The Icecite Research Paper Management System

Hannah Bast, Claudius Korzen

Department of Computer Science,
University of Freiburg (Germany)

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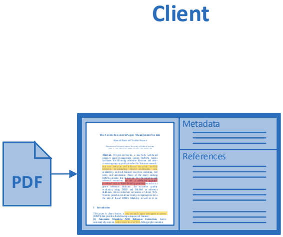
5. **Full-Featured Search**
   in metadata, references, annotations, full texts, etc.

System Overview



System Overview

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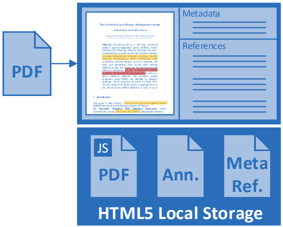

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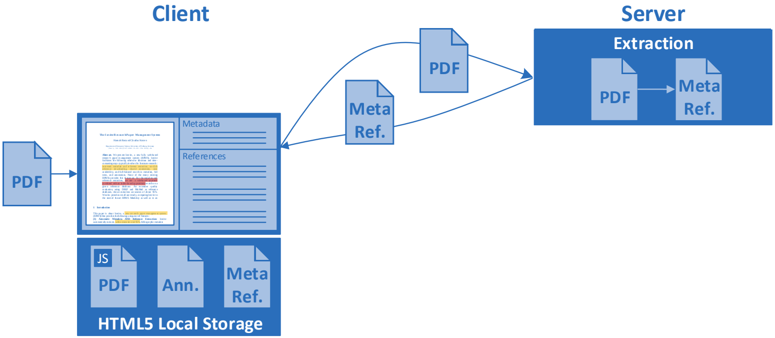

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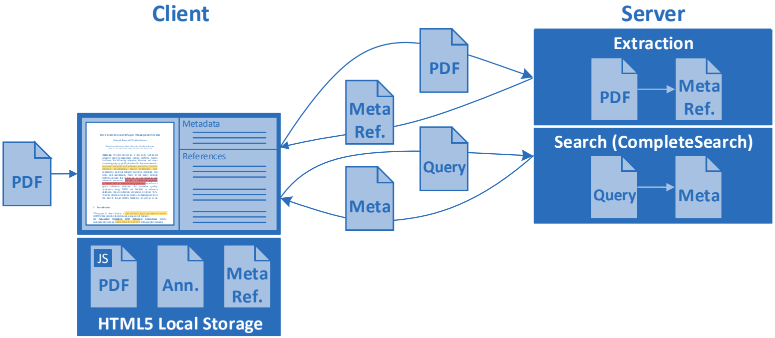

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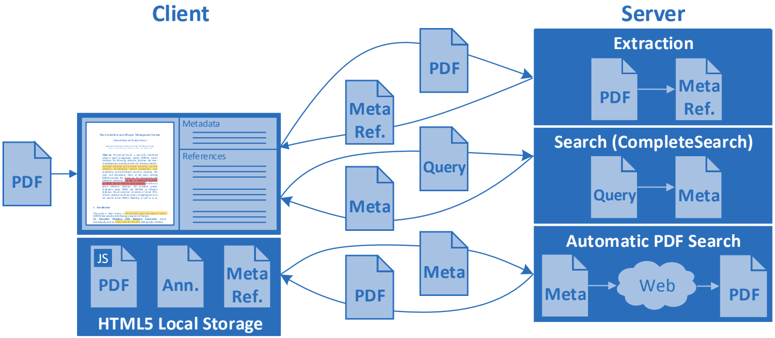

