Image Retrieval in the Unstructured Data Management System AUDR

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Outline

- Review of related work
- The scalable architecture of image management
  - ✓ Tetrahedral data model of image
  - ✓ An advanced unstructured data repository-AUDR
  - ✓ Image management system in AUDR
- A composite image retrieval algorithm
  - ✓ Visual retrieval
  - ✓ Textual retrieval
  - ✓ Fusion techniques
- Distributed storage and paralleled retrieval of images
  - ✓ Distributed image storage engine
  - ✓ Paralleled image retrieval engine
- Results and discussions

Related work

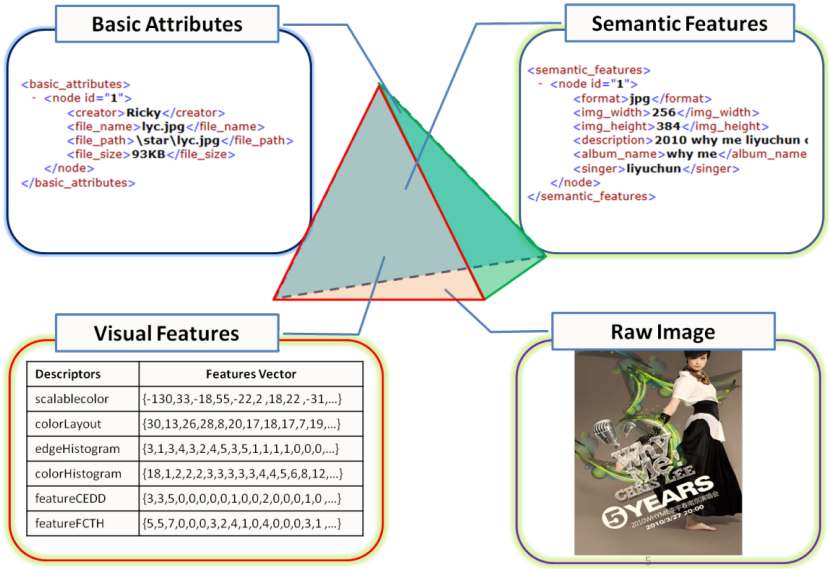
- **Motivation**
  - ✓ Exponential increase in digital image database sizes
  - ✓ Exponential increase in computing power and storage capacity
  - ✓ Increased use of image in entertainment, education, medicine, commercial fields.
- **Text-Based Image Retrieval**
  - ✓ Proposed in 1970s, such as Google, Yahoo! etc.
  - ✓ Manual annotation of images
  - ✓ Use text-based retrieval methods
- **Content-Based Image Retrieval**
  - ✓ Proposed in 1990s, such as QBIC, VisualSEEK, Photobook etc.
  - ✓ Extract visual features: color, shape, textual etc.
- **Image data management system**
  - ✓ Relational database: scalability and efficiency problem
  - ✓ Unstructed data management system

Tetrahedral data model of image

- Definition

Tetrahedron = (V, BA, SF, LF, RD, CONJS)

-V: identifier of tetrahedron
-BA: basic attributes facet
-SF: semantic feature facet
-LF: low-level feature facet
-RD: raw data
-CONJS: association between two facets



- Property

✓ integrity and data independence
✓ inner-correlation, extensibility, easy to implement

An advanced unstructured data repository

- Hierarchical structure
  - ✓data processing layer
  - ✓data operation layer
  - ✓data control layer
  - ✓data interface layer
  - ✓data service layer
- Advantage
  - ✓excellent expansion
  - ✓ high-efficient

