Effective Keyword Search for Software Resources installed in Large-scale Grid Infrastructures

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Computing Grids

- Distributed computing infrastructures that enable flexible, secure, coordinated resource sharing among dynamic collections of individuals and institutions *(Foster, Kesselman, Tuecke)*.
- Enable communities ("Virtual Organizations") to share geographically distributed resources as they pursue common goals --
- Key assumptions: absence of…
  - Homogeneity
  - Central location
  - Central control
  - Existing trust relationships

Computational Grids

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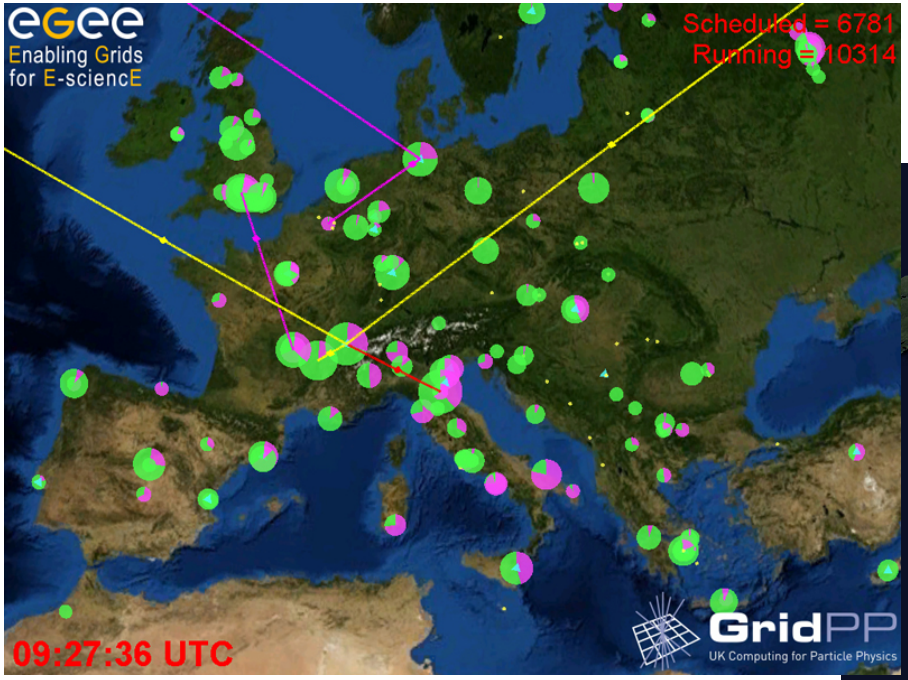
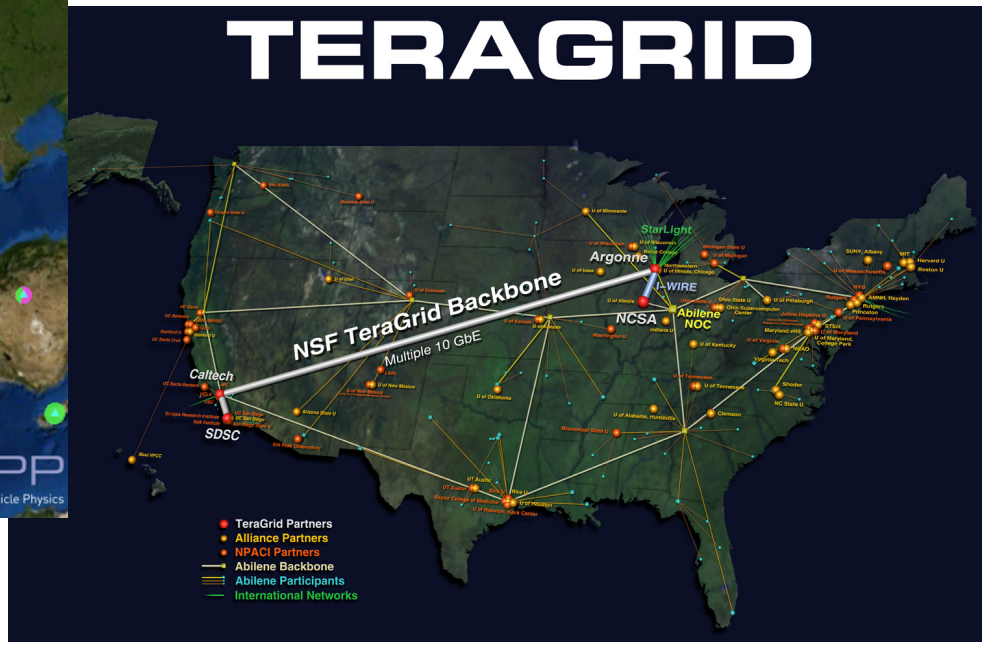
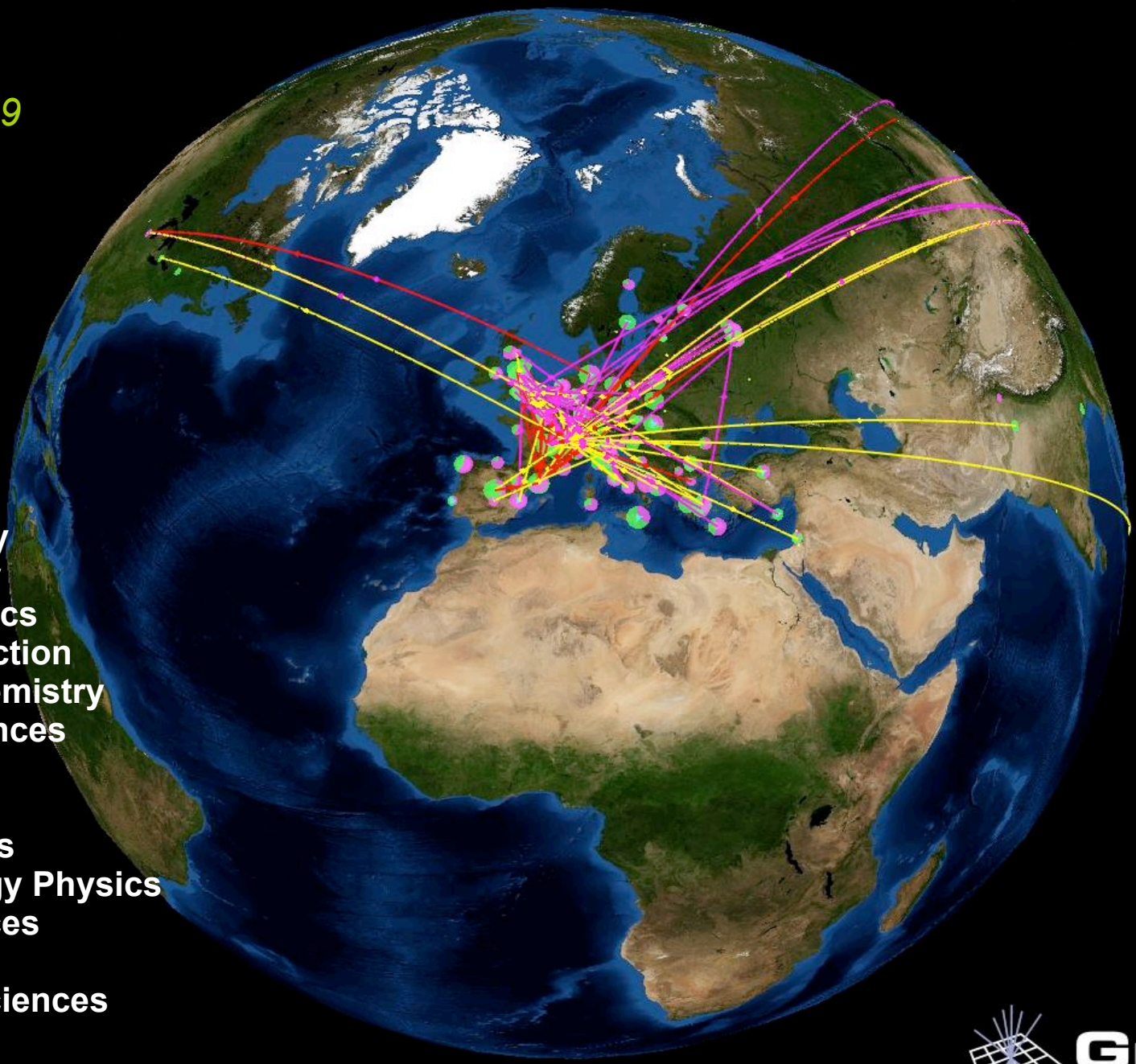




Enabling Grids for E-sciencE

2004-2009



Archeology
Astronomy
Astrophysics
Civil Protection
Comp. Chemistry
Earth Sciences
Finance
Fusion
Geophysics
High Energy Physics
Life Sciences
Multimedia
Material Sciences
…

GridPP
UK Computing for Particle Physics

eGee
Enabling Grids
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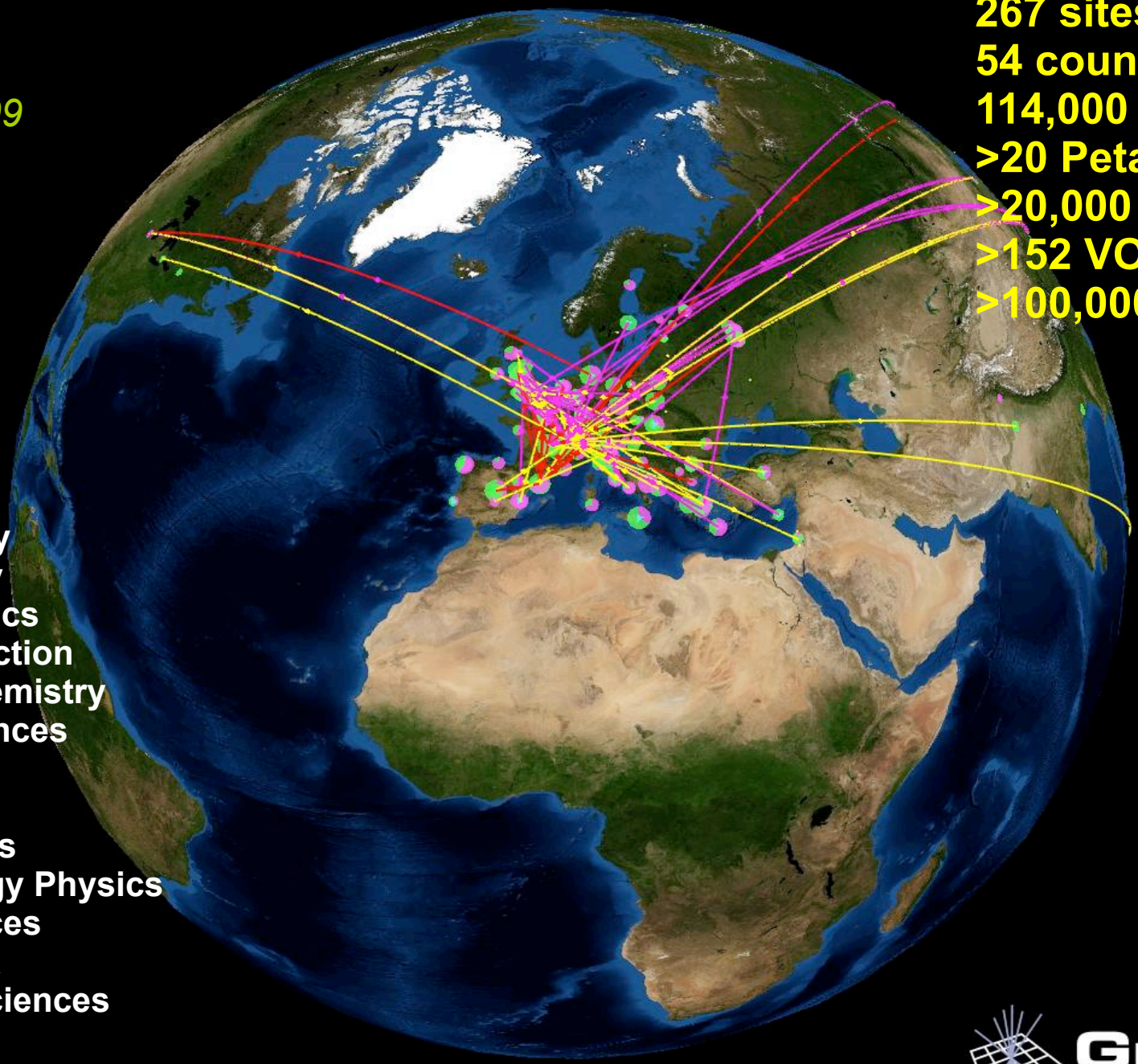

267 sites
54 countries
114,000 CPUs
>20 PetaBytes
>20,000 users
>152 VOs
>100,000 jobs/day

Archeology
Astronomy
Astrophysics
Civil Protection
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How can we search for software that is installed on the sites of a large-scale Grid infrastructure?

