Practical Language-Independent Detection of Near-Miss Clones

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Motivation

- Clones occur in any non-trivial application
- Studying clones can help us to understand how programmers use and re-use code
  - **Clones are more than just textually identical pieces of code**
- Near miss clones help identify how code propagates through an application and how it evolves

Clones

- Understanding of clones is useful
  - **Not all clones are bad nor should they all be removed**
- Exact clones have a clear definition
- Near miss clones are more difficult
  - **How close is close?**
  - **Are some changes more important than others?**

Clone Detection (Independent)

- Lexical Approaches [Baker93][Kamiya02]
  - **Substring comparisons**
  - **Independent of structural elements of the language**
- Neural Nets [Davey95]
  - **Language independent**
  - **Requires training sets and training time**

Clone Detection (Dependent)

- Concept Analysis[Kontogiannis96]
  - **Procedure and ADT level**
- AST Based [Baxter98]
- Metrics [Mayrand96]
  - **Procedure level**
- Slicing [Komondoor01]
  - **Finds non-contiguous, but does not handle near miss**
- Dependence Graph [Krinke01][Chen03]
  - **Both syntactic structure and data flow**

Why HTML?

- HTML is a prime candidate for clones
- Tools to reuse HTML are limited
  - **Requires server or client side scripts**
  - **Not really part of HTML itself**
- WYSIWYG tools such as Netscape editor, Dreamweaver and others promote cloning
  - **Copy/paste**

Why HTML?

- Web pages are expected to have a common look and feel (need for common HTML elements)
  - **CSS not sufficient**
- Many web designers have not been exposed to Software Engineering practices
  - **Graphic designers**

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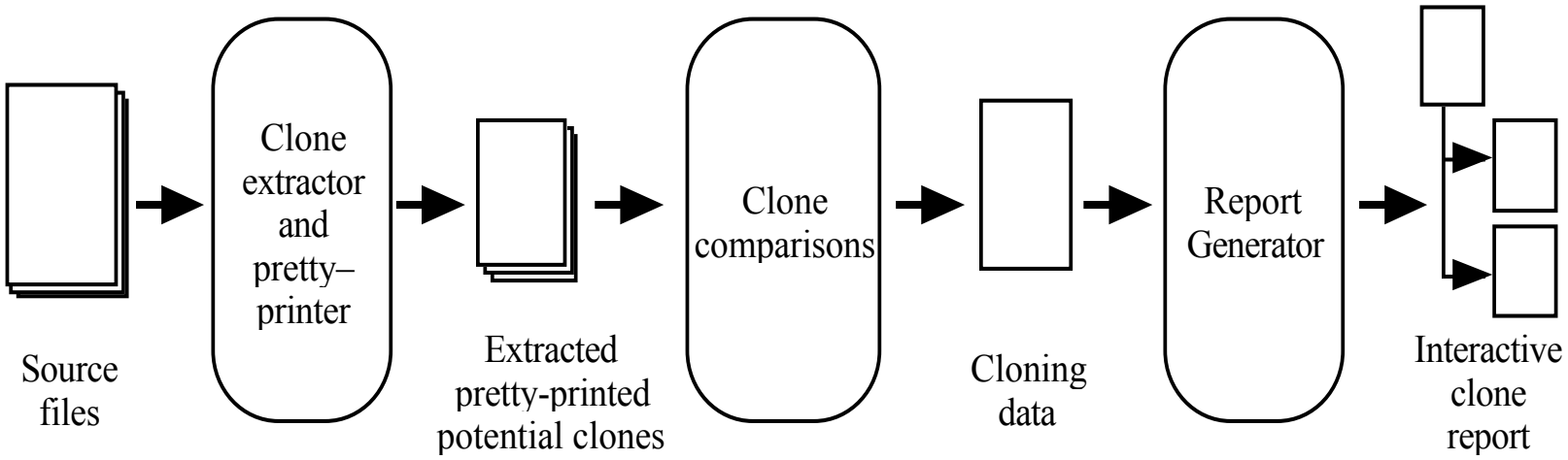
Last updated, February 17, 2004. Suggestions for improvement may be sent to thomas.dean@ece.queensu.ca

Mixing Lexical and Structural

- We mix the two levels in our approach
- Selection of potential clones is based on partial parses (island grammars)
- Clone identification is lexical
- Not semantic clones
  - **Looking for cut/paste/modify clones**

System Structure



Potential Clone Extraction

- Island Grammars[van Deursen99][Synytskyy03]
- Separate the token stream into interesting (islands) and uninteresting (water) segments
- Islands in a sea of water
  - **Pick out interesting elements in an otherwise uninteresting sequence of tokens**
- Nesting
  - **Islands can have lakes which can have smaller islands**

Islands

```
define program
  [repeat content]
end define

define content
      [interesting_element]
    | [uninteresting element]
end define
```