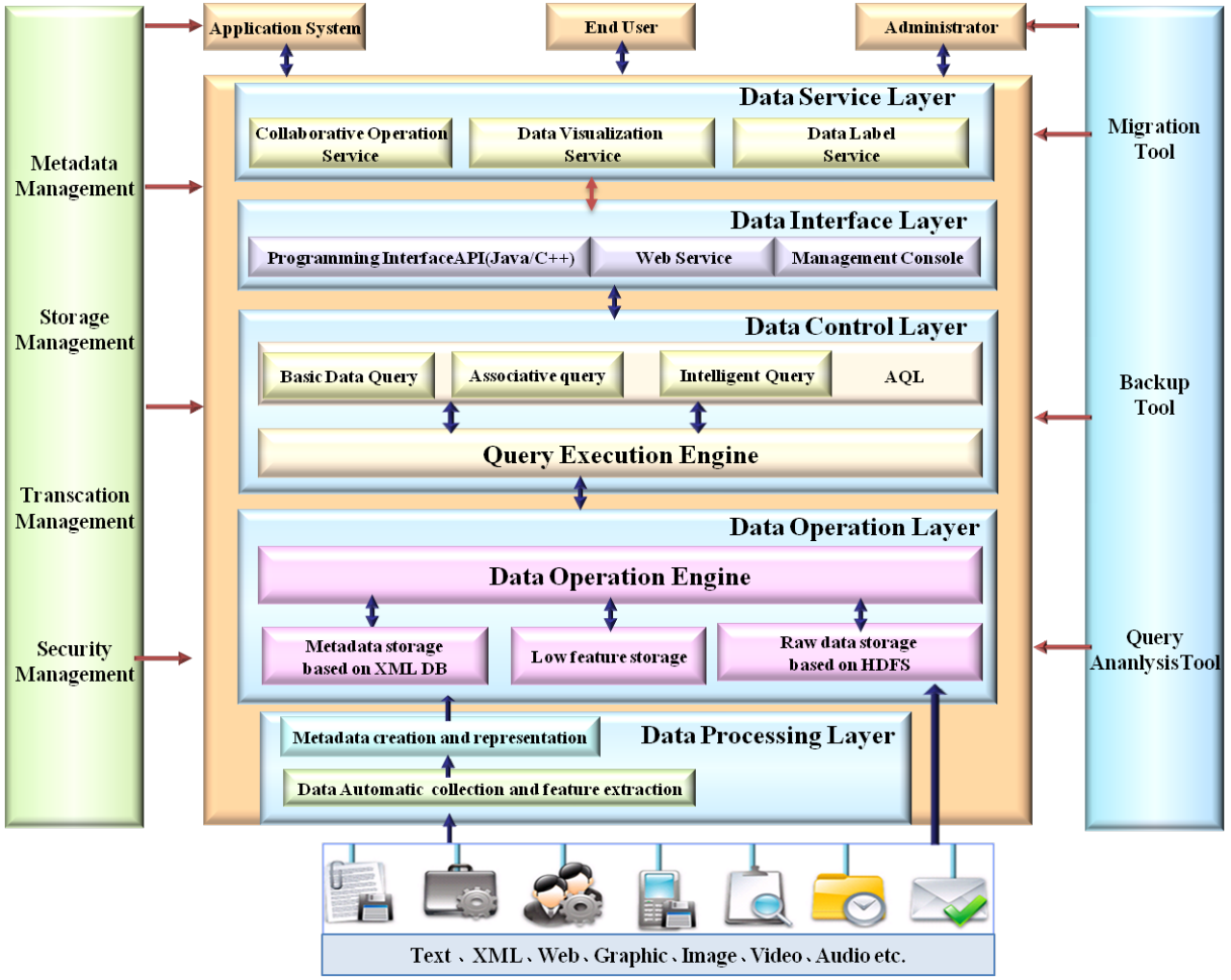
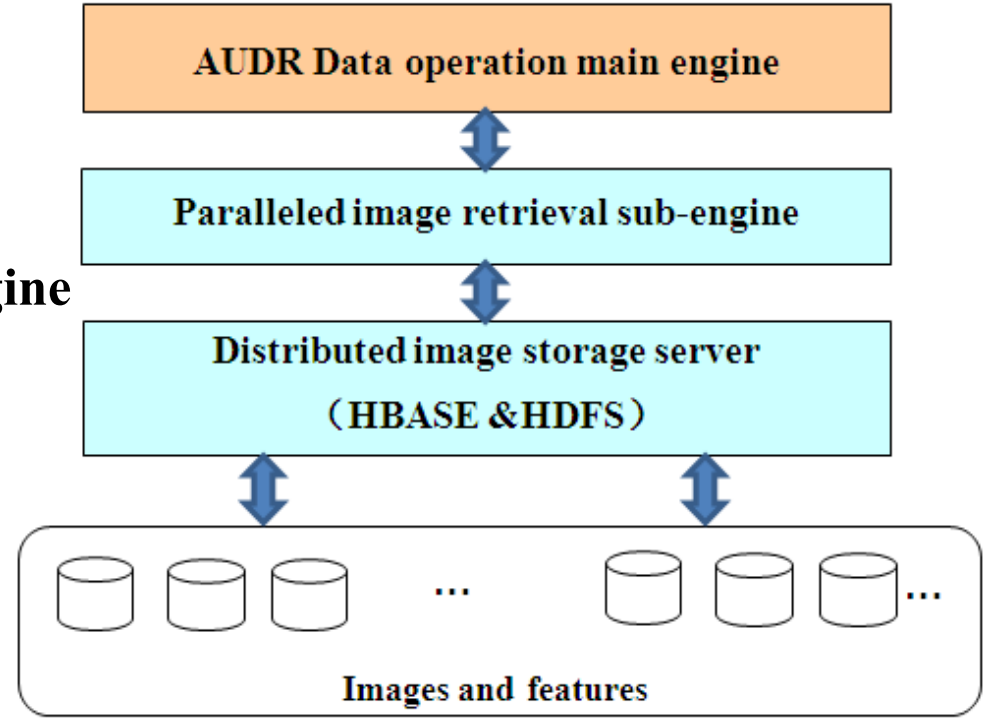


