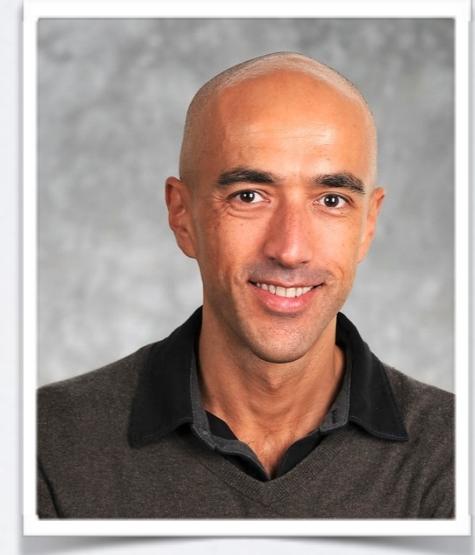
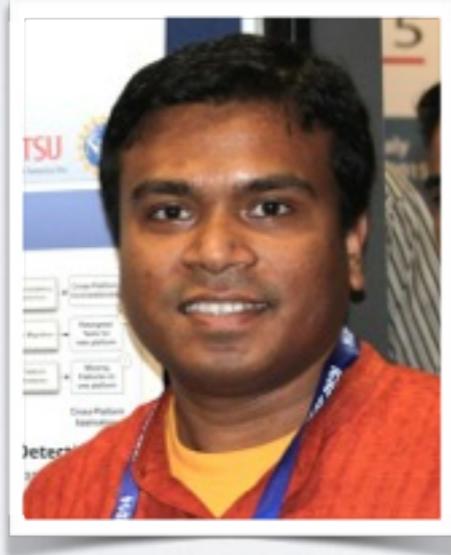




CROSS-PLATFORM FEATURE MATCHING FOR WEB APPLICATIONS



Shauvik Roy Choudhary, Mukul Prasad, Alessandro Orso





facebook

twitter

tumblr

Blogger

ebay

amazon

Google

Baidu 百度



Google Docs

Microsoft Office Live
Office Live
Office Live



EC EasyChair
The conference system

ACM DL DIGITAL LIBRARY IEEE Xplore®
DIGITAL LIBRARY

usbank

TurboTax

MULTIPLE PLATFORMS



Desktop version



Mobile version

Different User Interfaces for best user experience
Different Features (often missed unintentionally)

MISSING FEATURES



Desktop

Screenshot of the WordPress desktop editor interface:

- Left Sidebar:** Includes links for Dashboard, Posts (highlighted in blue), All Posts, Add New, Categories, Tags, Media, Pages, Comments, Appearance, Plugins (1), Users, Tools, Settings, and Collapse menu.
- Header:** Shows "MyWordpress", a refresh icon (6), a comment icon (0), "New", "View Post", "Howdy, admin", "Screen Options", and "Help".
- Main Area:** "Edit Post" screen for a post titled "Hello world!". The content area contains "Hello world!" and "Welcome to WordPress. This is your first post. Edit or delete it, then start blogging!".
- Right Sidebar:** "Publish" section with "Status: Published", "Visibility: Public", and "Published on: Feb 14, 2014 @ 14:09". Buttons for "Move to Trash" and "Update".
- Bottom:** "Format" dropdown, "Categories" section (highlighted with a red box) showing "Uncategorized" checked, and "Tags" section (highlighted with a red box).



Mobile

Screenshot of the WordPress mobile editor interface:

- Header:** Shows the blog title "Tripleodeon" and "Just another WordPress weblog".
- Top Bar:** Includes "Overview", "New post", "Edit post", "Comments", "Switcher", "Settings", and "Log out".
- Main Area:** "Edit post" screen for a post titled "Simple 'on-server' mobile AJAX". The content area contains "Simple 'on-server' mobile AJAX", "Status: Published", and "Content" (containing "How your mobile site may not be much more complicated than building one with a data API or AJAX").
- Bottom:** "Apply" button, a note about using HTML tags, and footer links for "Powered by the WordPress Mobile Pack | Theme designed by nboj" and "Switch to our desktop site".

USER COMPLAINTS



jhannigan

Member

When adding a post via mobile device
I don't seem to see an option for adding media or



angeloca

Member

At this point I am sure that nobody
is supporting this plugin anymore.

I switched to WP-Touch several weeks ago



libbyh

Member

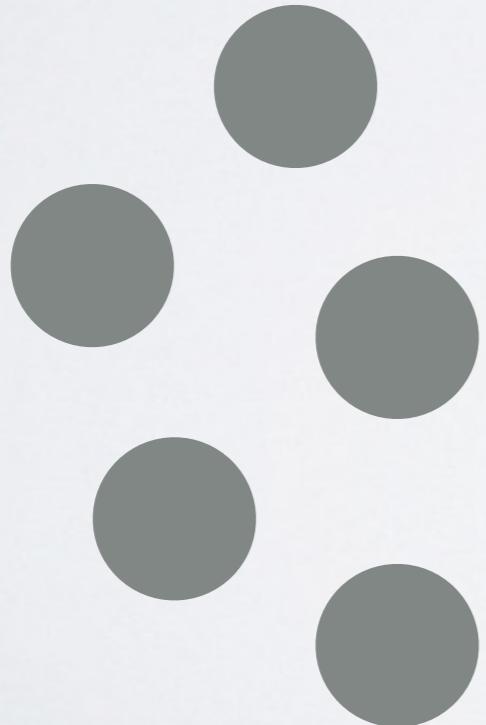
Is there a way ...? ... **the whole point of having a mobile theme was to make mobile access easier.**

PROBLEM

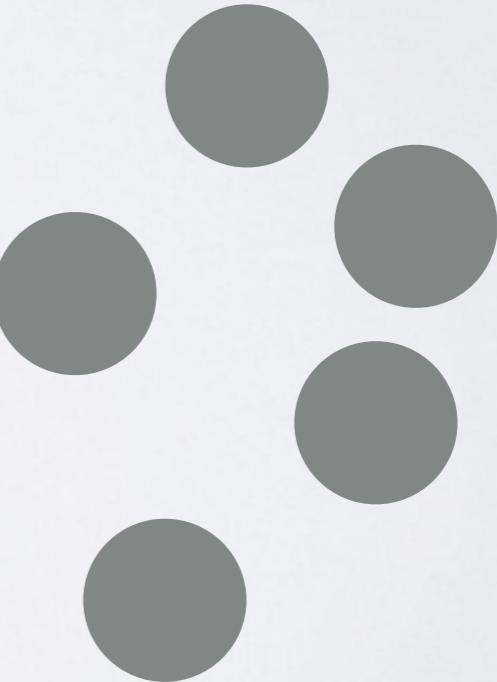
Find Missing Features



Desktop version



Mobile version



PROBLEM

Find Missing Features



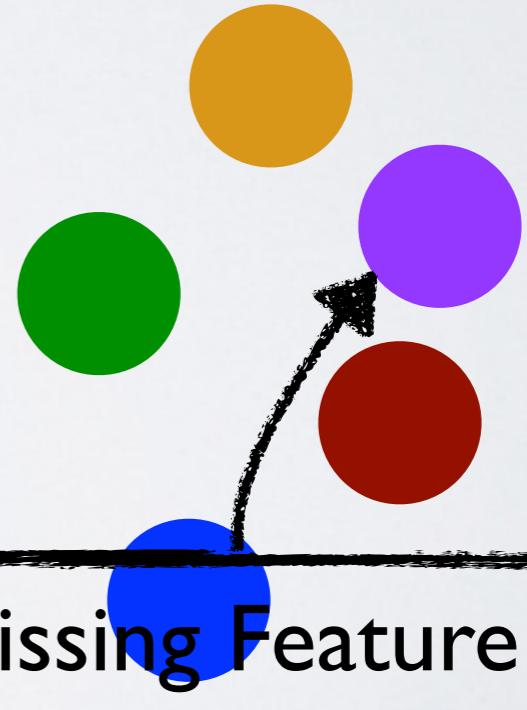
Desktop version



Missing Feature on Mobile



Mobile version



Missing Feature
on Desktop

CHALLENGE

The image displays two side-by-side screenshots of the Stack Overflow website. The left screenshot shows the original design with a light gray header and sidebar. The right screenshot shows a modified design with a dark blue header and sidebar. Both screenshots show the 'Top Questions' section and a 'CAREERS 2.0' sidebar.

