CSE 736
Database Seminar

Mohan Kumar Padmanabhan

cse@buffalo

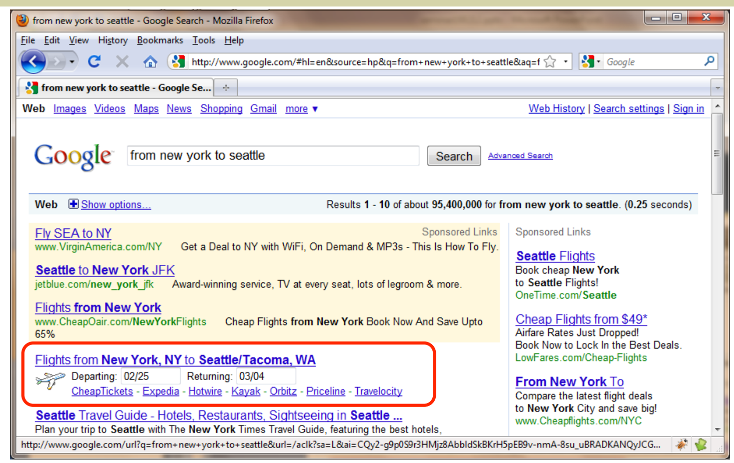
Papers Considered

- ✓ **Combining Keyword Search and Forms for Ad Hoc Querying of Databases**
  - ➢ Eric Chu, Akanksha Baid, Xiaoyong Chai, AnHai Doan, Jeffrey Naughton
  - ➢ Computer Sciences Department
  - ➢ University of Wisconsin-Madison
- ✓ Keyword Searching and Browsing in Databases using BANKS
  - ➢ Gaurav Bhalotia, Arvind Hulgeri, Charuta Nakhe, Soumen Chakrabarti, S. Sudarshan
  - ➢ Computer Science and Engineering Dept.
  - ➢ I.I.T. Bombay

Motivation

- General public is successful at using keyword search to discovering documents of interest in Internet search engines
- It is much more difficult to pose structured queries to satisfy information requests over structured databases
- Goal here is to explore techniques that assist users in posing ad hoc structured queries over relational databases

Google Example



Introduction

- It is easier to recognize a solution when presented with one
  - than constructing the solution from scratch
- Use keyword search to help the user find a manageably small set of relevant forms

user submits a keyword query → system returns a ranked list of relevant forms → user selects and uses one to build a structured query

Example

widom search

1. related_people_AVG.jsp (score : 1.0)
2. related_people_GROUPSELECT.jsp (score : 1.0)
3. related_people_INTERSECT.jsp (score : 1.0)
4. related_people_Reg.jsp (score : 1.0)
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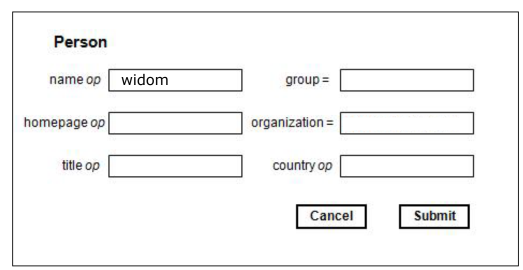
16. related_people_GROUPMAX.jsp (score : 0.8571430444717407)
17. related_people_GROUPMIN.jsp (score : 0.8571430444717407)
18. related_people_GROUPSUM.jsp (score : 0.8571430444717407)
19. related_people_MIN.jsp (score : 0.8571430444717407)
20. related_people_MAX.jsp (score : 0.8571429252624512)
21. co_author_CNT.jsp (score : 0.788425087928772)

Example (cont'd)

widom search

- Which two people are related
- Which two people are co-authors
- Details about a Person
- Who gives a Tutorial in which conference
- Who gives a talk in which conference
- Who gives a talk in which Organization
- Who is related to which Organization
- Who is related to which Area/Topic
- Who has served in which conference
- Person who has given a Conference talk, Organization talk and Tutorial
- Who has authored which publication
- Details about a Publication

Example (cont'd)



Options and Challenges

- How can one automatically generate a set of forms to support a wide range of queries?
- How specific or general should these forms be?
- How effective is keyword search in exploring this set of forms?
- What challenges arise in ranking the results of these keyword searches?

