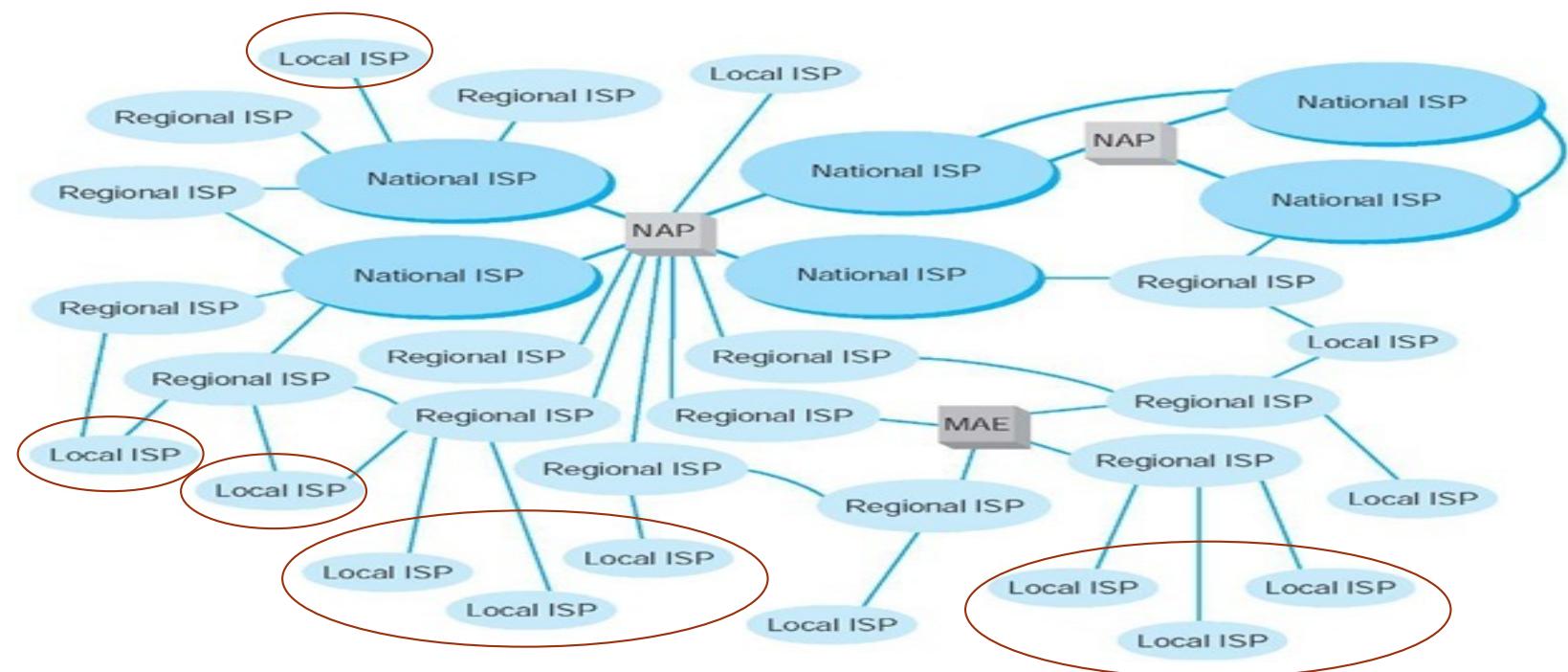
Hash-routing



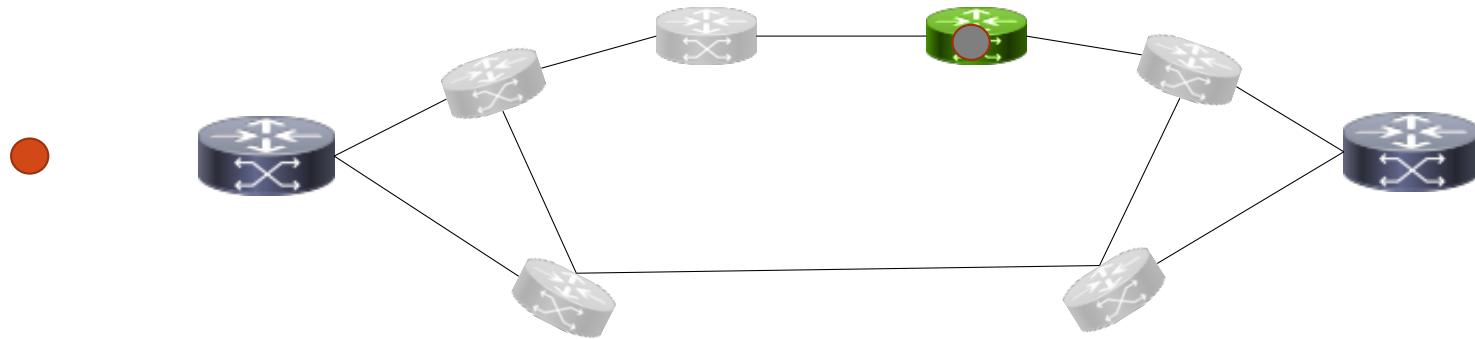
Hash-Routing In ICN

- Functional Entities
 - Edge nodes: Compute hash and forward request and content cache packets to responsible cache nodes
 - Cache nodes: Store content objects for which they are responsible
- Proposed routing schemes
