Fast Similarity Search for Structured P2P Systems

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Outline

- Motivation
- Related Work
- Fast Similarity Search
- Peer-to-peer **Fast S**imilarity **S**earch (P2PFastSS)
  - Examples
  - Algorithm
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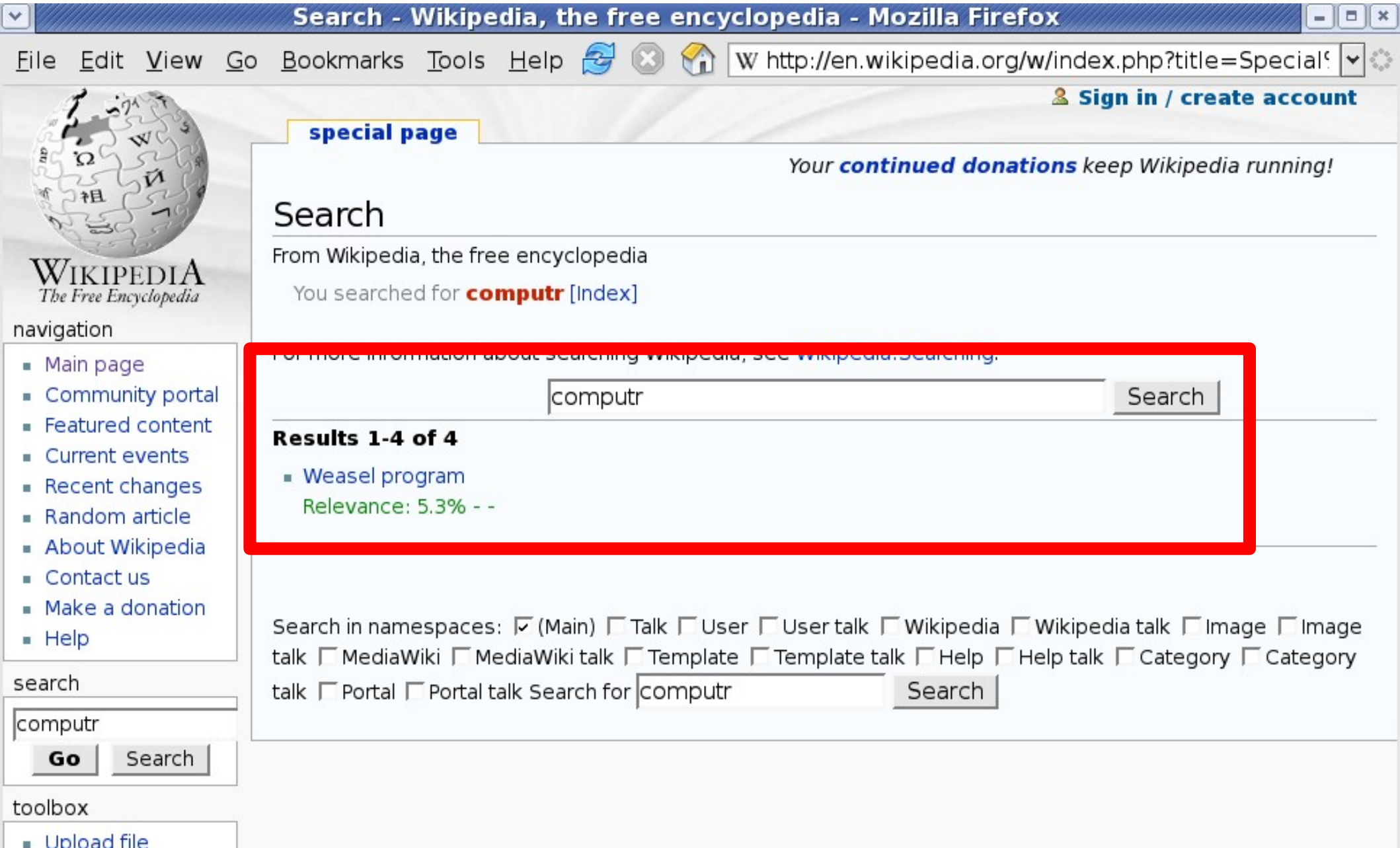
- Conclusion
- Demo

