ProFoUnd: Program-analysis–based Form Understanding

(joint work with M. Benedikt, T. Furche, A. Savvides)

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The Deep Web

Definition (Deep Web, Hidden Web, Invisible Web)

All the content on the Web that is not directly accessible through hyperlinks. In particular: HTML forms, Web services.

Size estimate: 500 times more content than on the surface Web! [BrightPlanet, 2001]. Hundreds of thousands of deep Web databases [Chang et al., 2004]

Sources of the Deep Web

Example

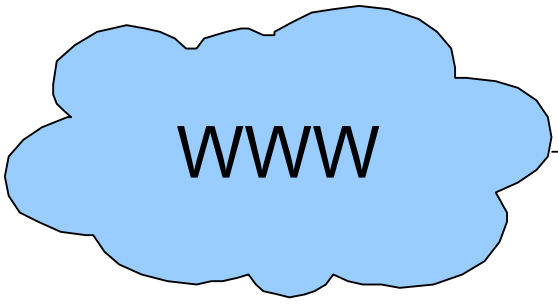
- *Yellow Pages* and other directories;
- Library catalogs;
- Weather services;
- US Census Bureau data;
- etc.

Discovering Knowledge from the Deep Web [Varde et al., 2009]

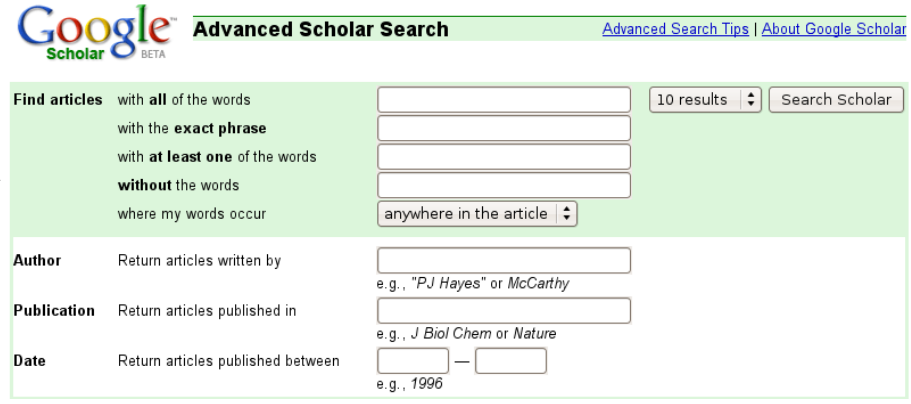
- Content of the deep Web hidden to classical Web search engines (they just follow links)
- But very valuable and high quality!
- Even services allowing access through the surface Web (e.g., e-commerce) have more semantics when accessed from the deep Web
- How to benefit from this information?