 - Base schemes: Symmetric, Asymmetric, Multicast
 - Hybrid schemes: Asymmetric-Multicast, Symmetric-Multicast

What Is A Network Here?

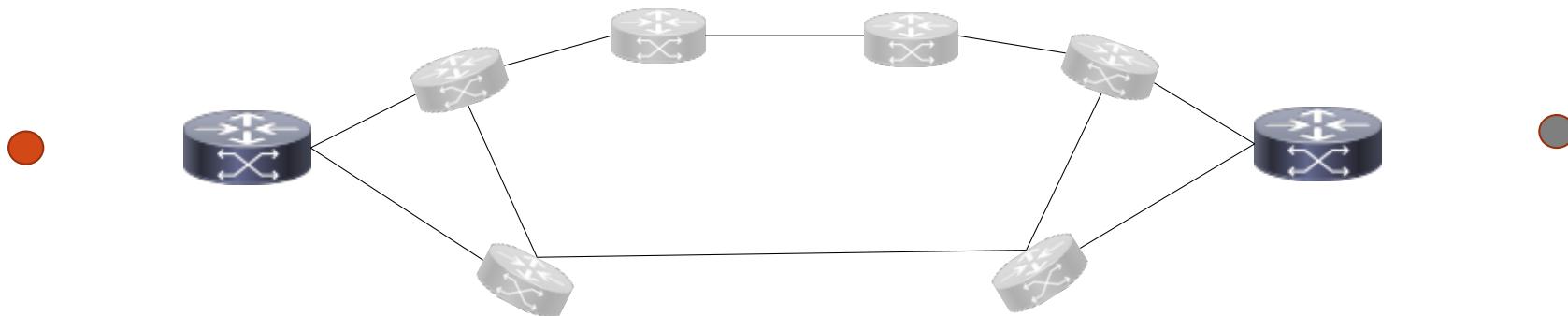


Request Routing (From Cache)



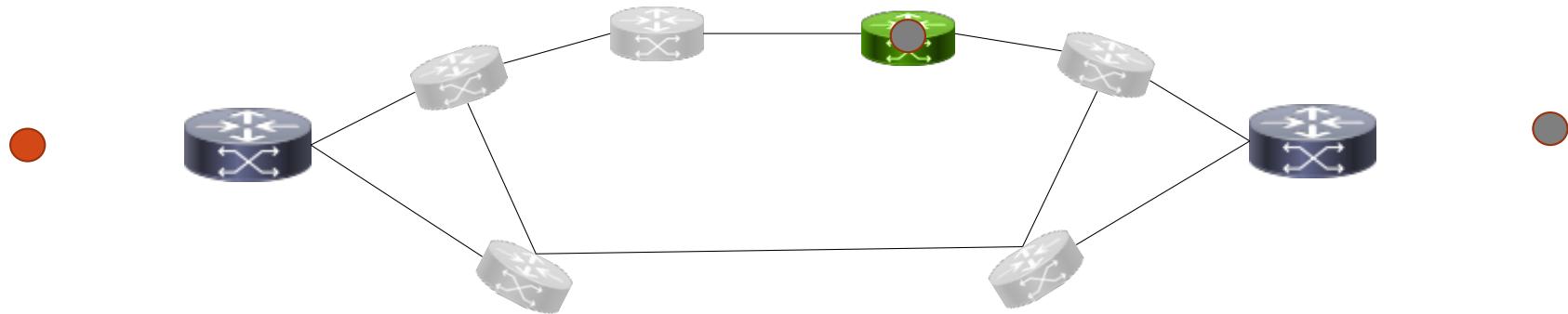
- Request is routed so that it passes through the responsible cache node