Motivation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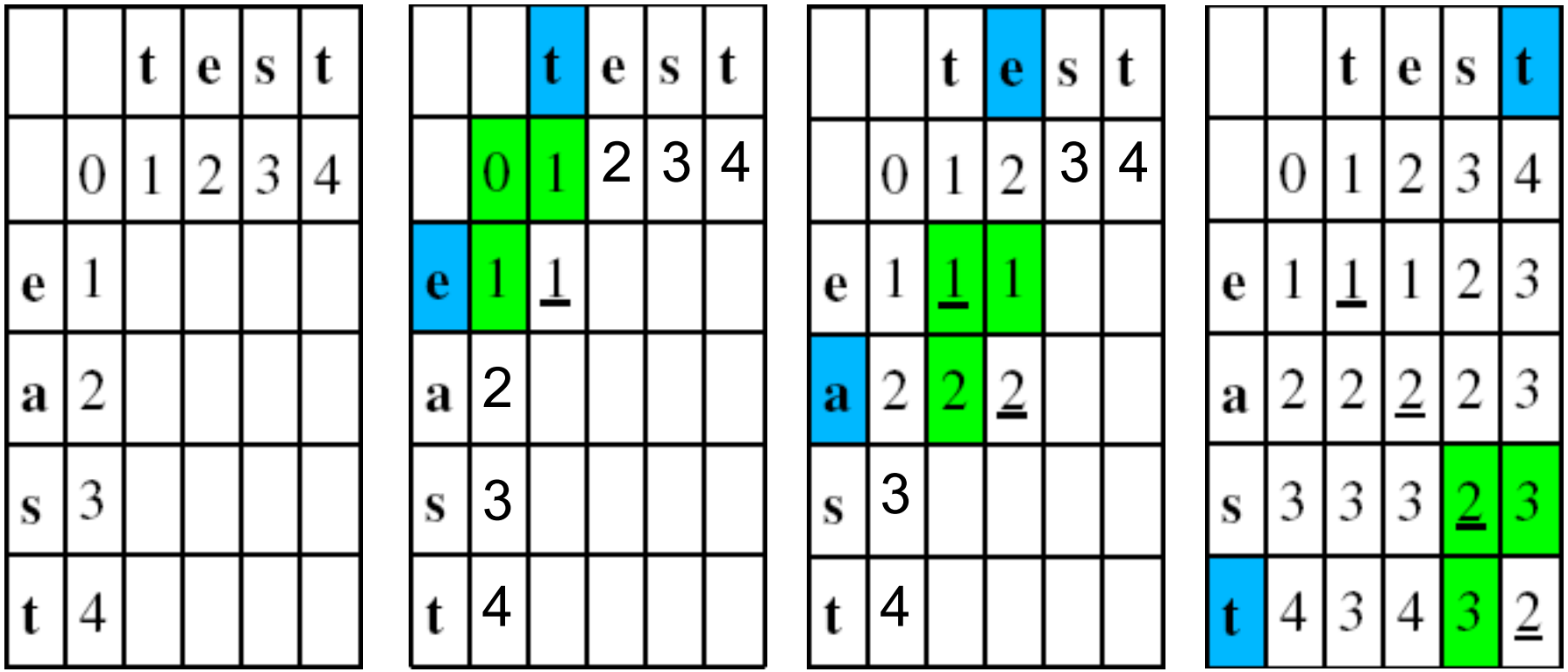
Search

Related Work – Edit Distance (1)

- Model of similarity: edit distance
- Edit distance between strings
  - Minimum # of operations to transform one into the other
  - Operations:
    - **insert**, **delete**, and **replace**
- Edit distance matrix calculation is costly
  - Uses matrix of size O(mn)

Related Work – Edit Distance (2)

- Example: edit distance (test,east) = 2



Related Work – Neighborhood Generation

- Neighborhood generation:
  - All possible strings for a given k are created
    - Neighbors for *test* with k=2: test, testa, testaa, testab, ... , tea, teb, tec, ..., teaa, teab, ...
  - Problem: large alphabet, large neighborhood size
    - Neighbors for *test* with k=2 result in **23883** neighbors