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low-cost entry to the infrastructure

What are the options?

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  - Semantic file systems do exist but are not widely adopted

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  - No embedded hyperlinks that could help with result ranking

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- **"Information Services for Large-scale Grids: A Case for a Grid Search Engine."** M. D. Dikaiakos, R. Sakellariou, and Y. Ioannidis. In *Engineering the Grid: status and perspectives*, Jack Dongarra, Hans Zima, Adolfy Hoisie, Laurence Yang, Beniamino DiMartino (Editors), pages 571-583. American Scientific Publishers, January 2006.
- **" A Core Grid Ontology for the Semantic Grid."** Wei Xing, M. D. Dikaiakos, and R. Sakellariou. In *Proceedings of the 6th IEEE International Symposium on Cluster Computing and the Grid (CCGrid 2006)*, Singapore, May 2006, pages 178-184

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- Software installed in Grid infrastructures is
  - found in various formats (sources, binaries, libraries)
  - located in *unstructured* repositories (file systems), alongside numerous resources of various types

Goal

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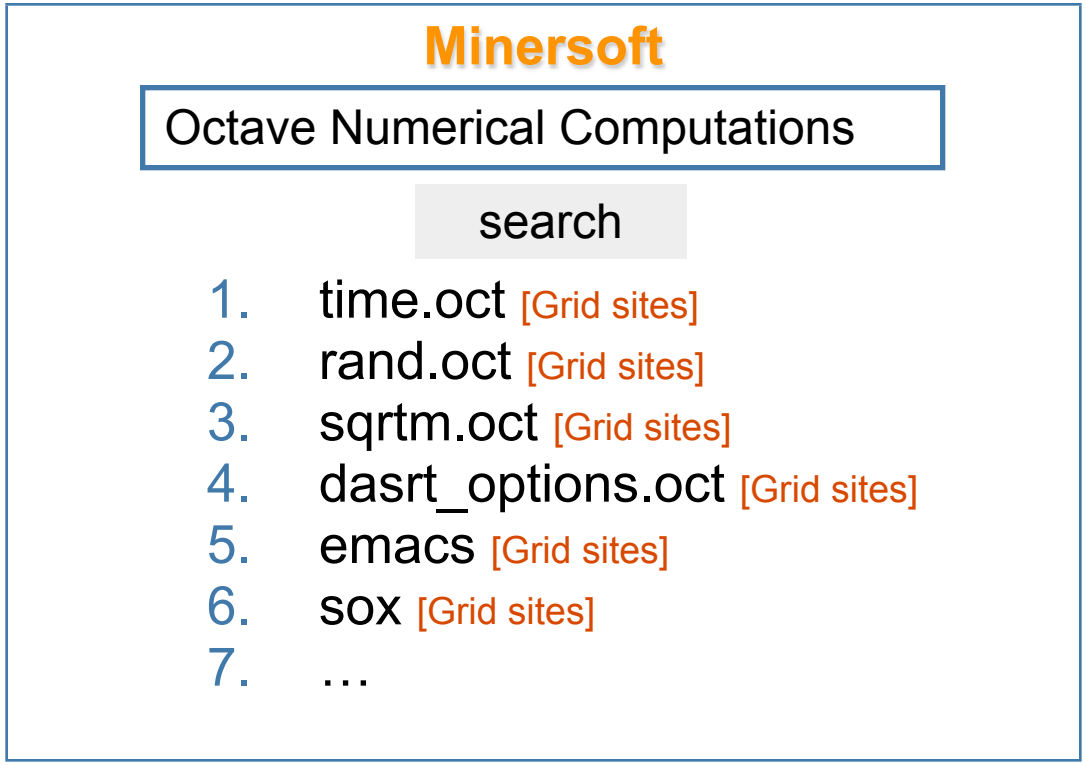

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- Build inverted indexes to support text-based software retrieval
- Evaluate the quality of Minersoft’s results using a real Grid testbed

Related Work on Software Retrieval

Approaches	Corpus	Search paradigm	Software resources			
			Binaries	Source Codes	Description Docs	Binary Libraries
GURU *IEEE Trans.Softw.Eng. 1991*	Software Repositories	Keyword-based				
SEC *ACM SAC, 2006*	Software Repositories	Keyword-based				
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Outline

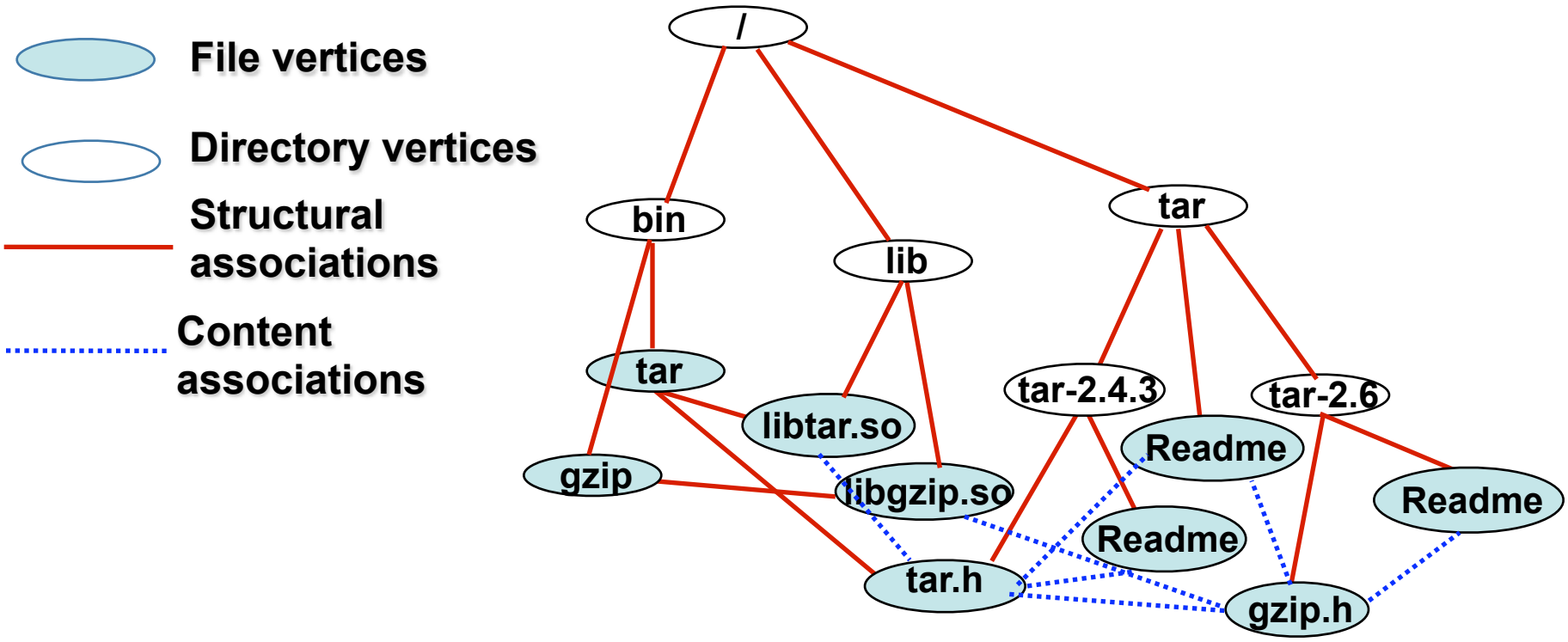
- Motivation, context, related work
- Minersoft: data structure and algorithm
- Architecture and implementation
- Evaluation
- Conclusions

Software Resource

- A software resource is a file that belongs to one of the following categories:
  - Executables (binaries or scripts)
  - Software libraries
  - Source codes
  - Unstructured or semi-structured software-description and software-configuration documents (manuals, readme files, makefiles RPMs)

Software Graph

- Software Graph is a weighted, metadata-rich, typed graph G(V,E)



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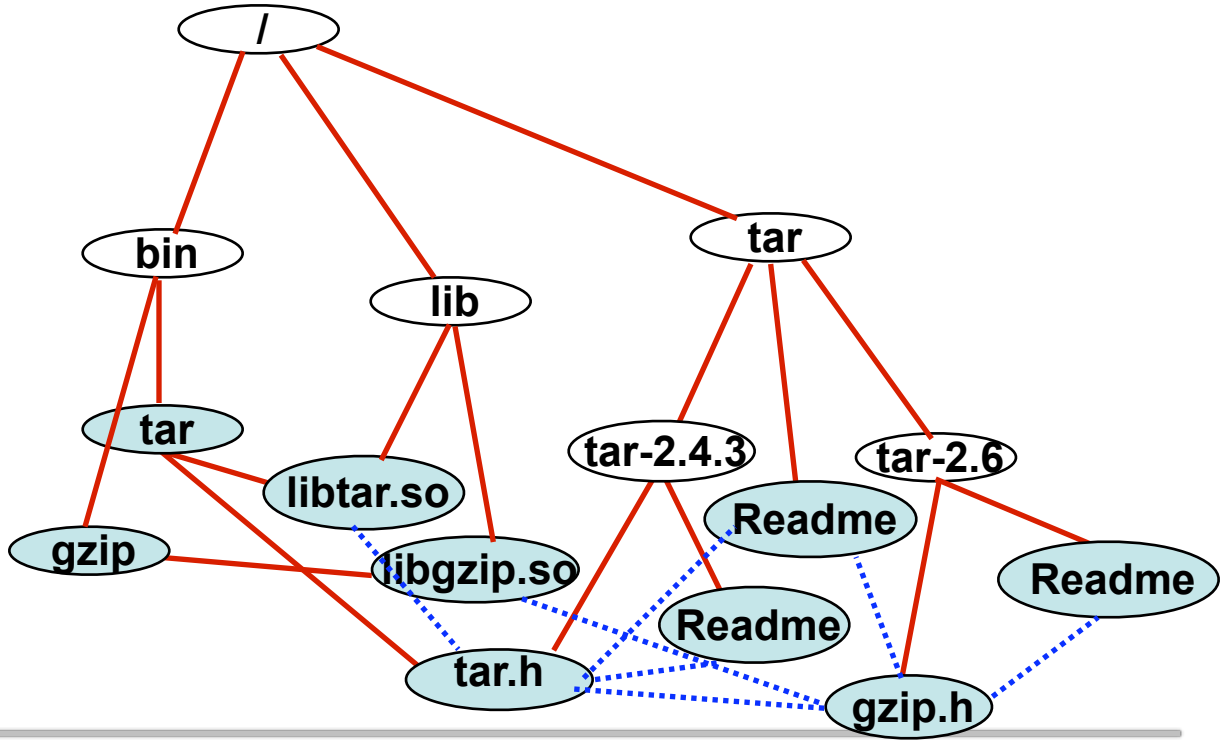
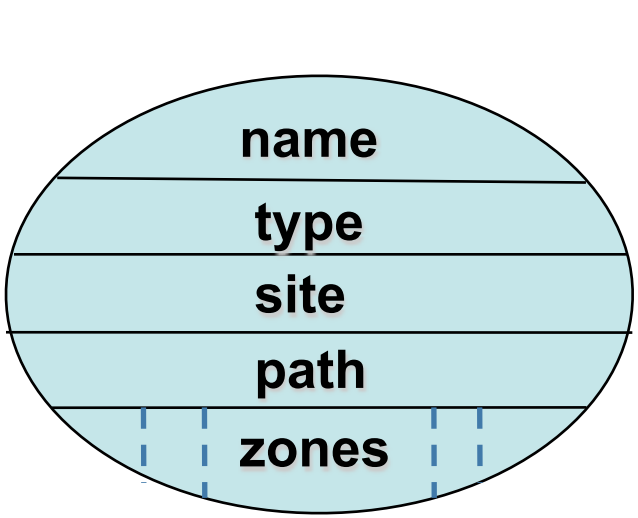
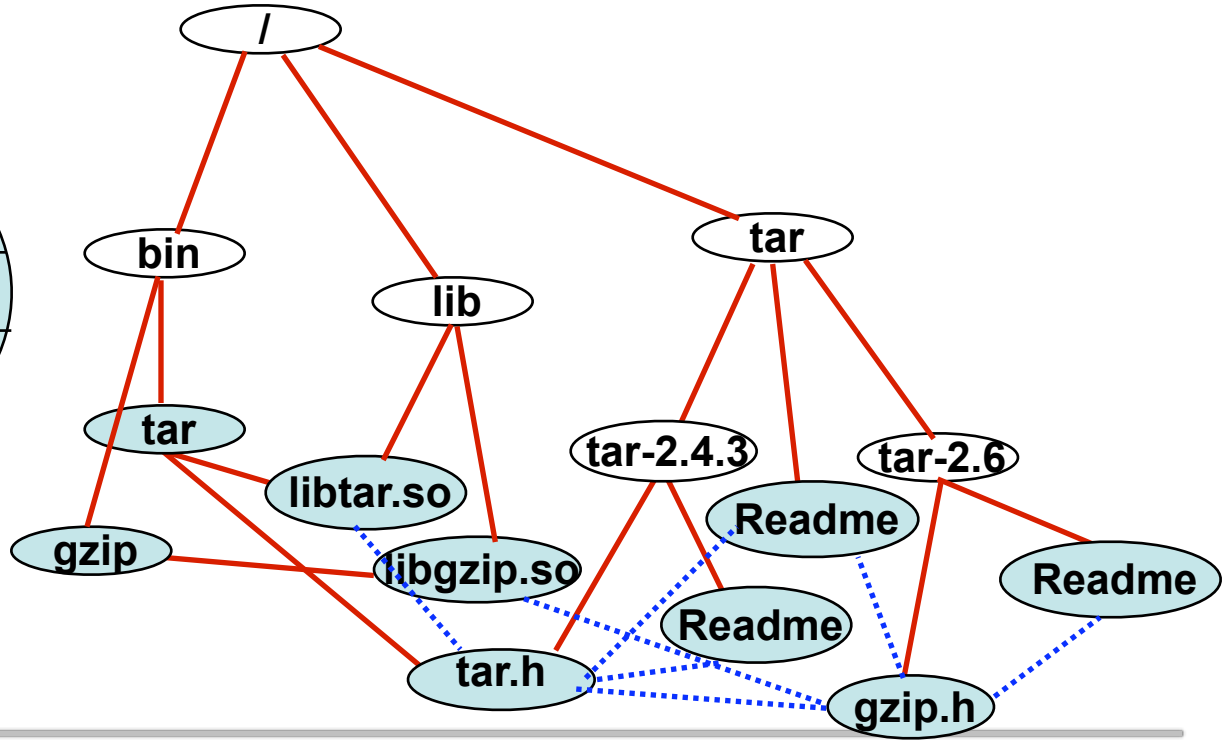


