

Automatic Generation of Artifacts for Two Web Application Testing Models

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The impetus

- Lots of web applications
- Web applications need testing
- Creating artifacts to test is slow work
- Artifacts → test cases also slow
- Slow, tedious web app testing →
no web app testing ☹
- So make testing easier

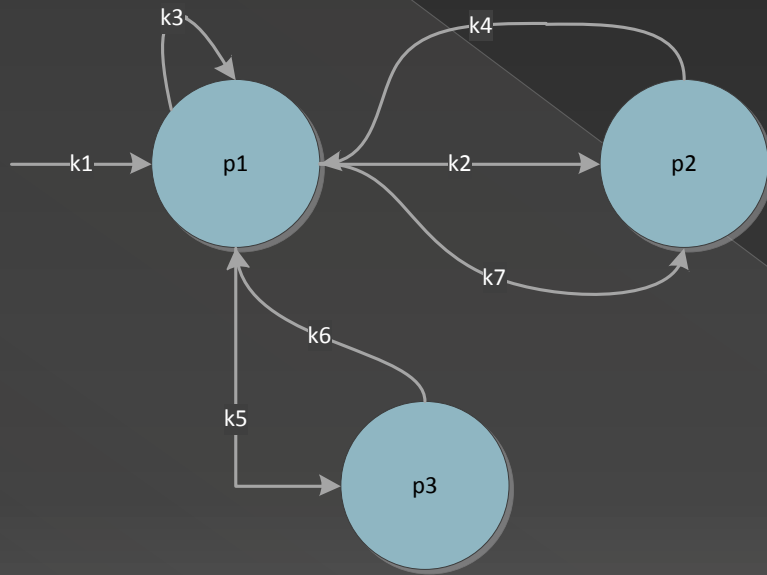
The project

- 2 web app testing models:
 - > Qian, Miao, Zeng Model (QMZ)
 - > Atomic Section Model (ASM)
- Write tools to generate artifacts:
 - > QMZ: test paths
 - > ASM: intermediate output that leads to test paths

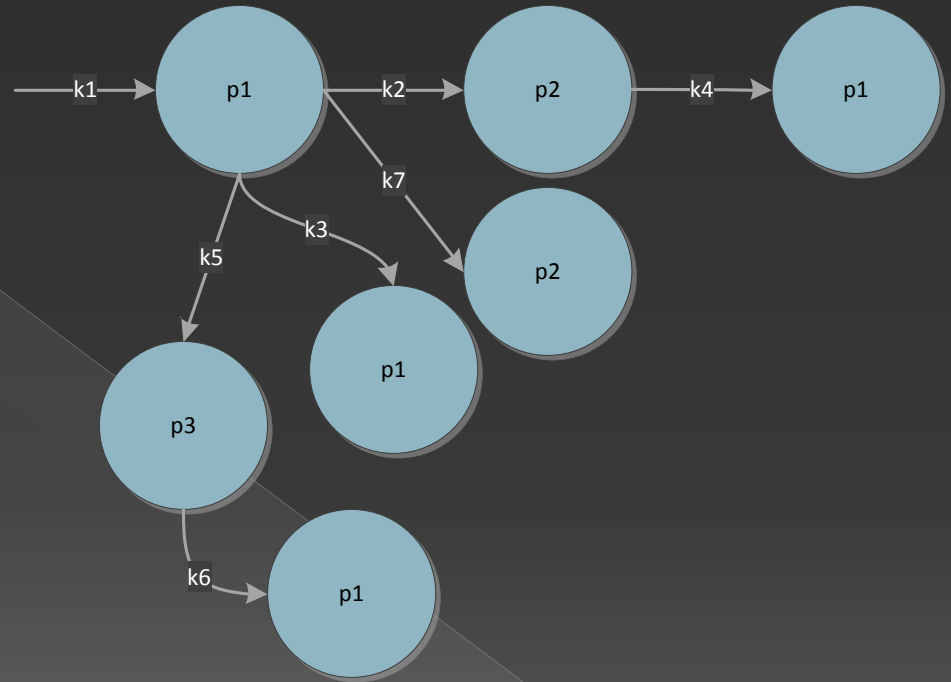
About QMZ

- Page Flow Diagram (PFD)
 - > Relationship among pages in web app
 - > Pages, transitions
 - > Can have cycles
- Page Test Tree (PTT)
 - > Built from PFD
 - > Acyclic
 - > Produces test paths