FastSS Algorithm

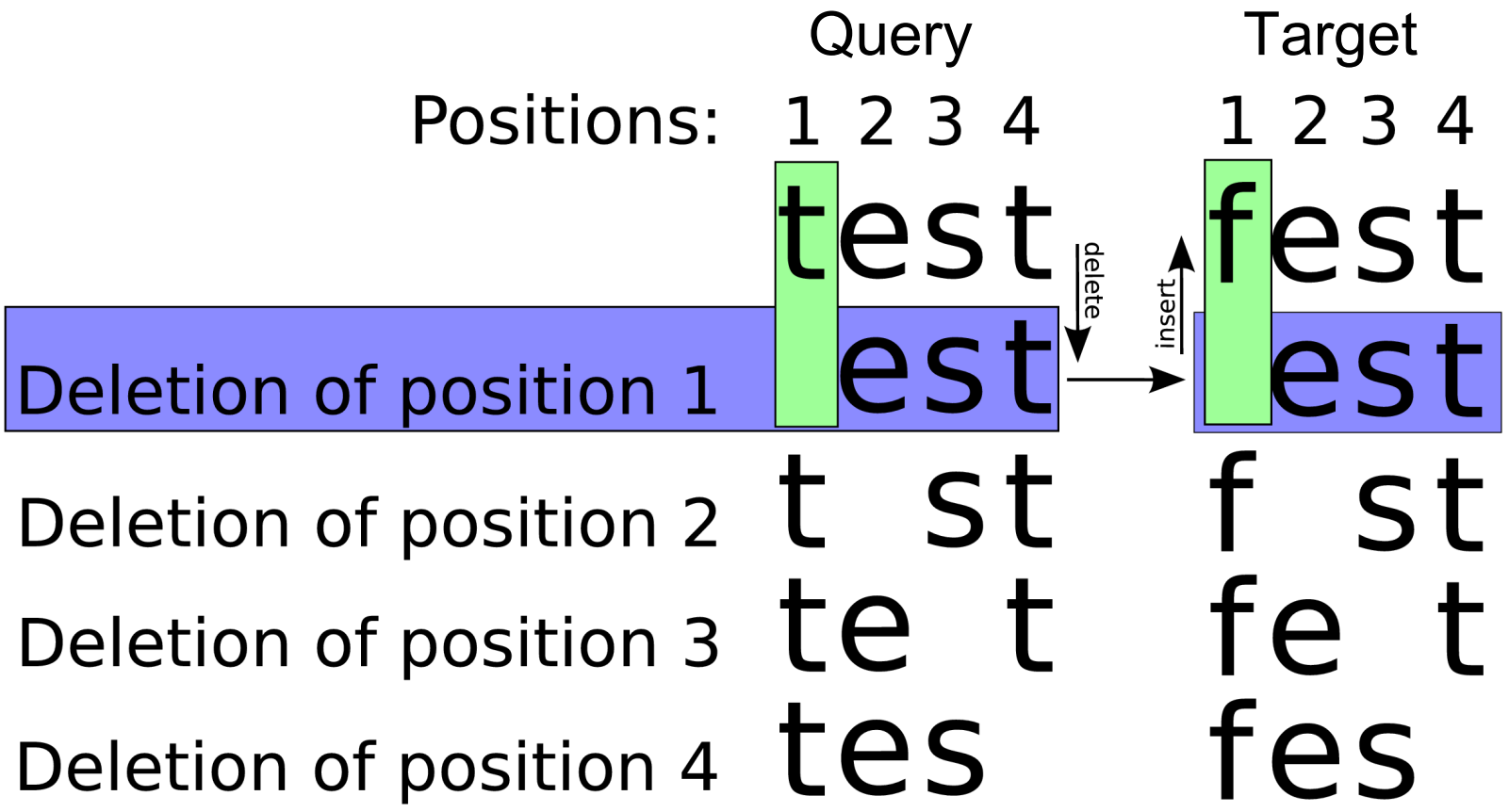
- **FastSS** uses edit distance metric
- Based on neighborhood generation
  - Generate neighbors with **deletions** on the query **and** target
  - Example test with k=2, neighborhood generation based on deletion:
    - test, est, st, et, es, tst, tt, ts, tet, te, tes

FastSS and NG

- FastSS does not generate as many neighbors as neighborhood generation
  - FastSS: 11 neighbors, enlarged target by 11 neighbors → **11 queries**
  - Full neighborhood generation: 23883 neighbors, target is not enlarged → **23883 queries**
- FastSS examples
  - In the following examples, search for k=1, 1-deletion neighborhood

