ELEC 875
Design Recovery
and
Automated Evolution

Grok and Sgrep

Today

- Semantic Grep
- Advanced TXL

Relational Databases

- On Disk Data Structures
  - ◊ optimized for huge databases
    - many millions of records
  - ◊ optimized for IT based queries
  - ◊
```
select avg(sales)
    from employee
    where commission > 0.5
```
  - ◊
```
select manager
  from employee
  where name = “James Higgins”
```
  - ◊ allows update to single records
- Spectacular for these types of queries

Program Analysis Queries

- example
  - ◊ Common Ancestor Subsystem of Two modules
    - equivalent IT query:
      common boss of two employees
    - requires recursive SQL (in latest version)
  - ◊ requires multiple queries to the same table
- updates to single records are rare
- often add entire derived relations to the database
- some individual queries
- Queries often need to use every record in the relation
- Relational DBs not optimized for these types of queries
  - ◊ not surprising, very minuscule portion of database use.

Grok

- Initial Version in 1995, Ric Holt
- Optimized for large Databases
  - ◊ hundreds of thousands of facts
- Heinlein - Stranger in a Strange Land

- Relational Algebra Calculator
  - ◊ Discrete Math
  - ◊ Sets and Relations

- Ram Based
  - ◊ Queries tend to use entire relations at a time
  - ◊ Recursive Queries

Grok - Input of Relations

- RSF - Rigi Standard Format
  - ◊ triple format

```
funcdef main main.c
defloc main “main.c:10”
include main.c stdio.h
calls main foo
sets foo x
parameter foo y
```

- Automiatic discovery of domain and range sets
  - ◊ just use names in relations
- Attributes are just another relation

Grok - Input of Relations

- TA - Tuple Attribute format
  - ◊ ER based notation
  - ◊ Definition of instances
  - ◊ Attributes instead of relations

```
funcdef main main.c
defloc main “main.c:10”

$INSTANCE main func {defloc=“main.c:10”}
```

  - ◊ Relations can also be extended
  - ◊ translated to RSF internally

Grok - Input of Relations

- TA -Schema Definition
  - ◊ Allows the user to specify the schema of the data
  - ◊ Not explicitly checked
  - ◊ Schema is also compiled into relations
  - ◊ Can write a grok program that checks the data against the schema
    - already done

Grok - Operators

- Sets
  - ◊ construction

    functions = { “main”, “foo”, “bar”, “bat” }

    vars = { “m”, “x”, “y” }

    refs = {“x”, “z”}
  - ◊ union/intersection/complement

    ents = functions + vars

    vrefs = vars ^ refs

    vnrefs = vars - refs
  - ◊ cardinality

    numvars = #vars
  - ◊ sets can be read and written to files, one entity per line

Grok - Operators

- Relations
  - ◊ Cross Product

    foo = functions X refs
  - ◊ Relations are sets of tuples, so all set operators work on relations in the obvious way
  - ◊ domain/range(codomain)

    f = dom foo

    r = rng refs
  - ◊ relation composition

    h = f o g == { (x,y) | y = g(f(x))}

Grok - Operators

- Relations
  - ◊ Id constructor (S is a set)

    r = id S === {(x,x)} for all x in S
  - ◊ inverse (n is a relation)

    m = inv n
  - ◊ transitive closure

    R+
  - ◊ Transitive, reflexiv closure

    R*

Grok - Operators

- Sets and Relations
  - ◊ projection (s is set, R is relation)
    s.R = { y | x in S and (x,y) in R)}
    R.s = s . inv R

  {“f”,”g”} . invokes == all functions invoked by f and g
  {“f”,”g”} . invokes+ = all functions invoked directly or indirectly by f and g
  {“f”,”g”} . invokes* = all functions invoked directly or indirectly by f and g including f and g.

Grok - Scripting

- Grok also has a scripting language:
  - ◊ conditionals (if)
  - ◊ looping
  - ◊ arguments
  - ◊ file io

- Other numerous options including options to ask for names of sets, relations and variables, string operations, id operations, file I/O

Grep

- problems with grep
  - ◊ no syntax awareness
  - ◊ grep “date” *.c gets:
    - – all variables with date the name
    - – all functions with date in the name
    - – all comments with date in them
  - ◊ scans code line by line. Fast for small file, slow for big systems (limited by I/O speed).
- advantages of grep
  - ◊ simple Regular Expression notation, easy for developers to understand

sgrep

- lets grep run on TA database
  - ◊ run fact extractor to get TA from code
  - ◊ contains an arbitrary model
    - – they use the software landscape model
    - – could be a Datrix or DMM model too.
- regular expressions can be limited to particular entities
  - ◊ variables containing “date” in the name
- regular expressions can be applied to results of queries.
  - ◊ all methods from class A that are overridden by class B and contain the “f.*bar” in the return type.

sgrep

- combination allows us to mix structural (grok queries) and lexical patterns.