QMZ PFD v. PTT



PFD with cycles

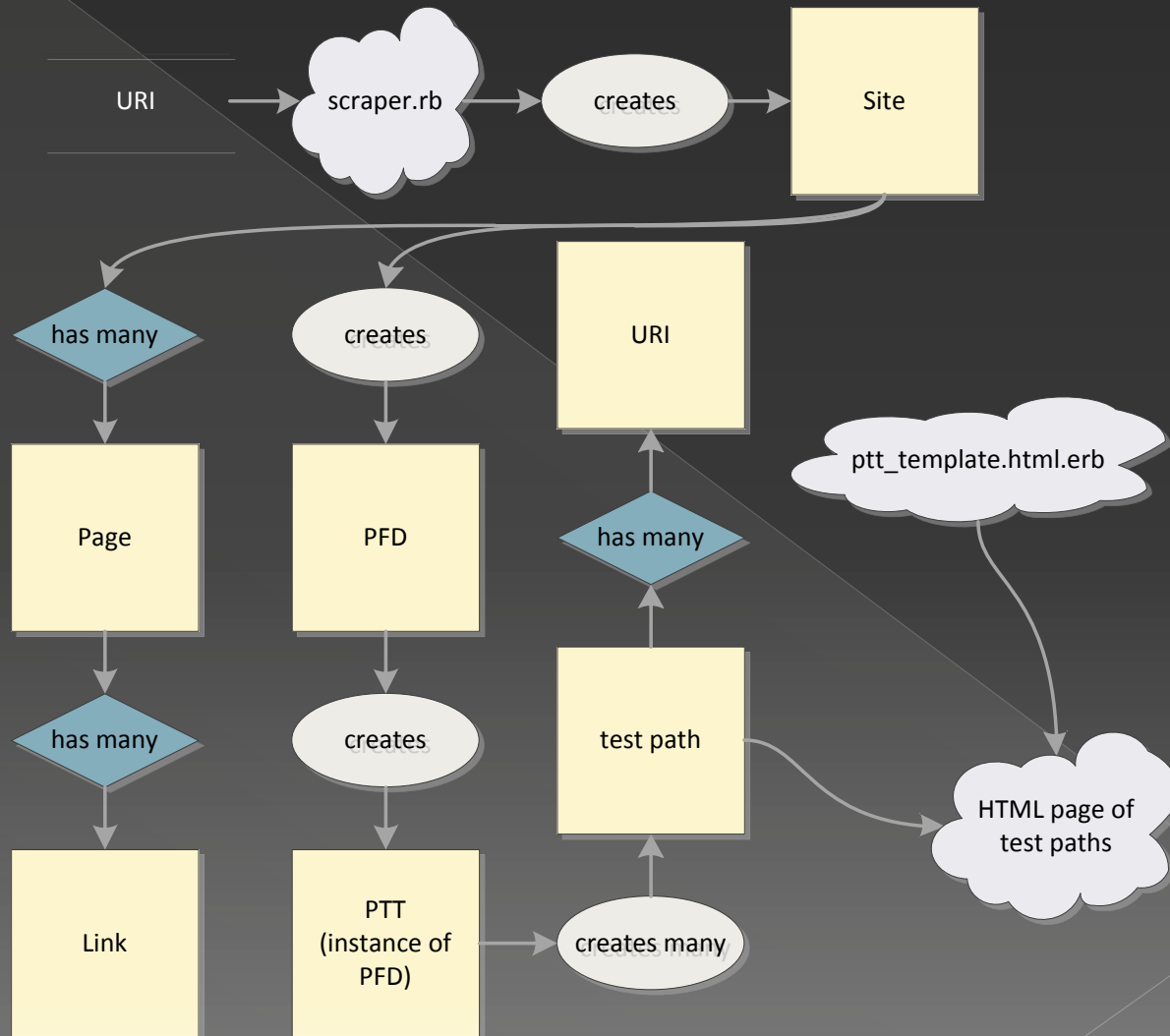


PTT without cycles

QMZ requirements

- ◉ Input: URI to web app
Output: list of test paths
- ◉ Scrape web pages, extract transitions
 - > Transition = link or form
- ◉ Construct PFD
- ◉ Transform to PTT
- ◉ Extract test paths from PTT

