DEWS: A Decentralized Engine for Web Search

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Web Search : Today

- Contemporary Web Search:
  - Logically centralized
  - Company controlled
- Problems
  - Censorship
  - Biased ranking
  - Privacy

Web Search : Decentralization

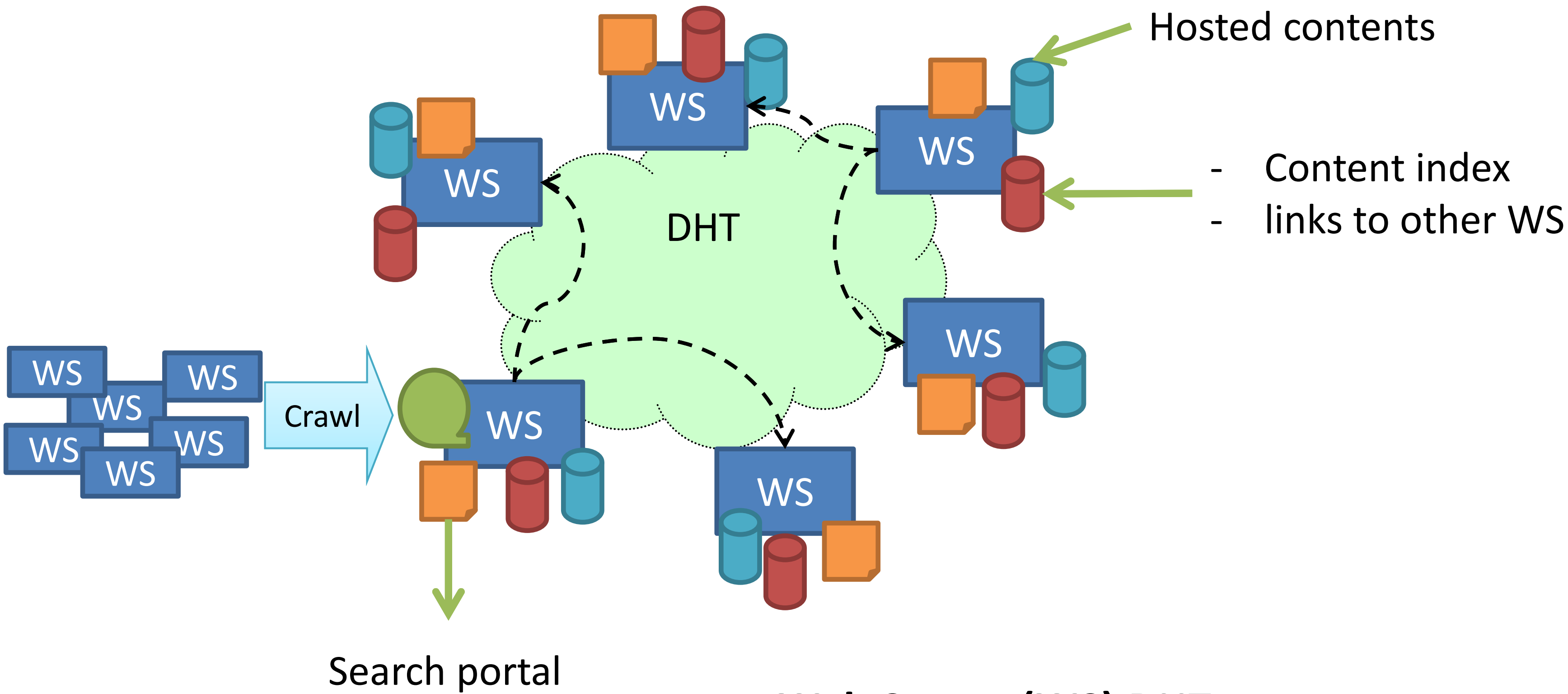
- Using P2P networks – YacY, Faroo
  - Search overhead
  - Churn
- DEWS:
  - P2P network between Webservers not end-hosts
  - Both decentralized and stable

Challenges

- Indexing the voluminous Web
- Resolving Web queries
- Ranking search results
- Incremental retrieval