Software Graph

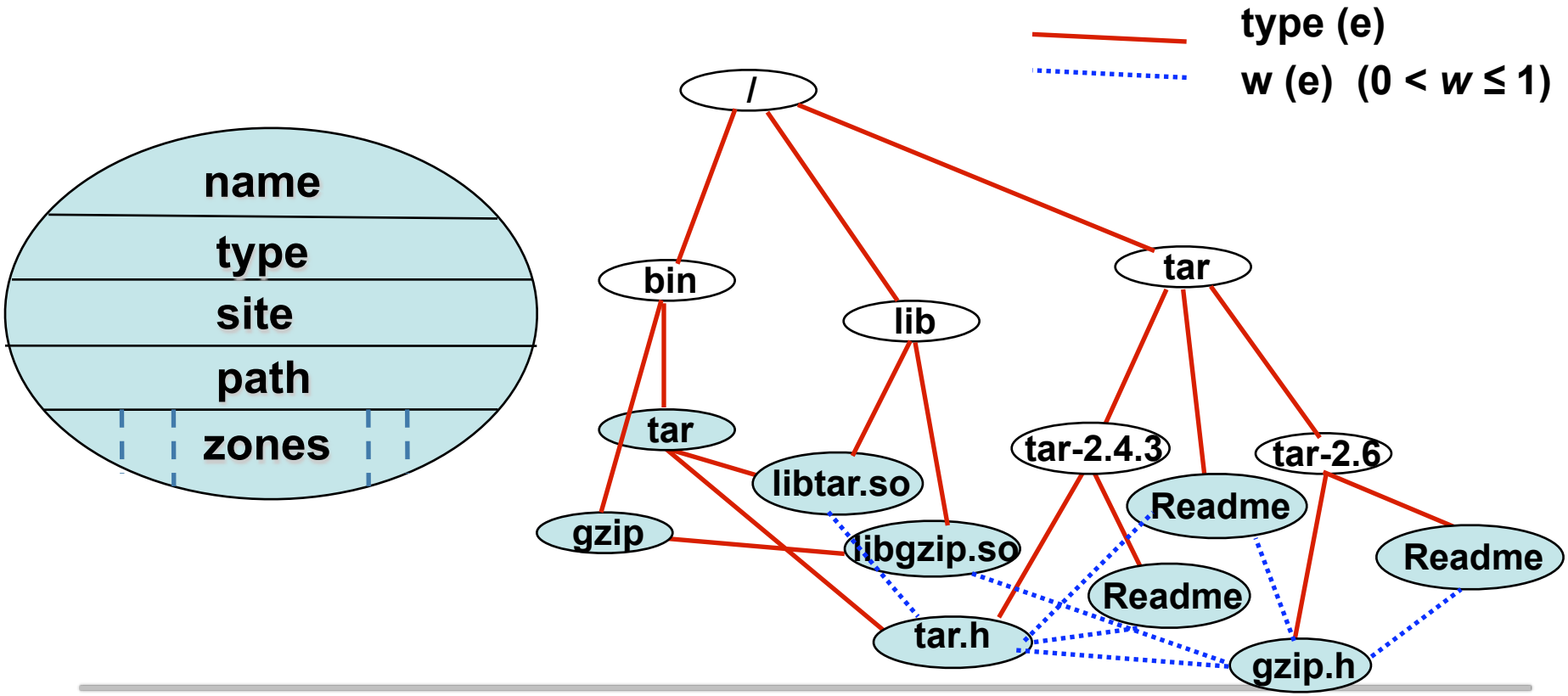
- Each vertex v is annotated with associated metadata attributes that describe v's content and context





Software Graph

- Each vertex v is annotated with associated metadata attributes that describe v's content and context
- Each edge *e* has a type and a weight



Minersoft Processing

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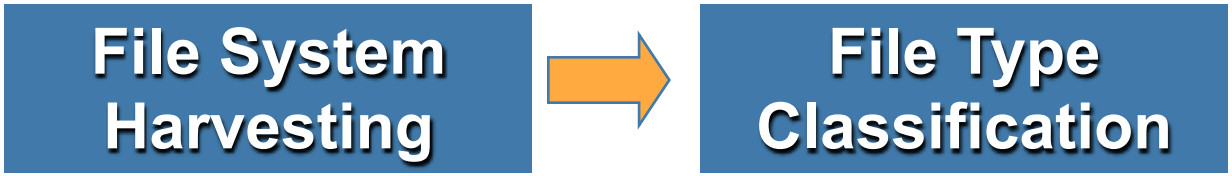
File System Harvesting

Minersoft Processing



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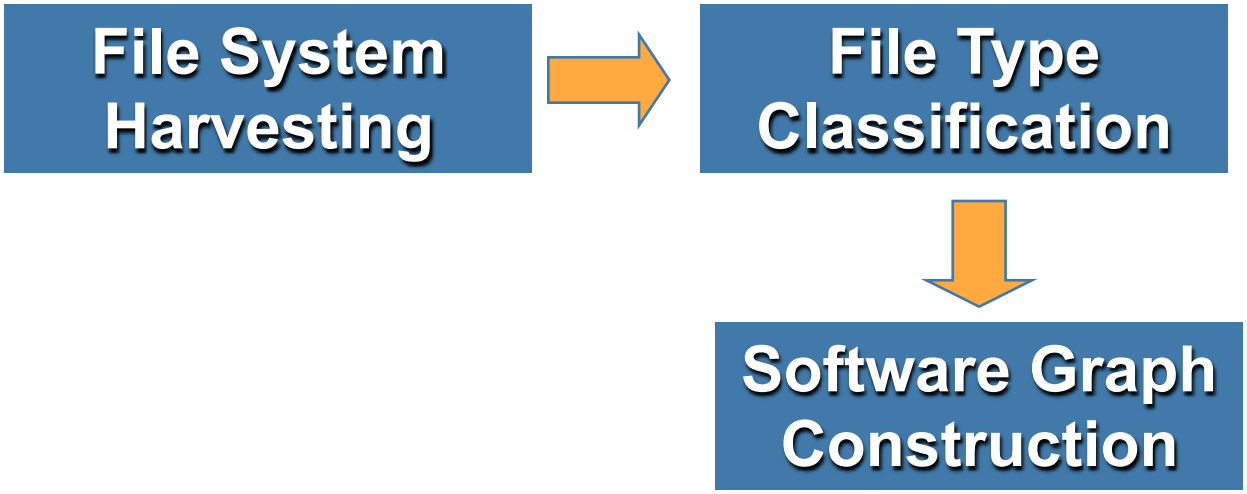

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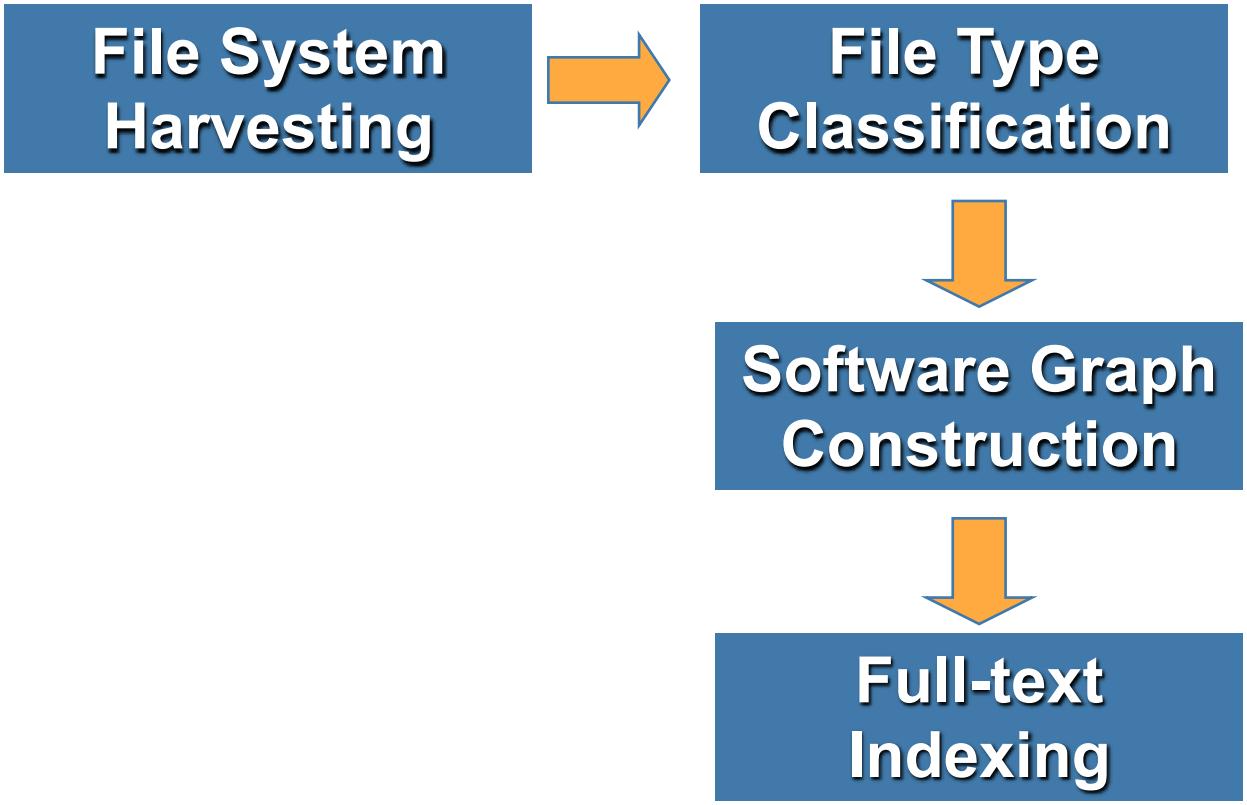