QMZ overview



QMZ implementation details

- ◉ Ruby 1.8.7 command-line script
- ◉ Web app language-agnostic
- ◉ YAML output to save progress
- ◉ Nokogiri 鋸 for HTML parsing
- ◉ ERB template for test path output
- ◉ Limitation: ignores JavaScript, AJAX

QMZ testing

- ◉ Run tool against known web apps
 - > Manual verification of test paths
- ◉ Run tool against unknown web apps
 - > Detect defects relating to:
 - Linked files (PDF, ZIP, non-HTML pages)
 - Link types (mailto, FTP)

QMZ output

```
>ruby scraper.rb -u
  "http://babyhealthlexington.org/"
Got URI http://babyhealthlexington.org/
Getting pages for site at
  http://babyhealthlexington.org/...
Got 8 new Pages linked from Page / (13 links)
.Got 2 new Pages linked from Page /wp-admin/ (3
links)
...Got error '405 Method Not Allowed' trying to
open URI http://babyhealthlexington.org/wp-
comments-post.php, skipping...
Got 3 new Pages linked from Page /2009/01/21/hello-
world/ (14 links)
..Got 1 new Page linked from Page
  /2009/01/21/hello-world/comment-page-1/ (14
links)
.Got 6 new Pages linked from Page
  /es/2009/01/21/hello-world/comment-page-1/ (14
links)
.....Got 21 pages for site at
  http://babyhealthlexington.org/

Pages in site rooted at
  http://babyhealthlexington.org/:
  /
  /wp-admin/
  /2009/01/21/hello-world/
  /category/updates/
```

```
  /es/
  /links/
  /people/
  /mission-statement/
  /history/
  /wp-login.php
  /wp-login.php?action=lostpassword
  /2009/01/21/hello-world/trackback/
  /2009/01/21/hello-world/comment-page-1/
  /es/2009/01/21/hello-world/
  /es/2009/01/21/hello-world/comment-page-1/
  /es/2009/01/21/hello-world/trackback/
  /es/category/updates/
  /es/links/
  /es/people/
  /es/mission-statement/
  /es/history/
```

```
Getting PFD for site
  http://babyhealthlexington.org/...
Converting PFD to PTT...
Writing HTML file with test paths to
  http.babyhealthlexington.org/index.html...
File successfully written
```

QMZ results

Test Cases for <http://babyhealthlexington.org/>

Test Case #1

1. / Via Start page
2. /history/ Via History
3. /history/ Via History

Test Case #2

1. / Via Start page
2. /history/ Via History
3. /mission-statement/ Via Mission Statement

Test Case #3

1. / Via Start page
2. /history/ Via History
3. /people/ Via People

Test Case #4

1. / Via Start page
2. /history/ Via History
3. /links/ Via Links

Test Case #5

1. / Via Start page
2. /history/ Via History
3. / Via Home

Test Case #6

1. / Via Start page
2. /history/ Via History
3. /history/ Via English

Test Case #7

1. / Via Start page
2. /history/ Via History
3. /es/history/ Via Español

Test Case #180

1. / Via Start page
2. /wp-admin/ Via Log in
3. /wp-login.php?action=lostpassword Via Lost your password?
4. /wp-login.php?action=lostpassword Via Get New Password

Test Case #181

1. / Via Start page
2. /wp-admin/ Via Log in
3. / Via â†š Back to Baby Health Service

Test Case #182

1. / Via Start page
2. /wp-admin/ via Log in
3. /wp-login.php via Log In
4. /wp-login.php?action=lostpassword Via Lost your password?

Test Case #183

1. / Via Start page
2. /wp-admin/ via Log in
3. /wp-login.php via Log In
4. / Via â†š Back to Baby Health Service

Test Case #184

1. / Via Start page
2. /wp-admin/ via Log in
3. /wp-login.php via Log In
4. /wp-login.php via Log In

Test Case #185

1. / Via Start page
2. / Via Search

Future work: QMZ

- Expand tool to take credentials
 - > Use sessions
 - > Allow further traversal of web app
- Take screenshots to partially automate testing
 - > One screenshot per transition
 - > Display alongside test paths

About ASM

- Component Interaction Model (CIM)
 - > “Individual HTTP requests to the server”¹ = pages
- Application Transition Graph (ATG)
 - > “Model of the entire web application”¹
- ATG outside scope of project, focus on CIM

¹ Offutt, Jeff and Wu, Ye, “Modeling Presentation Layers of Web Applications for Testing”, Springer's Software and Modeling, DOI: 10.1007/s10270-009-0125-4.