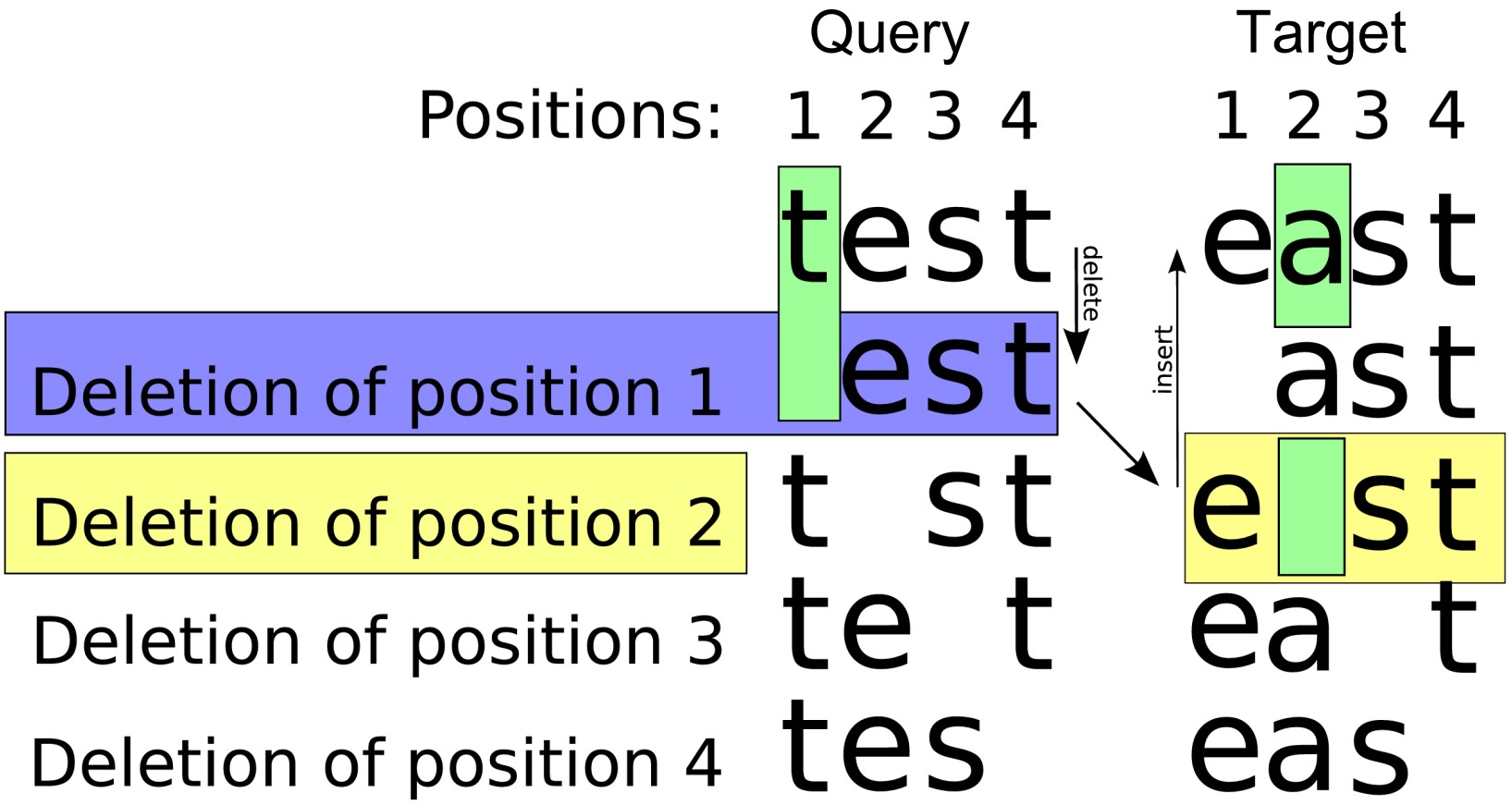
FastSS Example (1)