Focus here: Automatic, unsupervised, methods

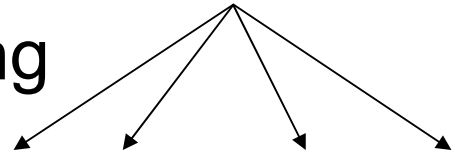
Extensional Approach

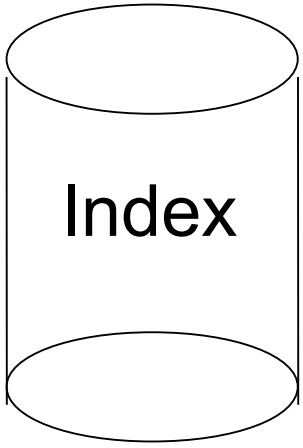


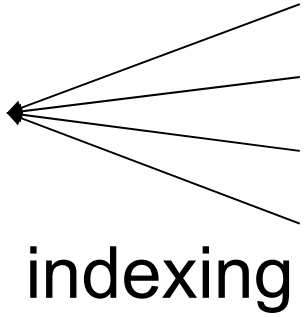
discovery



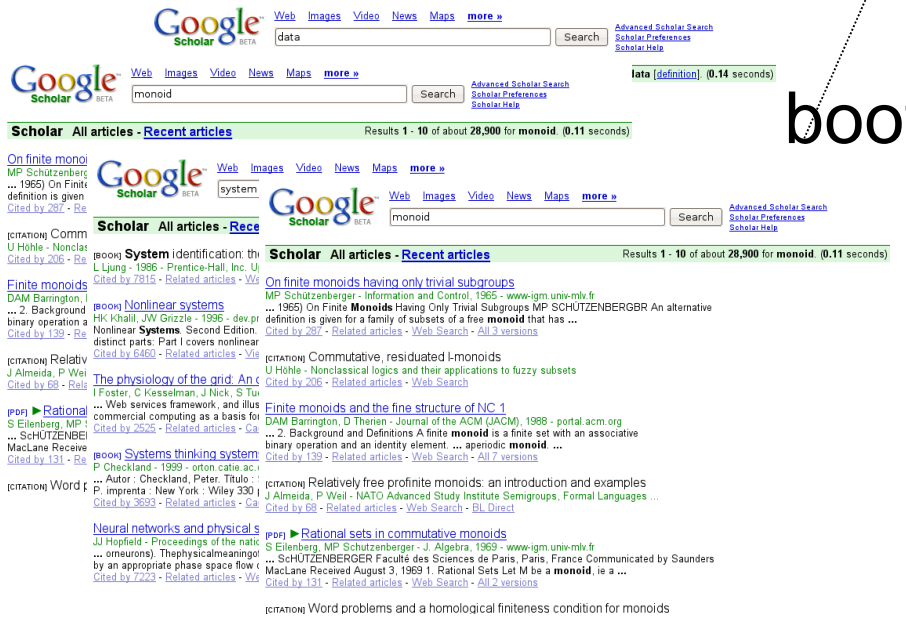
siphoning







indexing



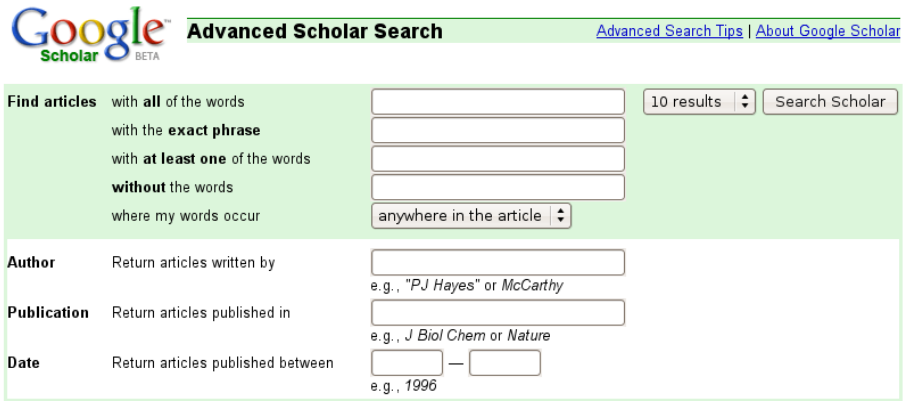
bootstrap

Notes on the Extensional Approach

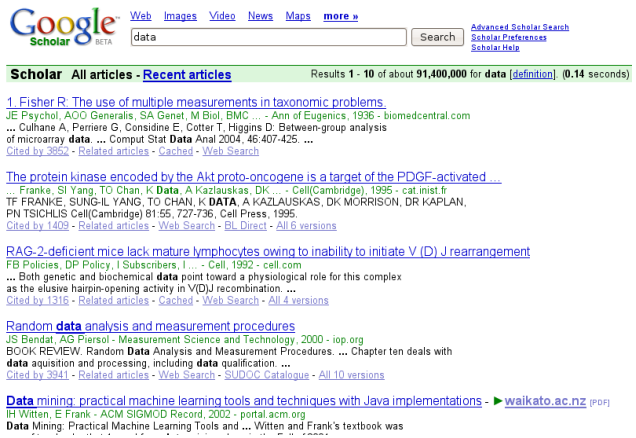
- Main issues:
  - Discovering services
  - Choosing appropriate data to submit forms
  - Use of data found in result pages to bootstrap the siphoning process
  - Ensure good coverage of the database
- Approach favored by Google, used in production [Madhavan et al., 2006]
- Not always feasible (huge load on Web servers)