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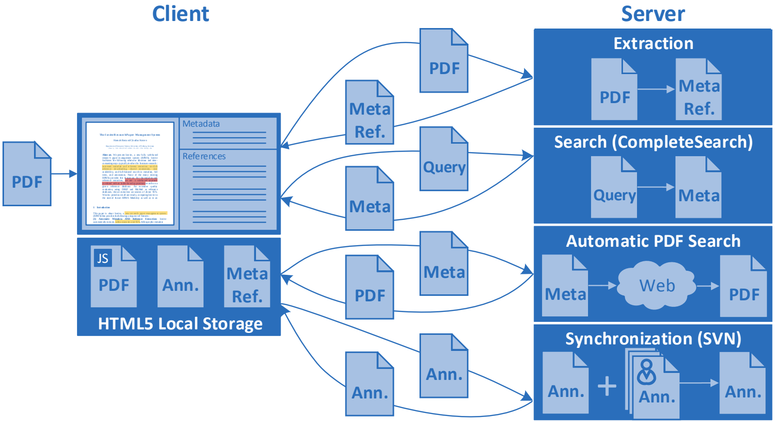

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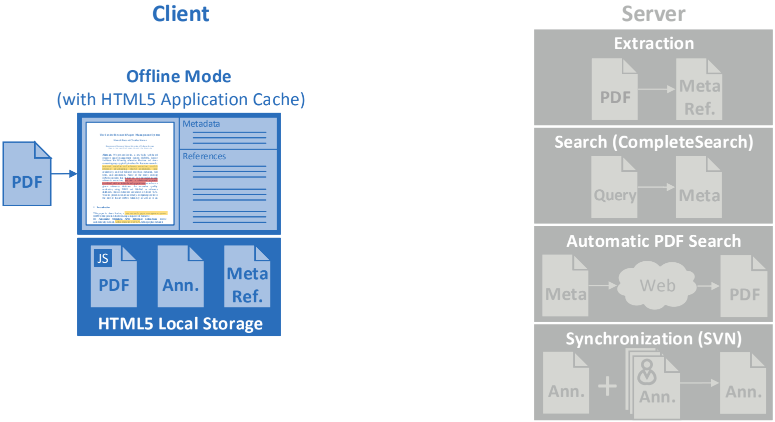


Client

Offline Mode
(with HTML5 Application Cache)

PDF

Metadata

References

JS
PDF

Ann.

Meta
Ref.

HTML5 Local Storage

Server

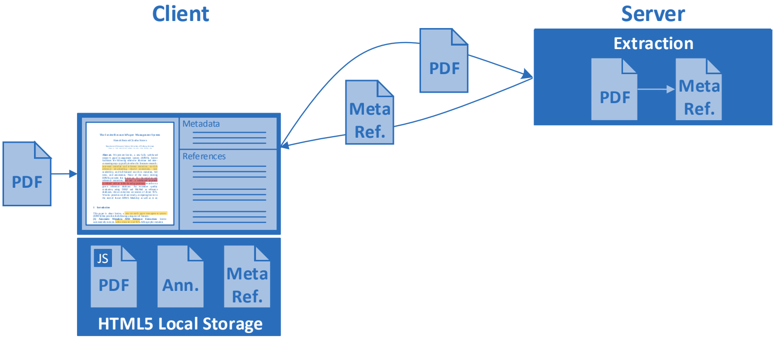
Extraction
PDF → Meta Ref.

Search (CompleteSearch)
Query → Meta

Automatic PDF Search
Meta → Web → PDF

Synchronization (SVN)
Ann. + Ann. → Ann.

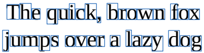
System Overview



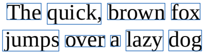
The General Extraction Process

- **Extraction** of text from PDF files along with position, height, width & font of each character:

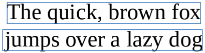
Output of **PDFBox**



Reassembling of **words**



... and **lines**.



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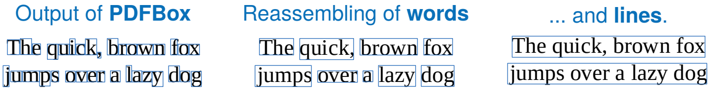

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- **Identification** of meaningful text lines:
  - The **title** line(s) in the front page.
  - The **references** in the bibliography.

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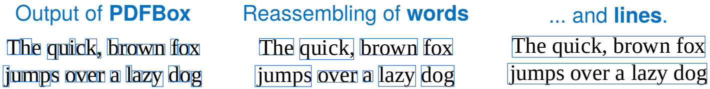

Output of **PDFBox**

The quick, brown fox
jumps over a lazy dog

Reassembling of **words**

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... and **lines**.