Stack Overflow (Original Design - Left):

- Questions: 0 answers: 0 views: 1 Once i drop the image over the canvas. It gets stick to it. I want to again move it on the same canvas using wpf. (wpf) 51s ago user2767164 1
- Questions: 0 answers: 3 views: 1 How to arrange data in array by month and year (php zend-framework multidimensional-array) 55s ago Mausami 126
- Questions: 0 answers: 2 views: 1 how to model a relation between 2 OR 3 items? (sql database database-design relational-database) 1m ago Lem0n 381
- Questions: 0 answers: 2 views: 1 xdocument parsing C# specific fields (parsing linq-to-xml) 1m ago John Simmons
- Questions: 0 answers: 2 views: 1 Access static variables inside functions from main() without using global in C++ (c++ arrays pointers) 1m ago user7190 1
- Questions: 0 answers: 6 views: 1 Parsing xlsx file using 'roo' gem, Load Error: can not find zip/zipfilesystem (ruby-on-rails ruby ruby-on-rails-3.2 rubygems) 2m ago Ashwini 120

CAREERS 2.0 (Left):

- <p> ♥ Your Job </p>

Stack Overflow (Modified Design - Right):

- Questions: 0 answers: 1 mapping json returned from controller to strongly typed view (jquery asp.net asp.net-mvc jquery-ajax) 50 secs ago user20358
- Questions: 1 answer: 1 Is there a way to find out more detail about my database connection issue? (php debugging error-handling) 52 secs ago Phil
- Questions: 0 answers: 1 Using Source Code Control in Oracle SQL Developer (oracle oracle11g) 57 secs ago pradeep

CAREERS 2.0 (Right):

- Seeking sharp, passionate Developers ThoughtWorks Atlanta, GA / relocation
- Entry Level Developer ThoughtWorks Atlanta, GA / relocation
- DevOps/ Web Operations Engineer IgnitionOne Atlanta, GA / relocation
- More jobs near Atlanta...

Expected to look different

MOTIVATING EXAMPLE



Desktop Version

MakeMyPost.com

Username

Password

Remember me (highlighted)

MakeMyPost.com

(highlighted) Home Blog Pages

CREATE POST

Post Title (highlighted)

Post Type Blog Pages (highlighted)

Post Body (highlighted)



Mobile Version

MakeMyPost.com

Username

Password

MakeMyPost.com

(highlighted) Home (highlighted)

CREATE POST

MakeMyPost.com

(highlighted) Home (highlighted)

CREATE POST

Home
Blog
Post

OPPORTUNITIES



NETWORK TRACES

Desktop

- I. REQUEST: GET /index.php
2. RESPONSE: 200 OK, 'text/html'
3. REQUEST: GET /style.css
4. REONSE: 200 OK, 'text/css'
5. REQUEST: GET /logo.png
6. REONSE: 200 OK, 'image/png'
7. REQUEST: GET /script.js
8. REONSE: 200 OK, 'text/javascript'
9. REQUEST: POST /login.php
user=user1&pass=..&sid=w2s31
10. RESPONSE: 200 OK, 'text/html'

-
- II. REQUEST: POST /create_blog.php
title=..&content=..
12. RESPONSE: 200 OK, 'text/html'

Mobile

- I. REQUEST: GET /index.php
2. RESPONSE: 200 OK, 'text/html'
3. REQUEST: GET /mobile_style.css
4. REONSE: 200 OK, 'text/css'
5. REQUEST: GET /logo_small.png
6. REONSE: 200 OK, 'image/png'
7. REQUEST: GET /mobile_script.js
8. REONSE: 200 OK, 'text/javascript'
9. REQUEST: POST /login.php
user=myUser&pass=..&sid=d4sW2
10. RESPONSE: 200 OK, 'text/html'

-
- II. REQUEST: POST /create_blog.php
title=..&content=..
12. RESPONSE: 200 OK, 'text/html'

NETWORK TRACES

Desktop

- I. REQUEST: GET /index.php
2. RESPONSE: 200 OK, 'text/html'
3. REQUEST: GET **/style.css**
4. REPONSE: 200 OK, 'text/css'
5. REQUEST: GET **/logo.png**
6. REPONSE: 200 OK, 'image/png'
7. REQUEST: GET **/script.js**
8. REPONSE: 200 OK, 'text/javascript'

9. R

usei

10. I

....

- II. REQUEST: POST /create_blog.php
title=..&content=..
12. RESPONSE: 200 OK, 'text/html'

Mobile

- I. REQUEST: GET /index.php
2. RESPONSE: 200 OK, 'text/html'
3. REQUEST: GET **/mobile_style.css**
4. REPONSE: 200 OK, 'text/css'
5. REQUEST: GET **/logo_small.png**
6. REPONSE: 200 OK, 'image/png'
7. REQUEST: GET **/mobile_script.js**
8. REPONSE: 200 OK, 'text/javascript'

9. R

usei

10. I

....

- II. REQUEST: POST /create_blog.php
title=..&content=..
12. RESPONSE: 200 OK, 'text/html'

Platform-specific resources

NETWORK TRACES

Desktop

- I. REQUEST: GET /index.php
2. RESPONSE: 200 OK, 'text/html'
3. REQUEST: GET /style.css
4. REONSE: 200 OK, 'text/css'
5. REQUEST: GET "

Mobile

- I. REQUEST: GET /index.php
2. RESPONSE: 200 OK, 'text/html'
3. REQUEST: GET /mobile_style.css
4. REONSE: 200 OK, 'text/css'
5. REQUEST: GET "

Generated or User Data

6. REQUEST: 200 OK, 'text/javascript'
7. REQUEST: POST /script.php
8. RESPONSE: 200 OK, 'text/javascript'
9. REQUEST: POST /login.php
user=**user1**&pass=..&sid=**w2s31**
10. RESPONSE: 200 OK, 'text/html'
-
11. REQUEST: POST /create_blog.php
title=..&content=..
12. RESPONSE: 200 OK, 'text/html'

6. REQUEST: 200 OK, 'text/javascript'
7. REQUEST: POST /script.php
8. RESPONSE: 200 OK, 'text/javascript'
9. REQUEST: POST /login.php
user=**myUser**&pass=..&sid=**d4sW2**
10. RESPONSE: 200 OK, 'text/html'
-
11. REQUEST: POST /create_blog.php
title=..&content=..
12. RESPONSE: 200 OK, 'text/html'

NETWORK TRACES

Desktop

- I. REQUEST: GET /index.php
2. RESPONSE: 200 OK, 'text/html'
3. REQUEST: GET /style.css
4. REPONSE: 200 OK, 'text/css'
5. REQUEST: GET /logo.png
6. REPONSE: 200 OK, 'image/png'
7. REQUEST: GET /script.js
8. REPONSE: 200 OK, 'text/javascript'
9. REQUEST: POST /login.php
user=user1&pass=..&sid=w2s31
10. RESPONSE: 200 OK, 'text/html'

-
- II. REQUEST: POST /create_blog.php
title=..&content=..
12. RESPONSE: 200 OK, 'text/html'

Mobile

- I. REQUEST: GET /index.php
2. RESPONSE: 200 OK, 'text/html'
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5. REQUEST: GET /logo_small.png
6. REPONSE: 200 OK, 'image/png'
7. REQUEST: GET /mobile_script.js
8. REPONSE: 200 OK, 'text/javascript'
9. REQUEST: POST /login.php
user=myUser&pass=..&sid=d4sW2
10. RESPONSE: 200 OK, 'text/html'