DEWS addresses the first 3 Challenges

Conceptual Overview



<u>Web Server (WS) DHT:</u>

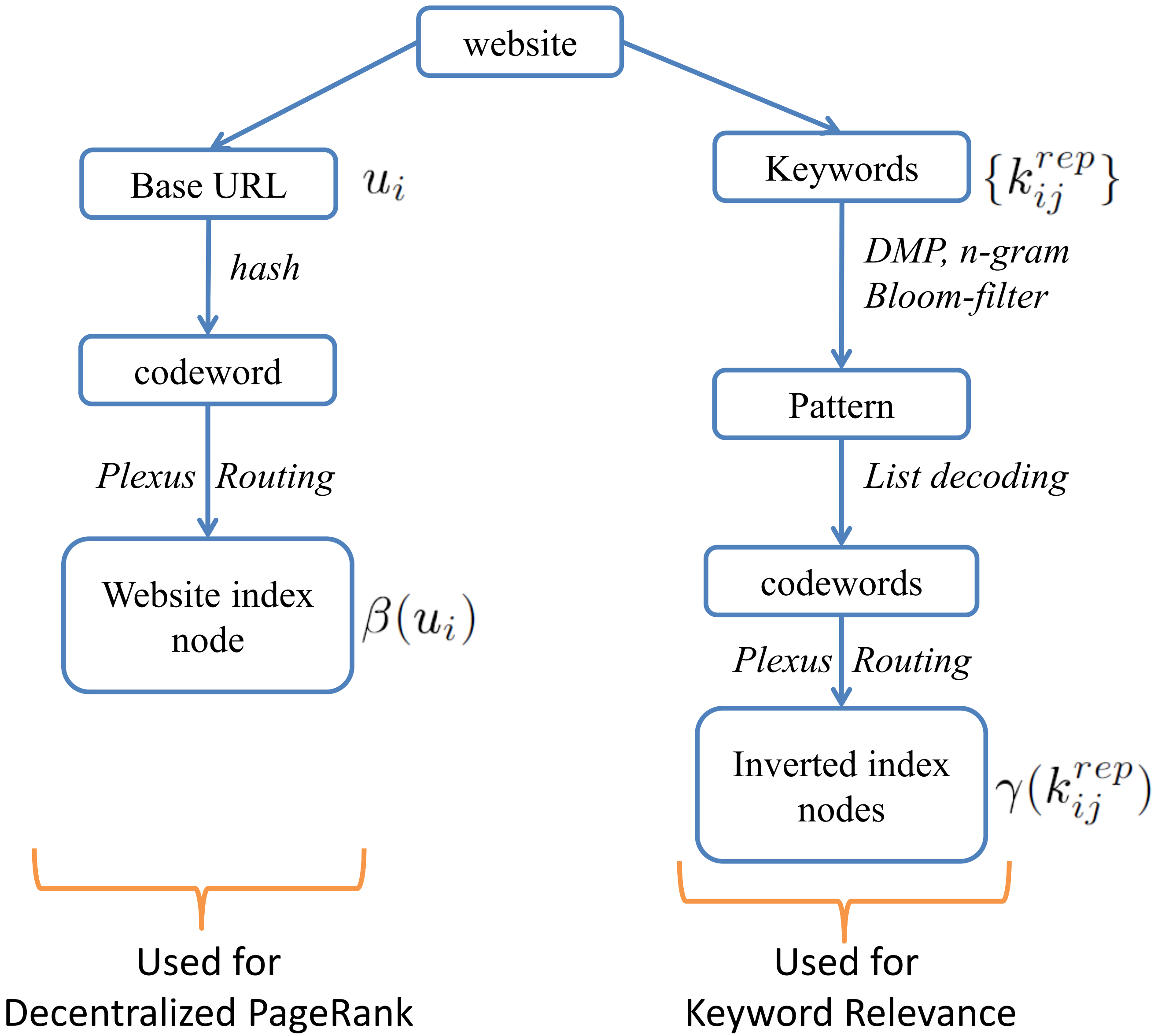
- Pros:
  - Very stable
  - 1 or 2 hop lookup via link cache
- Cons:
  - Additional overhead on WS