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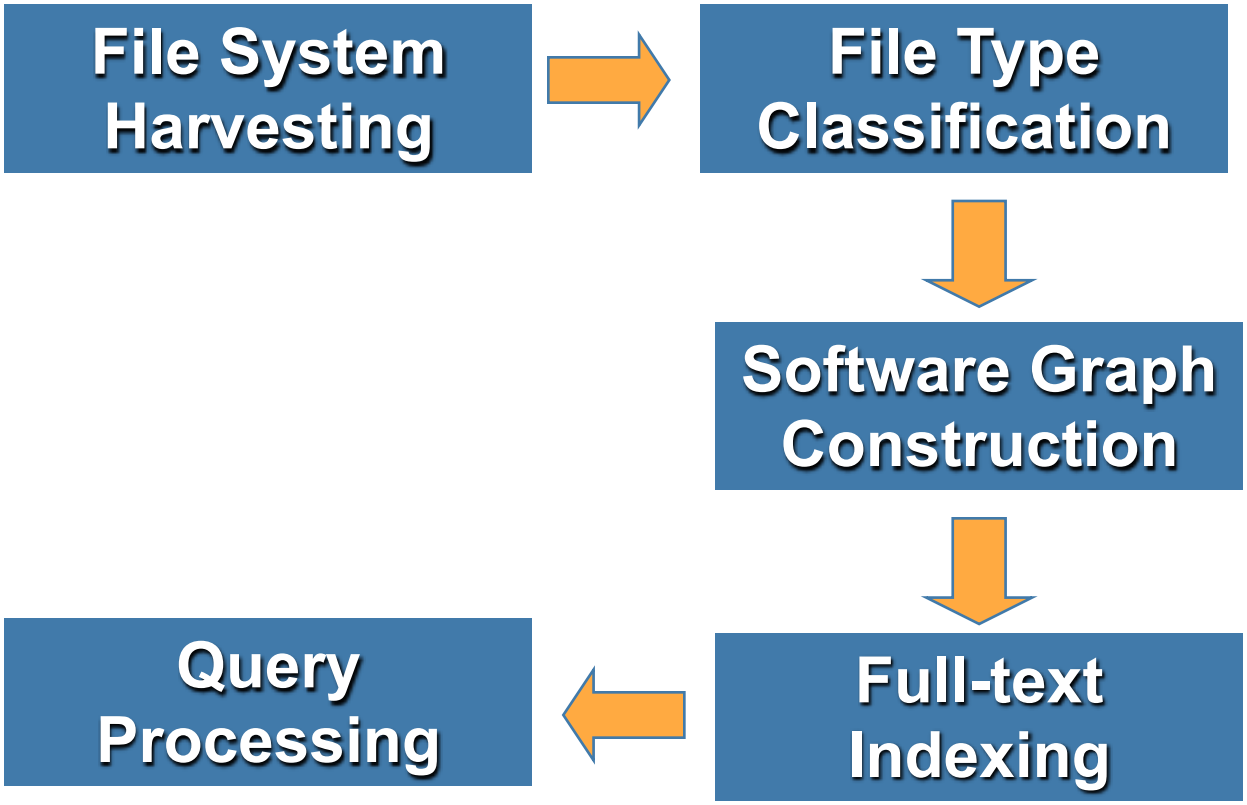

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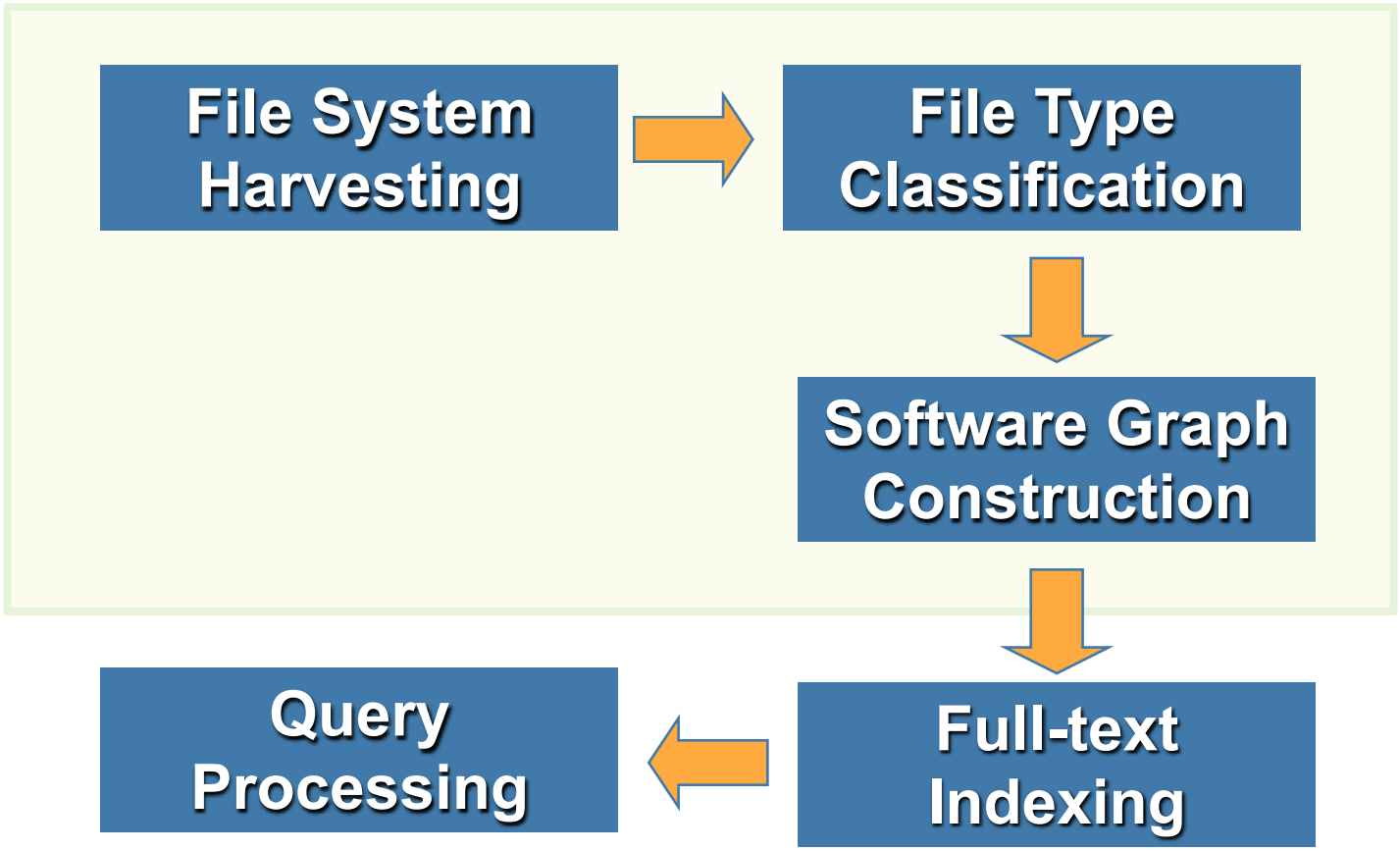
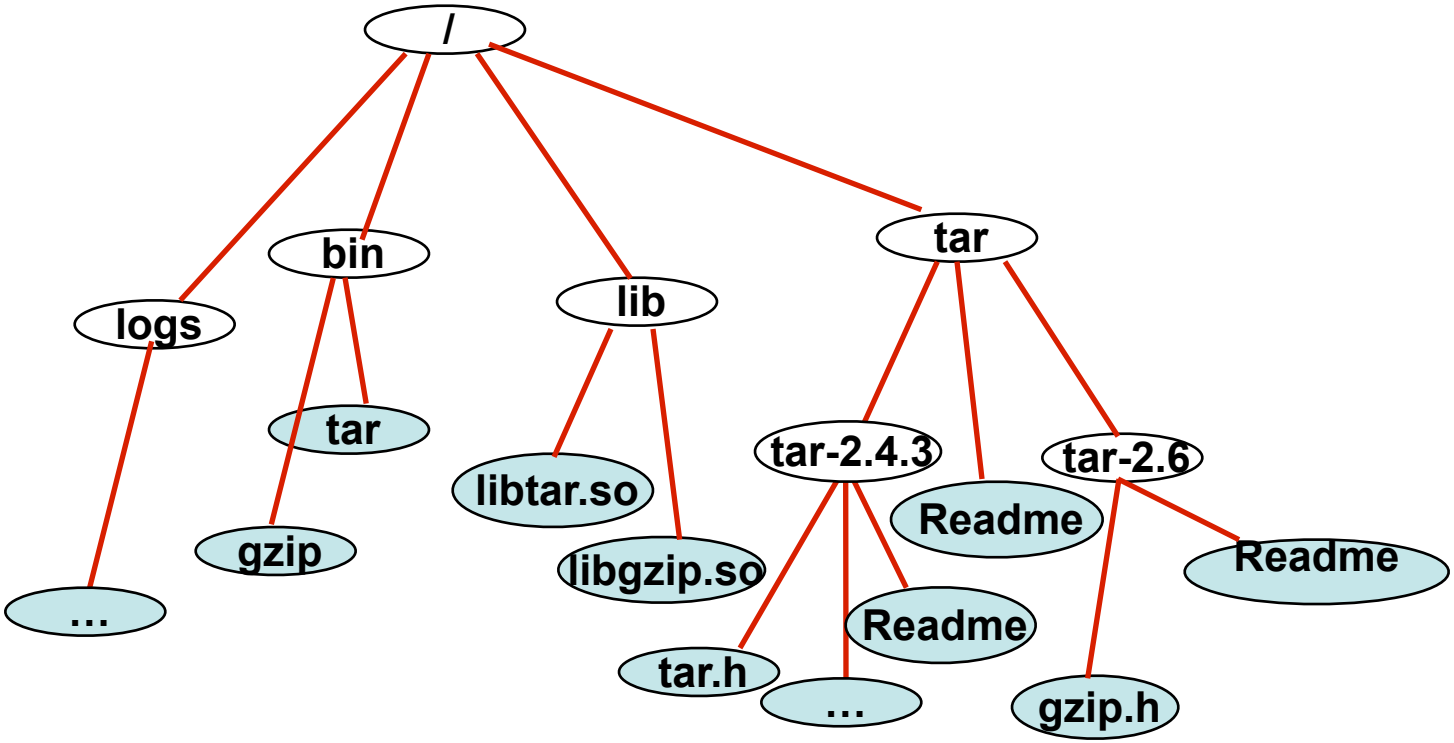


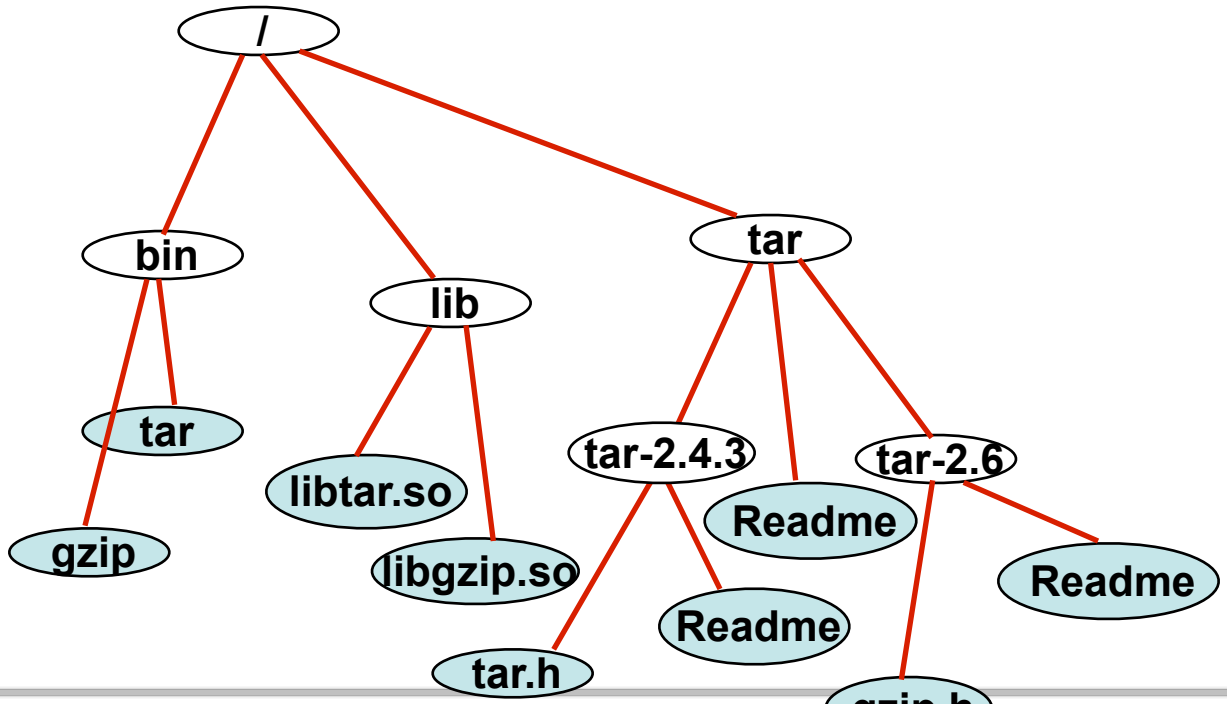
FST construction

- Scan the file-system and map the FST
  - Edges denote containment relationships inside the file-system
  - Stop lists