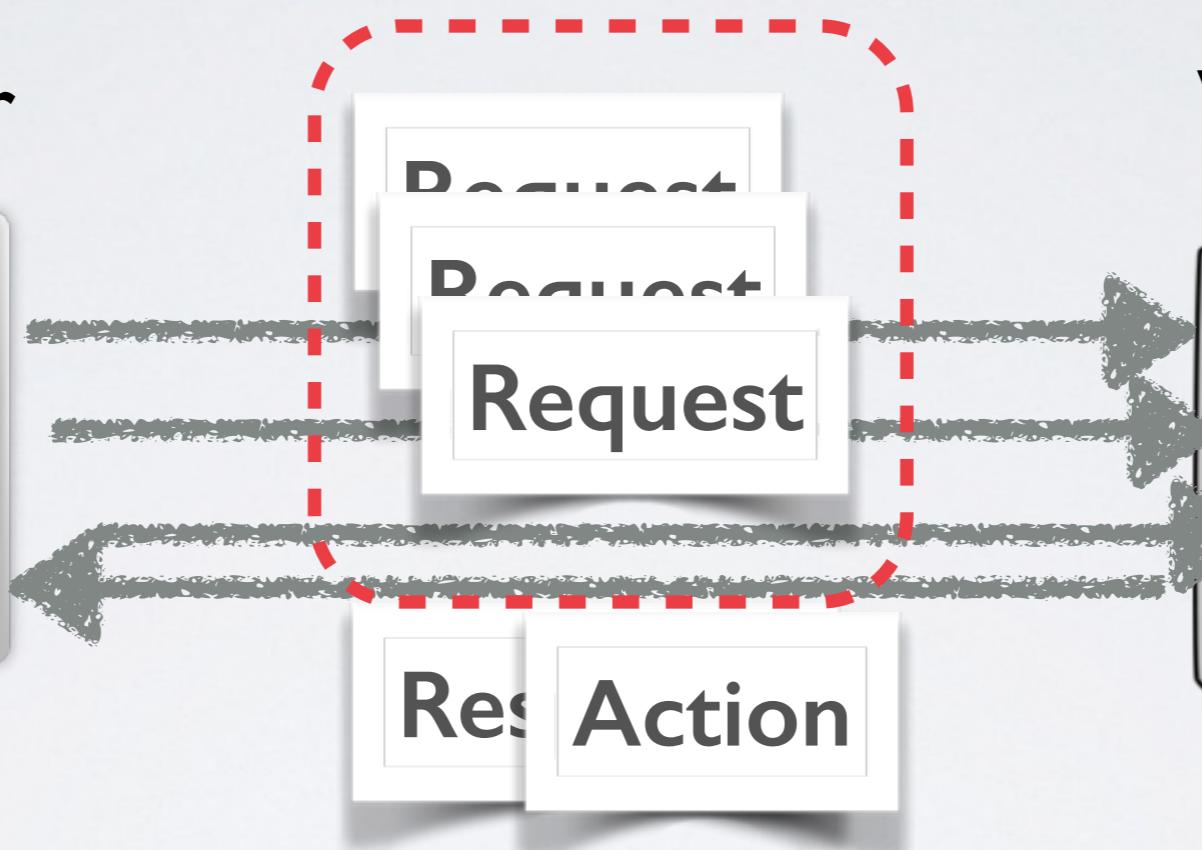
-
- II. REQUEST: POST /create_blog.php
title=..&content=..
12. RESPONSE: 200 OK, 'text/html'

TERMINOLOGY

Web browser



Web server



Trace = $\langle \text{req1}, \text{resp1} \rangle, \langle \text{req2}, \text{resp2} \rangle, \dots, \langle \text{reqN}, \text{respN} \rangle$

Service

Feature = Service1, Service2, ..., ServiceN

FEATURE EQUIVALENCE

- Two features from different platforms are equivalent, if they exercise the same set of services in the same sequence.



Desktop

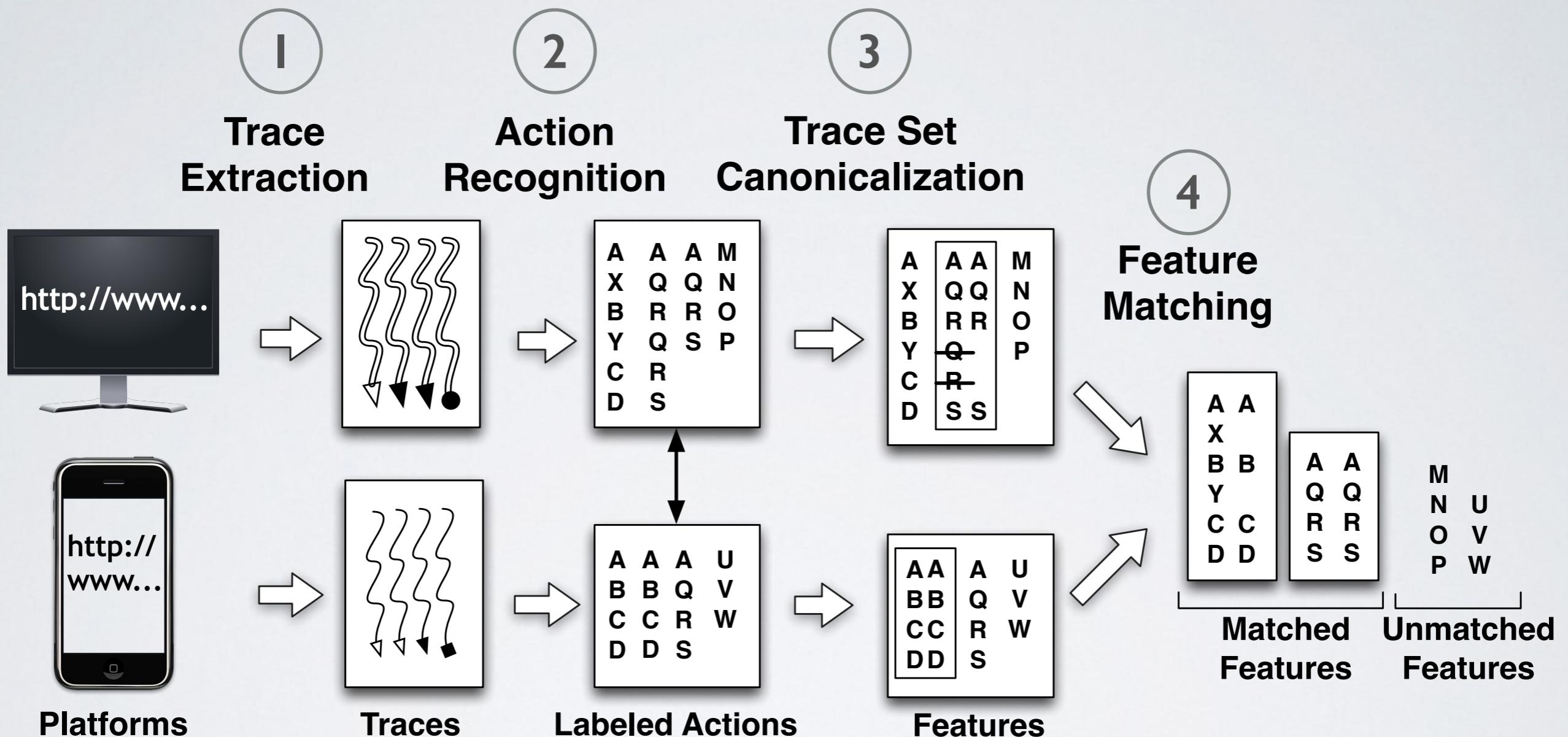
Action 1, Action2, ... ActionN
Feature = ~~Service1, Service2,... ServiceN~~