Plexus DHT

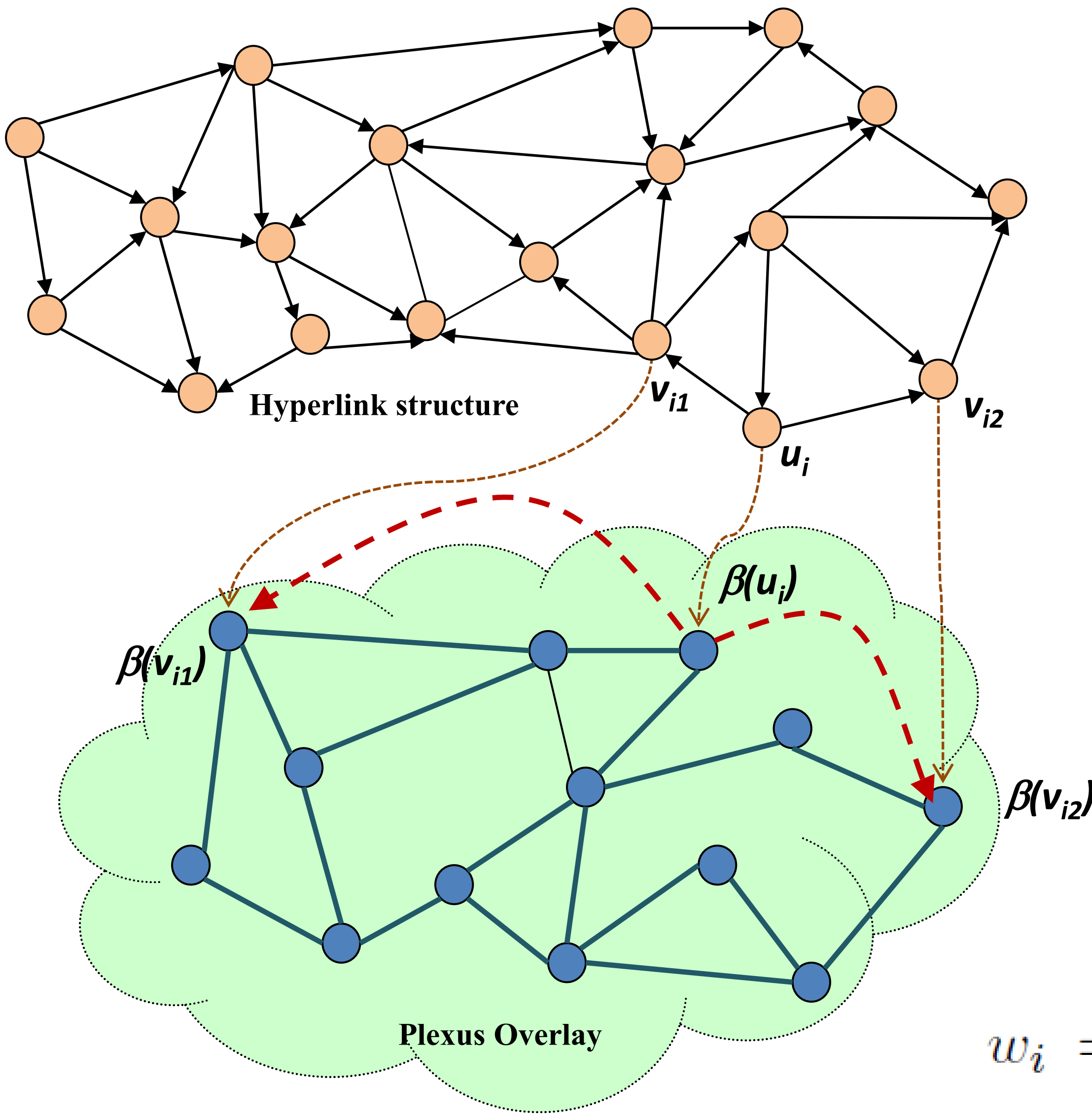
- Why Plexus[1]?
  - Efficient routing with dynamic load-balancing
  - Supports approximate matching
- How Plexus works:
  - Generates a bit-pattern from advertisement/query keywords
  - Decodes this pattern to codewords using a Linear Binary Code
  - Routes using the generator matrix of the LBC
- Modification to Plexus routing
  - DEWS aggregates routing messages and packs multiple queries in one message