- Can users really use the result of a keyword search to identify forms useful in satisfying their information requests?

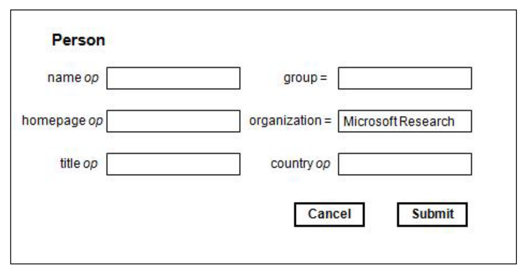
Dataset Considered

Entity tables: # rows	
person(id, name, homepage, title, group, organization, country)	68459
publication(id, name, booktitle, year, pages, cites, clink, link)	108972
topic(id, name)	736
organization(id, name)	163
conference(id, name)	170
Relationship tables:	
Records two related persons and strength of this pair	
related_people(rid, pid1, pid2, strength)	115436
Records related person-topic pair and strength	
related_topic(rid, pid, tid, strength)	114196
Records related person-organization pair and strength	
related_organization(rid, pid, oid, strength)	2436
Records a person giving a tutorial in a conference	
give_tutorial(rid, pid, cid)	132
Records a person giving a talk in a conference	
give_conf_talk(rid, pid, cid)	131
Records a person giving a talk at an organization	
give_org_talk(rid, pid, oid)	913
Records a person serving in a conference and the assignment	
serve_conf(rid, pid, cid, assignment)	3591
Records a person as an author of a publication and the position of the person's name on the list of authors	
write_pub(rid, pid, pub_id, position)	328410
Records a pair of co-authors and strength	
co_author(rid, pid1, pid2, strength)	56370

Approach

- Form generation
- Map keyword queries to forms
- Eliminate forms that do not produce answers with respect to a given keyword query
- Ranking and grouping forms
- Experiments and user study

Query Forms



Query Forms

- When the form is empty, it maps to the template

  SELECT *
  FROM person
  WHERE name *op value AND homepage op value*
  AND title *op value AND group op value AND*
  organization *op value AND country op value*

- A template with user-specified parameters corresponds to a SQL query

  SELECT *
  FROM person
  WHERE organization = 'Microsoft Research'

Form Generation

- Let D be a database instance and S_D be the schema of D
- Form generation:
  1. Specify a subset of SQL as the target language to implement the queries supported by forms
  2. Determine a set of "skeleton" templates specifying the main clauses and join conditions based on the chosen subset of SQL and S_D
  3. Finalize templates by modifying skeleton templates based on the desired form specificity
  4. Map each template to a form

SQL'

Let B = (SELECT **select-list**
FROM **from-list**
WHERE **qualification**
[GROUP BY **grouping-list**
HAVING **group-qualification**])
where

- **select-list** comprises a list of column names, and, if applicable, a list of terms having the form *aggop(column-name)*, with *aggop* being one of {MIN, MAX, COUNT, SUM and AVG}
- **from-list** is a list of tables
- **qualification** is a conjunction of the conditions of the form *expression op expression*. An expression is a column name or a constant, and *op* is one of the comparison operators {<, <=, =, <>, >=, >, LIKE}
  - Note: we do not allow nested queries in FROM and WHERE clauses
- **grouping-list** and **group-qualification** are as defined in SQL-92 (i.e., no *every* or *any* in *group-qualification*)

- We consider queries of the form B [UNION|INTERSECT B]

Skeleton Templates

- Ex_{basic}: SELECT *
  FROM *Ri*
  WHERE *predicate-list*

- Ex_{FK}: SELECT *
  FROM give_tutorial t, person p, conference c
  WHERE t.pid = p.id AND t.cid = c.id AND p.name
  op expr AND … AND c.name op expr

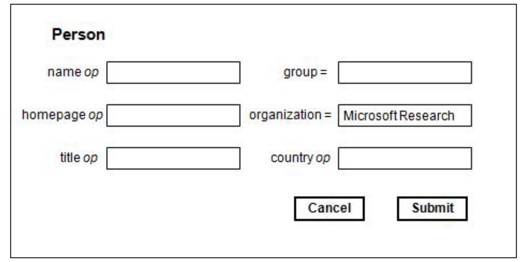
- Ex_{EQ}: SELECT non-key attributes from p
  FROM give_tutorial t, give_conf_talk c,
  give_org_talk o, person p
  WHERE t.pid = c.pid AND c.pid = o.oid AND
  o.pid= p.id AND p.name *op expr AND … AND*
  p.country *op expr*