Classification and pruning

- Normalize file-names
- Extract path-names
- Apply expert rules and use syscalls to classify files
- Drop irrelevant files and childless directories



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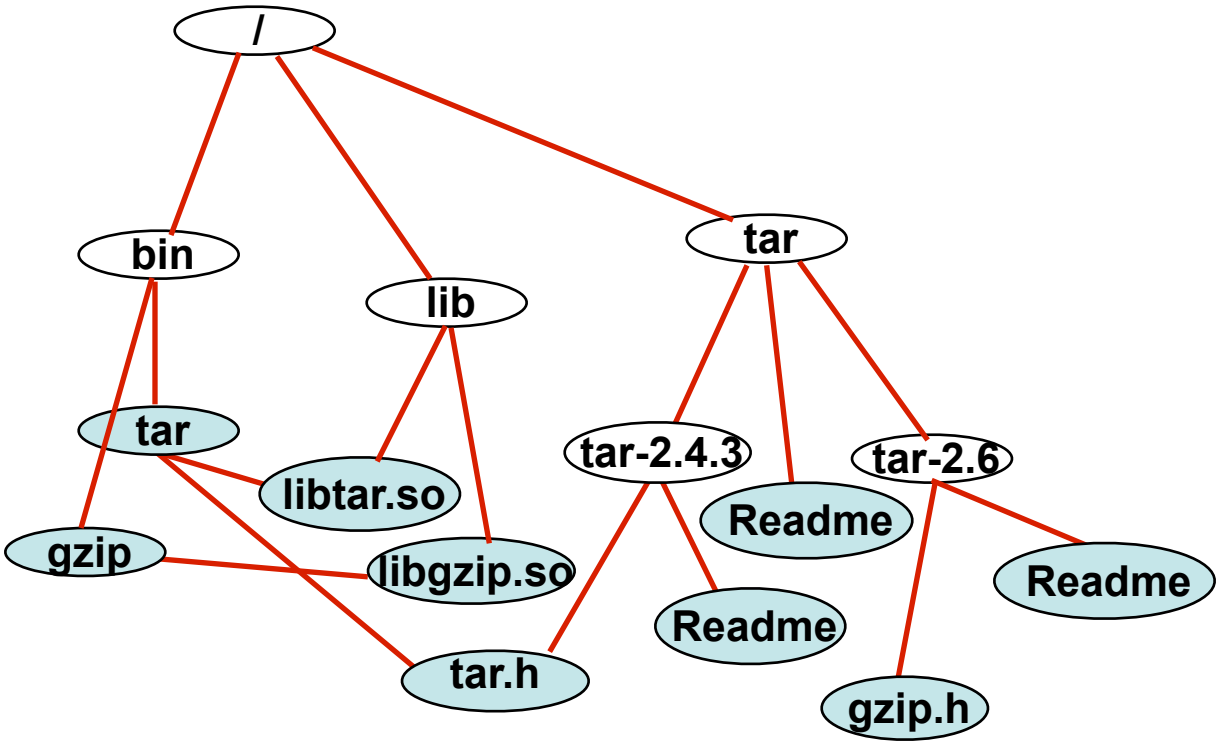
  - file-system organization practices about software documentation
- Looking for:
  - Documentation files describing software via 1-1 (man pages, javadocs) or 1-many relationships (readme’s)
  - Dependencies between libraries and binary executables

Structural-dependency elicitation



Keyword scrapping

- Parse the content of SG vertices and extract descriptive keywords
  - Assign them to the vertex “content zone”
- Content parsing
- Stop-word elimination
- Stemming
- Keyword extraction
- Computationally demanding and data-intensive task

Keyword flow

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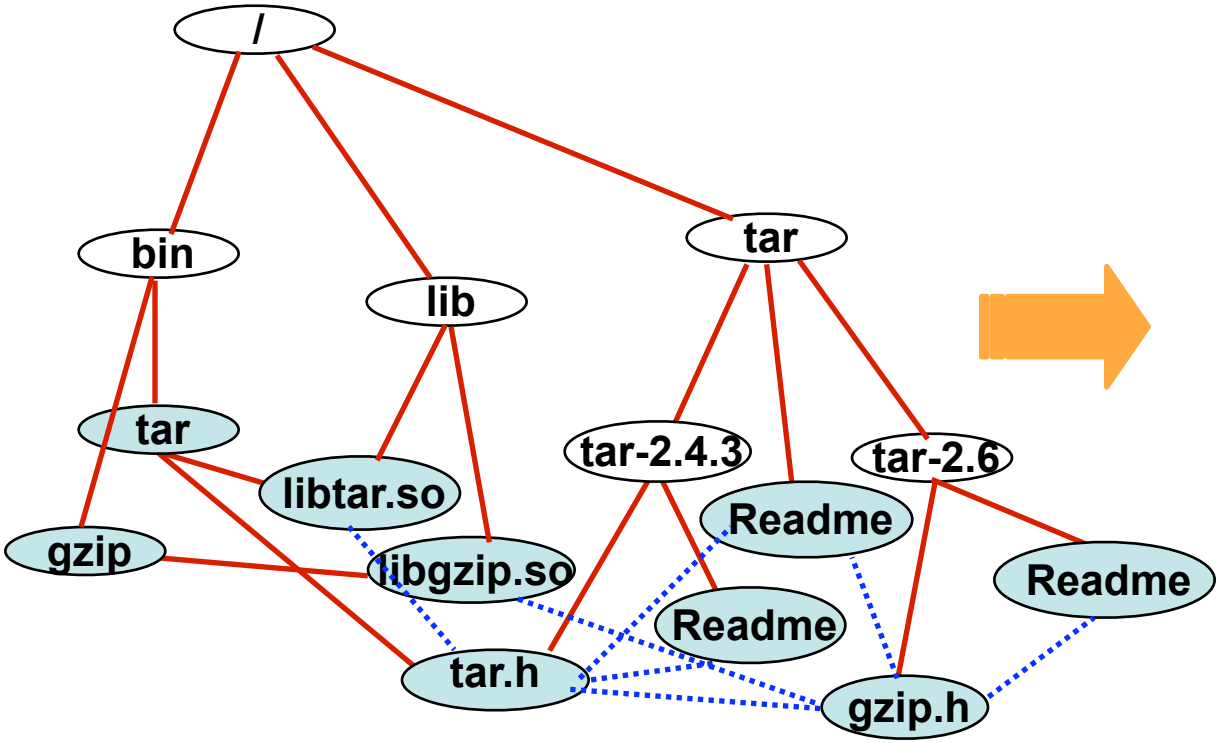
  - Zone gets the weight of the SG's edge, normalized so that the sum of the zone-weights of each SG vertex is equal to one.

Inverted index construction & merge



terms	postings
winzip	1,2,…
octave	3,6,…
….	…..

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Minersoft Harvester Challenges

- Take advantage of Grid computing and storage
  - Distribute parts of computation to Grid sites
- Avoid overloading Grid sites
  - Apply load-balanced techniques
- Overlap local computation with I/O
  - Employ multi-threading jobs
- Adapt to the Grid sites policies
  - Number of jobs in queuing systems
  - Total time that a job is allowed to run on a given site

Minersoft Architecture

- Map-reduce like architecture
- Harvesting and indexing is done by multithreaded Grid jobs
- The harvester and indexer jobs process a specific number of files => splits
- Split size:
  - Each split is chosen so that the crawling and indexing can be distributed within the system time constraints
- Duplicate elimination

"Harvesting Large-Scale Grids for Software Resources," A. Katsifodimos, G. Pallis, M. D. Dikaiakos, *Proceedings of the **9th IEEE International Symposium on Cluster Computing and the Grid, (CCGrid09)***, May 18-21, 2009. Shanghai, China, pp. 252-259.

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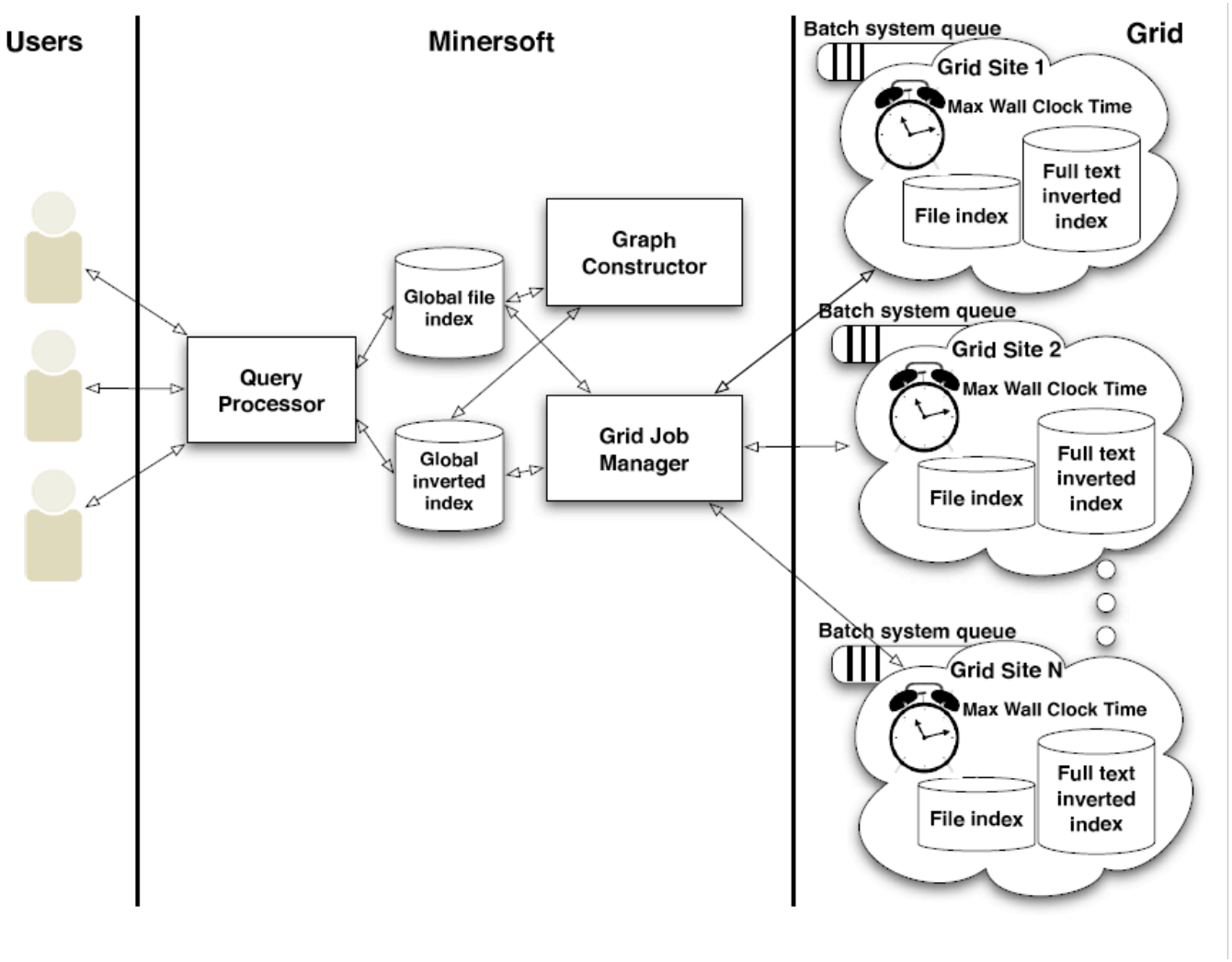