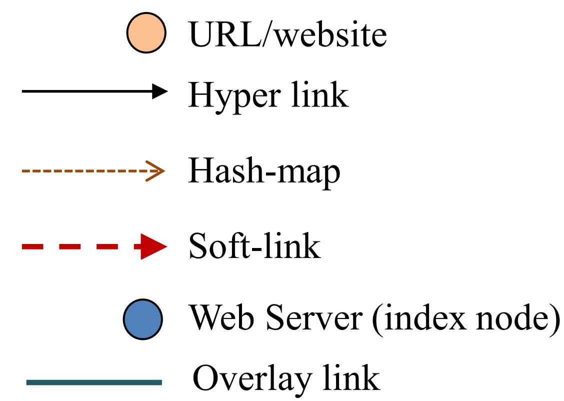
[1] R. Ahmed and R. Boutaba. Plexus: A Scalable Peer-to-peer Protocol Enabling Efficient Subset Search. In IEEE/ACM Transactions on Networking (TON). IEEE Press, Vol. 17(1), pp. 130-143, February 2009.

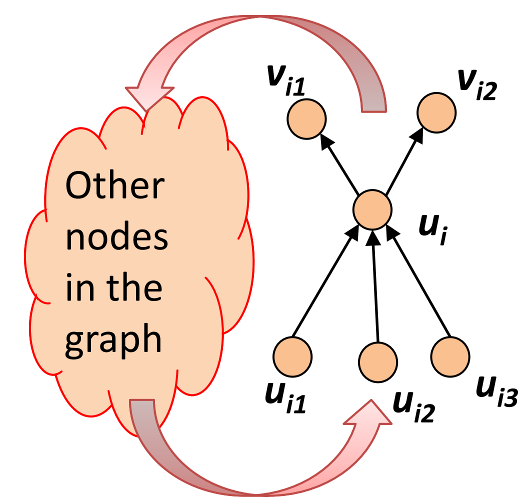
Indexing Mechanism



Decentralized PageRank

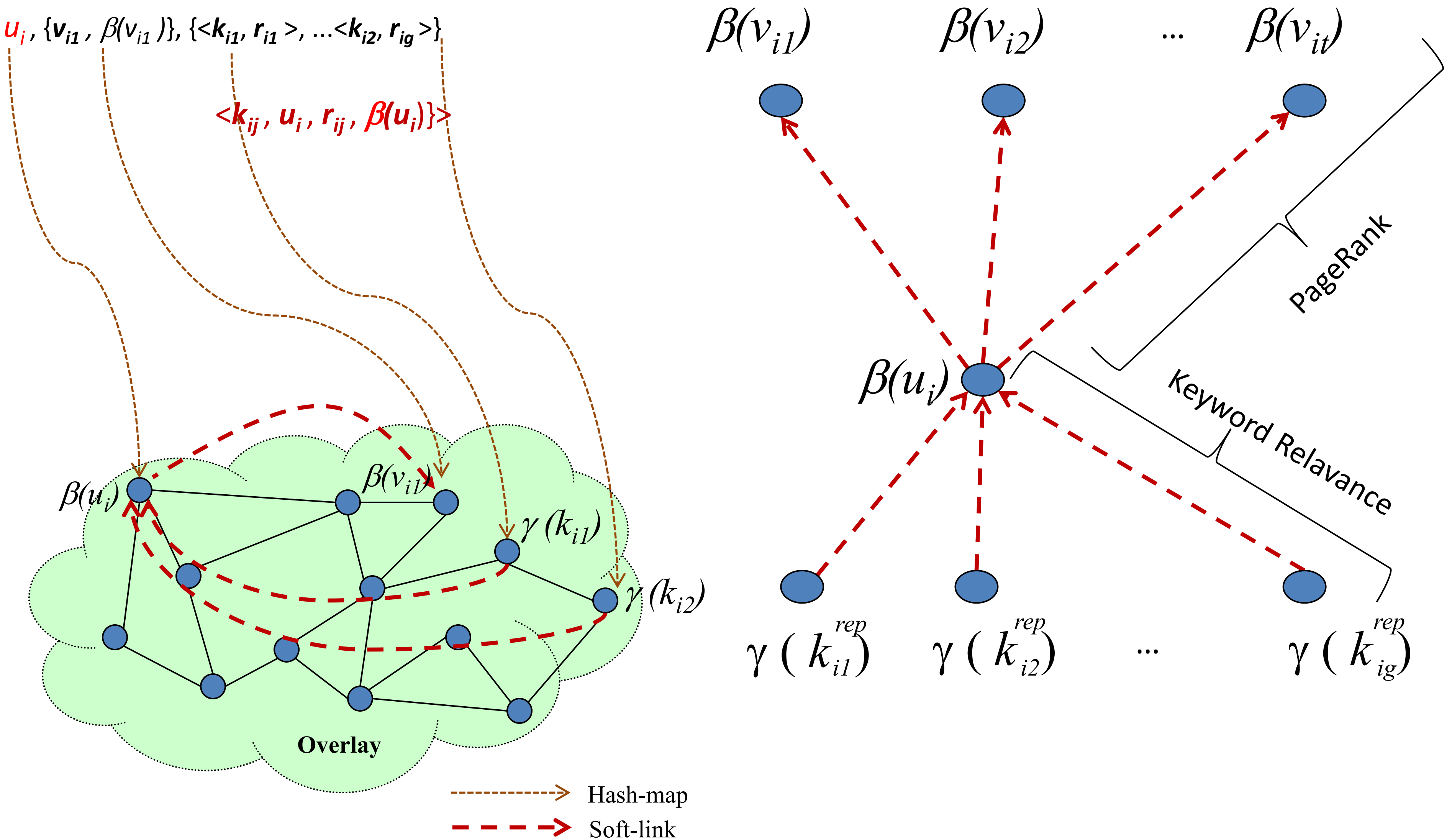