Form Specificity

- Fewer, more general forms
  - *Pro* - easier to find a form that supports the query a user has loosely in their mind
  - *Con* - the user may have difficulty in understanding and using this form, especially when he or she is not familiar with the data model and the query language
- Larger number of more specific forms
  - *Con* - harder to find a form that matches the user's specific information need
  - *Pro* - when one is found, the necessary customization to express the query is minor

Form Specificity

- Form specificity
  - *Form complexity*, which refers to the number of parameters on a form
  - *Data specificity*, which refers to the number of parameters with fixed values on a form



Form Specificity

- Map each skeleton template, which has only a SELECT-FROM-WHERE construct, to one large template supporting aggregation, GROUP BY and HAVING, and UNION and INTERSECT
- Such a multi-purpose query template could be too complex
- We reduce form complexity by dividing SQL' into subsets:
  1. **SELECT:** the basic SELECT-FROM-WHERE construct
  2. **AGGR:** SELECT with aggregation
  3. **GROUP:** AGGR with GROUP BY and HAVING clauses
  4. **UNION-INTERSECT:** a UNION or INTERSECT of two SELECT
- We do not consider data specific forms

Mapping Query Templates to Forms

- To build a form for each query template, we use the following standard form components:
  - **Label:** for displaying text such as description for the form, the name of an attribute, a database constant, etc.
  - **Drop-down list:** for displaying a list of parameter values from which users can choose one. For example, we use a drop-down list to allow users to choose the target attribute for an aggregation.
  - **Input box:** for specifying a parameter value on the form
  - **Button:** for functions such as submit, cancel, and reset

Automating Form Generation

- Template generator uses the aforementioned specification for SQL' and query classes
- Input: a data set and its schema
- A form designer can specify the desired form complexity and data specificity
- Output is a set of templates based on these configurations
- Scripts to transform these templates into forms and to add a form description to each form

Keyword Search for Forms

- Basic idea here is to treat a set of forms as a set of documents, then let users use keyword search to find relevant forms
- Form contains parameters, which are undefined until users fill out the form at query time
- **Naïve-AND** – user specifies a data value, we will get no answers
- **Naïve-OR** – some forms would be returned if the user includes in the query at least one *schema term*
  - Data terms would be ignored

Example

- Query: **Widom conference**
  - We like to know for which conferences a researcher named **Widom** has served on the program committee
- Assume **Widom** is a data term and **conference** is a schema term
- Using Naïve-AND, we would get no forms, since **Widom** does not appear on any forms
- Using Naïve-OR, we would ignore **Widom** and get all forms that contain **conference**

Keyword Search for Forms

- Data specific form – many combinations and high storage and maintenance costs
- Transform a user's keyword query by checking to see whether the terms from the query appear in the database
  - user-provided keyword appears both as a schema term and as a data term
  - keyword appears in multiple attributes, possibly of different tables
- Use **Double-Index OR (DI-OR)** and **Double-Index AND (DI-AND)**

Double-Index OR (DI-OR)

Input: A keyword query $Q = [q1\ q2....\ qn]$
Output: A set of *form-ids F'*
Algorithm:

```
FormTerms = {}, F' = {}
// Replace any data terms with table names
for each q_i ∈ Q
      if DataIndex(q_i) returns <table, tuple-id> pairs
            Add each table to FormTerms
      Add q_i to FormTerms          // q_i could be a form term
// Get form-ids based on FormTerms
FormIndex(FormTerms) => F'          // OR semantics
return F'                           // Ordered by ranking scores
```


DI-OR Example

- Query: **Widom conference**
- Using DI-OR, we would find that **Widom** appears in the **person** table
- The resulting rewritten keyword query would be **Widom person conference**, evaluated with OR semantics

DI-OR Summary

- Approach satisfies the new semantics
- Results are often too inclusive
- Approach similar to DI-OR but with AND semantics required
- Wrong to simply do one AND-query with all the terms in *FormTerms*
  - A data term may appear in multiple unrelated tables -> no form returned

Double-Index AND (DI-AND)