Intensional Approach

discovery



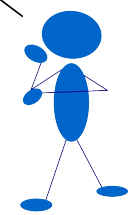
probing



analyzing

Form wrapped as a Web service

query



Notes on the Intensional Approach

- More ambitious [Chang et al., 2005, Senellart et al., 2008]
- Main issues:
  - Discovering services
  - Understanding the structure and semantics of a form
  - Understanding the structure and semantics of result pages
  - Semantic analysis of the service as a whole
- No significant load imposed on Web servers

Outline

Introduction

ProFoUnd

JavaScript and the Deep Web

Form Understanding through JavaScript Analysis

Conclusions

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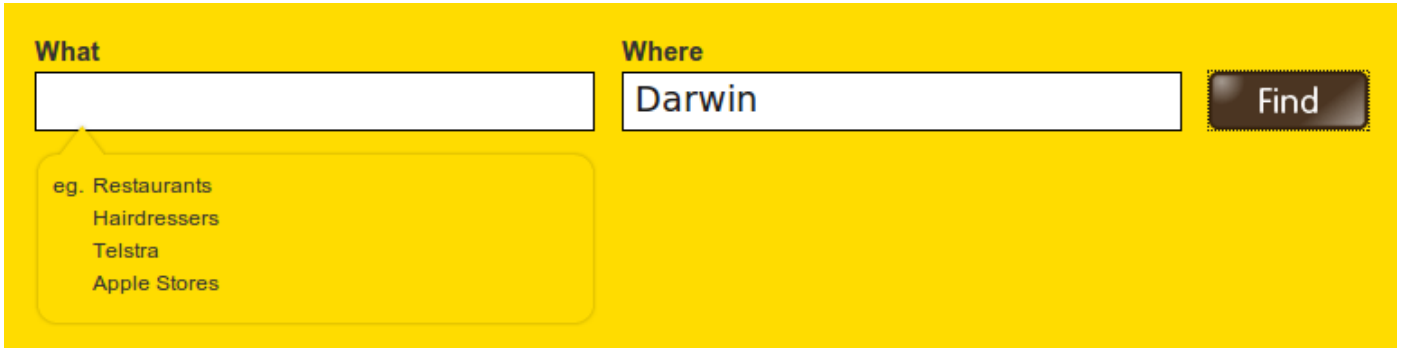
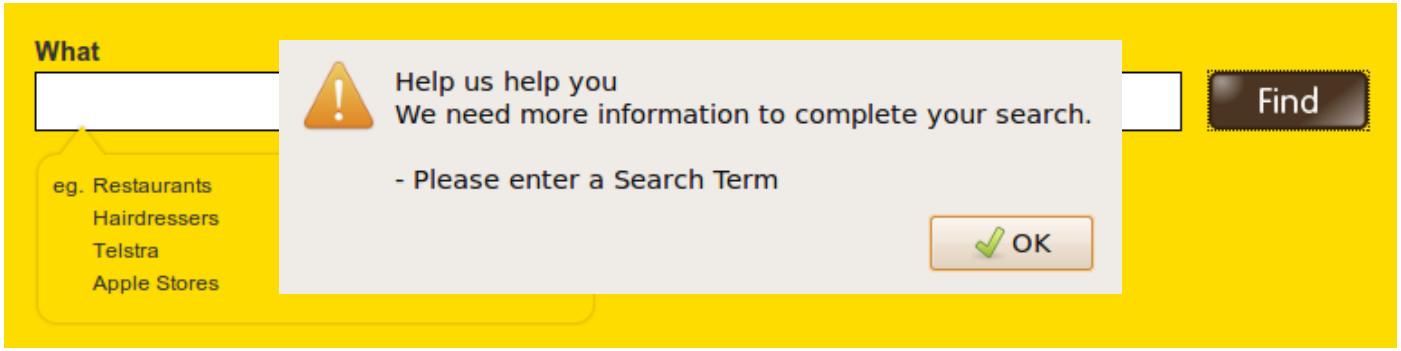
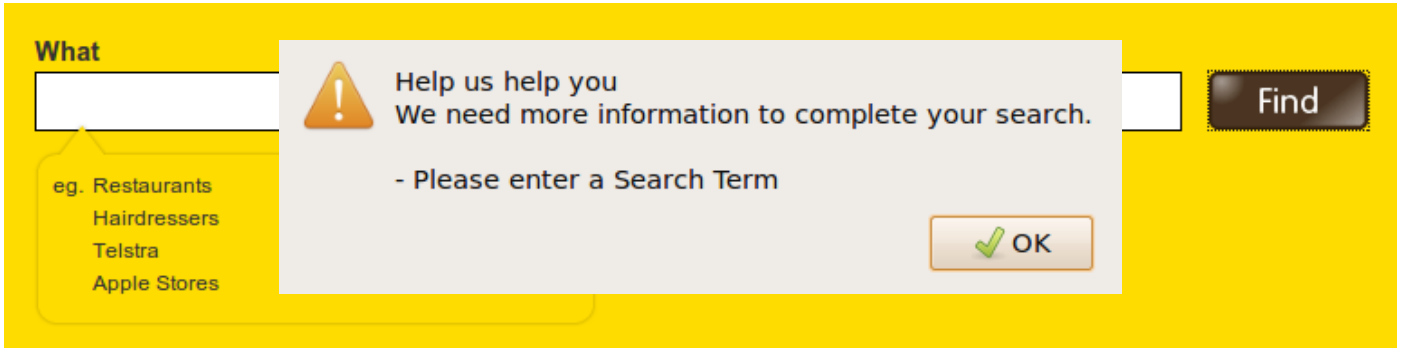
Better Form Analysis