Request Routing (From Storage)



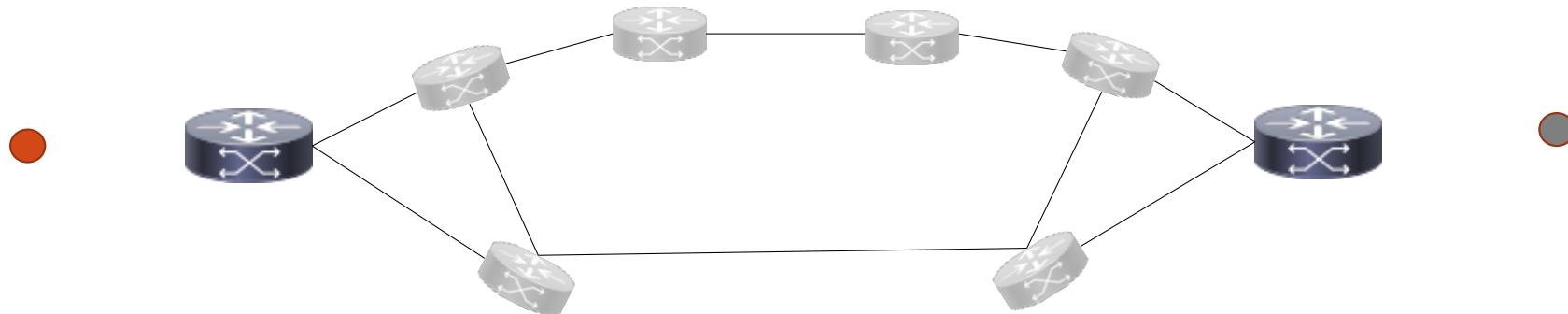
- Data is not cached at the designated cache node, so it is fetched from source (for example)

Symmetric Content Routing



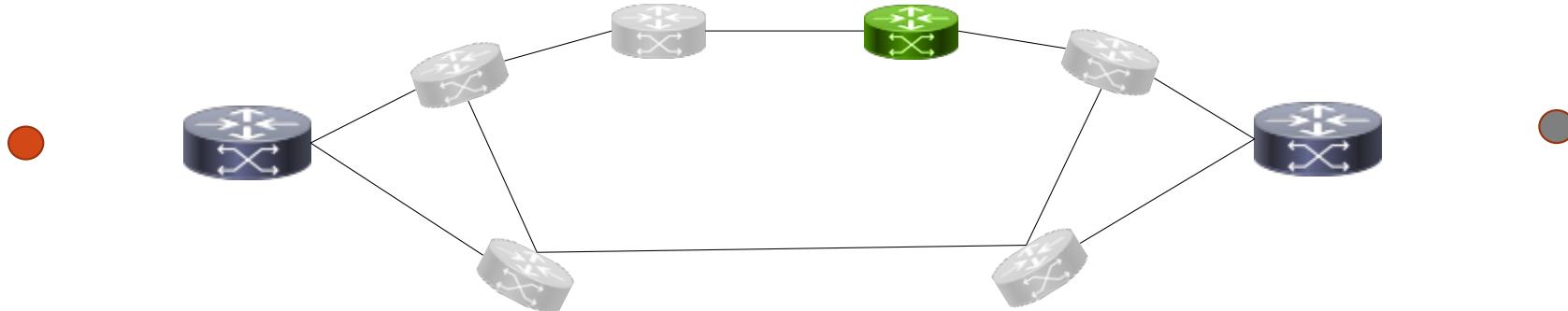
- Content flows back along the same path as the request to let the cache node cache the data.
- Cache node may not be on shortest path increasing load on links in the network