Input: A keyword query $Q = [q1\ q2....\ qn]$
Output: A set of *form-ids F'*
Algorithm:

```
FormTerms = {}, F' = {}
// Replace any data terms with table names
for each q_i ∈ Q
   Sq_i = {}                                    // Bucket for q_i
   if DataIndex(q_i) returns <table, tuple-id> pairs
      for each table
         if table ∉ FormTerms
            Add table to Sq_i and FormTerms
   if q_i ∉ FormTerms
      Add q_i to Sq_i and FormTerms
```

Double-Index AND (DI-AND) (cont'd)

```
// Get form-ids based on Sq_i
S_Q' = EnumQueries(∀ Sq_i)     // Enumerate all
                               // unique queries, each having one
                               // term from each Sq_i
for each Q' ∈ S_Q'
    FormIndex(Q') => F'        // AND semantics on FormIndex
return F'                      // Ordered by ranking scores
```


DI-AND Example

- Query: **Widom conference**
- Using DI-AND, we would generate two queries:
  1. **person conference** and
  2. **Widom conference**
- Evaluate each with AND semantics, and return the union of the results
- In this case, **Widom conference** would lead to an empty result

DI-AND Summary

- Large number of queries generated – but most of them are duplicates
- Query – mix of data terms
  - ➢ Add synonyms to a query based on a thesaurus during query evaluation
  - ➢ Add a set of synonyms to each form during form generation
- Selected and added a set of keywords to what we call a form profile for each form

DI-AND Summary (cont'd)

- DI-AND can return forms that can never produce results with respect to the user query
  - – When a search involves a table referenced by many other tables, DI-AND returns all the forms for all these tables, even though some may return no answer with respect to the user query
- We need to identify and filter these **dead forms** from the results

Dead Forms Example

- Query: **John Doe**
- Assume **John Doe** appears in the **person** table, but is not involved in any relationship
  - That is, the **John Doe** tuple in **person** is not referenced by any tuple in any relationship table
- In addition to returning forms for the **person** table, DI-AND would return forms for all the relationship tables that reference **person**
- Since **John Doe** appears only in **person**, if the user enters **John Doe** in the **person.name** field on any of these join forms, they will return empty results

Double-Index-Join

Input: A keyword query *Q = [q1 q2.... qn]*
Output: A set of *form-ids F'*
Algorithm:

FormTerms = {}, *F'* = {}, *X* = {}
// Replace any data terms with table names
for each $q_i \in Q$
Sq_i = {}
if DataIndex(q_i) returns <*table, tuple-id*> pairs
for each *table T*
let *I* be the set of *tuple-ids* from T
if $T \notin$ *FormTerms*
Add T to Sq_i *and FormTerms*
// New "join" step
SchemaGraph(*T*) returns *refTables*

Double-Index AND (DI-AND) (cont'd)

for each *refTable*
if DataIndex(*refTable:tid*) is NULL for every $tid \in I$
FormIndex(*T AND refTable*) => *X*
if $q_i \notin$ *FormTerms*
Add q_i *to* Sq_i *and FormTerms*
// Get form-ids based on form terms
$S_{Q'}$ = EnumQueries($\forall\ Sq_i$)
for each $Q' \in S_{Q'}$
FormIndex(*Q'*) => *F'*
return *F' – X*   *// Filter "dead" forms*

DISPLAYING RETURNED FORMS

Ranking Forms

- The Lucene score for a query ***Q*** *and a* document ***D*** *is:*

$$score(Q,D) = \overbrace{\boxed{coord(Q,D)}}^{\text{Score factor based on \# of query terms found in D}} * \overbrace{\boxed{queryNorm(Q)}}^{\text{Normalizing factor}} * \sum_{t\,in\,Q} \left[\underbrace{\boxed{tf(t\,in\,D)}}_{\text{Term frequency of t in D}} * \underbrace{\boxed{idf(t)^2}}_{\text{Inverse term frequency of t in D}} * \underbrace{\boxed{t.getBoost()}}_{\text{Search time boost of t}} * \underbrace{\boxed{norm\,(t,D)}}_{\text{Index time boost}} \right]$$