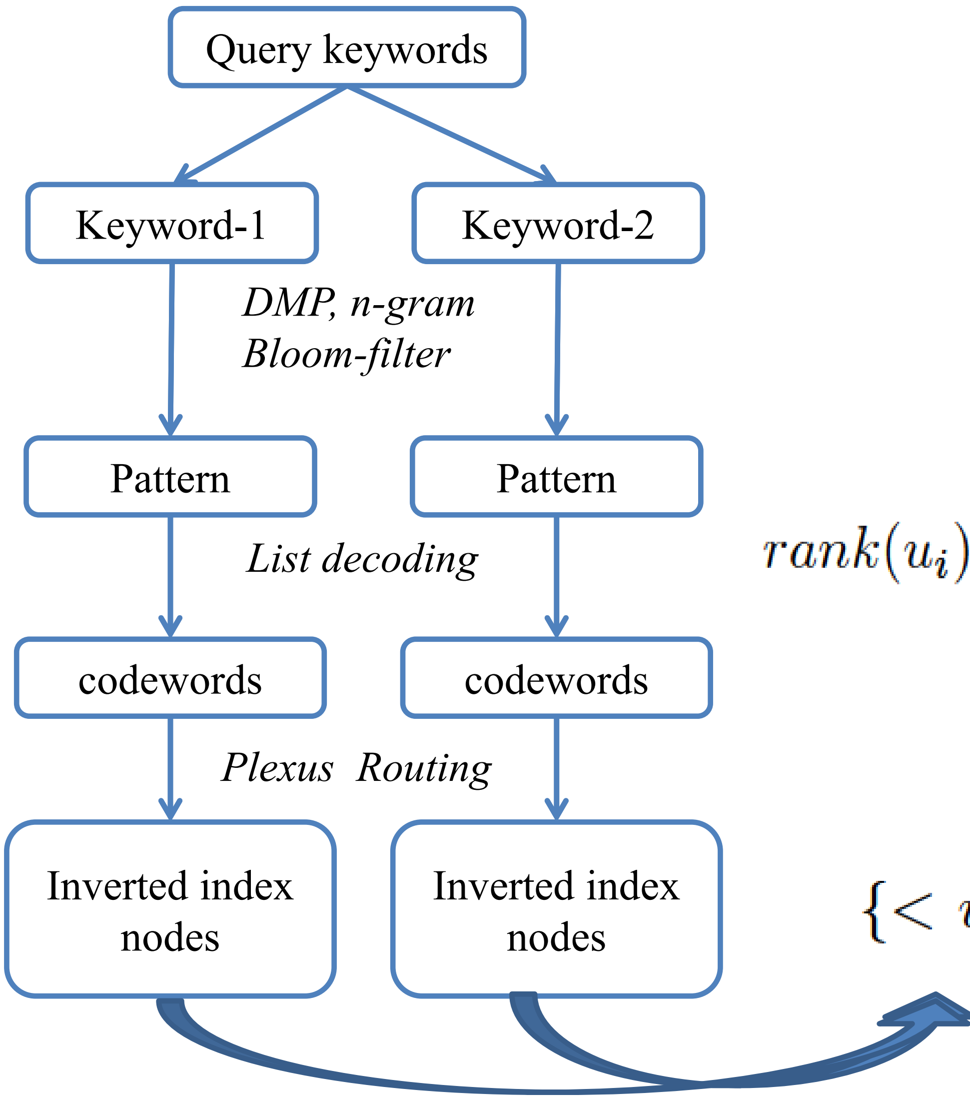


$$w_i = (1-\eta) + \eta \sum_{t=1}^{g} \frac{w_{it}}{L(u_{it})}$$

Distributed Inverted Index



Resolving Web Query



Pagerank weight of u_i

Relevance of u_i to q_l

1 if q_l is in u_i; 0 otherwise

$$rank(u_i) = \sum_{q_l} \sum_{u_i} \vartheta_{il}(\mu \cdot w_i + (1-\mu) \cdot r_{il})$$

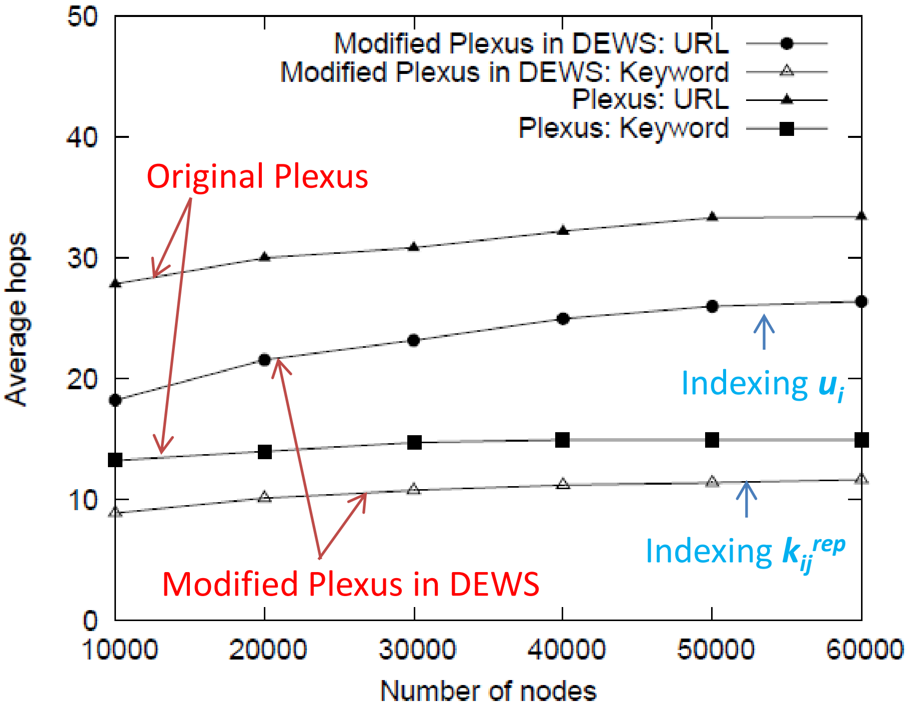
query keyword

$$\{< u_i, w_i, r_{il} >\}$$

Evaluation

- Simulation Setup
  - Web Track dataset from LETOR 3.0
    - ~ 1 million webpages and ~11 million hyperlinks
  - WS network size – up to 100,000 nodes.
- Measurements
  - Routing performance: scalability & overheads
  - Ranking performance: accuracy & convergence rate
  - Search performance : flexibility & accuracy
- Here we present two important results