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- **Identification** of meaningful text lines:
  - The **title** line(s) in the front page.
  - The **references** in the bibliography.
- **Matching** of each extract against reference databases.
  - DBLP with ~**2.2 million computer science** records.
  - PubMed with ~**22 million life sciences** records.

- Assumption: Title lines ...
  - . . . are placed in the first pages **upper half**.
  - . . . are **emphasized**.

Extraction of Bibliographic Metadata

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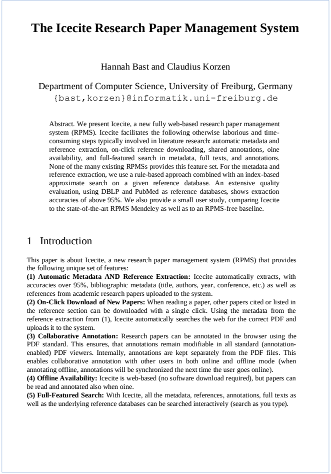

The Icecite Research Paper Management System

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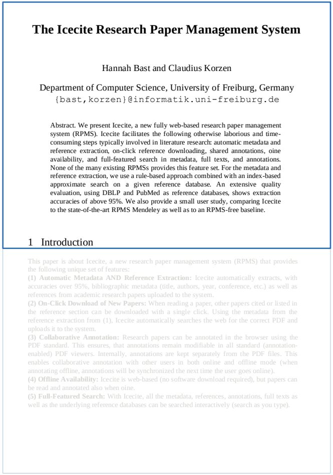

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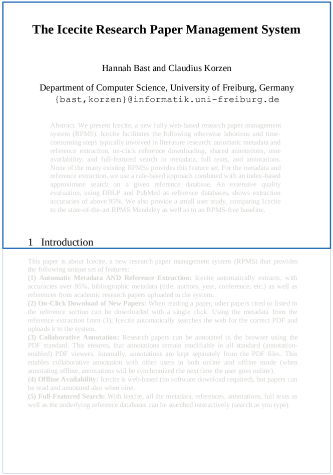

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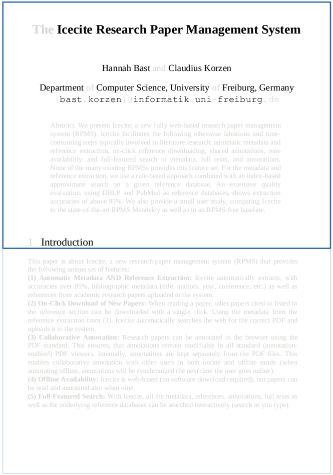

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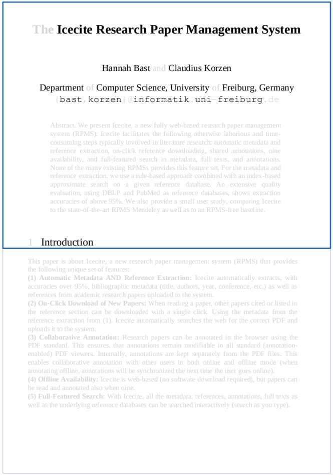
- Filter all such lines and remove all **stopwords** (“the”, “and”, etc.).
- Search for the remaining words in the reference database.



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- Result: **candidate records**; sorted by the number of words in common with the extracts.
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  - Normalized Smith-Waterman similarity scores between ...
    - the **title** of R and *EX* (= extract of the first pages upper half).
    - the **author(s)** of R and *EX*.
  - “Flag scores”, indicating if ...
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- The **related record** is the record with the highest total score (the sum of the computed scores).

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References Identification (1)

- Search for a proper **bibliography section header** (like “*References*”, “*Bibliography*”, “*Literature*”, etc.).
- To identify the individual references, the **type** of each subsequent line in the bibliography is determined.

A given reference consists of the following types:

1. **Reference Header**: The first line of the reference.
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- Assumptions:
  - All references in the bibliography share the same order of metadata fields.
  - Author(s) are the first metadata field in a reference.