Asymmetric Content Routing



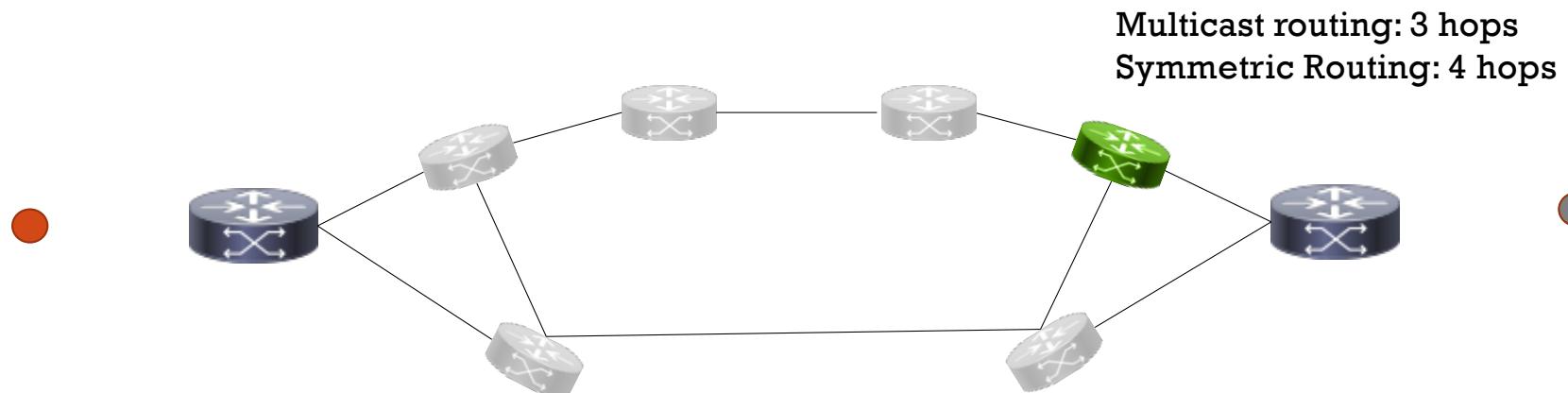
- Send content through shortest paths
- Reduces intradomain link loads
- Cache nodes with small betweenness centrality may be underutilized

Multicast Content Routing



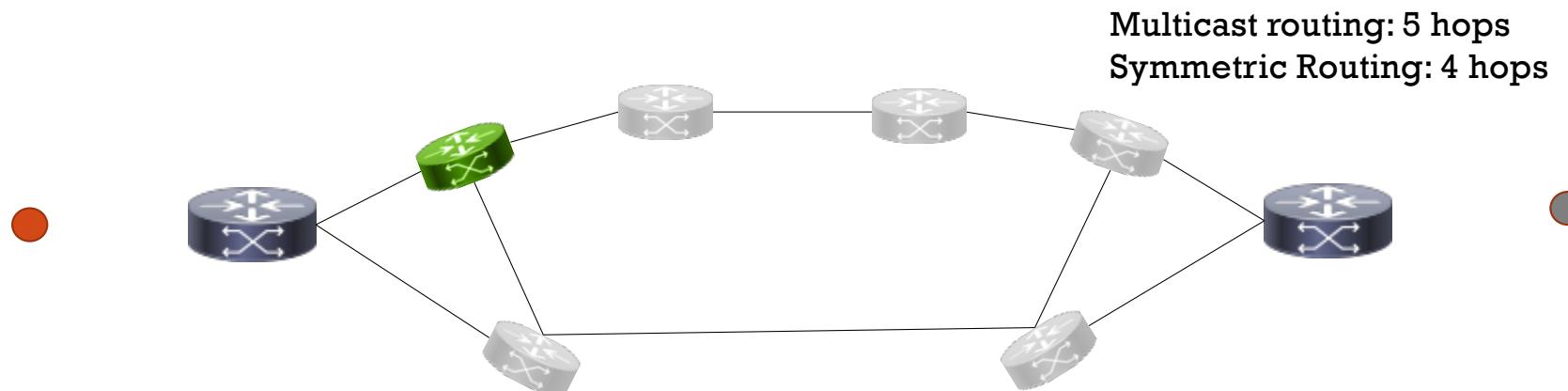
- Sent content through shortest path
- But send a copy to cache