Image management system in AUDR

- **Distributed image storage server**
  - ✓extract features in parallel
  - ✓provide access interface
- **Paralleled image retrieval sub-engine**
  - ✓master-slave architecture
  - ✓index and memory cache
- **Advantage**
  - ✓massive data storage
  - ✓real-time retrieval



A composite image retrieval algorithm

- **Visual Retrieval**
  - ✓Simple Color Histogram
  - ✓Tamura Texture Feature
  - ✓Fuzzy Color and Texture Histogram

  } Locality-sensitive hashing index

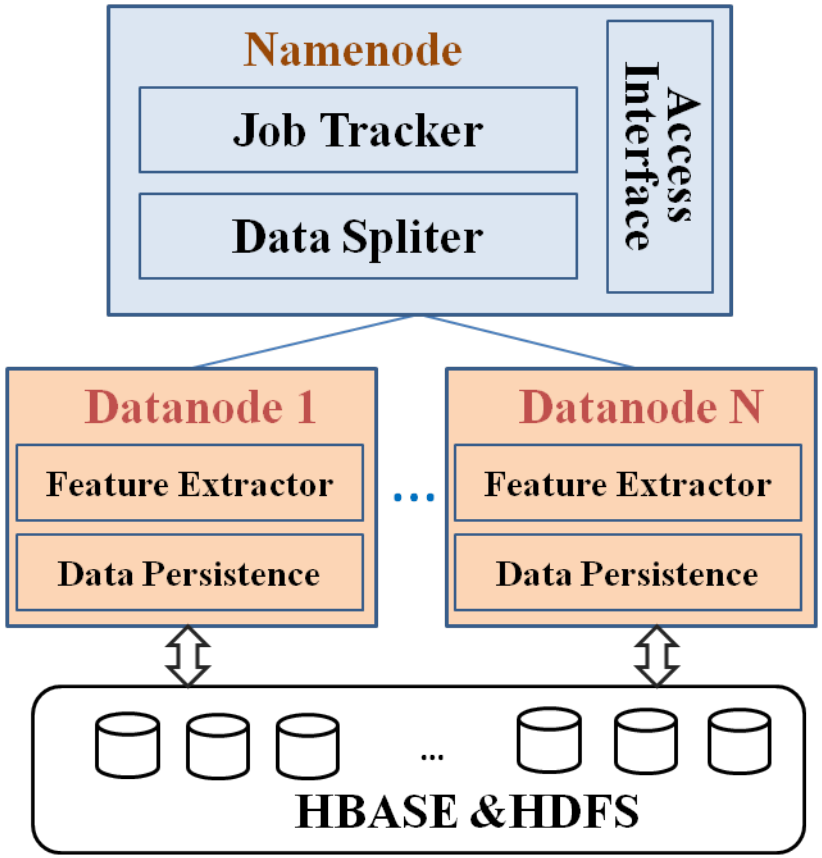
  - ✓SIFT local feature

  } Inverted index

- **Textual Retrieval**
  - The Vector Space Model
    - ✓Apache Lucene Tool
    - ✓BM25 scoring approach
  - The Topic Model
    - ✓Latent Dirichlet Allocation
    - ✓Bayes chain: topic~word and document~topic
- **Fusion Techniques**
  - combSUM: visual retrieval, textual retrieval
  - combMNZ: mixed retrieval