- Edit distance (test,fest) = 1



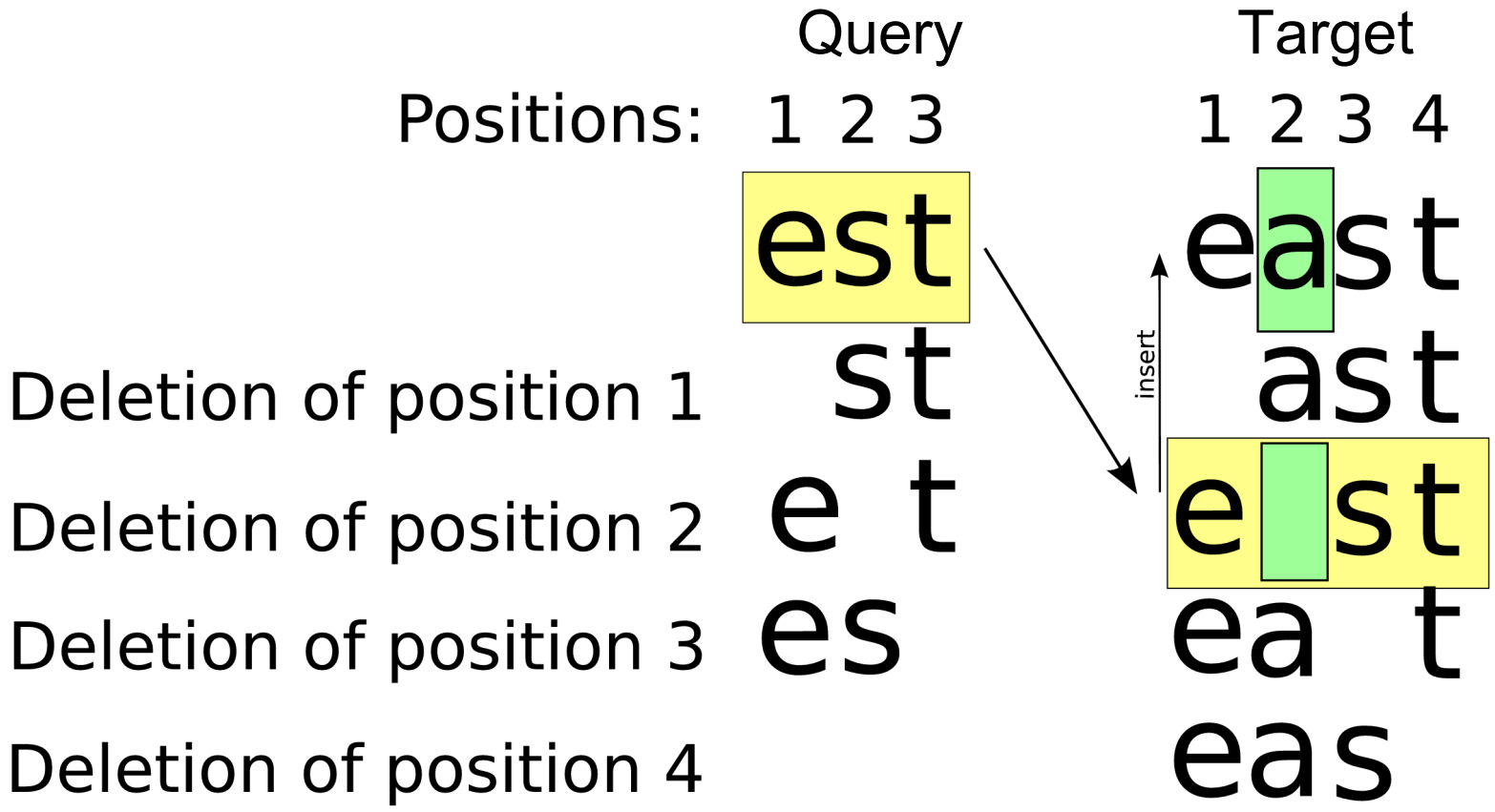
FastSS Example (2)

- Edit distance (test,east) = 2
  - Different delete positions



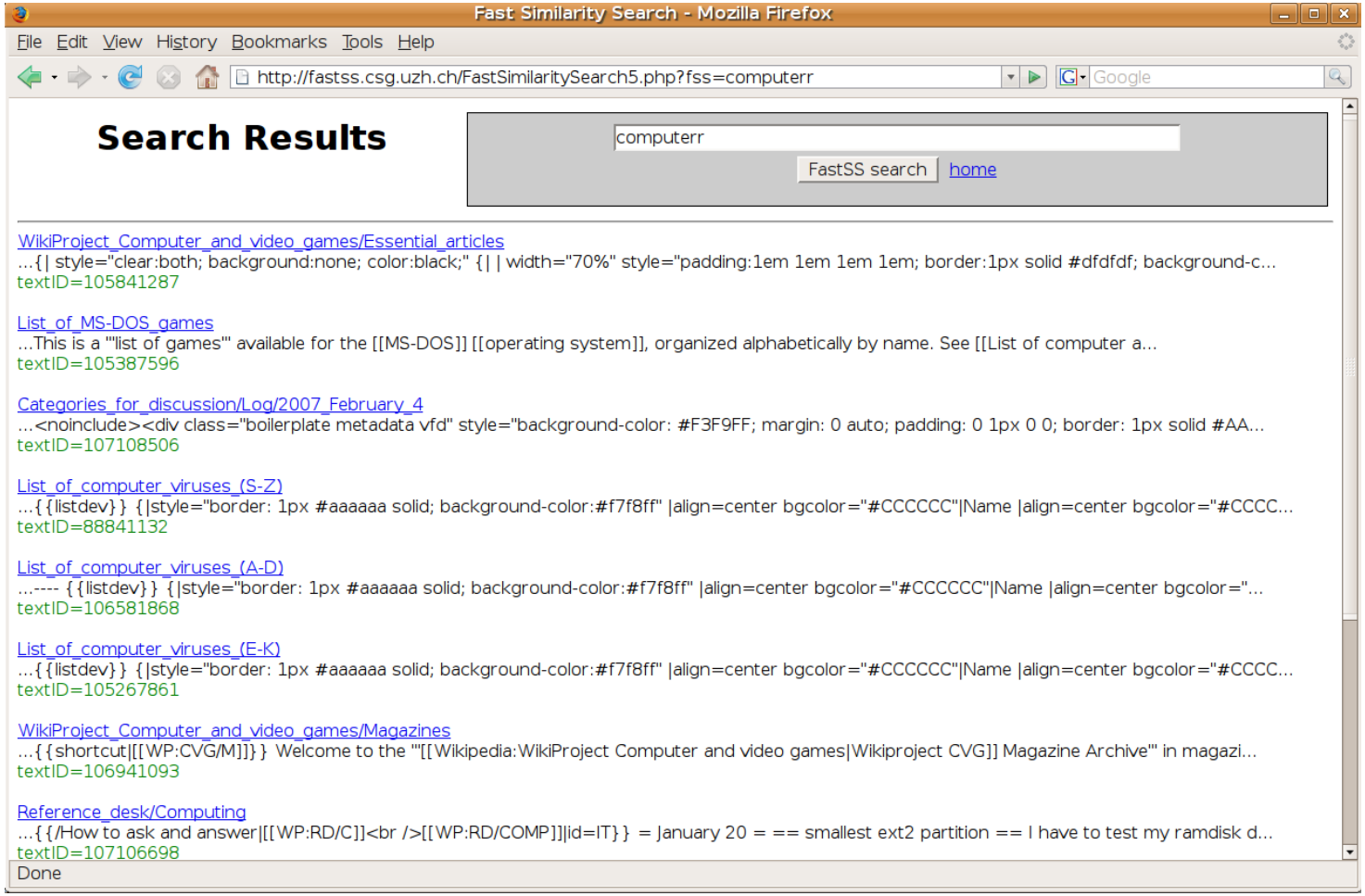
FastSS Example (3)