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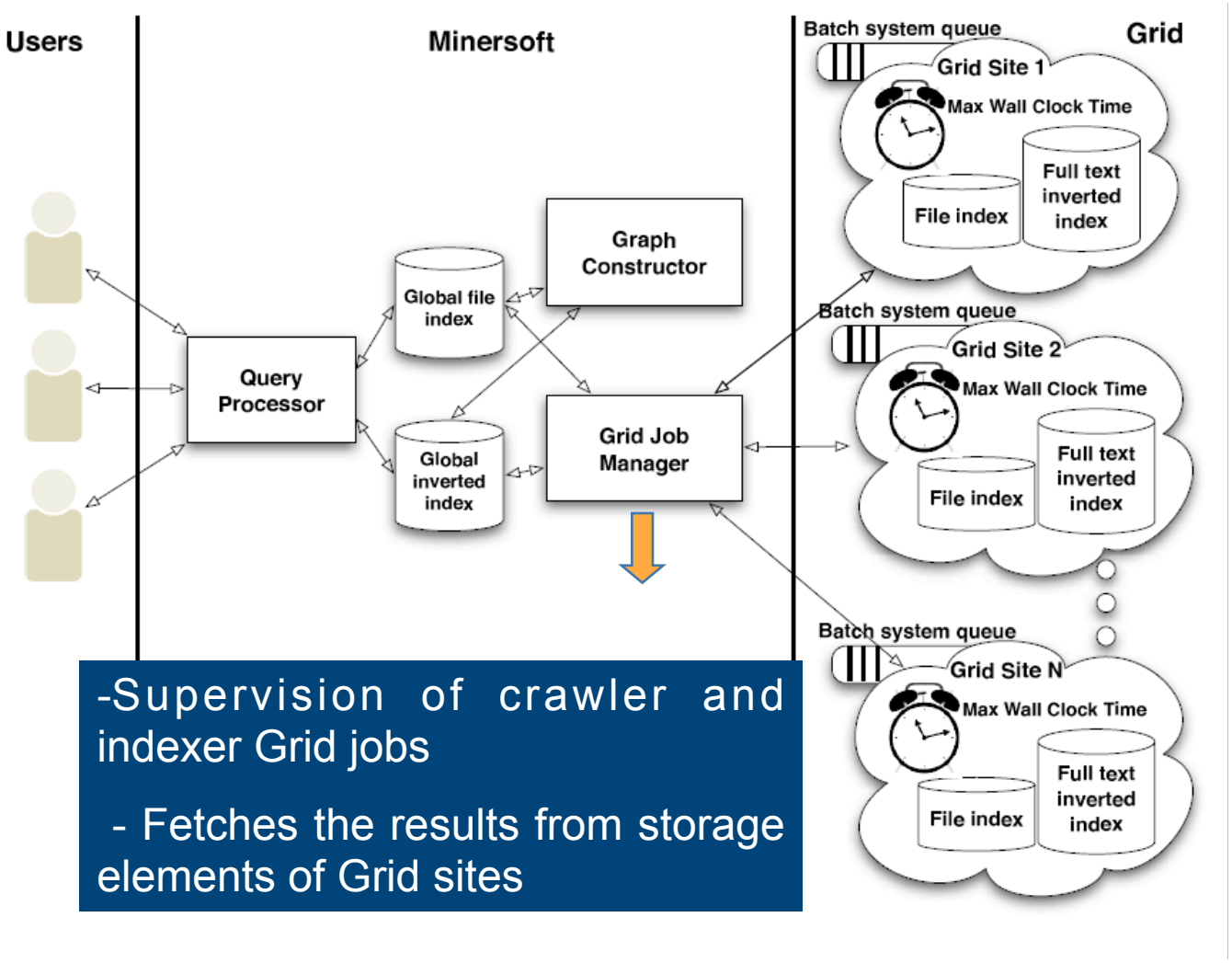
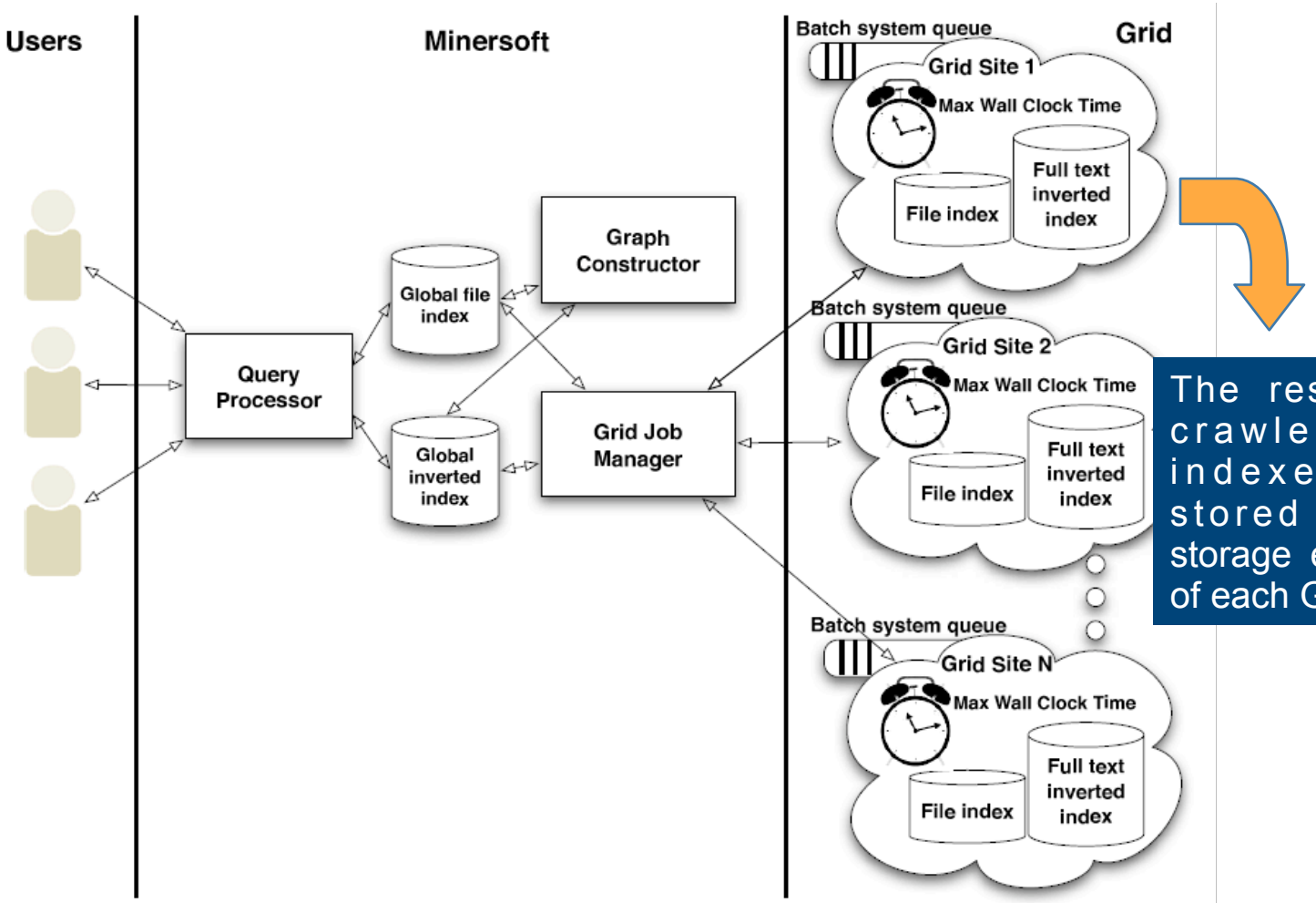


-Supervision of crawler and indexer Grid jobs

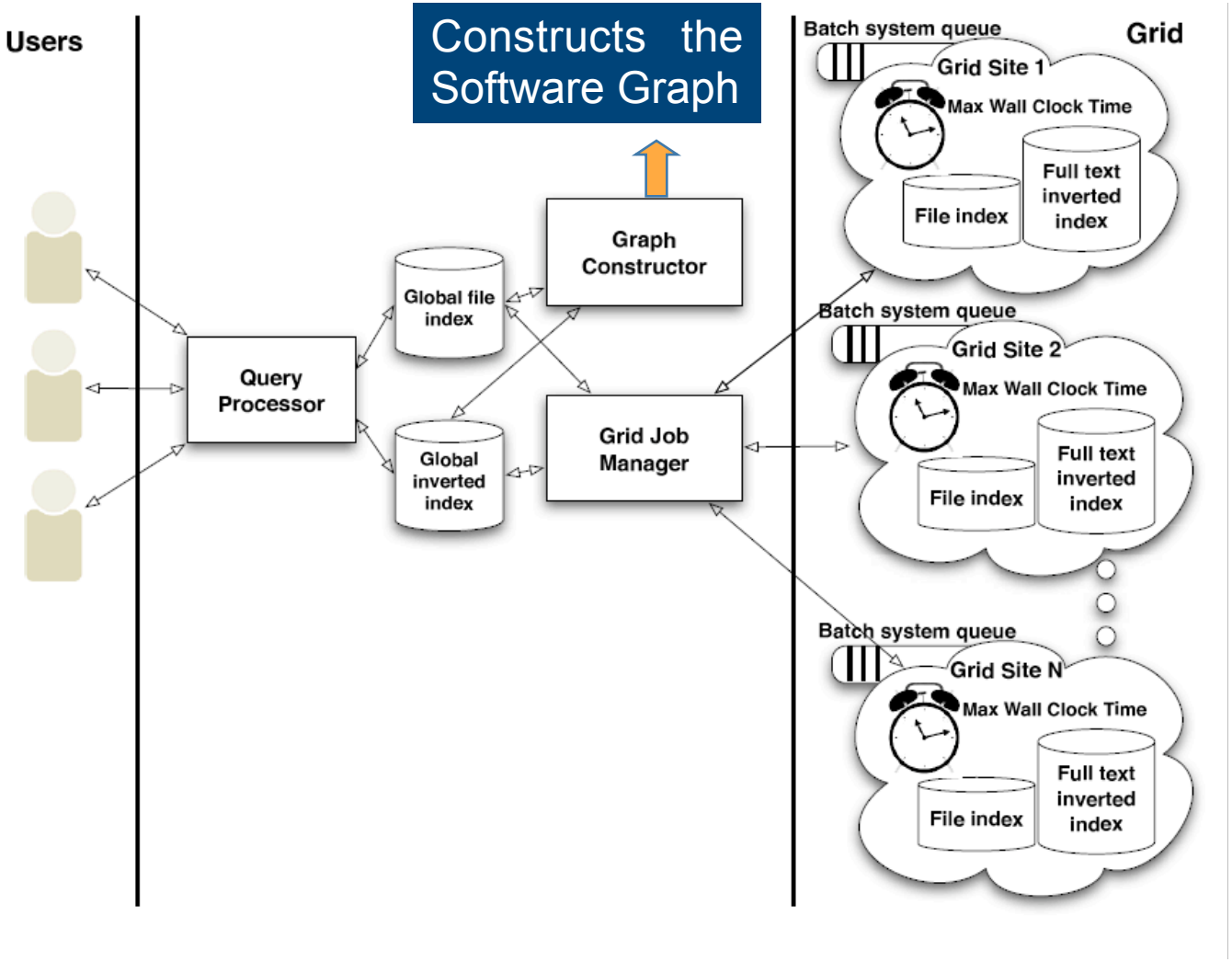
- Fetches the results from storage elements of Grid sites

Minersoft Architecture



The results of crawlers and indexers are stored at the storage elements of each Grid site

Minersoft Architecture



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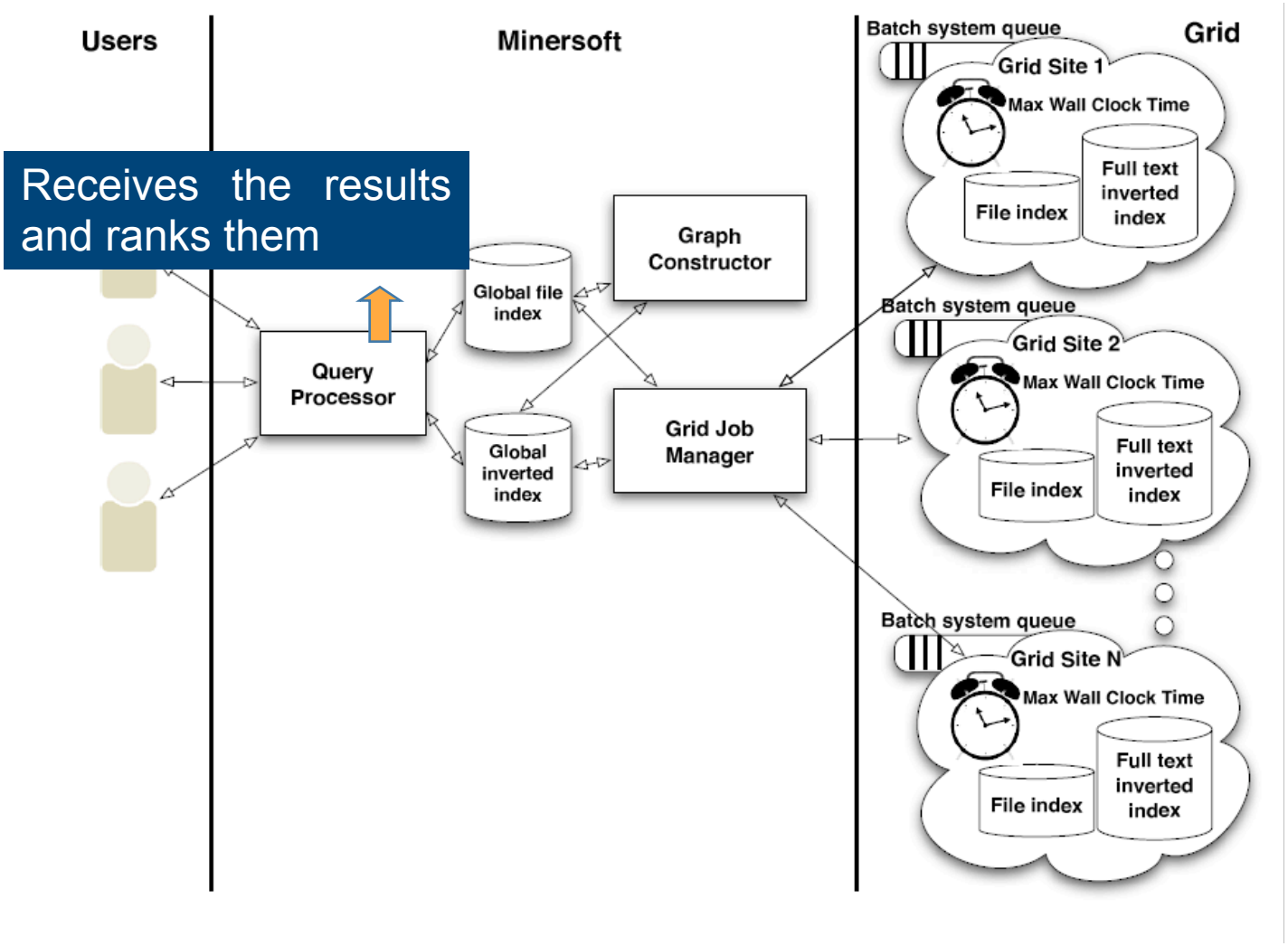