About CIM

- ◉ Atomic sections
 - > Labeled $p_1 \dots p_n$
- ◉ Transitions
 - > Forms, hyperlinks
- ◉ Component expression
 - > Represents web page
 - > Combines atomic sections:
 - Selection, sequence, iteration, aggregation
 - > Ex.: $(p_1 \mid p_2).p_3.p_4^*.\{p_5\}$

Atomic sections, component expressions

ERB file

```
<% if @list.empty? %>
  <p>No values</p>
<% else %>
  <h1>Lots of values!</h1>
<% end %>
<h2>Content</h2>
<% @list.each do |value| %>
  <%= value %><br/>
<% end %>
<%= render :partial =>
  'list_footer' %>
```



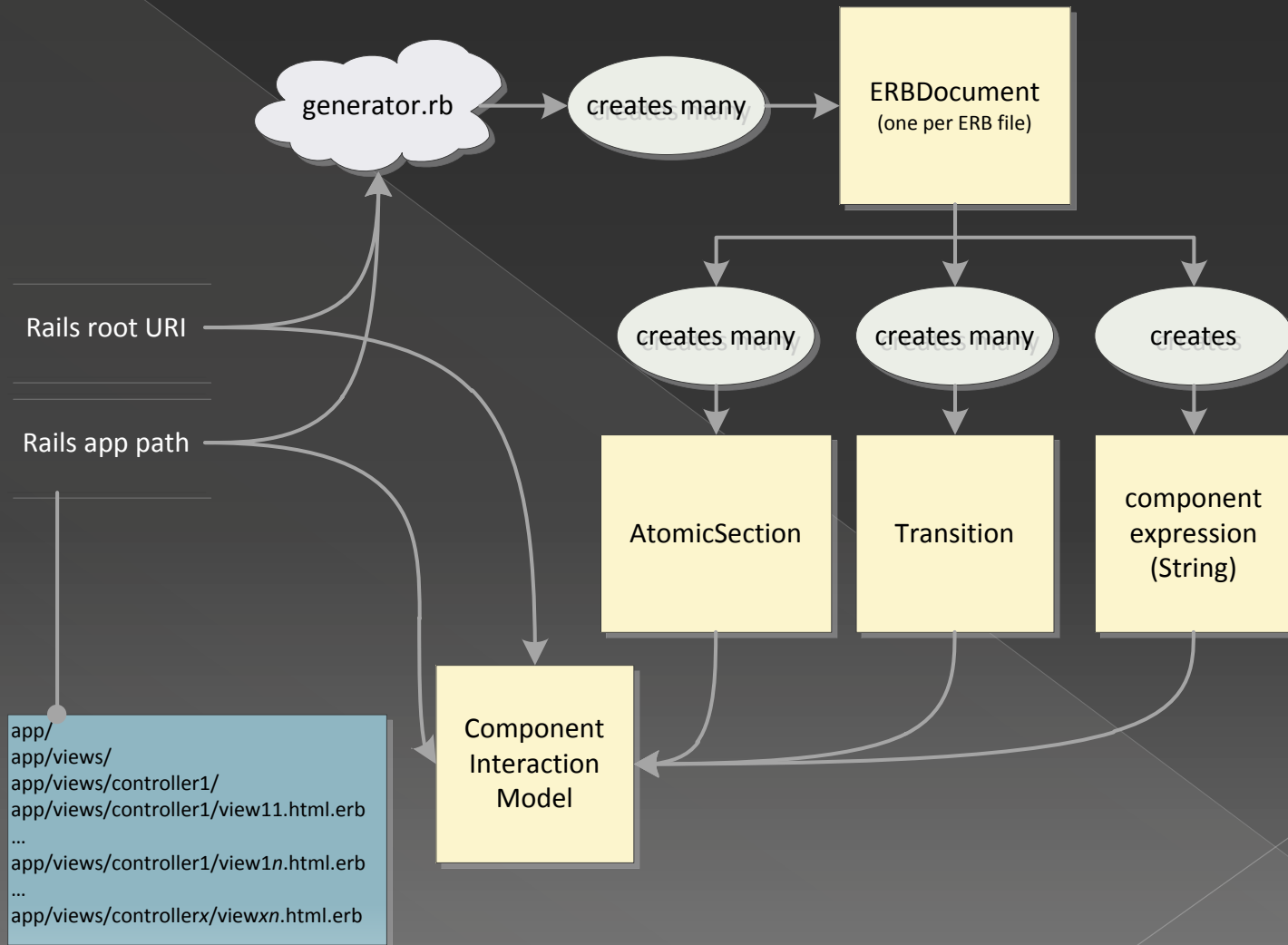
Component expression

(p1 | p2).p3.p4*.{p5}

ASM requirements

- Input: Rails ERB file(s), URI to web app
Output: one CIM per file
- Identify atomic sections
- Construct component expression
- Identify transitions
- Output CIM(s)

ASM overview



ASM implementation details

- ◉ Ruby 1.8.7 command-line script
- ◉ Targets Ruby on Rails web apps
- ◉ Nokogiri 鋸 for HTML parsing
- ◉ Treetop for ERB parsing
- ◉ ruby_parser for Ruby parsing
- ◉ Limitation: ignores JavaScript, AJAX*

* Except Rails methods `form_remote_tag`, etc.

ASM testing

- ◉ Test::Unit unit tests
 - > Mainly for component expressions
- ◉ Known Rails app
- ◉ Unknown Rails apps found on Github
- ◉ Generate CIM for file, manually verify correctness
- ◉ Wrong component expression → new unit test

ASM single-file output

```
>ruby single_file_generator.rb
app\views\test\_feedback.html.erb
"http://example.com"
Parsing ERB file
app\views\test\_feedback.html.erb...
Source file:
app\views\test\_feedback.html.erb
0: handled_style = feedback.is_handled ==
  0 ? "unhandled_feedback" : ""

1: Atomic Section #1 (indices 1..3):
  1: div id => "feedback_<%=
    feedback.id.to_s %>", class =>
      "feedback_item <%= handled_style %>"

  2: div class =>
    "listed_full_width_object"

  3: div class =>
    "listed_feedback_checkbox"

4-10: if feedback.is_handled == 0