Lucene Scoring Terms

- The factors involved in Lucene's scoring algorithm are as follows:
  1. **tf** = term frequency in document = measure of how often a term appears in the document
  2. **idf** = inverse document frequency = measure of how often the term appears across the index
  3. **coord** = number of terms in the query that were found in the document
  4. **lengthNorm** = measure of the importance of a term according to the total number of terms in the field
  5. **queryNorm** = normalization factor so that queries can be compared
  6. **boost(index)** = boost of the field at index-time
  7. **boost(query)** = boost of the field at query-time

Ranking Forms

- Very specific forms have problems
- Form specificity increases => number of forms created from each skeleton template increases
- Forms based on the same skeleton template (sister forms) become increasingly similar
- When a query is relatively vague, there is not enough information to determine the user’s intent
- Many sister forms within each group => required form may get pushed low

widom search

1. related_people_AVG.jsp (score : 1.0)
2. related_people_GROUPSELECT.jsp (score : 1.0)
3. related_people_INTERSECT.jsp (score : 1.0)
4. related_people_Reg.jsp (score : 1.0)
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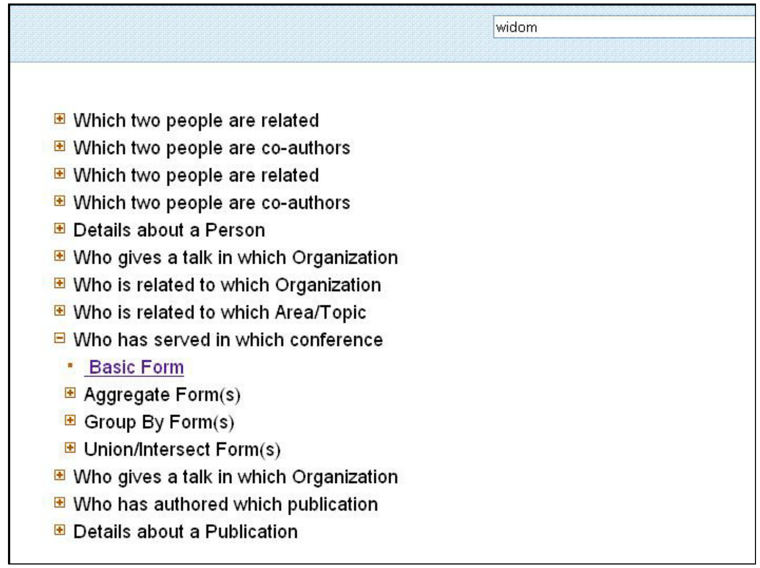
Grouping Forms

- Given a list of forms ordered by each form's score, our first approach comprises two steps

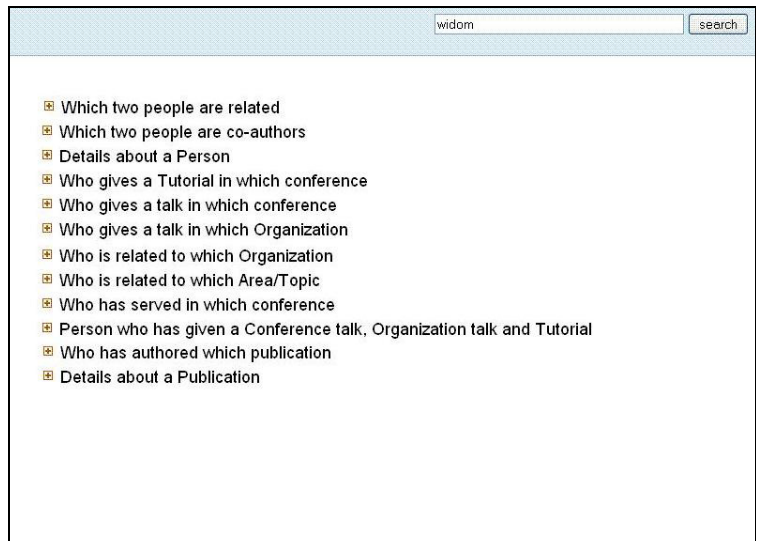
1. Form first-level groups by grouping consecutive sister forms with the same score.
2. In each first-level group, group forms by the four query classes described in slide 15, and display the classes in the order of *SELECT, AGGR, GROUP, and UNION-INTERSECT.*



Grouping Forms

- When two sister forms have different ranking scores such that they are not consecutive, they join different first-level groups
- These groups still have the same description and could confuse users