Islands

```
define interesting_element
        [table_element]
    |   [form_element]
end define

define uninteresting_element
     [token_or_key]
end define
```

Islands and Formatting

- Islands identify potential clones (tables & forms)
  - **extracted to individual files**
- Formatted to make best use of lexical tools
  - **Important elements get their own lines**
  - **Unimportant elements share lines**

```
<table
border=1
id="innerTable1"
>
<tr>
```

```
<td>
content of table cell
</td>
</tr>
</table>
```

Lexical Comparison

- Unix diff
  - **Ignore white space (indentation)**
  - **Ignore addition and deletion of blank lines**
- Threshold based on # of lines that change
  - **Number of unique lines / Total # of Lines**
  - **Experimentally set (tried up to 70% unique code)**
  - **30%**
- Diff finds longest common subsequences
  - **Some common lines are counted as different**

Lexical Comparison

- Special Cases
  - **Identical clones (0% difference)**
  - **Only one file has unique lines (addition/deletion)**
    - Experimentally found to be nesting, so discarded
- Sub clones
  - **Children of clones are clones?**
    - In identical clones, uninteresting
    - In near miss clones, interesting

Advantages

- No need for full language analysis
  - **Complete parses are not necessary**
  - **Semantic Analysis is not necessary**
  - **Less overhead**
- Islands are only used to identify potential clones
- Comparisons are Lexical
  - **Simplicity and speed**

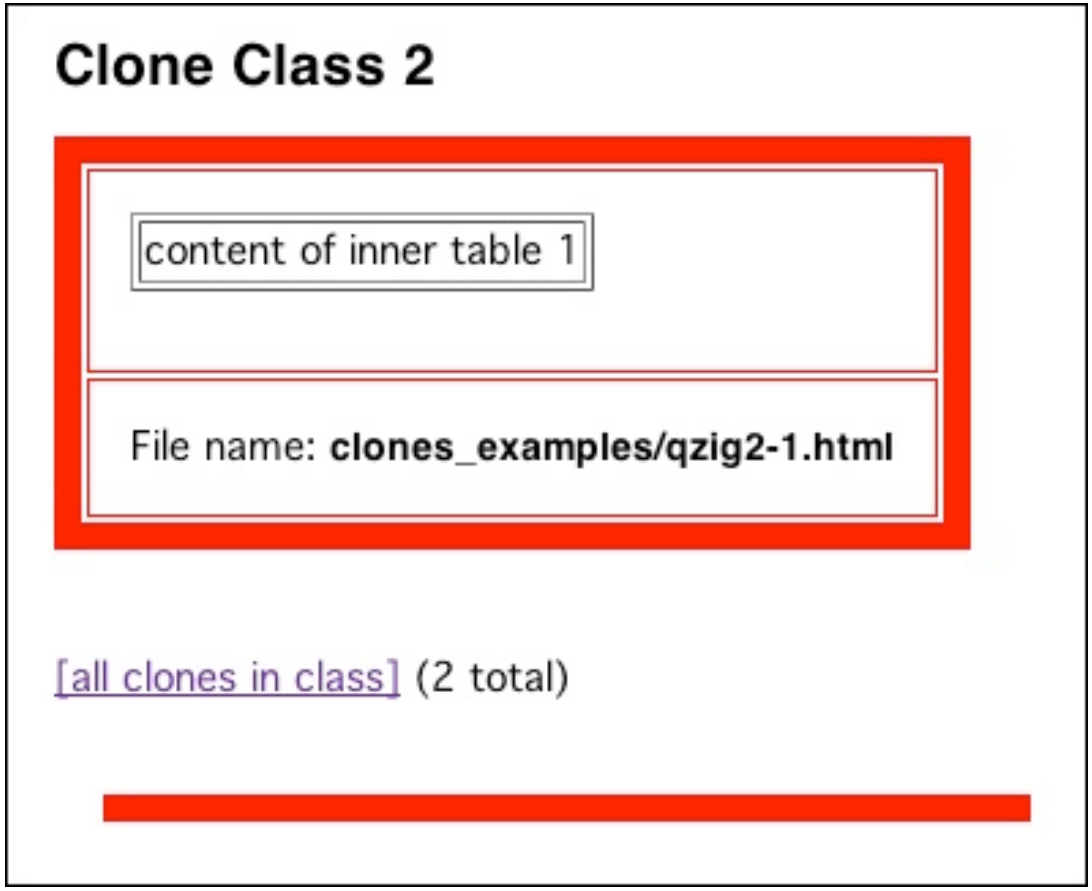
Optimization

- Many, many comparisons of files
  - **Run diff, count lines, compute ratio**
  - **Diff is primary cost >> reduce # of times diff is run**
- Size Restrictions
  - **Files must be comparable in size (max 200%)**
- Group matches into clone classes
  - **Distinguished element of class is the exemplar**
  - **Only compare to the exemplar, not to other members of the class**