Symmetric Multicast Content Routing



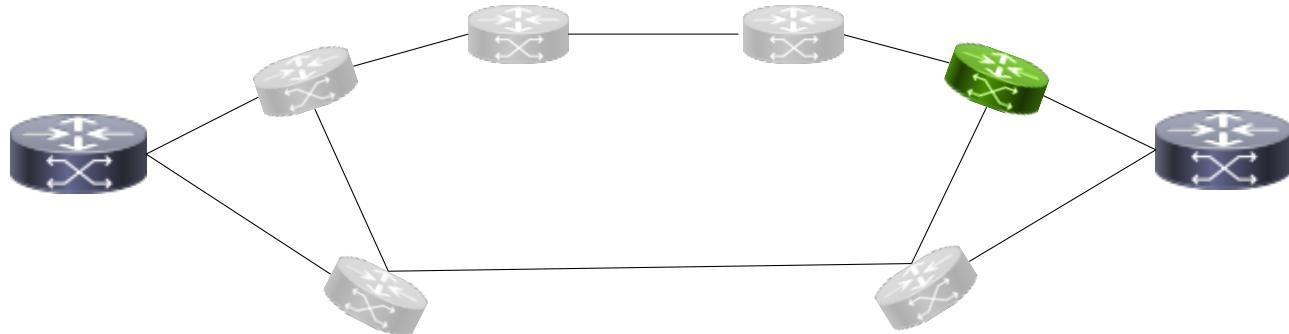
- Total hops to perform multicast routing is lesser

Symmetric Multicast Content Routing



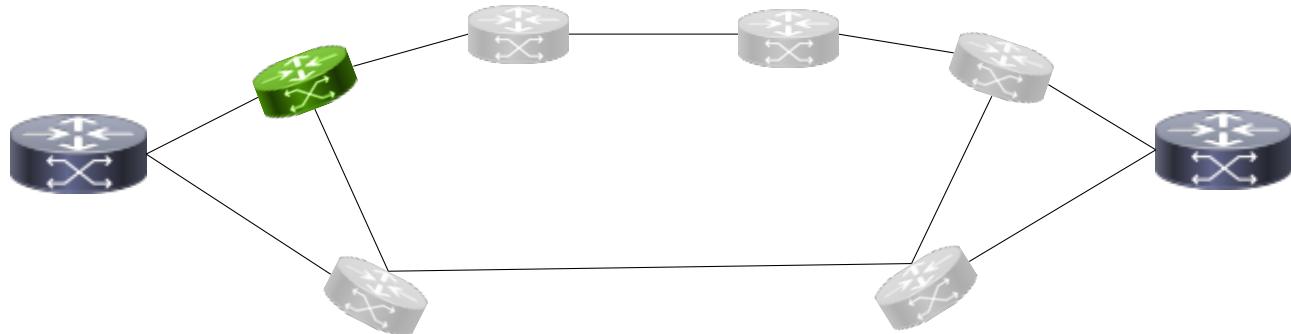
- Total hops to perform symmetric routing is lesser