Better Form Analysis



Better Form Analysis




```
// Do not submit unless form is valid
$j("#searchForm").submit(function(event) {
  $j("#searchFormLocationClue").val($j("#searchFormLocationClue").val().trim());
  if ($j("#searchFormBusinessClue").val().isEmpty()) {
    alert('Help us help you\nWe need more information to
      complete your search.\n\n- Please enter a Search Term');
    return false;
  } else {
    return true;
  }
});
```

JavaScript: the Data Language of the Web

- Lots of JavaScript code on the Web (source is always available!)
- Lots of information can be gained by static analysis of this code:
  - Required fields
  - Dependencies between fields (if x is filled in, so should be y; the value of x should be less than that of y; etc.)
  - Datatype of each fields (regular expressions, numeric types, dates, etc.)
- Is this feasible in practice?

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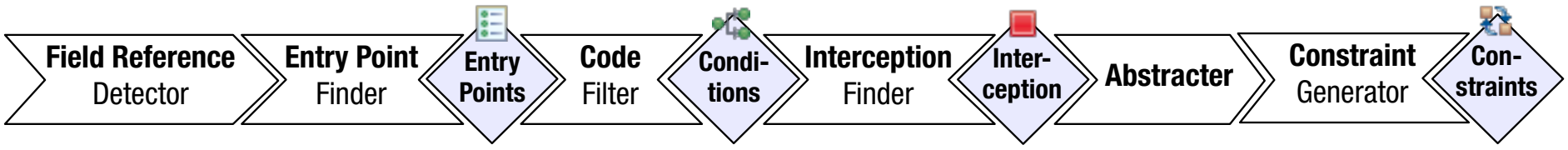
ProFoUnd architecture



- Entry points are HTML event attributes, setting of event handlers in code, etc. (event: *click* on a submit button, *submit* on a form)
- Conditions are (in)equality tests on form field values (possibly aliased)
- Interceptions are interruptions of the form submission process (error messages, simple `return false;` in event handler, etc.)