- Edit distance (est,east) = 1
  - Different word length



FastSS on Wikipedia

- FastSS in a centralized system using PHP and MySQL (indexed complete English Wikipedia)



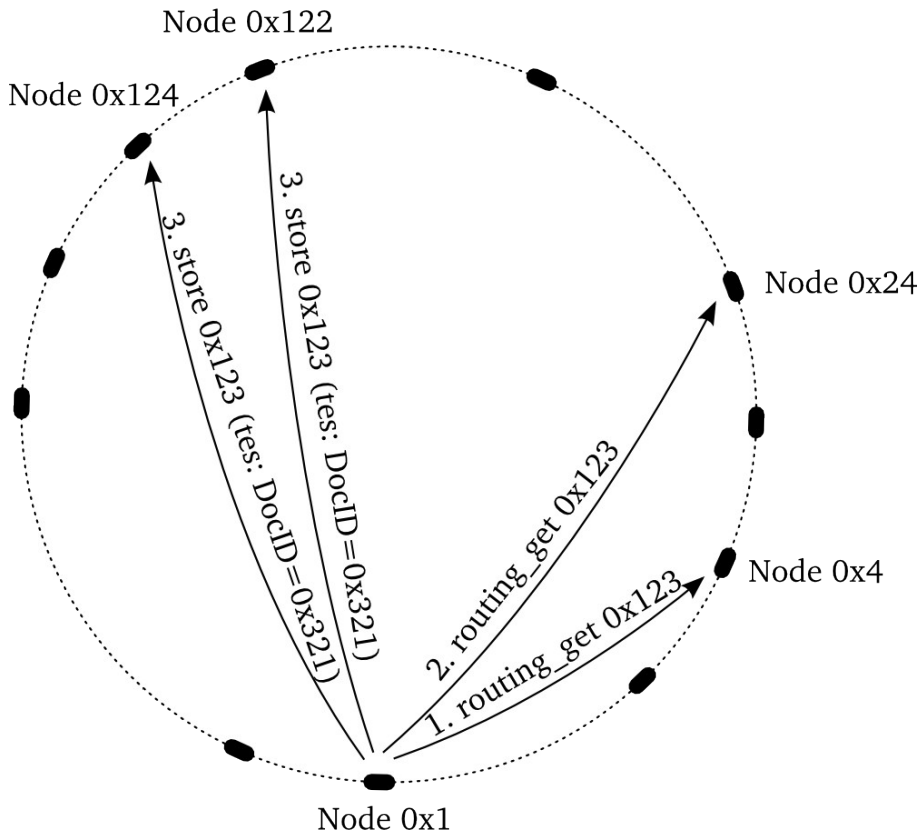
FastSS on Wikipedia

- Scalability issues (1 similarity search ~ 1-2s)
  → Distributed system for better scalability
- No support for similarity search in DHT
  - Operations: `get(hash)`, `put(hash,value)`
  - Only exact matches are returned