Asymmetric Multicast Content Routing



- Cost of multicast routing is acceptable

Asymmetric Multicast Content Routing



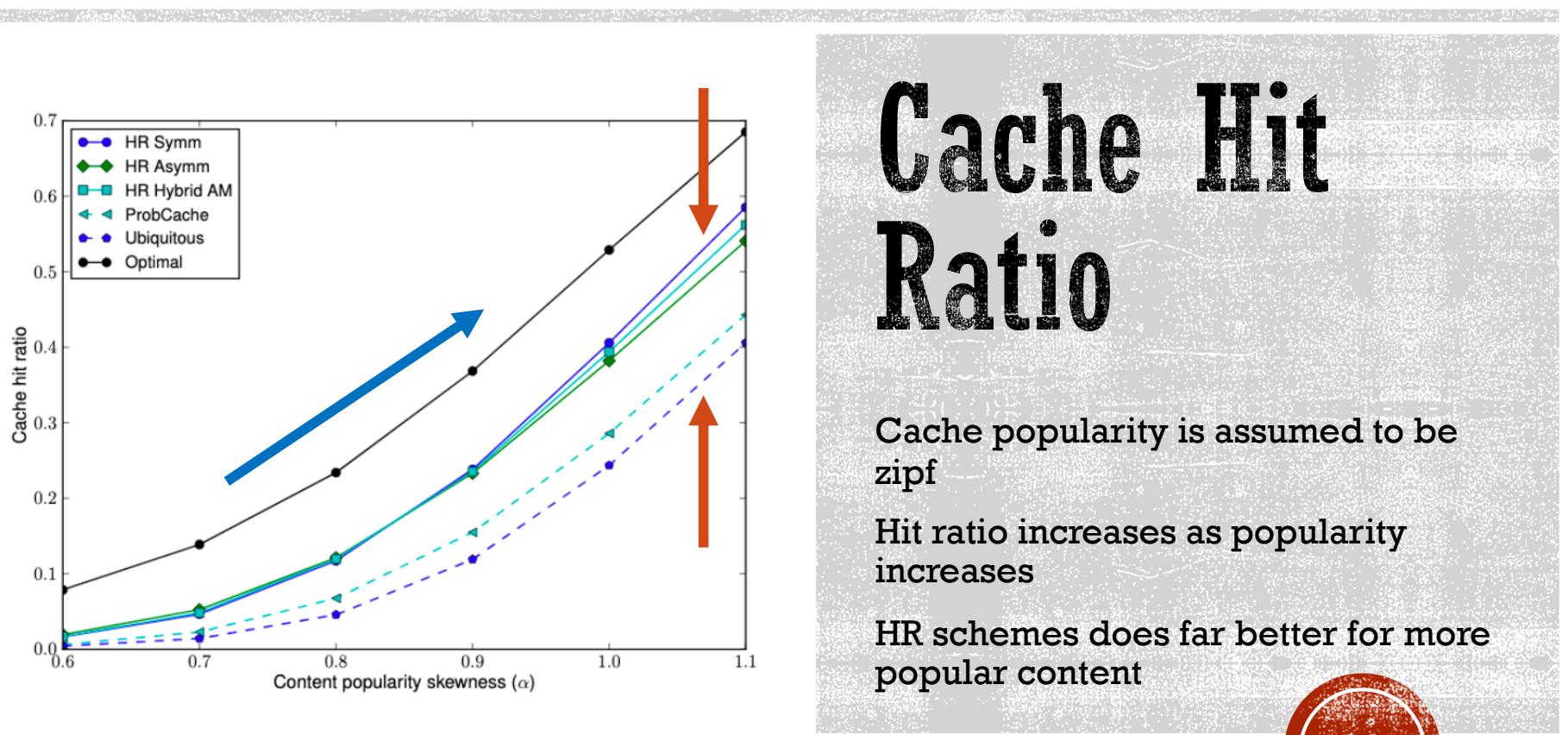
- Cost of multicast routing is greater than some threshold

Asymmetric Multicast Cost

- Network Diameter: longest shortest path in the network
- Asymmetric multicast determines the cost of multicast routing as a ratio of the cost of reaching the caching node and the network diameter.
- If this cost exceeds a predefined threshold then multicasting is not performed.

Skewness

- A distribution has three things:
 - Mean
 - Median
 - Standard Deviation (std)
- Skewness = $(\text{Mean} - \text{Median}) / \text{std}$
- How far is the mean from the median in units of std
- Higher skewness implies some content is more popular than others.