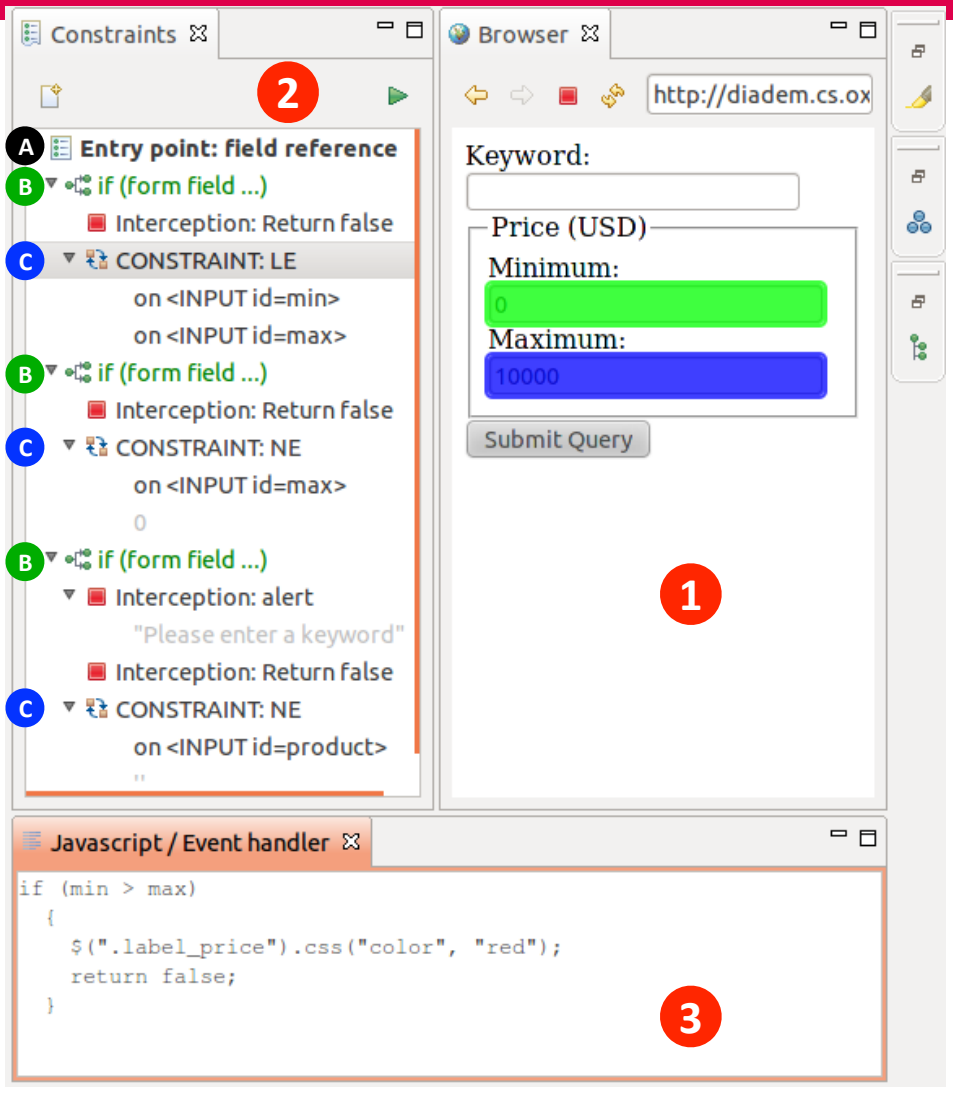
Abstracting the code

- Rice's theorem: no hope in a sound and complete constraint finder
- But that's ok! Anything that we can learn is more than what we have at the moment.
- Coarse abstraction of the JS code:
  - Only conditions on the code flow from entry points to interceptions are considered.
  - We consider only a simple subset of the JS language; anything beyond that is ignored.
  - Side-effects are mostly ignored
- As a consequence: no guarantee of either soundness or completeness $\Rightarrow$ only experimental guarantees