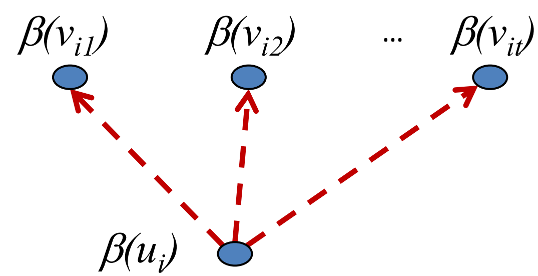
Routing Performance

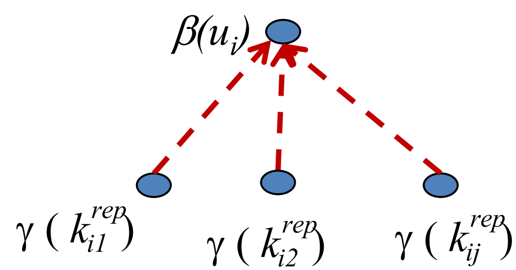


Advertisement Scalability

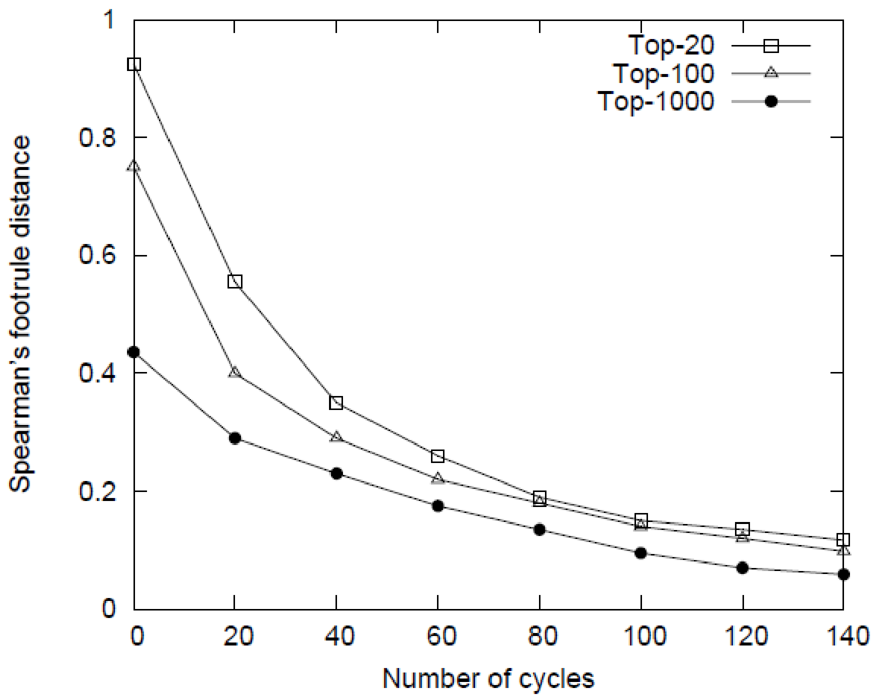
Observations:

- Advertisement hops do not increase significantly with network size
- Route aggregation in DEWS significantly reduces advertisement overhead
- URL advertisement requires more hops than keyword advertisement

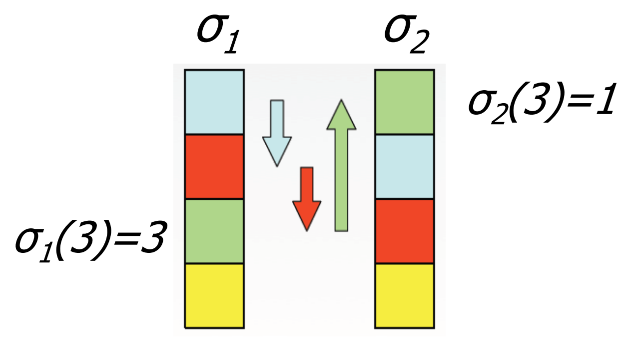




Ranking Accuracy



Ranking Accuracy



$$F(\sigma_1, \sigma_2) = \frac{\sum_{i=1}^{k} |\sigma_1(i) - \sigma_2(i)|}{k * k}$$

Observations:

- Spearman's footrule distance decays rapidly with simulation time, which indicates fast convergence of our distributed ranking algorithm
- Variation in Top-20 and Top-100 elements is not high => DEWS is close to centralized ranking

Summary

- DEWS is a self-indexing architecture for the Web
  - provides censorship resistance
  - delivers unbiased ranking of search results
  - makes it hard to track users' search history
- Future Research:
  - Support for incremental retrieval in DEWS
    - Can be achieved by gradually increasing decoding radius in Plexus routing.
  - Develop a working prototype of DEWS and deploy in the Web

Questions?