→ Use FastSS on top of DHT

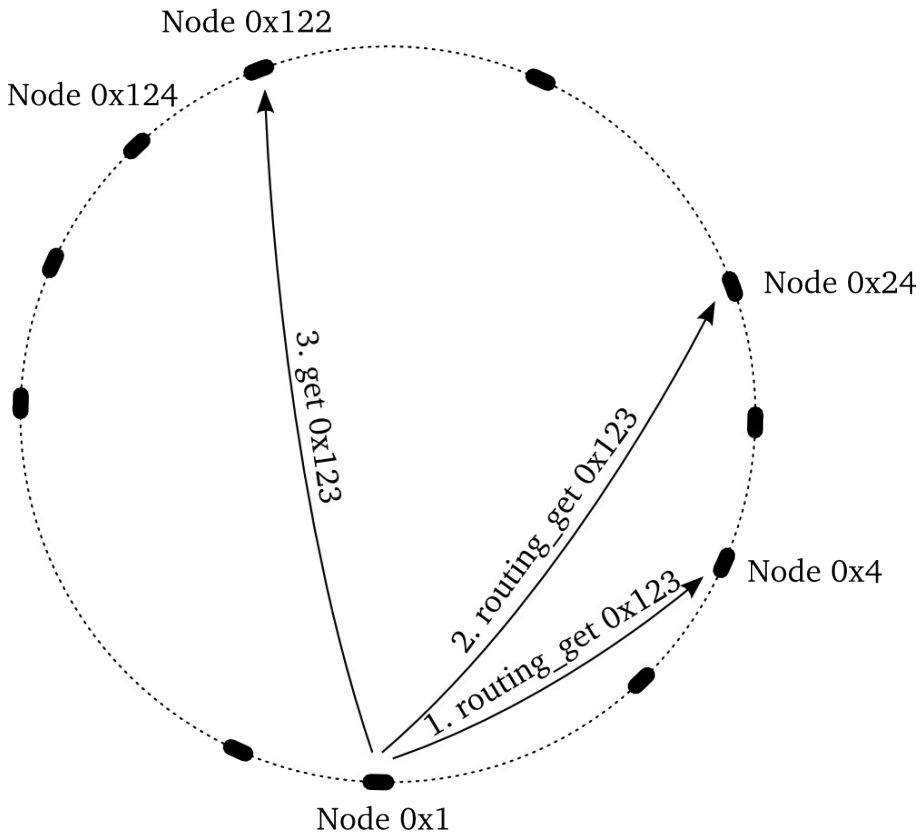
P2PFastSS – Algorithm Indexing

- Index documents using `put(hash(document),document)`
- Index all neighbors (test,tes,tst,tet,est) using `put(hash(neighbor),point to document)`



P2PFastSS – Algorithm Search

- User searches for “tesx”
- Neighbors are generated (tesx, esx, tsx, tex, tes)
  - `get(hash(neighbor))`
  - Yields pointer to document
  - `get(hash(document))`



P2PFastSS – Implementation

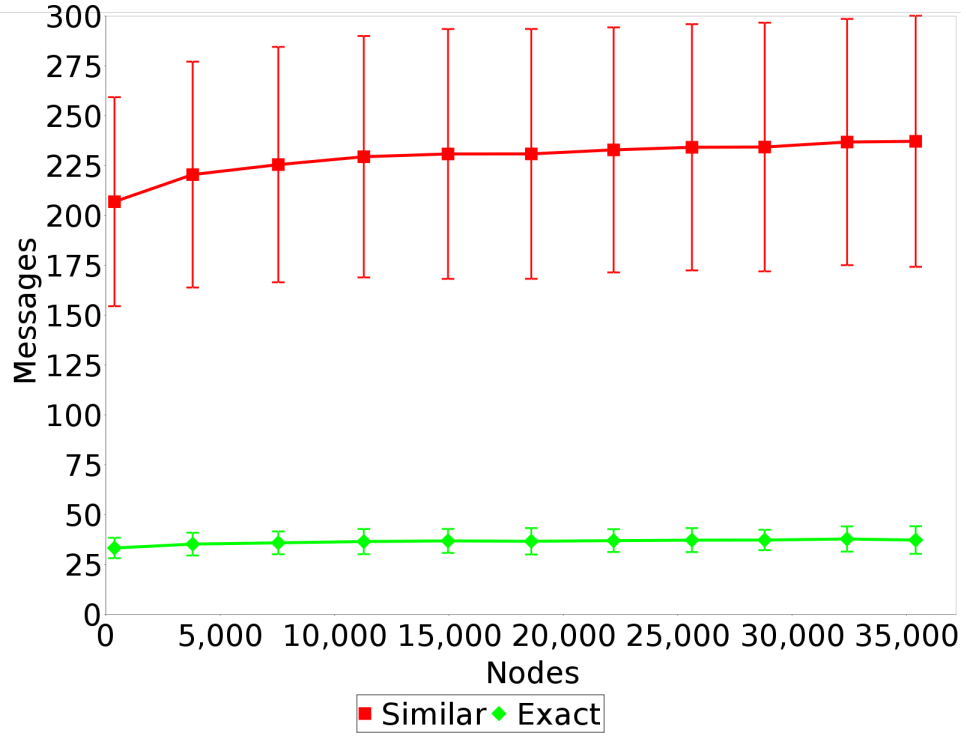
- P2PFastSS
  - Implemented in Java
  - Uses a DHT based on the Kademlia routing algorithm
  - Deployed on ~360 PlanetLab hosts
    - up to 100 nodes on each PlanetLab host
    - up to 34,200 nodes in total
    - new tests use EMANICSLab
  - Edit distance (k) set to 1
  - Every word with length 3 to 16 was indexed