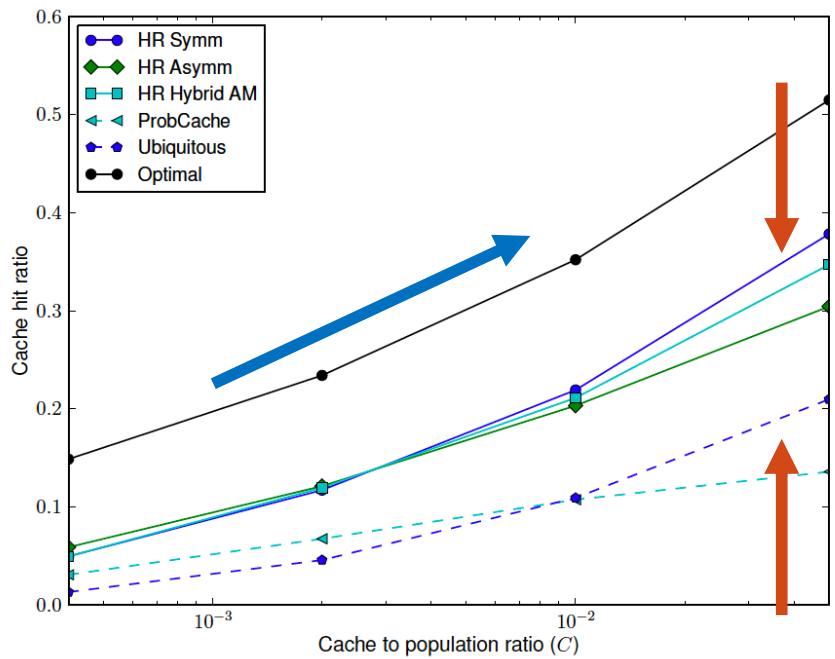


Cache Hit Ratio

Cache popularity is assumed to be zipf

Hit ratio increases as popularity increases

HR schemes does far better for more popular content

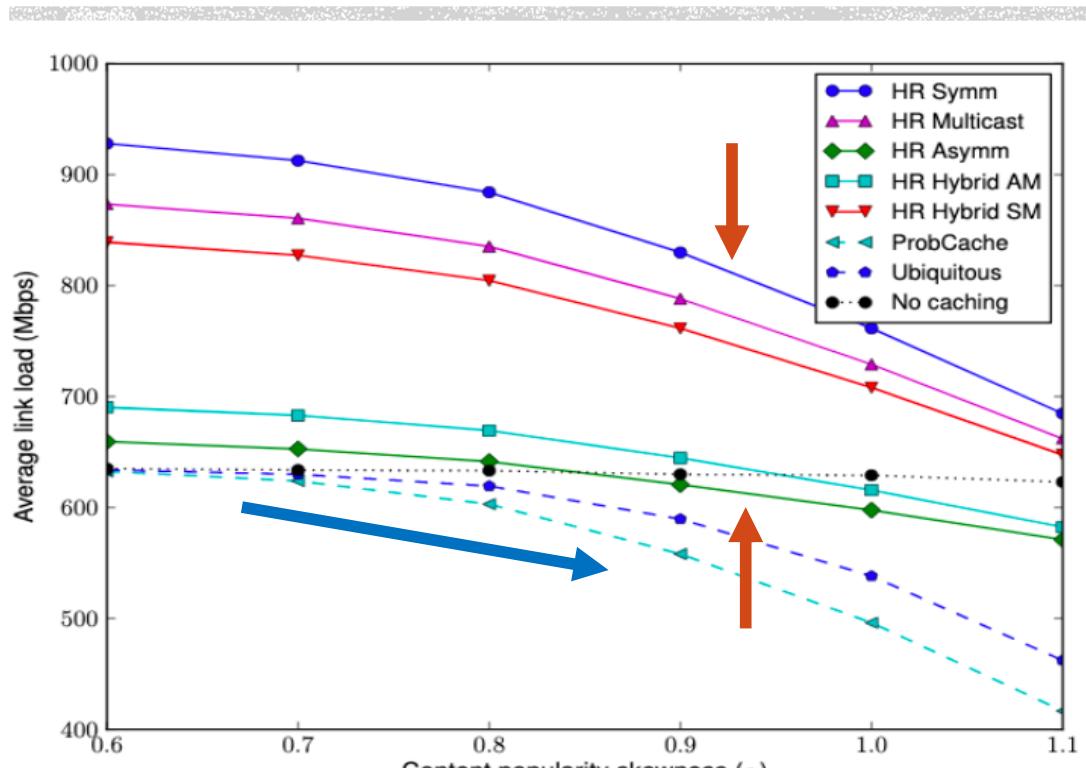


Cache Hit Ratio To Population

Population is all the available content

Cache hit ratio increases as cache to population ratio decreases

HR schemes cache ~25 – 35% of all content for lower cache to population ratios, much higher than others



Avg Link Load To Content Popularity

As content popularity increases, link load decreases

But the decrease is much lesser for HR schemes than for other algorithms.

SUMMARY

Use of hash-routing to determine authoritative caches for data and related content routing

Edge nodes compute hash

Authoritative cache nodes cache data

Base content routing schemes are symmetric, asymmetric and multicast

Base schemes can be combined to form hybrid schemes:

1. Symmetric multicasting
 2. Asymmetric multicasting
-

Questions And Criticisms

- @anguyen0204 commented on how ISP bias would increase content popularity skewness.
@anguyen0204 and @s-hanna15 had questions regarding security.
@mralexjacobson was dubious about what the authors are trying to do here.
@s-hanna15 also asked which scheme was preferable.
@bushidocodes asked if these schemes would work in presence of encryption or streaming protocols like HTTP2.