Engineering issues to deal with

- Extracting a Web form model: DIADEM's tools `http://www.diadem-project.info/`
- Parsing JavaScript: Mozilla Rhino (but see later)
- JavaScript frameworks: ad-hoc support for most popular ones (jQuery, Prototype, ASP.NET generated code, YUI, Dojo, MooTools)
- Evaluating JavaScript code (e.g., to determine what a jQuery selector (`$.("form#lookup .product")`) returns): Mozilla JS engine
- Abstraction, alias references, etc.: ProFoUnd core, developed from scratch

ProFoUnd interface [Benedikt et al., 2012]



1. Web page view, with fields highlighted
2. Constraints found: $min < max$, $max \neq 0$, $product \neq$ ”
3. JS fragment for the highlighted constraint

Preliminary evaluation

- 70 real-estate websites containing search forms
- 30 out of 70 use client-side validation, with a total of 35 constraints
- 100% precision: all identified constraints are correct
- 63% recall: 22 out of 35 JS-enforced constraints were found
- Why did we miss some?
  - Use of complex JavaScript features, such as `eval`
  - Code obfuscation by introducing extra layers of computation
  - Limitations of the abstracter – work in progress!

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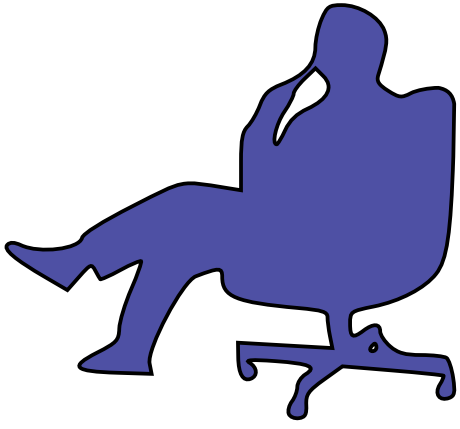
ProFoUnd

Conclusions

In brief

- Exploiting data from the deep Web in an automatic manner: non-trivial, largely open problem
- Classical techniques exploit both domain knowledge and the structure of forms and result pages
- Possible to get very precise information about the behavior of Web forms by static analysis of client-side code

Perspectives



- Use a real JS parser (Rhino has lots of limitations); trying with SpiderMonkey, Mozilla's JS engine
- Large-scale evaluation, application to deep Web crawling
- Type inference for form fields: regular expressions, simple datatypes
- Combining with dynamic analysis
- Type inference for AJAX applications: static analysis of AJAX calls to determine input and output types (possibly JSON or XML types)

PhD Opportunity

PhD scholarship on this topic at U. Oxford, looking for excellent candidates!

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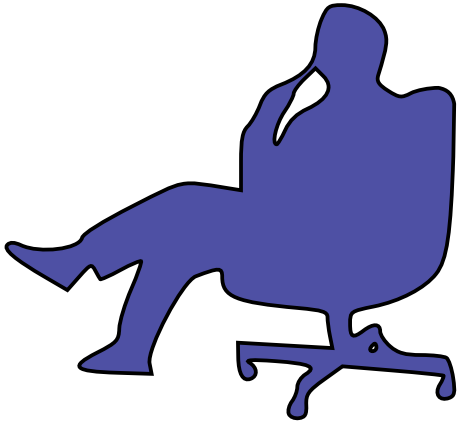

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Merci.

Michael Benedikt, Tim Furche, Andreas Savvides, and Pierre Senellart. ProFoUnd: Program-analysis–based form understanding. In *Proc. WWW*, Lyon, France, April 2012. Demonstration.

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