- Solution: first group the returned forms by their table, then order the groups by the sum of their scores



EXPERIMENTS

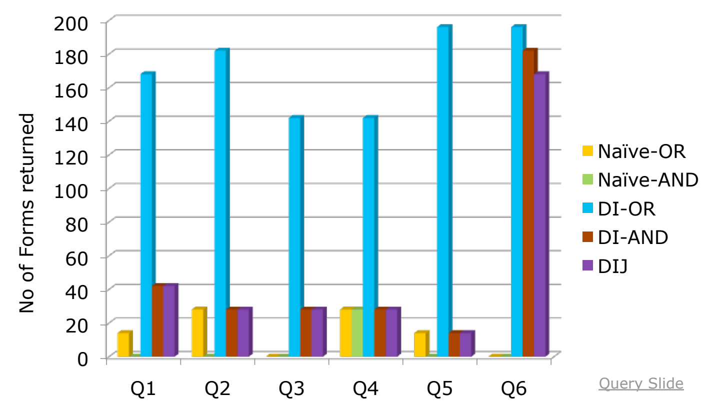
Experimental Setup

- Search interface implemented with Perl CGI scripts
- MySQL as the back-end database
- Apache Web Server to host the service
- Forms
  - 14 Skeleton templates – one for each of the table
  - Based on query classes in slide 15, 1 SELECT template, 5 AGGR templates(one for each aggregate), 6 GROUP templates (one for each aggregate and one without aggregate) and 2 UNION-INTERSECT templates
  - Totally 14 * 14 = 196 forms

Queries Presented

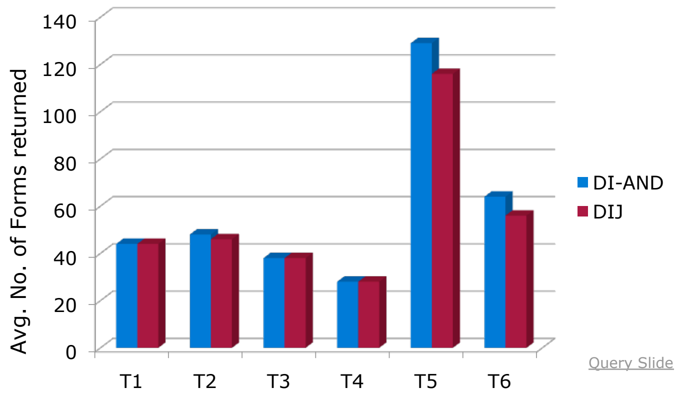
- T1: Find all people who have given a tutorial at VLDB
  - "tutorial vldb"
- T2: Find topics of areas related to Jeff Naughton.
  - "jeff naughton research area"
- T3: Find people who have served as the SIGMOD PC chair
  - "sigmod chair"
- T4: Find the first author of all papers cited more than 5 times.
  - "paper citation"
- T5: Find the number of people who have co-authored a paper with David Dewitt.
  - "david dewitt coauthor"
- T6: Find people who have published with David DeWitt or Jeff Naughton.
  - "dewitt naughton

