Google's MapReduce and Sawzall

CSCI 334
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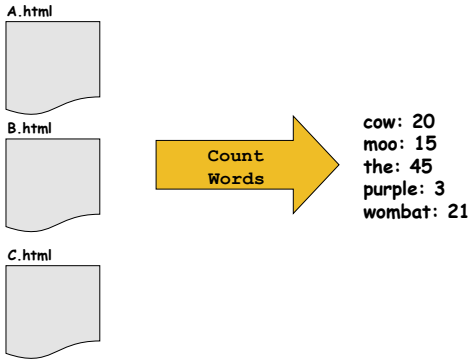

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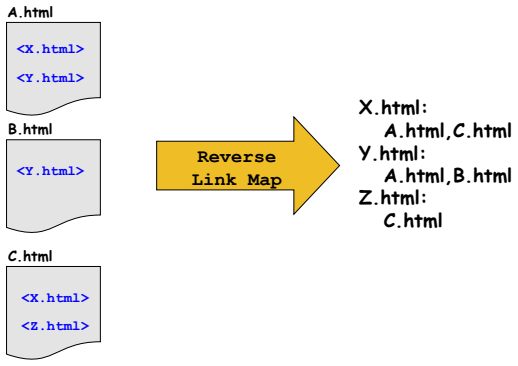

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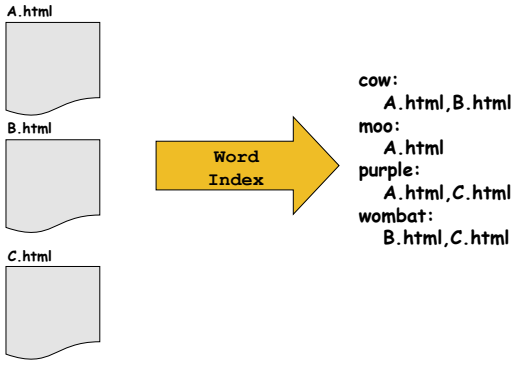

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Computations Over Data

- Word Count
- Reverse Link Map
- Word Index
- Links out of a domain
- **Page Rank**
- log file processing

- But.... many terabytes of data
  - **1 terabyte = 1000 Gigabytes**
    = 1 099 511 627 776 bytes

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Computing Infrastructure

- > 500,000 computers (as of 2007?)
- Distributed network of clusters around world

- Problems:
  - need to coordinate computers
  - machines fail constantly
  - network, failure, computer/data locations, etc. should be transparent to user running analyses.

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Dean & Ghemawat

We designed a new abstraction that allows us to express the simple computations we were trying to perform, but hides the messy details of parallelism, fault-tolerance, data distribution, and load-balancing... Our abstraction is inspired by the *map* and *reduce* primitives in Lisp and many other functional langauges.

- Map: apply fn to every element of list
- Reduce: combine values in list to form a single "summary value"

  (eg: reduce list of nums by summing them)

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MapReduce and Sawzall

- MapReduce (Dean and Ghemawat)
  - distributed computer management
- Sawzall (Pike et al.)
  - language for writing code to perform data analysis

- Papers up on web page
- Cloud Compute Services:
  - Hadoop, Amazon EC2, IBM SmartCloud, ...

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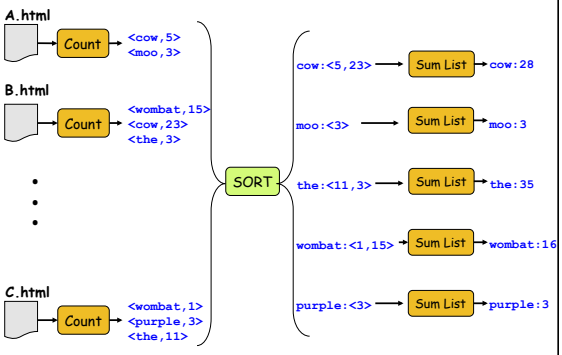
Count Words



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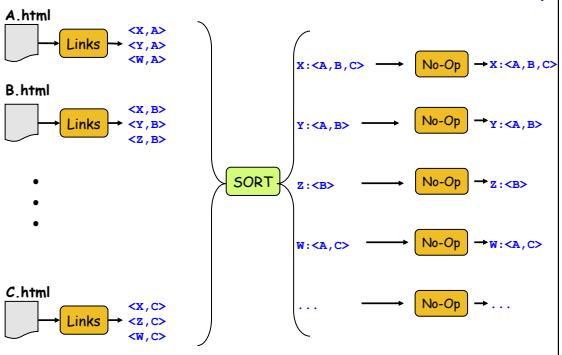
Reverse Link Map



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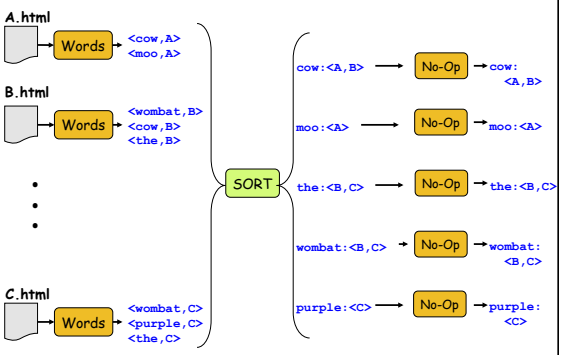
Word Index



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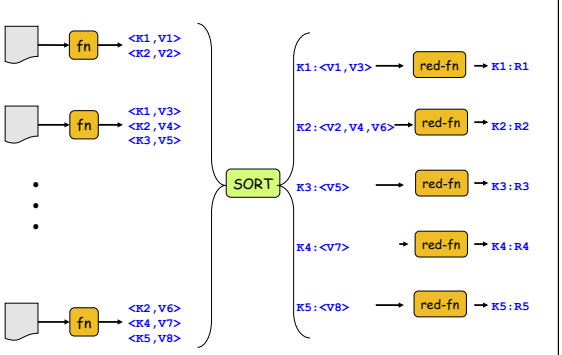

map-fn: page -> <Key,Value> List red-fn: Value List -> Value

Summary

- Performance:
  - search 10 billion unordered records in 80 sec
  - sort 10 billion records in 800 sec
- Page Rank: 24 separate map-reduce operations
- Sawzall/MapReduce execution model:
  - specify data set, map fn, reduce fn
  - most map/reduce functions < 50 lines of code
  - hides details of distributed system
  - fault tolerant, fast, flexible architecture

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of Queries for Each Latitude/ Longitude

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of Queries for Each Latitude/ Longitude

```
proto "querylog.proto"

queries_per_degree: table sum[lat: int][lon: int] of int;

log_record: QueryLogProto = input;

loc: Location = locationinfo(log_record.ip);

emit queries_per_degree[int(loc.lat)][int(loc.lon)] <- 1;
```

map phase produces key-value pairs of form <(lat,lon),1>
reduce phase sums up values for each key

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Page with Highest Page Rank

```
proto "document.proto"

max_pagerank_url:
  table maximum(1) [domain: string] of url: string
        weight pagerank: int;

doc: Document = input;

emit max_pagerank_url[domain(doc.url)] <- doc.url
   weight  doc.pagerank;
```

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