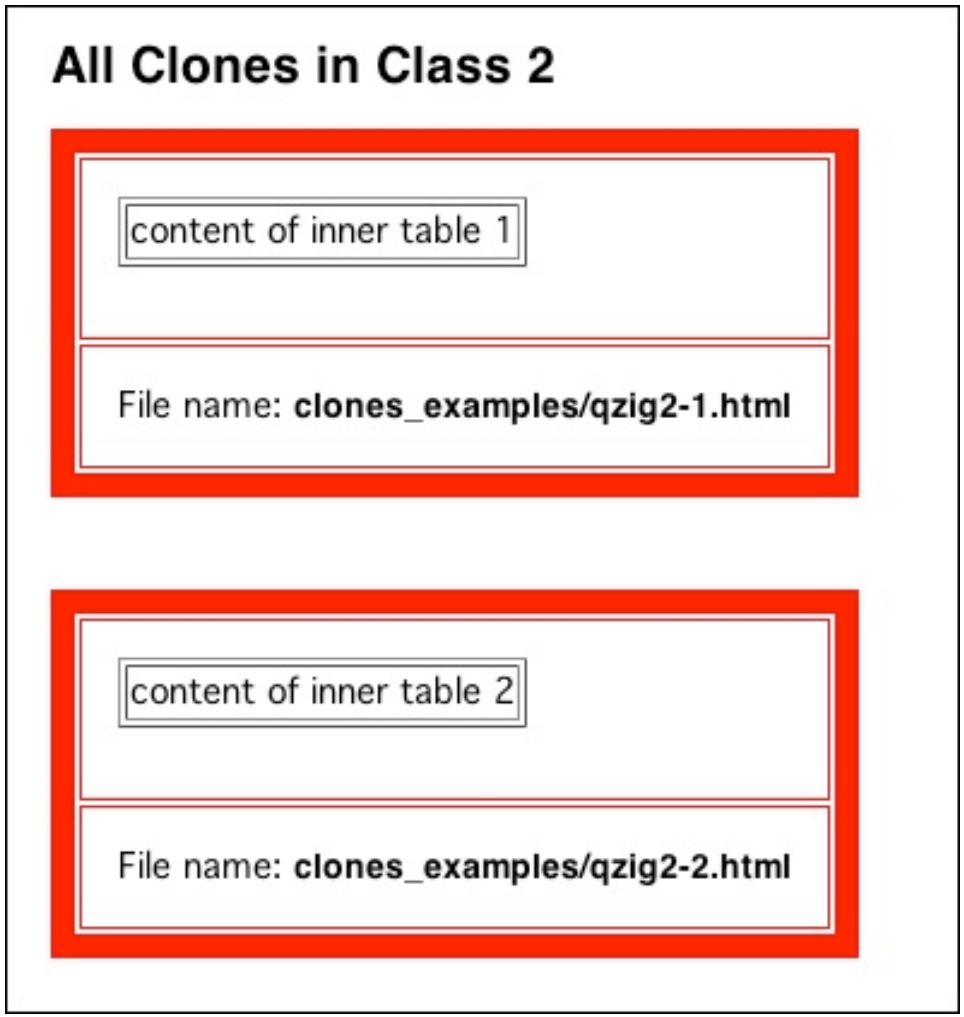
Reporting

- Difficult to execute clones in conventional programming languages in isolation from the whole program
  - **Execution results difficult to visualize**
  - **Must examine code view of clones**
- HTML elements are “executable” by the browser
  - **Can visualize directly**
- Clone Report
  - **One master page shows the exemplars**
  - **Each exemplar is linked to a page that shows all members of the clone class**

Reporting (Exemplar Page)



Reporting (Clone Class pages)



Case Study: Results

	SGPS	TXL
Lines of Code	10378	9436
Potential Clones	686	170
Comparisons	2543	883
Clone Classes	37	24
Time	5 mins	3.75 mins

Case Study: Stats

- 5.4% of potential clones unique in SGPS
- 23.5% of potential clones unique in TXL
- Does not represent true cloning rates since only islands considered as potential clones
  - **Water not included in statistics**
  - **Water could have clones, but we don't look for them (i.e. cloned text)**

Case Study: Types of Clones

- Look and Feel
  - **Large items such as navigation bars (SPGS)**
- Layout
  - **Smaller items, multiple items on a single page (Txl download links)**
- Whole Page
  - **Small clone classes, not a lot of page cloning in our sample set**

Future Work

- What is a near miss clone?
  - **min 70% code share (max 30% unique code) is an initial approximation**
  - **Not a good long term answer**
  - **Tunable parameter?**
- Any near miss clone metric is, to some extent, subjective

Future Work

- Clone Resolution
  - **Synytskyy, Cordy, Dean (WSE 2003)**
  - **Dynamic generation of clones using server side or client side scripting**
    - Parameterize changes
  - **Interactive authoring interface to fine tune clone detection and choose between resolution methods**

Questions?