Results



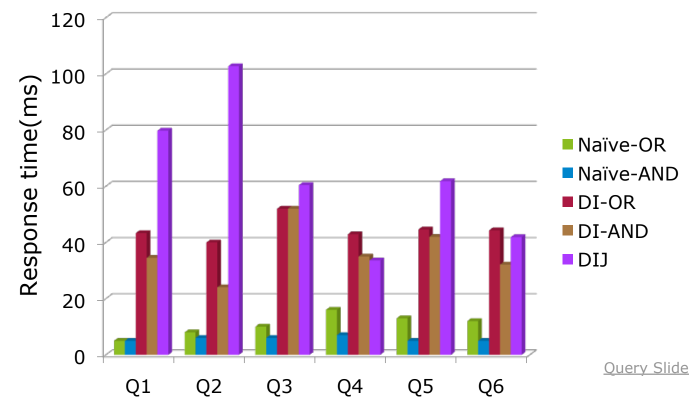
Query Slide

Results



Query Slide

Results



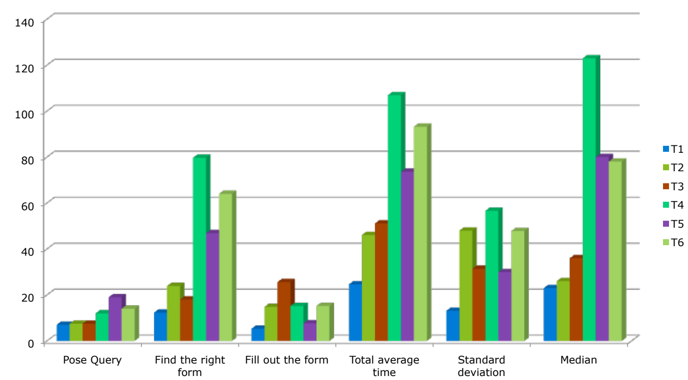
Query Slide

Ranking and Displaying Forms

F1	Flat Rank				Group Rank			
	H	**M**	**L**	**#F**	**H**	**M**	**L**	**#G**
T1	1	1	1	44	1	1	1	3.14
T2	1	1	69	46	1	1	7	3.7
T3	1	1	1	38	1	1	1	2.7
T4	1	15	15	28	1	2	2	2
T5	4	21	21	116	1	2	4	11.57
T6	1	12	12	56	1	1	6	4

The highest (H), median (M), and the lowest (L) flat and group ranks for each queries, and the average number of forms (#F) and groups (#G) returned, based on the results of 7 users.

User Interaction with Keyword Search and Forms



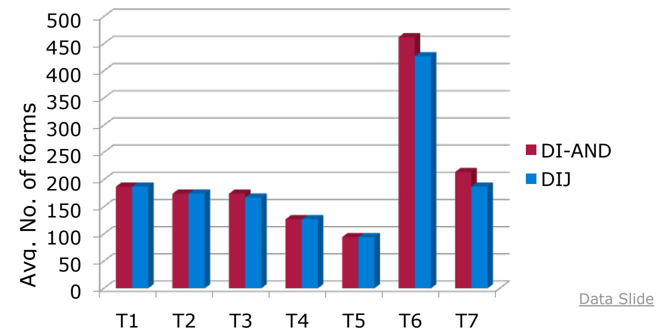
The breakdown of the time of using DIJ by 7 users

Impact of Adding Forms

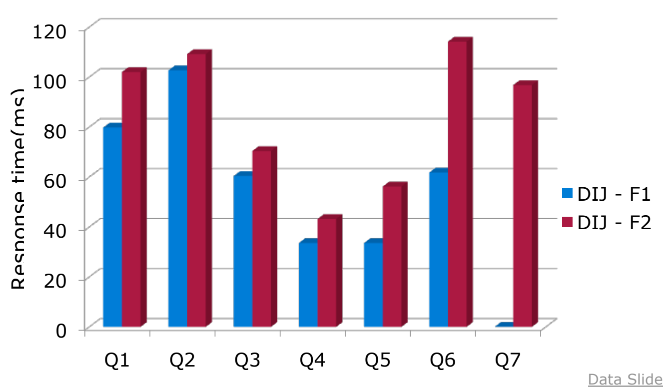
- Forms for all combinations of equijoins involving 2 relationship tables and person table

- T7: Find people who have given a conference talk and given a tutorial.
  - “conference tutorial”

Impact of Adding Forms - Results



Impact of Adding Forms - Results



Related Work

- Query By Example
  - Skeleton tables presented to users
  - Users fill blanks in tables to specify constraints
  - Still require an understanding of relational model
- Basic keyword search over databases
  - Basic query specifications cannot be done
- Auto distinguish between schema and data terms
  - Little support for structured queries

Issues Addressed

- Designing and generating forms in a systematic fashion
- Handling keyword queries that are a mix of data terms and schema terms
- Filtering out forms that would produce no results with respect to a user’s query
- Ranking and displaying forms in a way that help users find useful forms more quickly