  Content and sections:
    5: Atomic Section #2 (indices 5..7):
      5: div class =>
        "handle_feedback_button"

      6: <%= link_to "Mark as handled",
        handle_admin_feedback_path(feedback)
        , :method => :put
      7: /div

  8: else
    Content and sections:
      9: Atomic Section #3 (indices
        9..9):

      9: &nbsp;

      Close:
        10: end

      11: Atomic Section #4 (indices 11..13):
        11: /div
        12: div class => "listed_feedback_field"

        13: b

      14-20: if feedback.author_id ==
        "Anonymous"
        Content and sections:
          15: Atomic Section #5 (indices 15..15):
            15: Anonymous

          16: elsif feedback.author_id ==
            "virheilmoitus500"
            Content and sections:
              17: Atomic Section #6 (indices
                17..17):
                17: Errorpage500

            18: else
              Content and sections:
                19: Atomic Section #7 (indices
                  19..19):
                  19: <%= feedback.author_id

              Close:
                20: end

      21: Atomic Section #8 (indices 21..33):
        21: /b

        22: /div
        23: div class => "listed_feedback_field"

        24: <%=
          feedback.created_at.to_formatted_s(:
            basic_date_format_minutes)
        25: /div
        26: div class =>
          "listed_feedback_field_wider"

        27: <%= feedback.url
        28: /div
        29: div class =>
          "listed_feedback_content"

        30: <%=
          text_with_line_breaks(feedback.conte
            nt)
        31: /div
        32: /div
        33: /div

        Component Interaction Model
          Start page:
            app\views\test\_feedback.html.erb
          Start URL:
            http://example.com/test/_feedback
          Component expression:
            p1.(p2|p3).p4.(p5|p6|p7).p8
          Transitions:
```