Implementation details

Grid job manager	
Crawler	
Indexer	

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Testbed

Grid Site	Number of Software Files
AEGIS01-PHY-SCL	120,369
CY-03-INTERCOLLEGE	72,424
CY-01-KIMON	565,799
RO-08-UVT	157,591
HG-05-FORTH	1.508.986
BG04-ACAD	2.632.193
Total	**5.057.362**

Evaluation

- Data collection
  - 6 Grid sites of EGEE infrastructure
- Queries
  - 27 queries, (provided by EGEE users)
- Relevance Judgment
  - Satisfied
  - Not satisfied
  - Very satisfied

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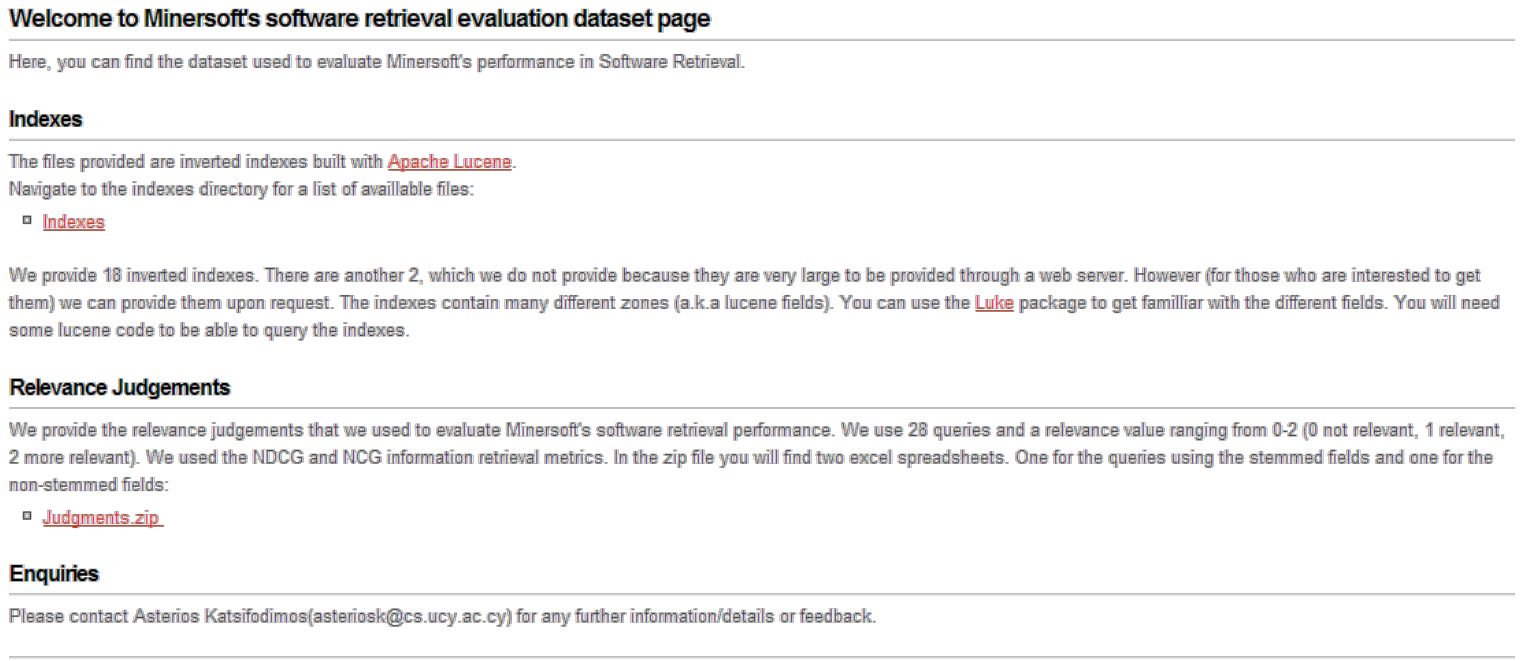
General-content queries	Software-specific queries
linear algebra package; fast fourier transformations; symbolic algebra computation library; mathematics statistics analysis; earthquake analysis; scientific data processing; statistical analysis software; atlas software	ImageMagick; lapack library; GSL library; crab; k3b cd burning; xerces xml; gcc fortran; octave numerical computations; matlab; hpc netlib; scalapack; mpich; autodock docking; boost c++ library; subversion client; java virtual machine; ffmpeg video processing; FFTW library

Benchmark Data Set



Welcome to Minersoft's software retrieval evaluation dataset page

Here, you can find the dataset used to evaluate Minersoft's performance in Software Retrieval.

Indexes

The files provided are inverted indexes built with Apache Lucene.
Navigate to the indexes directory for a list of availlable files:

- Indexes

We provide 18 inverted indexes. There are another 2, which we do not provide because they are very large to be provided through a web server. However (for those who are interested to get them) we can provide them upon request. The indexes contain many different zones (a.k.a lucene fields). You can use the Luke package to get familliar with the different fields. You will need some lucene code to be able to query the indexes.

Relevance Judgements

We provide the relevance judgements that we used to evaluate Minersoft's software retrieval performance. We use 28 queries and a relevance value ranging from 0-2 (0 not relevant, 1 relevant, 2 more relevant). We used the NDCG and NCG information retrieval metrics. In the zip file you will find two excel spreadsheets. One for the queries using the stemmed fields and one for the non-stemmed fields:

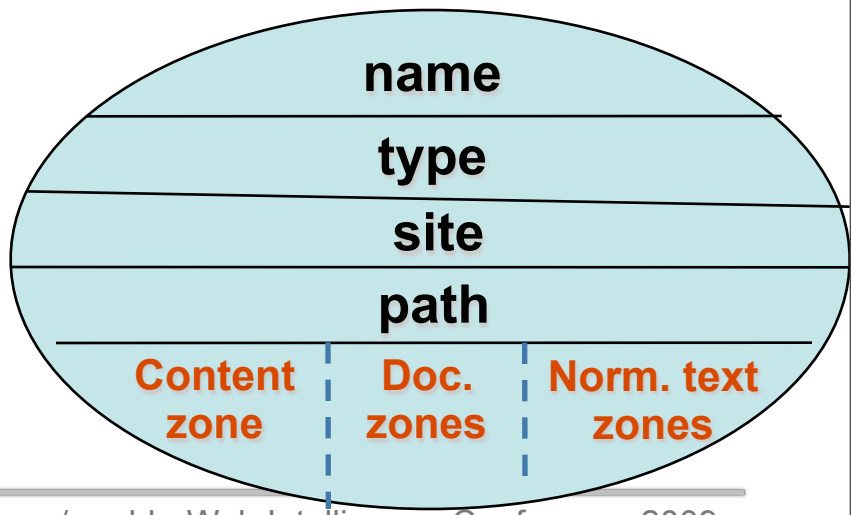
- Judgments.zip

Enquiries

Please contact Asterios Katsifodimos(asteriosk@cs.ucy.ac.cy) for any further information/details or feedback.

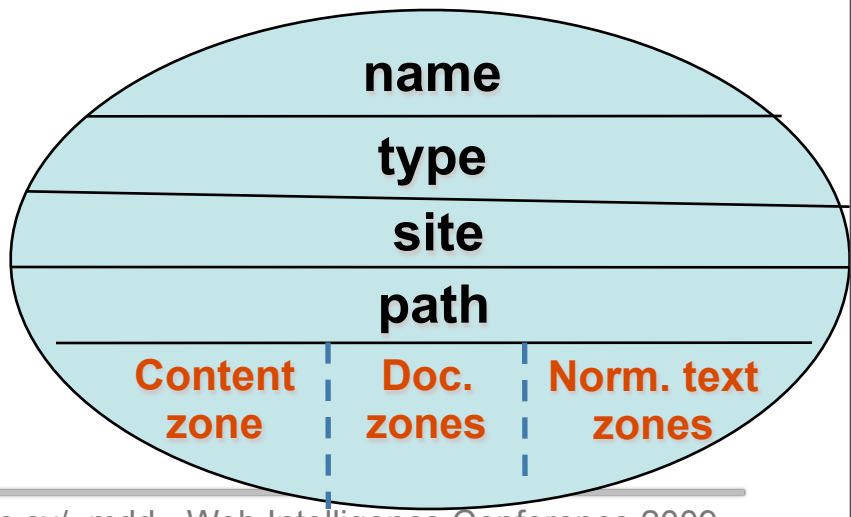
- https://thales.grid.ucy.ac.cy/minersoft/dataset/

Examined Metrics



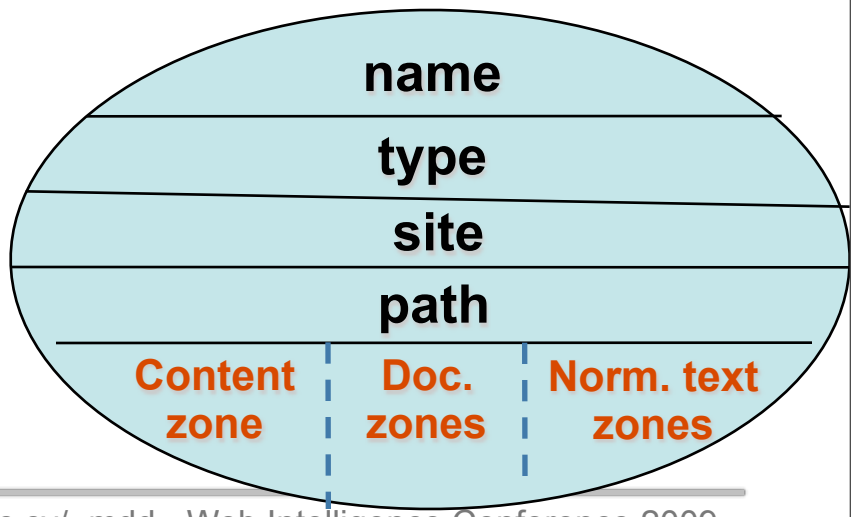
Examined Metrics

- Precision@20
- Normalized Discounted Cumulative Gain (NDCG)



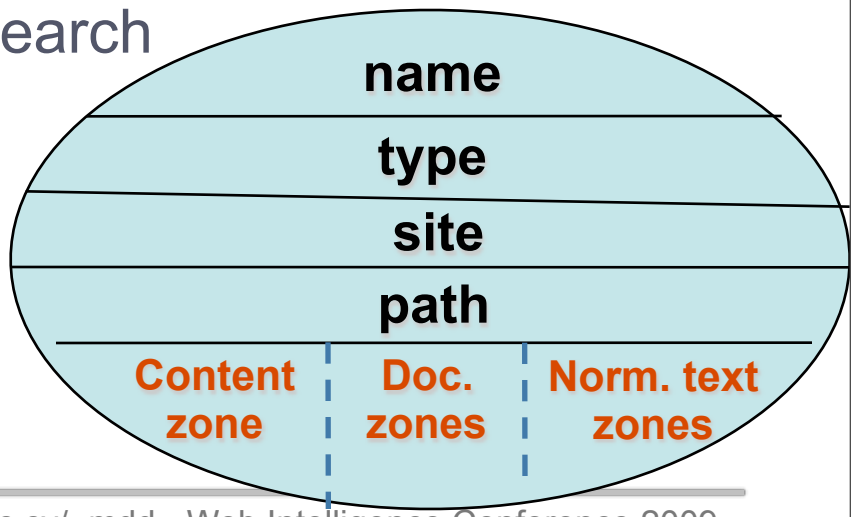
Examined Metrics

- Precision@20
- Normalized Discounted Cumulative Gain (NDCG)
- Normalized Cumulative Gain (NCG)