Scope of Future Work

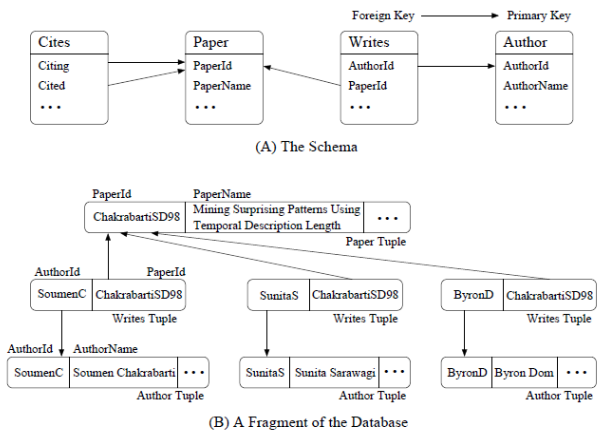
- Developing automated techniques for generating better form descriptions
- Exploring the tradeoffs between keyword search directly over the relational database and the above explained approach

Keyword Searching and Browsing in Databases using BANKS

What is BANKS

- Browsing ANd Keyword Searching
- Framework for keyword querying of relational databases.
- It makes joins implicit and transparent, and incorporates notions of proximity and prestige when ranking answers
- Novel, efficient heuristic algorithms for executing keyword queries

Dataset and Representation



BANKS Model

- Database modeled as directed graphs
  - Tuple being a node in the graph
  - Foreign-key-primary-key acting as directed edge
- Weights are assigned to the nodes and edges
- Nodes are identified corresponding to the search terms
- Answer to a query is a rooted directed tree
- Nodes fetched and ordered by a particular relevance score
- A heuristic backward expanding search algorithm used for computing query results

Backward Expanding Search Algorithm

- For each keyword, set of nodes are identified which are relevant to the keyword
- For each node, a copy of Dijkstra's single source shortest path algorithm is executed
- Each copy runs backward to run a common vertex from which a forward path exists to at least one node in each set
- Such paths define a rooted directed tree with the common vertex as the root and the corresponding keyword nodes as the leaves
- The connection trees generated by the algorithm are only approximately sorted in the increasing order of their weights.

Browsing BANKS

- Every displayed foreign key attribute value becomes a hyperlink to the referenced tuple
- Since the entire database is like a complex graph, various functionalities are provided
  - Projecting away columns
  - Selection on a column
  - Joining with foreign keys
  - Grouping by column
  - Sorting by a column

Example Result

Table = PAPER

PAPERID	TITLE	YEAR
ChakrabartiSD98	Mining Surprising Patterns Using Temporal Description Length.	

Table = WRITES

NAME	PAPERID
Soumen Chakrabarti	ChakrabartiSD98

Table = AUTHOR

NAME	URL
Soumen Chakrabarti	

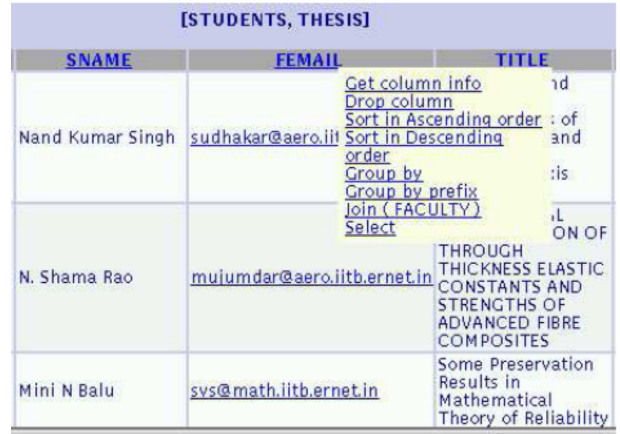
Table = WRITES

NAME	PAPERID
Sunita Sarawagi	ChakrabartiSD98

Table = AUTHOR

NAME	URL
Sunita Sarawagi	

Browsing BANKS - Example



Comparison: BANKS vs. Keyword-Forms

- In BANKS, the schema of tables are provided as hyperlinks. Browsing data is enabled by clicking these hyperlinks
- In Keyword-forms, schema is represented as forms and required data is entered in forms

Comparison: BANKS vs. Keyword-Forms

- In BANKS, grouping of data done as part of the schema hyperlink while browsing the data
- In Keyword-forms, aggregate operations are done through forms. Appropriate forms need to be selected to get aggregated results

Comparison: BANKS vs. Keyword-Forms

- Users need to know the schema in BANKS or the system needs to be able to map user-specified attributes to system attributes.
- In Keyword-Forms, schema elements are present in forms and no operators required in keyword search.

THANK YOU