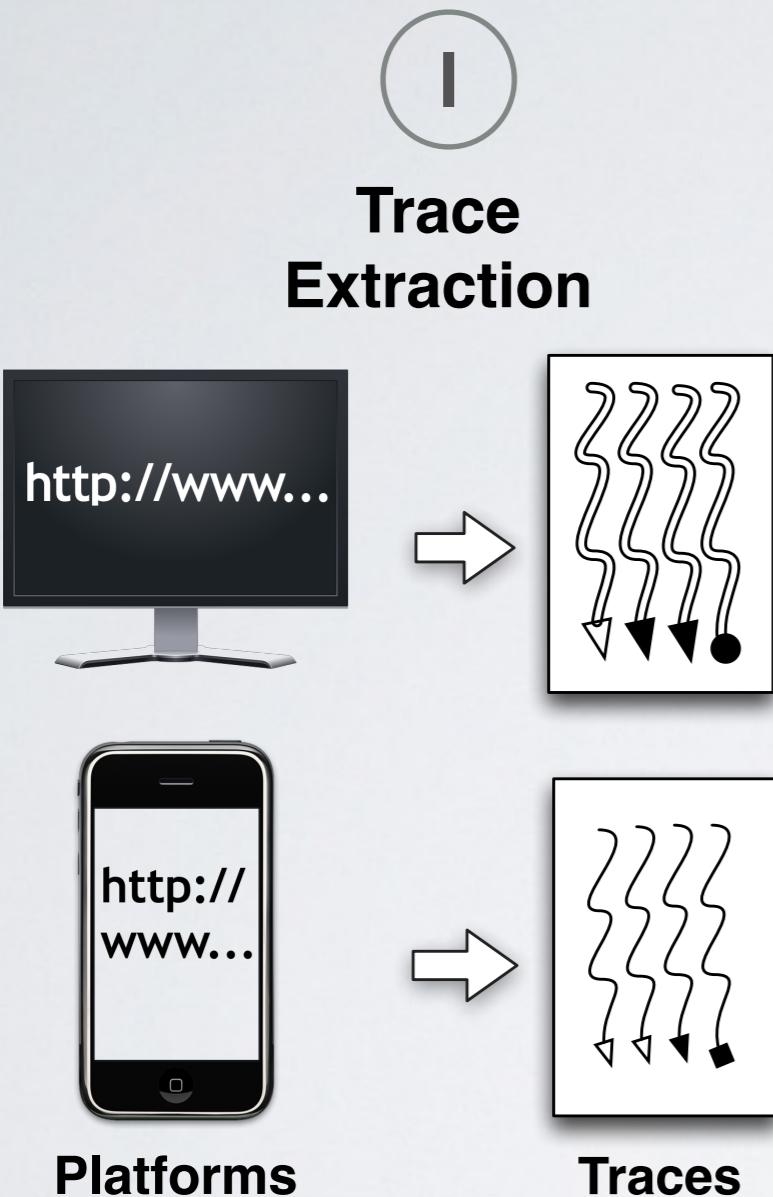
Mobile

Action 1, Action2, ... ActionN
Feature = ~~Service1, Service2,... ServiceN~~

APPROACH OVERVIEW



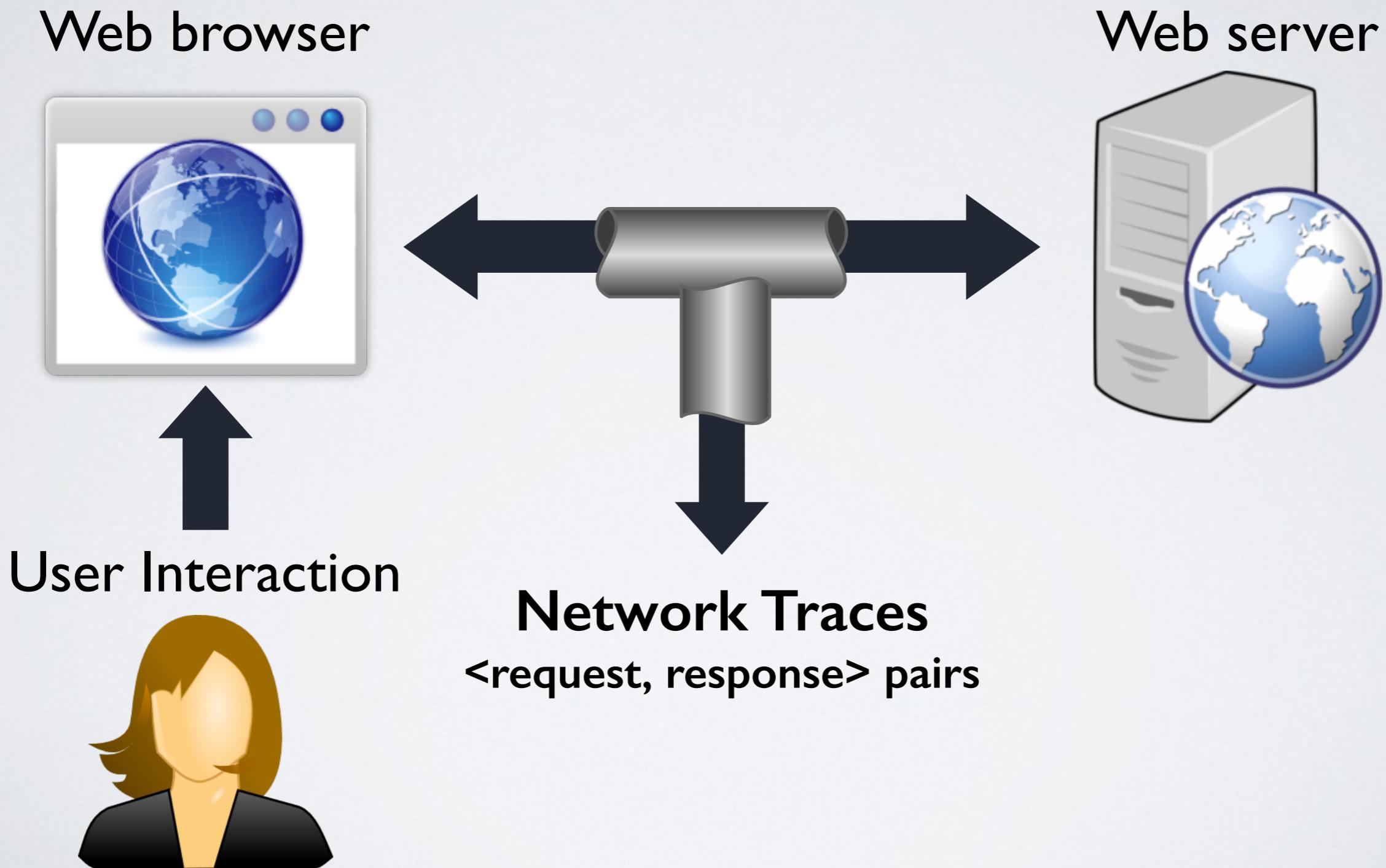
APPROACH OVERVIEW



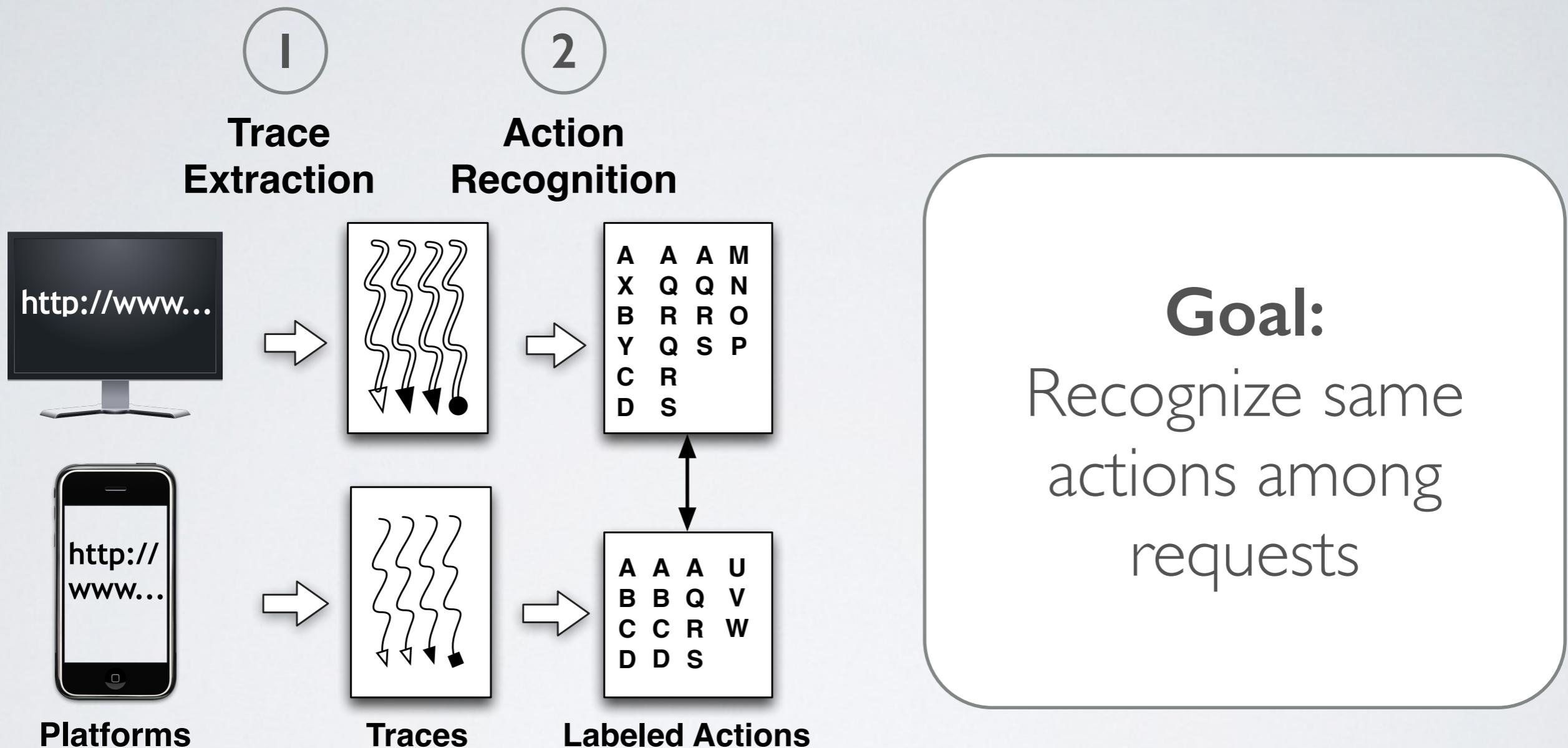
Goal:

Collect network traces for feature matching

I TRACE EXTRACTION



APPROACH OVERVIEW



2. ACTION RECOGNITION

1. REQUEST: GET /index.php
2. RESPONSE: 200 OK, 'text/html'
- ~~3. REQUEST: GET /style.css~~
4. RESPONSE: 200 OK, 'text/css'
- ~~5. REQUEST: GET /logo.png~~
6. RESPONSE: 200 OK, 'image/png'
7. REQUEST: GET /script.js
8. RESPONSE: 200 OK, 'text/javascript'
9. REQUEST: POST /login.php
user=user1&pass=..&sid=w2s31
10. RESPONSE: 200 OK, 'text/html'
-
11. REQUEST: POST /create_blog.php
title=..&content=..
12. RESPONSE: 200 OK, 'text/html'

Ignore requests
to stylistic resources

Domain specific
vocabulary to identify
keywords in requests

2. ACTION RECOGNITION

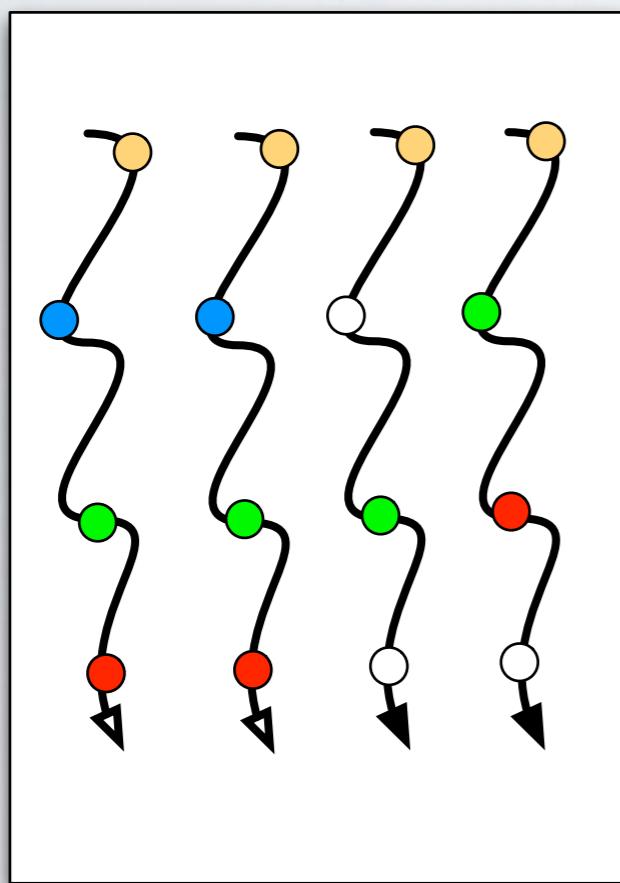
1. REQUEST: GET /index.html
2. RESPONSE: 200 OK, 'text/html'
3. REQUEST: GET /style.css
4. RESPONSE: 200 OK, 'text/css'
5. REQUEST: GET /logo.png
6. RESPONSE: 200 OK, 'image/png'
7. REQUEST: GET /script.js
8. RESPONSE: 200 OK, 'text/javascript'
9. REQUEST: POST /login.php
user user1&pass=pass1&sid=sid1
10. RESPONSE: 200 OK, 'text/html'
11. REQUEST: POST /create_blog.php
title title1&content=content1
12. RESPONSE: 200 OK, 'text/html'



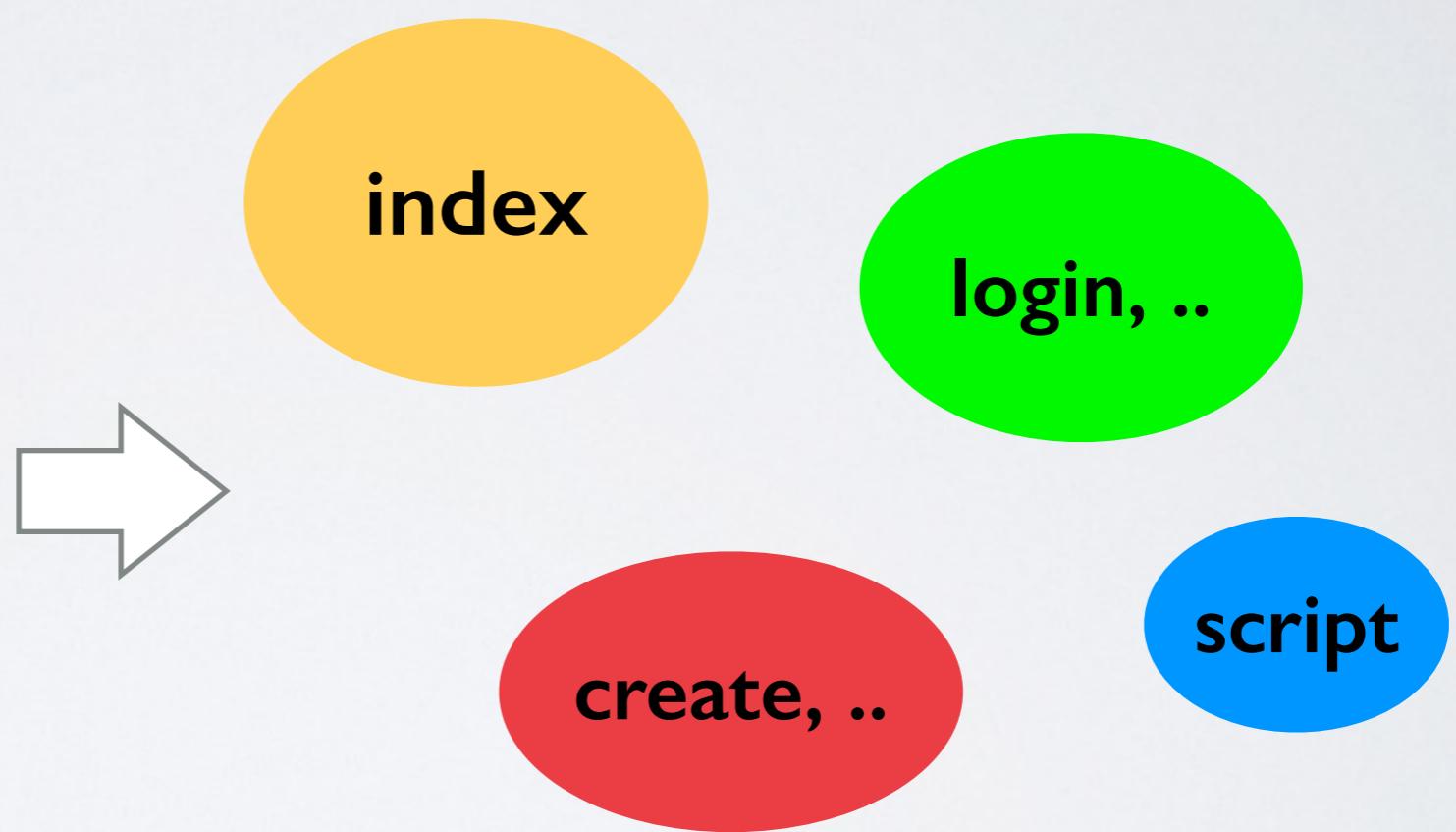
(‘index’),
(‘script’),
(‘login’, ‘user’, ‘pass’, ‘sid’),
(‘create’, ‘blog’, ‘title’, ‘content’)