– key relation is the contains relation which is given by the 'in' query verb.

– need a mapping from the equivalent of contains in the extracted model.

– similar to the Holt, Fahmy and Cordy paper.

- Contrast back to Lethbridge and Singer

sgrep

- Implementation:
  - Front end for a grok server
  - translates to grok and executes
  - applies pattern matching to result

- Grok is a complex language, sgrep attempts to simplify

- assumes some relation names (contains)

sgrep

- Queries:

  - pattern is entity --- result is a set

    pattern is run against projection of $INSTANCE

    $INSTANCE x entity

    get is function* right projection

    *getChar is ** left projection

    Start by right projection:

    $INSTANCE.{'function'}

    then do a regular expression match on result

    - simplest query to implement
    - Can also returns attributes

sgrep

- Queries:
  - pattern is entity in pattern --- result is a set
  First part is the same as before, but constrained by the *contains*+ relation
  get is function in parser.c*

  not clear if
  get is function in pars*.c*
  is supported
- clear extension if not.

sgrep

- Queries:

  - pattern is entity <relation> pattern is entity

        --- result is a relation

  find sets for the left and right *is* and then find those tuples in relation that match..

  * *is function <calls> getc is* *

  Two sets (based on first query)

  Match against relation

sgrep

- Queries:

- pattern is entity in pattern <relation> pattern is entity in pattern
  -- result is relation

  Find sets for left and right and relation

  ** is function in parser.c <calls> * is function in scanner.c*

sgrep

- Queries:

  - pattern is entity <relation+> pattern is entity

    --- result is a relation

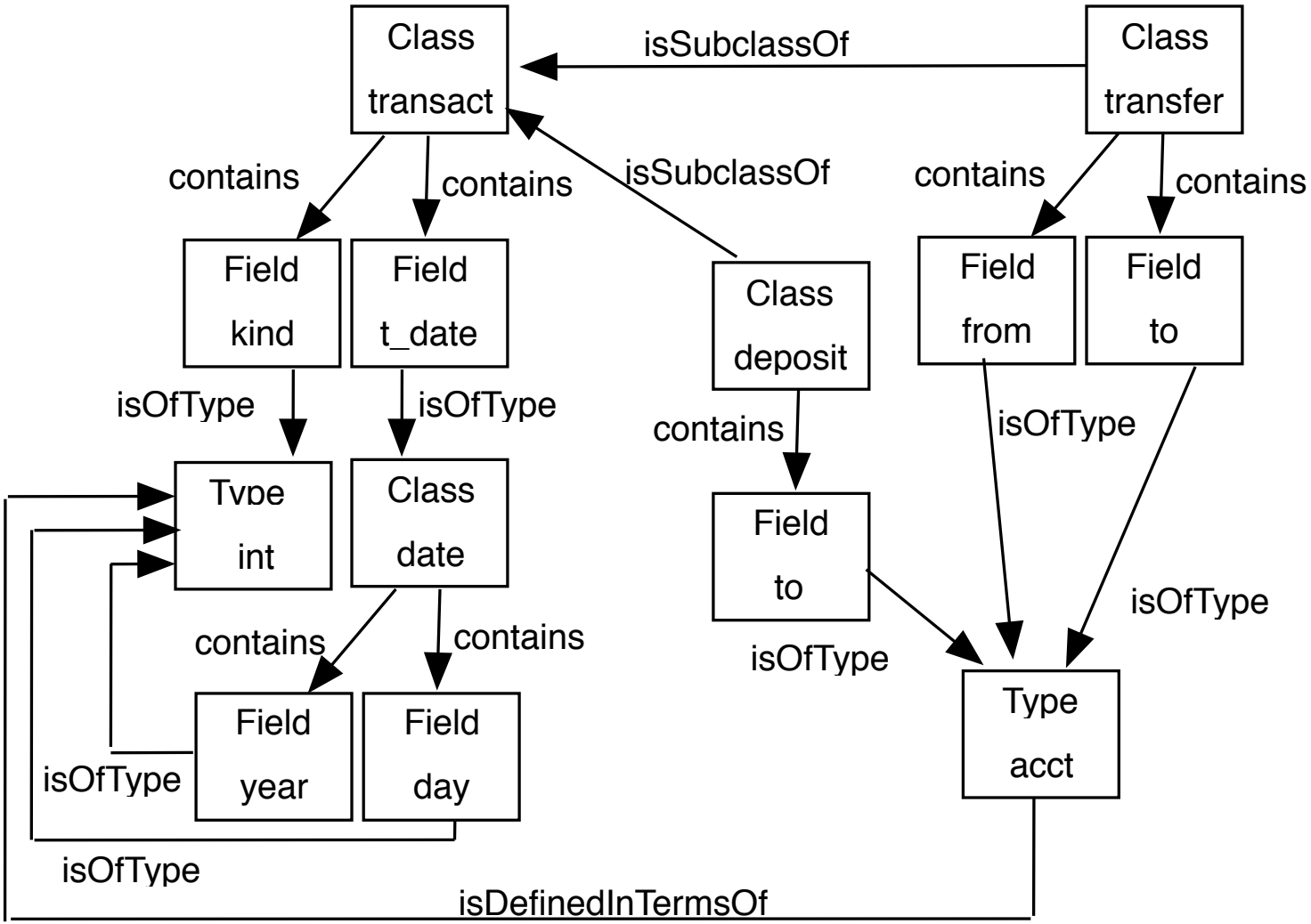
  find sets for the left and right *is* and then find those tuples in transitive closure of relation that match..