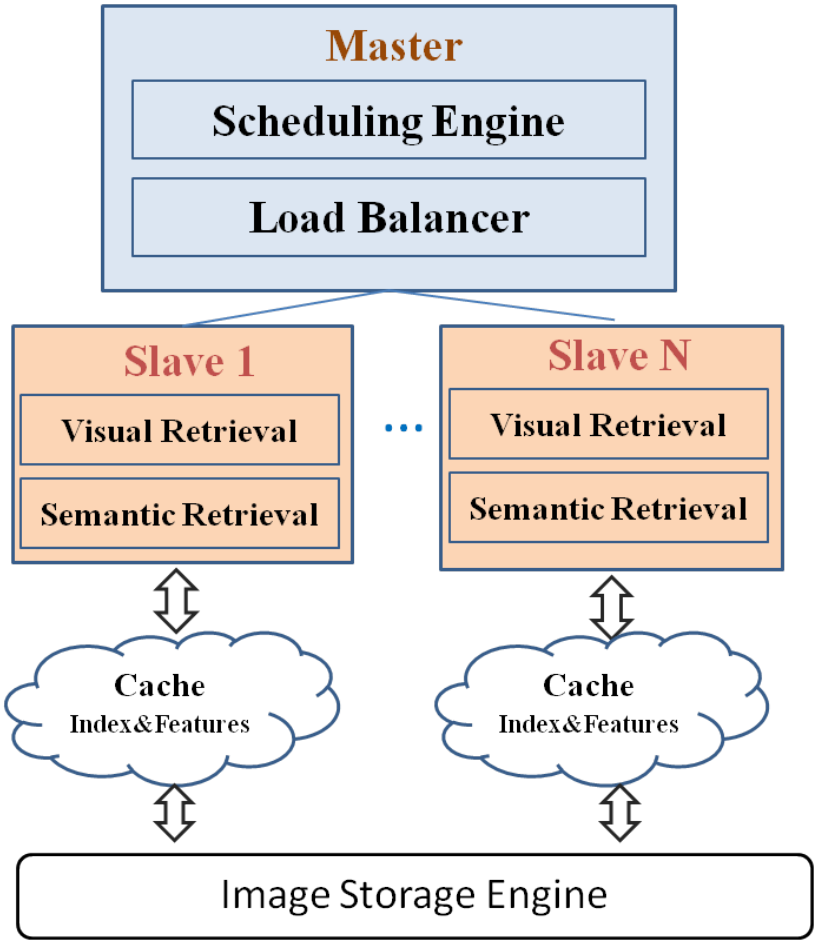
Distributed image storage engine

- **Storage strategy**
  - ✓HDFS: raw data, including original image and thumbnails
  - ✓HBase: basic attributes, semantic and visual features
- **MapReduce Processing:**
  - ✓Namenode: split data into segments
  - ✓Datanode: start one map task to process each segment.



Paralleled image retrieval engine

- **Master**
  - ✓maintain information of all the slaves
  - ✓schedule the retrieval task
  - ✓ merge retrieval results
- **Slave**
  - ✓undertake computing task on local data
  - ✓send local results to Master



Experimental results

- **Dataset**
  - ✓ImageCLEF 2011 medical dataset: 231,000 images associated with metadata
  - ✓ImageNet: 111,489 images and add annotations manually

- **Implementation**
  - ✓storage cluster: 9 nodes using PC, 1 master and 8 slaves (3GHz, 4G Memory)
  - ✓computing cluster**:** 3 nodes, 1 master (2.13GHz, 16G memory), 2 slaves (2.93GHz, 4G memory)

- **Evaluation of visual retrieval on ImageCLEF dataset**

Features	MAP	P10	P20	Bpref
SCH	0.0047	0.0367	0.0267	0.0497
Tamura	0.0039	0.0297	0.0263	0.0454
FCTH	0.0089	0.0733	0.0517	0.0567
SIFT	0.0032	0.0265	0.0234	0.0412
FUSE	0.0112	0.0700	0.0617	0.0555

  - ✓the global features are better than the local features
  - ✓fusing results obtained by single feature can improve performance

Experimental results

- **Evaluation of textual retrieval on ImageCLEF dataset**

Method	MAP	P10	P20	Bpref
lucene	0.1758	0.3133	0.27	0.2187
lucene_and_tm	0.1917	0.34	0.305	0.2237
BM25_and_tm	0.0878	0.19	0.165	0.125

✓Topic model could discover the abstract topics.

✓The results produced by lucene and topic model are more semantic related.