Keywords

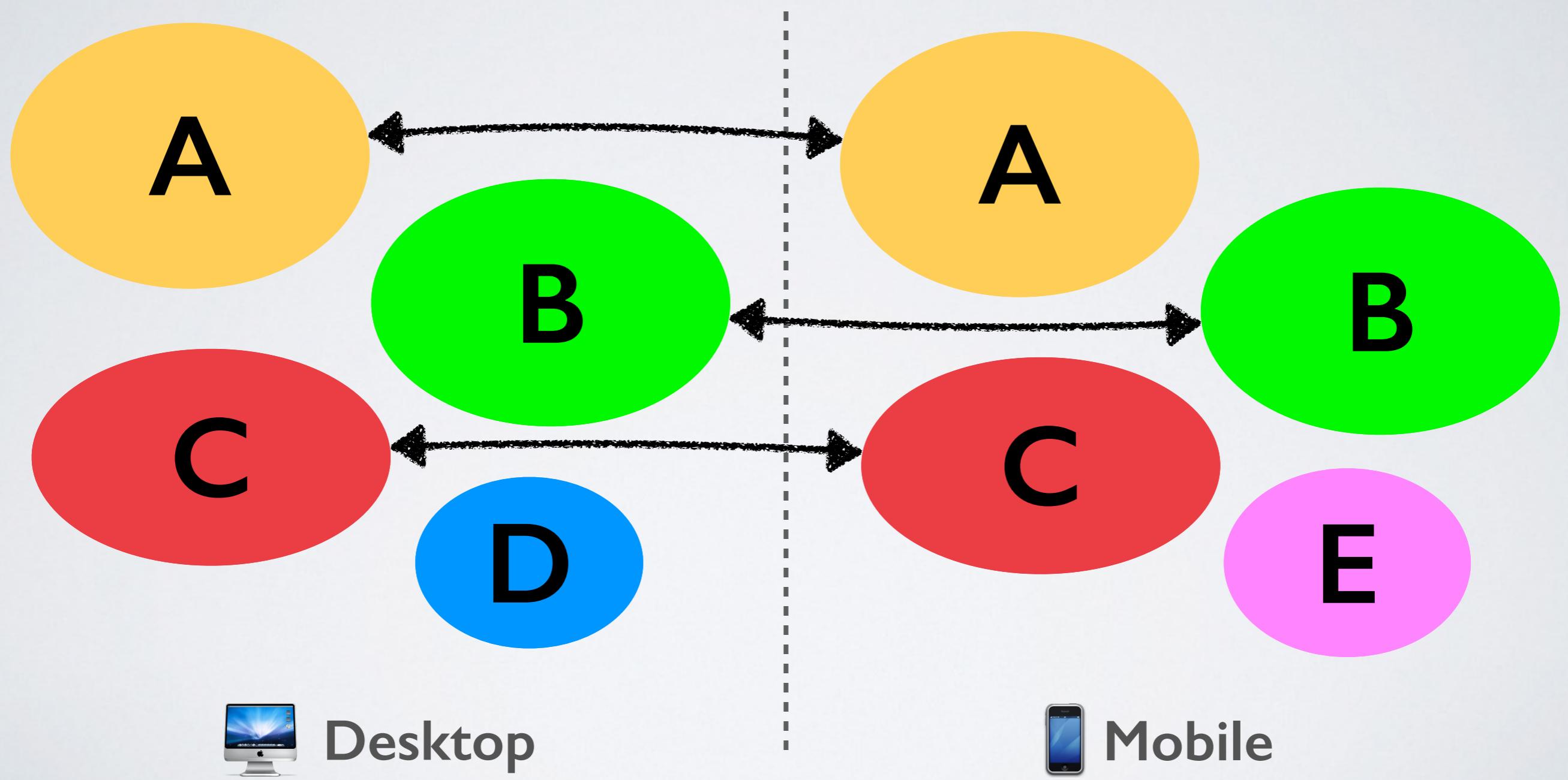
2. ACTION RECOGNITION



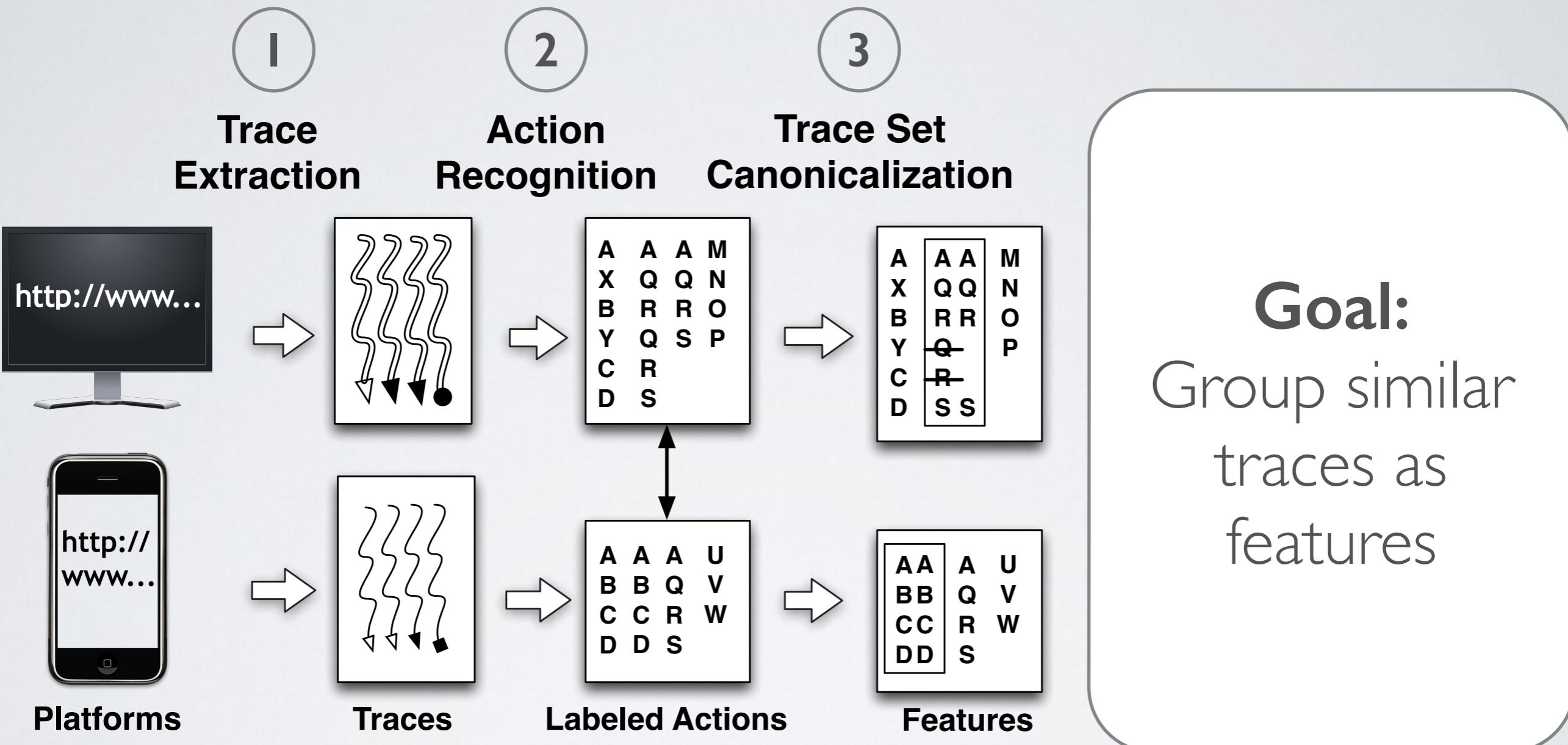
Traces



2. ACTION RECOGNITION



APPROACH OVERVIEW

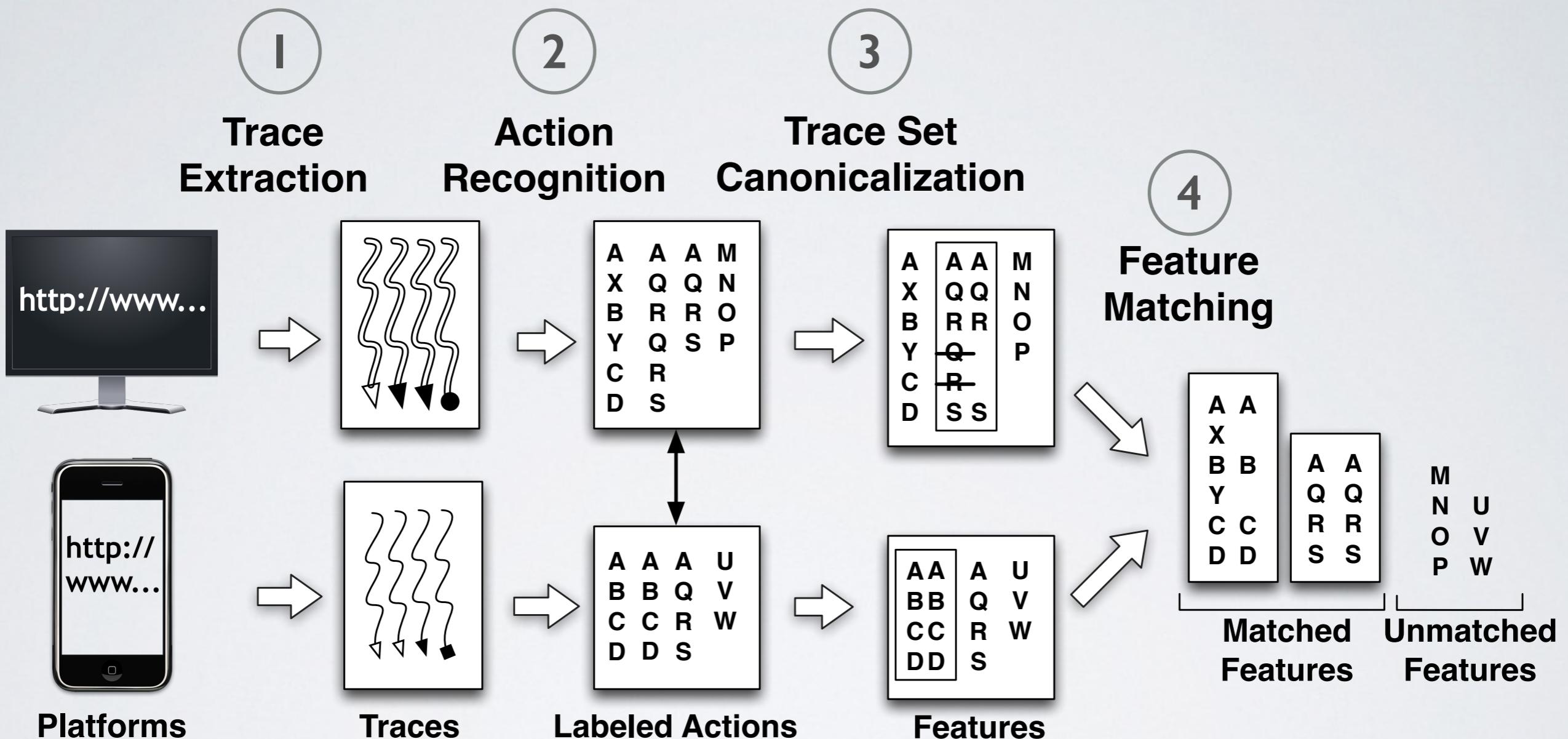


3. TRACE SET CANONICALIZATION



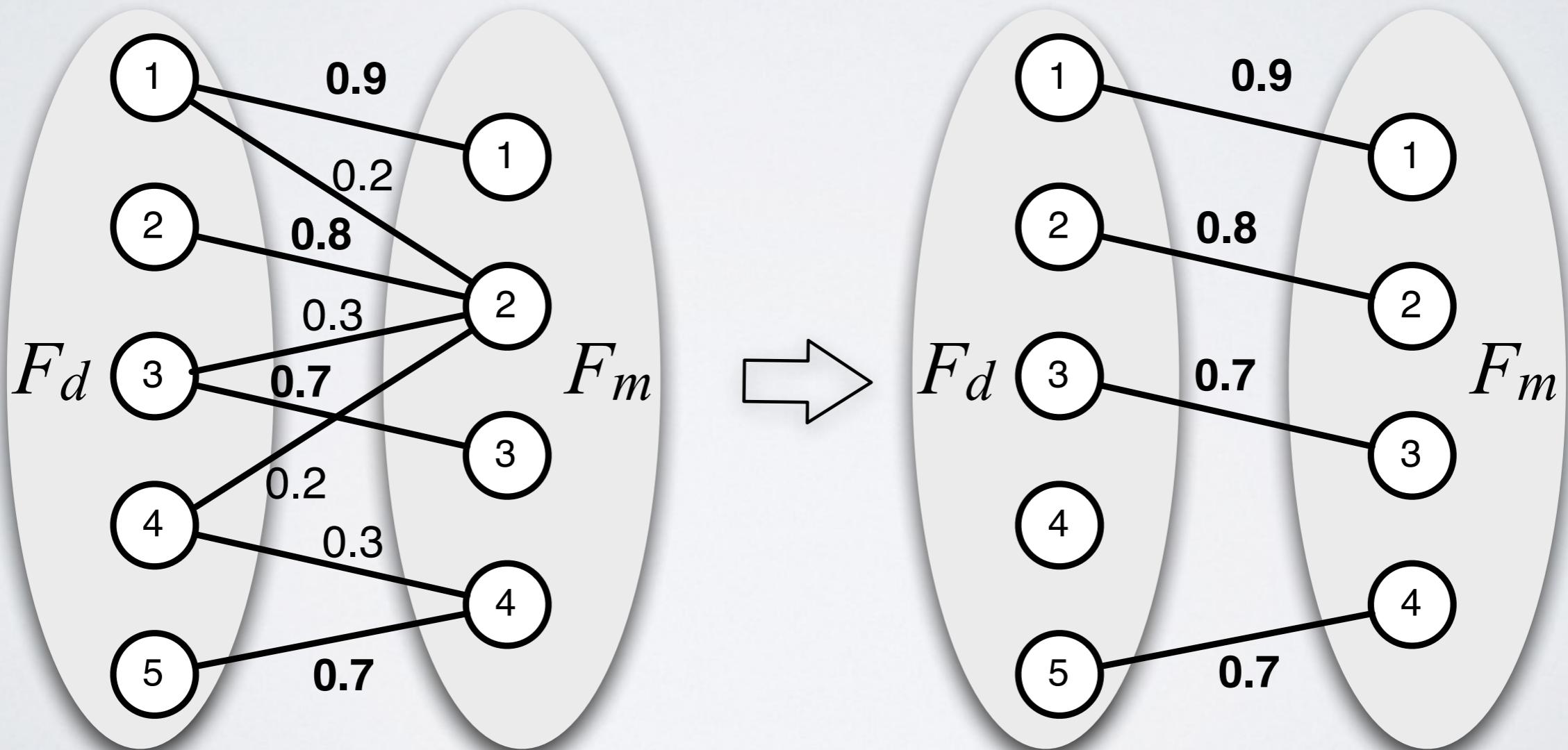
Tandem repeat: A set of two or more contiguous repetitions of a sequence
(used in the context of DNA sequences)

APPROACH OVERVIEW



4. FEATURE MATCHING

Maximum Weighted Bipartite Matching (MWBM) problem
Hungarian Algorithm [Kuhn 1955]



EMPIRICAL EVALUATION

- **Tool:** FMAP (Feature Matching Across Platforms)
 - a. HTTP trace capture browser extension
 - b. Feature matcher tool
- **Research Questions:**
 - **RQ1:** How effective is FMAP in recognizing web application actions?
 - **RQ2:** How effective is FMAP in matching features between the desktop and mobile versions of real web applications?