ASM entire-app output

```
> ruby .\generator.rb draganc-asi-da1935f
"http://example.com"
Looking in directory draganc-asi-
da1935f/app/views
Looking in directory draganc-asi-
da1935f/app/views/user_mailer
Parsing ERB file draganc-asi-
da1935f/app/views/user_mailer/
welcome.erb...

-----
No data in file draganc-asi-
da1935f/app/views/messages/ create.erb,
skipping
Looking in directory draganc-asi-
da1935f/app/views/layouts
Parsing ERB file draganc-asi-
da1935f/app/views/layouts/
_version.html.erb...
Component Interaction Model
  Start page: draganc-asi-
da1935f/app/views/layouts/
_version.html.erb
  Start URL:
http://example.com/layouts/_version
  Component expression: p1.{p2}
  Transitions:

-----
Parsing ERB file draganc-asi-
da1935f/app/views/coreui/profile/
new.html.erb...
Component Interaction Model
  Start page: draganc-asi-
da1935f/app/views/coreui/profile/
new.html.erb
  Start URL:
http://example.com/coreui/profile/new
  Component expression: (p1|NULL).{p2}.p3
  Transitions:
Form Transition

-----
Parsing ERB file draganc-asi-
da1935f/app/views/coreui/profile/
link.html.erb...
Component Interaction Model
  Start page: draganc-asi-
da1935f/app/views/coreui/profile/
```

```
link.html.erb
  Start URL:
http://example.com/coreui/profile/link
  Component expression: p1
  Transitions:

-----
Parsing ERB file draganc-asi-
da1935f/app/views/coreui/profile/
edit.html.erb...
Component Interaction Model
  Start page: draganc-asi-
da1935f/app/views/coreui/profile/
edit.html.erb
  Start URL:
http://example.com/coreui/profile/edit
  Component expression:
p1.p2.(p3|p4).p5.p6.p7.p8.p9.(p10|p11).p1
2

-----
Parsing ERB file draganc-asi-
da1935f/app/views/coreui/profile/
destroy.html.erb...
Component Interaction Model
  Start page: draganc-asi-
da1935f/app/views/coreui/profile/
destroy.html.erb
  Start URL:
http://example.com/coreui/profile/destroy
  Component expression: p1
  Transitions:

-----
Parsing ERB file draganc-asi-
da1935f/app/views/application/
index.html.erb...
Component Interaction Model
  Start page: draganc-asi-
da1935f/app/views/application/
index.html.erb
  Start URL:
http://example.com/application/index
  Component expression: p1.(p2|NULL).p3
  Transitions:
Link Transition
<http://example.com/application/index> -->
<http://example.com/test>
```

```
Underlying code:
<a href="/test">

-----
Link Transition
<http://example.com/application/index> -->
<http://example.com/doc/sms>
Underlying code:
<a href="/doc/sms">
Looking in directory draganc-asi-
da1935f/app/views/application/doc
Parsing ERB file draganc-asi-
da1935f/app/views/application/doc/
tutorial.html.erb...
Component Interaction Model
  Start page: draganc-asi-
da1935f/app/views/application/doc/
tutorial.html.erb
  Start URL:
http://example.com/application/doc/
tutorial
  Component expression: p1
  Transitions:
Link Transition
<http://example.com/application/doc/
tutorial> --> <http://example.com/test>
Underlying code:
<a href="/test">
Link Transition
<http://example.com/application/doc/
tutorial> -->
<http://example.com/doc/session>
Underlying code:
<a href="/doc/session">

-----
```

Future work: ASM

- ◉ Incorporate layouts into component expressions
- ◉ Include partials' component expressions in parent component expression
- ◉ Recognize branching in ERB output tags
- ◉ Combine CIMs into ATG, generate test paths

Project statistics

- ◉ ASM tool
 - > 2,699 lines of code (LOC)
 - > 241 lines of comments
 - > 47 files
- ◉ QMZ tool
 - > 590 LOC
 - > 35 lines of comments
 - > 8 files
- ◉ 108 commits, 9,067 additions, 369 deletions

Conclusion

- No more manual:
 - > Traversal of web app – QMZ tool identifies paths available to user
 - > Identification of atomic sections and transitions, construction of component expression – ASM tool does this
- Automated test artifact generation → easier testing → more testing (we hope!)

Demo

Questions?