Extraction of Bibliographic References

References Identification (2)

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- Line L_i is a reference header, if one of the following is true:
  - L_i starts with a reference anchor.

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References Identification (2)

Variant 1	Variant 2	Variant 3
[1] Z. Guo and H. Jin. Reference Metadata Extraction from Scientific Papers. In PDCAT, pages 45-49, 2011. [2] M.-Y. Kan and Y. F. Tan. Record Matching in Digital Li- brary Metadata. Commun. ACM, 51(2):91-94, 2008.	Z. Guo and H. Jin. Reference Metadata Extraction from Scientific Papers. In PDCAT, pages 45-49, 2011. M.-Y. Kan and Y. F. Tan. Record Matching in Digital Library Metadata. Commun. ACM, 51(2):91-94, 2008.	H. Han, C. L. Giles, E. Manavoglu, H. Zha, Z. Zhang, and E. A. Fox. Au- tomatic Document Metadata Extrac- tion Using Support Vector Machines. JCDL, pages 37-48, 2003. M.-Y. Kan and Y. F. Tan. Record Mat- ching in Digital Library Metadata. Commun. ACM, 2008.

- Line L_i is a reference header, if one of the following is true:
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Extraction of Bibliographic References

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- Line L_i is a reference end, if one of the following is true:
  - L_{i+1} is a reference header.
  - L_{i-1} and L_{i+1} share the same endpoint and L_i ends prior to that.

Extraction of Bibliographic References

References Matching

- Line L_i denotes the end of the bibliography, if ...
  - L_i is the last line of the document.
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- Further challenge: figures/tables within bibliographies.

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- **References Matching**: As for the title matching with ...
  - $EX =$ the extracted reference string,
  - a further “flag score”, indicating if
    - EX includes the **page numbers**, reported by the record R.

Experiments

Experimental Setup

- Measurements:
  - **Extraction accuracies** (for identification and matching)
  - **Running times**
- Ground truthes:
  - Correct **titles + record keys** of 690 DBLP- and 500 PubMed-papers.
  - 1012 **references + record keys** from 91 DBLP papers and 1235 references + record keys from 34 PubMed papers.
- Applied hardware: Single machine with
  - 4 Intel Xeon 2.8 GHz processors
  - 35GB main memory.

Experiments

Extraction Accuracies & Running Times

Accuracies		num.	max.	corr. extracts	corr. matches
Meta.	DBLP	690	679	672 (98.9%)	665 (97.9%)
	PubMed	497	490	474 (96.7%)	468 (95.5%)
Ref.	DBLP	1012	997	974 (97.7%)	951 (95.4%)
	PubMed	1235	1235	1179 (95.5%)	1166 (94.4%)

Experiments

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	PubMed	1235	1235	1179 (95.5%)	1166 (94.4%)

Running Times		total	identifying	querying	matching
Meta.	DBLP	137.7ms	31.1ms (23%)	73.1ms (53%)	33.5ms (24%)
	PubMed	479.6ms	44.9ms (9%)	341.3ms (71%)	93.4ms (20%)
Ref.	DBLP	54.2ms	14.7ms (27%)	19.7ms (36%)	19.8ms (37%)
	PubMed	91.4ms	10.2ms (11%)	47.4ms (52%)	33.8ms (37%)

User Study

- Assessment of the **user experiences** with Icecite.
- 12 participants (1 female, 11 males; between 22-30 years)
- They were asked to ...
  - solve 9 common literature research tasks with Icecite and
    - a plain baseline approach (**Google Scholar**).
    - a state-of-the-art RPMS (**Mendeley**).
  - estimate the **required time** for each task; in mins.
  - rate their (subjective) **satisfaction**; score 1 – 5 (low – high).

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- The feedback was very positive:

Results	G. Scholar	Mendeley	Icecite
∅ time (mins)	4.0	4.7	**2.2**
∅ satisfaction (1-5)	2.8	3.4	**4.3**

Thank you for your attention.