BASELINE

- **Current practice:** Developers manually keep track of features across platforms
- **Baseline tool:**
 - Action recognition using unique URLs
 - Trace set canonicalization using exactly matching sequence of actions
 - Feature matching using edit distance for MWBM

SUBJECT APPLICATIONS

6 open source and 3 public web applications

Criteria: Popular applications with significant different across mobile & desktop

Subject	Type	Mobile plug-in
wordpress	Blogging	wordpress mobile pack
drupal	Content Management	nokia mobile theme
phpbb	Forum	artodia mobile style
roundcube	Email	mobilecube theme
elgg	Social Networking	elgg mobile module
gallery	Photo Management	imobile theme
wikipedia.org	Wiki	-
stackoverflow.com	Q&A	-
twitter.com	Social Networking	-

PROTOCOL

I. Trace collection:



\times subjects \times (desktop | mobile)

2. Feature matching using tool and baseline

3. Manually analyzed results to compute accuracy

$$F\text{-score} = 2 \times \frac{precision \times recall}{precision + recall}$$

RQ2: FEATURE MATCHING

BASELINE

Subject	Features		Matched	T Pos	F Pos	F Neg		T Neg		F-score
	D	M				D	M	D	M	
wordpress	29	8	8	3	5	2	1	21	1	48.0%
drupal	13	13	12	12	0	0	0	0	0	100.0%
phpbb	11	11	3	3	0	9	9	0	0	40.0%
roundcube	6	7	10	4	6	0	0	0	0	57.1%
elgg	9	7	9	2	7	4	0	0	0	30.8%
gallery	31	4	0	-	-	-	-	-	-	-
wikipedia.org	11	10	17	4	13	1	4	8	1	34.0%
stackoverflow.com	18	14	13	3	10	4	1	1	0	32.4%
twitter.com	16	11	0	-	-	-	-	-	-	-
Total	144	85	72	31	41	20	15	30	2	51.5%

RQ2: FEATURE MATCHING

FMAP

Subject	Features		Matched	T Pos	F Pos	F Neg		T Neg		F-score
	D	M				D	M	D	M	
wordpress	29	8	8	7	1	0	0	21	0	93.3%
drupal	13	13	12	12	0	0	0	0	0	100.0%
phpbb	11	11	10	10	0	1	1	0	0	95.2%
roundcube	6	7	4	4	0	2	3	0	0	76.2%
elgg	9	7	5	5	0	1	1	3	1	90.9%
gallery	31	4	3	2	1	1	1	26	0	66.7%
wikipedia.org	11	10	7	7	0	1	1	3	2	93.3%
stackoverflow.com	18	14	10	9	1	1	1	7	3	90.0%
twitter.com	16	11	2	2	0	8	8	6	1	33.3%
Total	144	85	61	58	3	15	16	66	7	86.3%

RQ2: FEATURE MATCHING

FMAP

	Features	Reported	T Pos	F Pos	F Neg	T Neg	-
RQ2: How effective is FMAP in matching features between the desktop and mobile versions of real web applications?							
F-Score:	86.3% (FMAP)						
51.5% (Baseline)							

stackoverflow.com	18	14	10	10	9	9	1	1	1	1	7	3	90.0%
twitter.com	16	11	2	2	2	2	0	0	8	8	6	1	33.3%
Total	144	85	61	61	58	58	3	3	15	16	66	7	86.3%

40
—
56

**Missing features reported by FMAP
confirmed from user reports & software fixes**

LIMITATIONS AND FUTURE WORK

- **Trace Collection:**
 - General trace collection strategies
 - Broader user population
- **Intentionally omitted vs Missing features:**
 - Both currently reported as missing features
 - Study distribution & account for omitted features
- **White/Grey-box approach** to identify features

ARTIFACT



<http://gatech.github.io/fmap>

- Open source tool release
 - ▶ HTTP trace capture browser extension
 - ▶ Feature matcher tool
- Experimental data — Collected student traces
- Documentation and Validation URLs

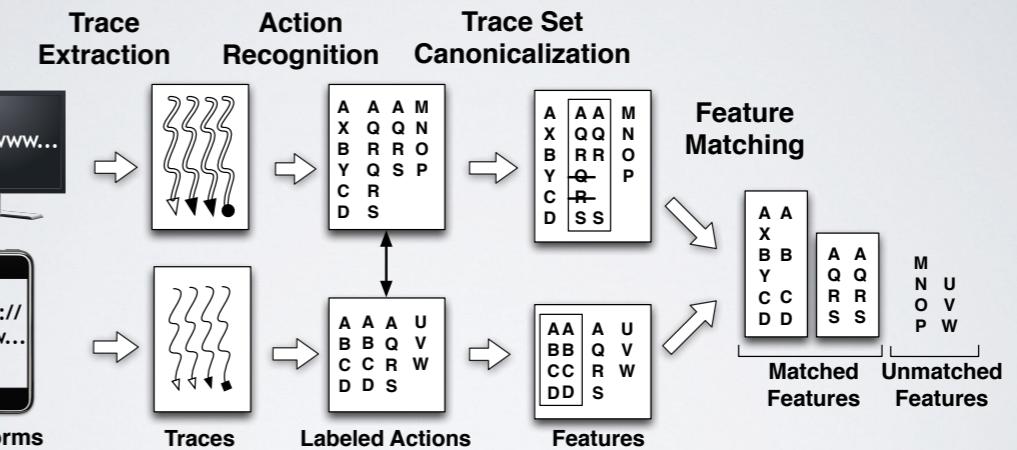
RELATED WORK

- **Cross-Browser Testing**
[Roy Choudhary et. al., Mesbah et. al., Dallmeier et. al]
 - Both presentation & function expected to be identical
- **Inferring API Migration Mappings**
[Gokhale et. al., Zhong et. al., Robillard et. al.]
 - Mapping atomic actions (functions) between API versions
 - Input: population of pairs of equivalent traces
- **Reverse Engineering of Web Applications**
[Mesbah et. al., Schur et. al., DiLucca et. al., Elbaum et. al.]
 - Generate model of web application

MISSING FEATURES

The image shows two screenshots of a WordPress dashboard. On the left is the desktop version, showing a sidebar with navigation links like Posts, Media, Appearance, Plugins, Users, Tools, and Settings. The main area displays a post titled "Hello world!" with options to Add New, Publish, Move to Trash, and Update. On the right is the mobile version, which has a similar layout but is optimized for a smaller screen, showing a post titled "Simple 'on-server' mobile AJAX". Both versions include standard WordPress UI elements like buttons, dropdown menus, and status indicators.

APPROACH OVERVIEW



RQ2: FEATURE MATCHING FMAP

Features	Reported	T Pos	F Pos	F Neg	T Neg	
----------	----------	-------	-------	-------	-------	--

RQ2: How effective is FMAP in matching features between the desktop and mobile versions of real web applications?

F-Score: 86.3% (FMAP)

51.5% (Baseline)

stackoverflow.com	18	14	10	10	9	9	1	1	1	1	7	3	90.0%
twitter.com	16	11	2	2	2	2	0	0	8	8	6	1	33.3%
Total	144	85	61	61	58	58	3	3	15	16	66	7	86.3%

34

ARTIFACT



<http://gatech.github.io/fmap>

- Open source tool release
 - ▶ HTTP trace capture browser extension
 - ▶ Feature matcher tool
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- Documentation and Validation URLs