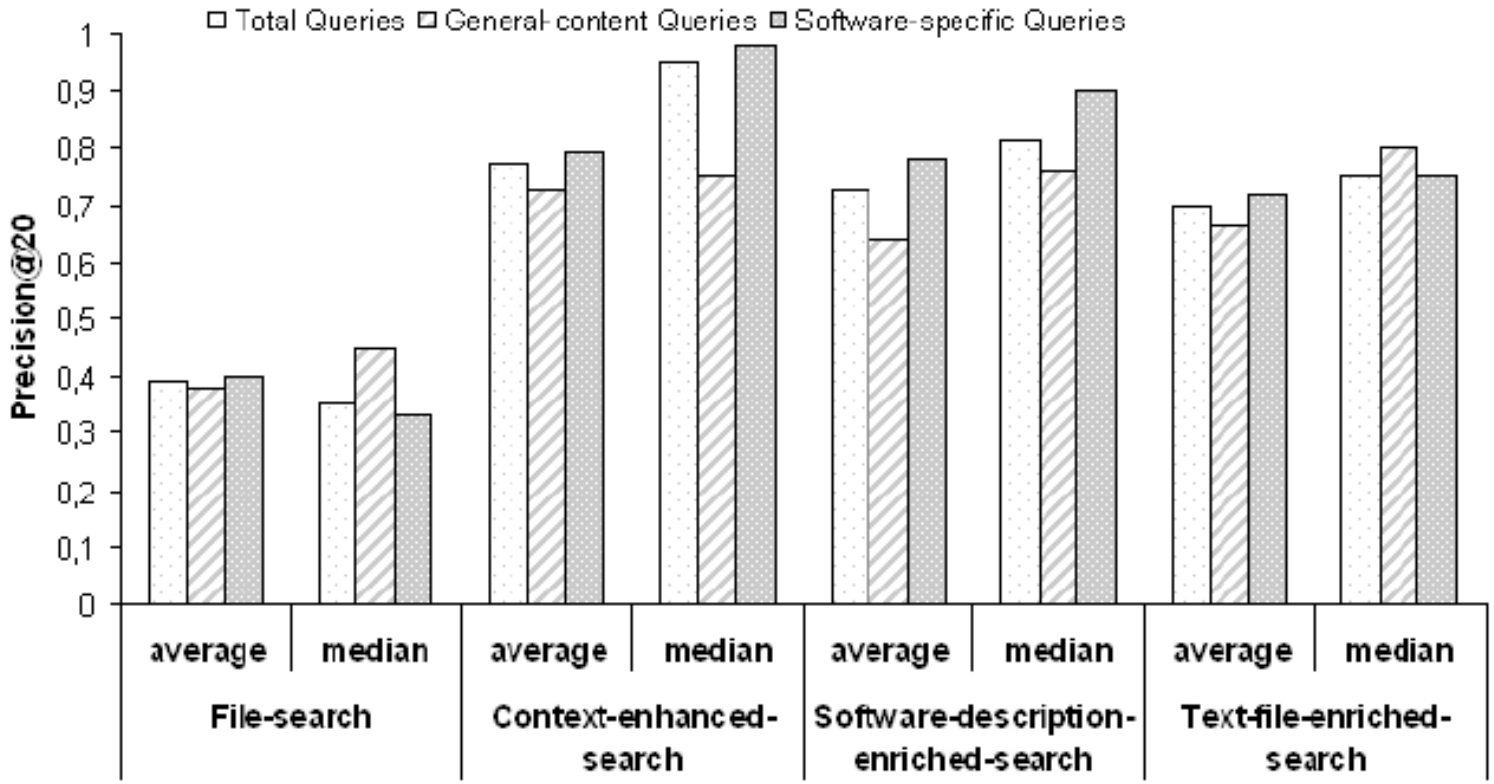


Examined Metrics

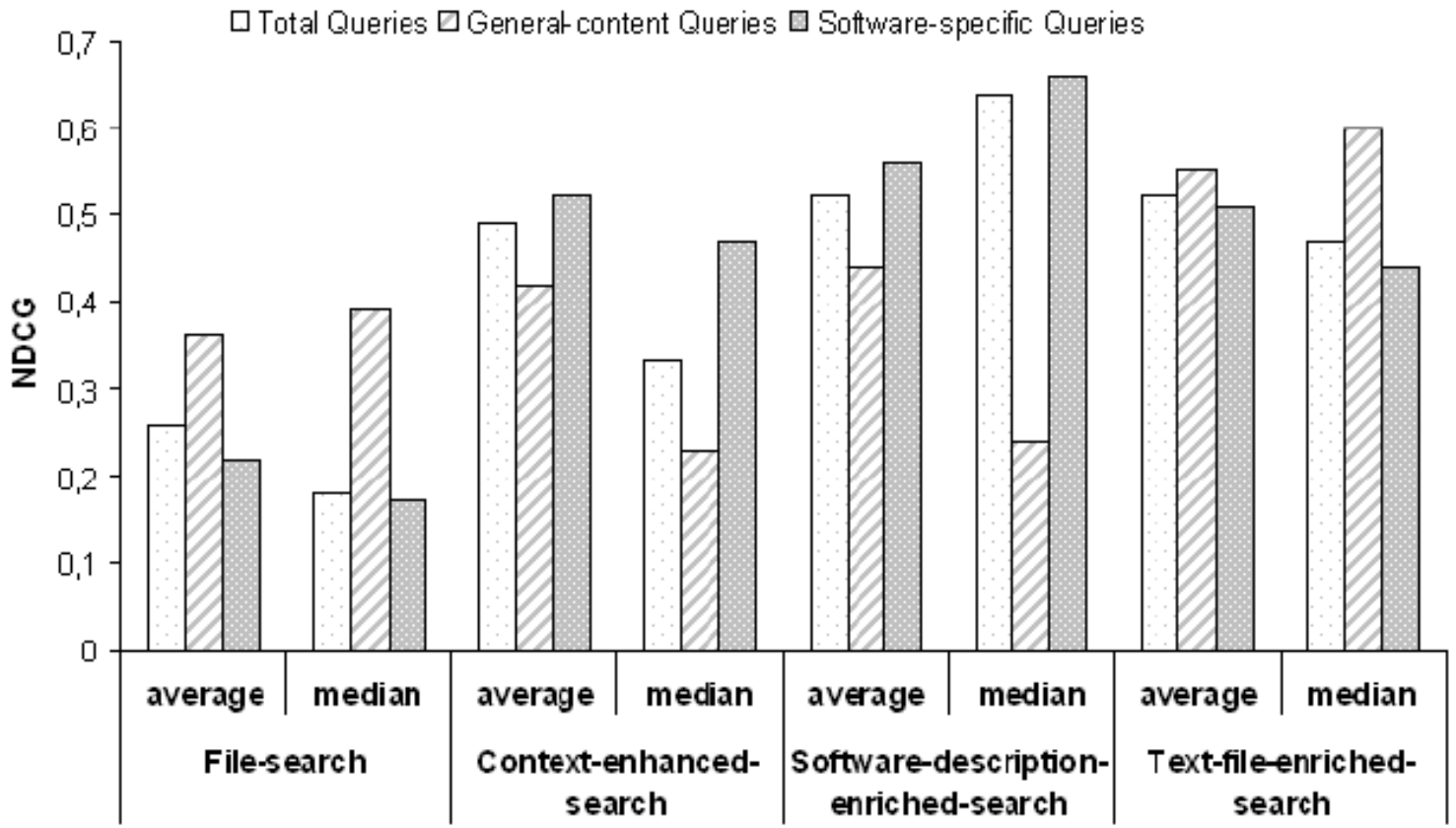
- Precision@20
- Normalized Discounted Cumulative Gain (NDCG)
- Normalized Cumulative Gain (NCG)
- Scenarios:
  - File-search
    - full-text content of discovered files
  - Context-enhanced search
  - Software-description-enriched search
  - Text-file-enriched search



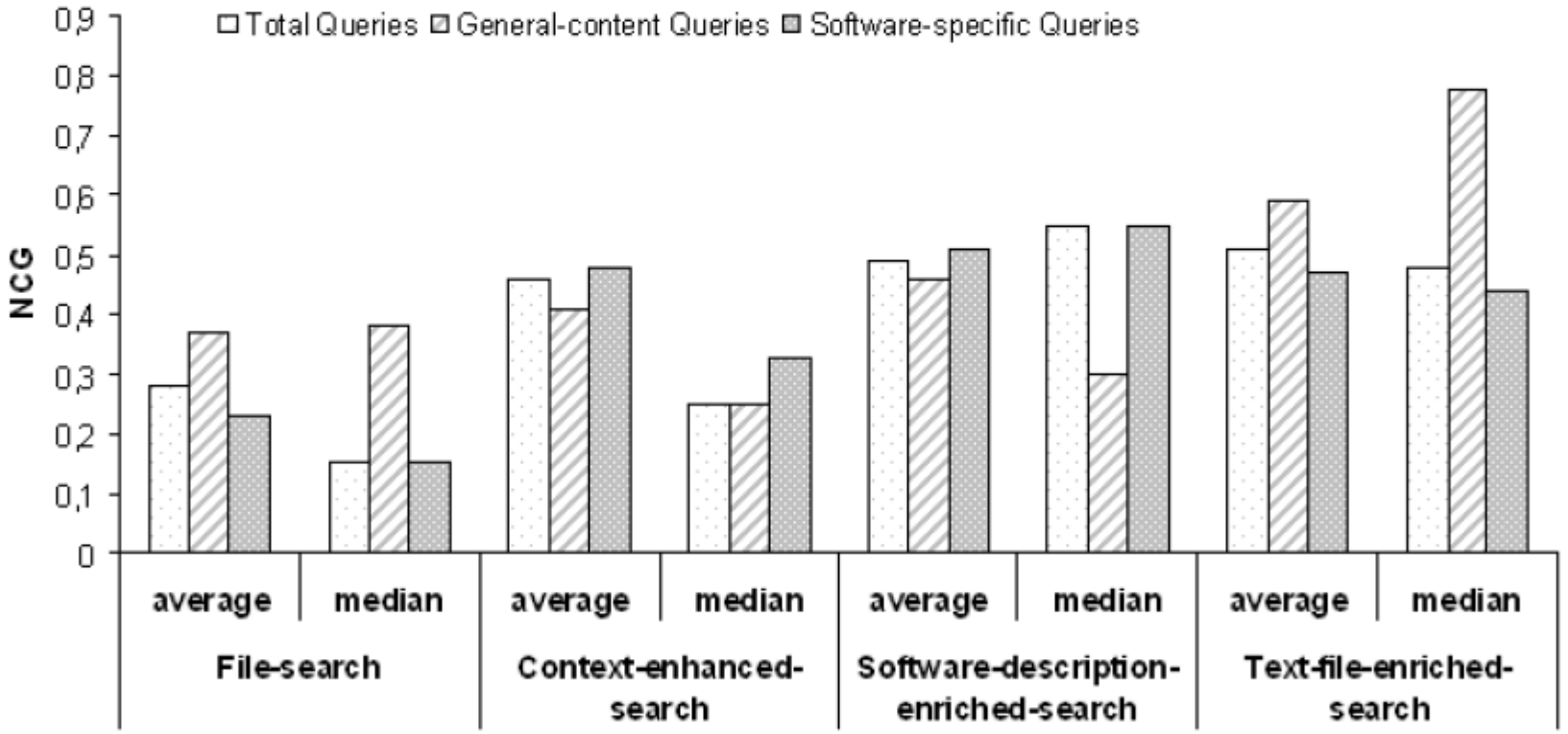
Experimental Evaluation



Experimental Evaluation



Experimental Evaluation



Conclusion – Future Work

- Minersoft - a Grid harvester which enables keyword-based searches for software installed on Grid computing infrastructures
- The results of Minersoft harvesting are encoded in a weighted typed graph, called the Software Graph
- **Ongoing work**: to extend Minersoft so as to support search on Cloud infrastructures
- **Future work**: to represent software resources using an ontology