- **Evaluation of mixed retrieval on ImageCLEF dataset**

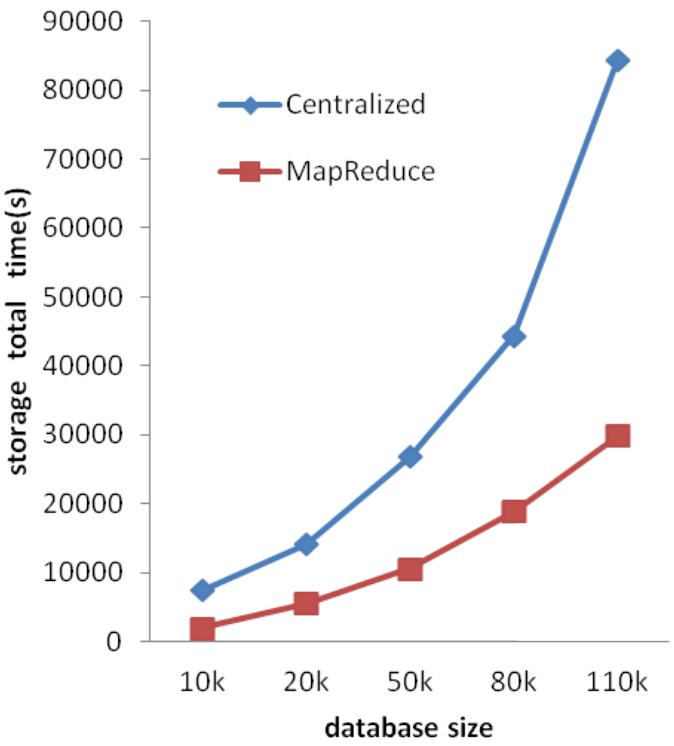
Method	MAP	P10	P20	Bpref
Linear fusion	0.1556	0.2764	0.2350	0.1925
Pseudo-relevance	0.2341	0.3643	0.3327	0.2405

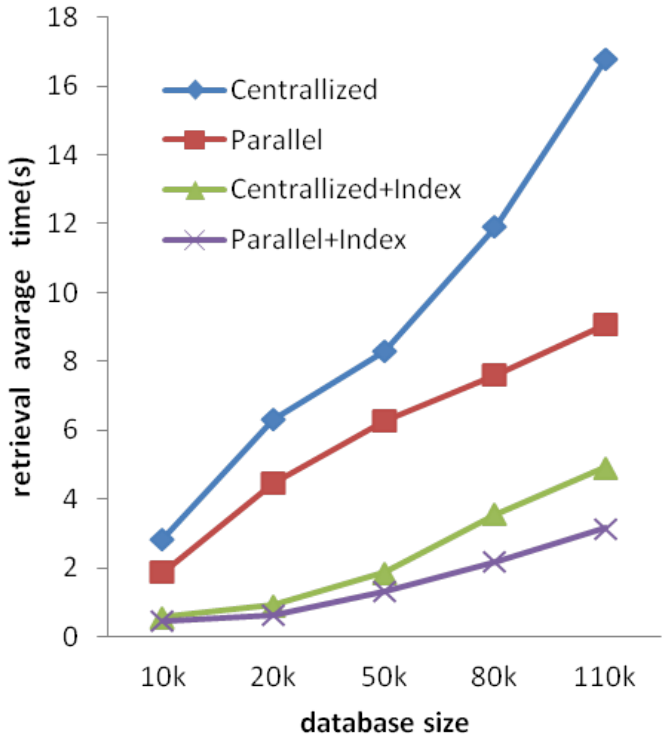
✓Linear fusion: reduce the performance for the semantic gap.

✓Pesudo-relevance: take the caption of top 20 in visual runs as query expansion to boost the text runs, it enhances the result obviously.

Experimental results

- **System Performance on ImageNet dataset**





✓Storage performance: the advantage of MapReduce processing mode is obvious.

✓Retrieval performance: parallel way and index can accelerate efficientcy greatly.

Conclusions

- Propose a scalable architecture for image management based on Tetrahedral Data Model in an advanced unstructed data repository-AUDR
  - ✓distributed storage engine
  - ✓parallel computing engine
- Propose a new image retrieval algorithm incorporating rich visual features, two text models and the specific fusion techniques
- Feature work
  - ✓query expansion using specific terminologies
  - ✓machine learning methods to support more intelligent management

Thank You

Questions?

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