  * *is function <calls+> getc is **

sgrep

- Does not handle composite relation queries
  - what variables are modified when I call this function?
  - composes *calls*+ and *sets*

Relational Algebra Practice..



the types of all fields of subclasses of the class 'transact'

Advanced TXL

- Based on Talks from TXL website (in particular Andrew Malton's talk)
- Grammars, Fact Extraction, Transformation

TXL Uses

- Original Purpose: Language Prototyping
  – C++ was originally implemented as a pre processor for C (but not in TXL).
- Annotation (i.e. add XML markup to Code)
- Fact Extraction
- Analysis (find 32 bit dependencies)
- Dialect Conversion

  e.g. transform deprecated functions in Java
- Software Transformation

  e.g. convert constant shifts to bit field (Brian Le Breton)
- Software Migration (language translation)

TXL Terminology

- Parsing Terminology
  – token, nonterminal, parse tree
- TXL terms
  – pattern (a source code fragment that is matched in a tree)
  – variable (a variable is bound to a tree or subtree. Once bound it cannot be changed except global variables)
  – type (a terminal or non-terminal name that designates the type a variable can match)

Tokens

- Terminal symbols
- Identified as token classes which have a value

[id]	identifier: a Z xyzzy
[upperid]	user case identifier: Z XYZZY
[number]	number: (>= 0) 3 3.4
[charlit]	character literal: 'abcdefg'
[stringlit]	string literal: "abcdefghij"
[key]	any keyword defined in keys section
[token]	any terminal that is not a keyword.

Nonterminals

- created by define or modified by redefine statements
- parse rules for grammar

```
define postfix_cexpression
      [cprimary][repeat postfix_extension]
end define
define cprimary
    [reference_id] | [constant] | [string] |  '( [cexpression_list] ')
end define
define postfix_extension
         '[ [assignment_cexpression] ']
      |  '([list argument_cexpression] ')
      |   '. [id] |   '-> [id]  |   '++ |   '--
end define
```

Variables

- Identifier that is bound to a value of a nonterminal or terminal type

replace [postfix_cexpression]
  Function [id] (Parms [list argument_cexpression])

construct X [cexpression]
  3 + 'y

Patterns

- A sequence of tokens and variable that match a type

replace [postfix_cexpression]
  Function [id] (Parms [list argument_cexpression])

- Patterns bind variables to values.

Naming Conventions

- Like most languages, TXL does not enforce any particular naming convention.

variables: LeadingUpperCamelCase

type: [loading_lower_underscores]

rules: [leadingLowerCamelCase]

Subgrammars

- The base grammars from the TXL website are generic and generally match the published grammar. Often a task will be easier with a slightly different grammar.

```
include "C.grm"
include "TypedefOverrides.Grammar"
```

- Small local overrides grammar can be done inline in the program

Overrides

- The base grammars from the TXL website are generic and generally match the published grammar. Often a task will be easier with a slightly different grammar.

```
include "C.grm"
include "TypedefOverrides.Grammar"
```

Overrides

- Small local overrides grammar can be done inline in the program

```
redefine postfix_cexpression
      [function_call] | ...
end define
define function_call
   [function_name] '( [repeat cexpression] ')
end define
define function_name
   [file_op] | [reference_id]
end define
define file_op
   'fopen | 'fclose
end define
```

Overrides

- Small local overrides grammar can be done inline in the program

```
rule report_fopen
   replace $ [function_call]
      FileFunction [file_op] '(  Parms [list argument_cexpression] ')
    construct Msg [stringlit]
      _ [+ "found call to file operation"]
        [print]
    by
      Fn '( Parms ')
end rule
```