P2PFastSS – Performance

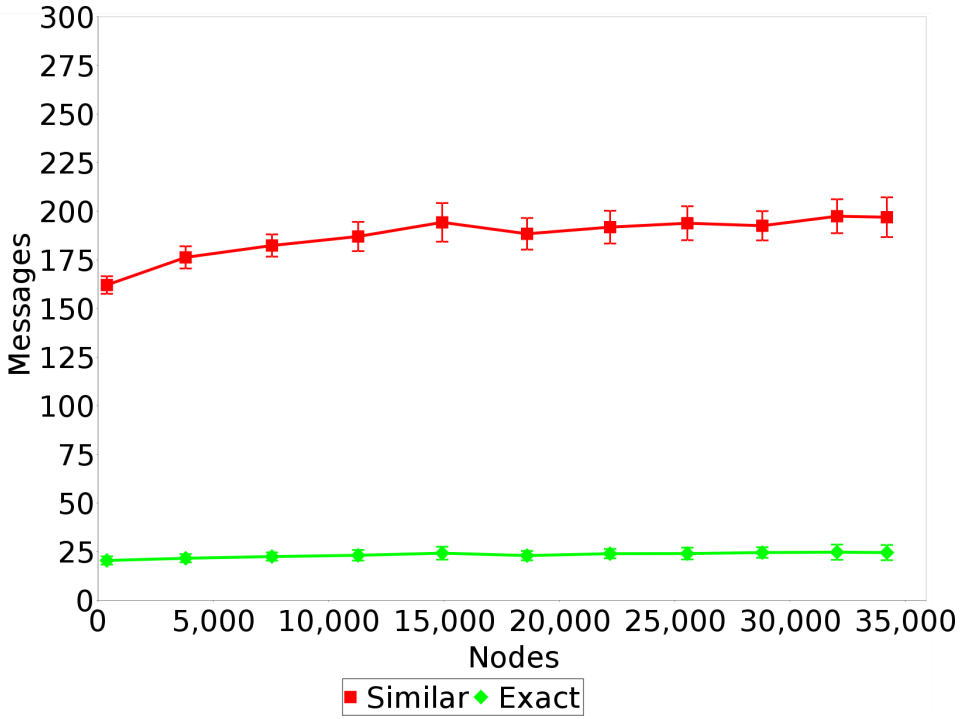
- 100 Wikipedia abstracts indexed
  - Total 2,392 words
  - Average word length is 7 characters
- Message, time, and storage measurements
- All experiments carried 50 times
  - Average values shown, with error bars

P2PFastSS – Performance
Number of Messages for Indexing

- m is between 3 and 16
  - High value for standard deviation
  - Short words need less messages
- Redundantly stored in 2 nodes



P2PFastSS – Performance
Number of Messages on Search



- Word length 7
- Overhead introduced by P2PFastSS is m^k
  - m is average word length (7)
  - k is edit distance (1)
- Logarithmic growth observed

P2PFastSS – Performance Time Measurements

- Indexing time
  - Similarity indexing
    - 0.67 to 16.99s
  - Exact indexing
    - 0.18 to 15.94s
- Lookup time
  - Similarity search
    - 0.5 to 11.6s (average is less than 3s)
  - Exact search
    - 0.2 to 4.5s (average about 2s)
- High variability due to real-world conditions
- Storage operation is slower than searching
  - keywords are stored with the redundancy factor r (2)

Conclusions

- Message overhead
  - Ca. seven times that of exact search
- P2PFastSS
  - Only 1.5 times slower than an exact search
  - Edit distance 1
- Difference due to benefits of distributed parallel computation
- P2PFastSS performs a similarity search in average in less than 3 s with more than 34,000 nodes on PlanetLab
  - Average load average on PlanetLab ~9.9

Demo

Demo

Thank You For Listening

Questions?

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