unCaptcha

A Low-Resource Defeat of reCaptcha's Audio Challenge

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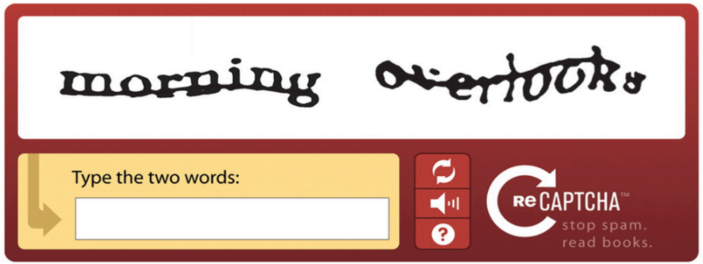
Acknowledgements

Captchas

- **C**ompletely **A**utomated **P**ublic **T**uring test to tell **C**omputers and **H**umans **A**part
- Captchas are the **primary defense** for many online services against bots
  - Prevents automated account creation
  - Bot service abuse
  - Artificial flow of information

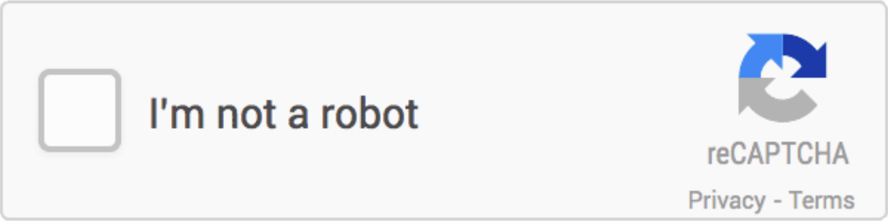
Testing for humanity with reCaptcha

2009 – 2014



- Based on transcription
- Text-based challenges
- Acquired **then defeated** by Google

2014 – present

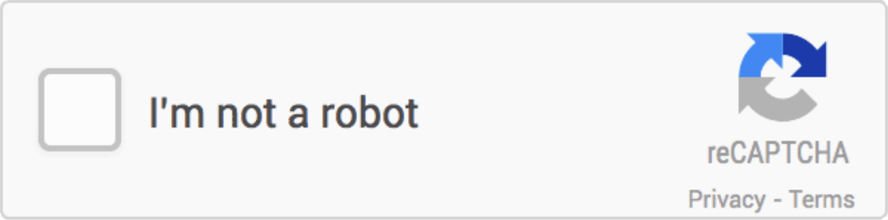


- Based on recorded user interaction
- Used by **hundreds of thousands** of sites
- **“Easy on humans, tough on bots”**

reCaptcha: How it works

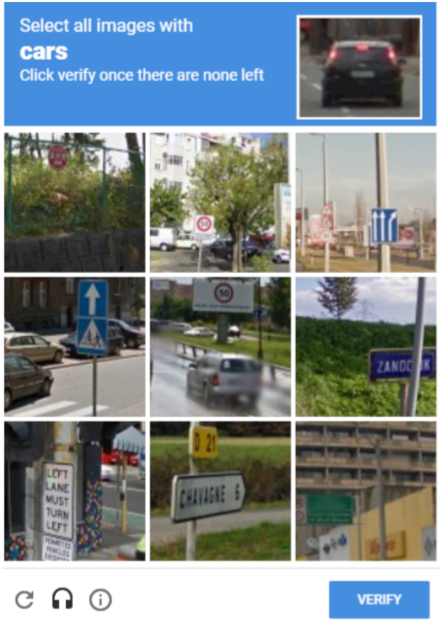
- **Risk analysis engine** takes in information from the browser
    - Most importantly: **cookies**

- Each time a browser interacts with a Google service, that interaction is recorded with their cookie
    - Allows for the **noCaptcha reCaptcha**



reCaptcha Challenges

Image recognition



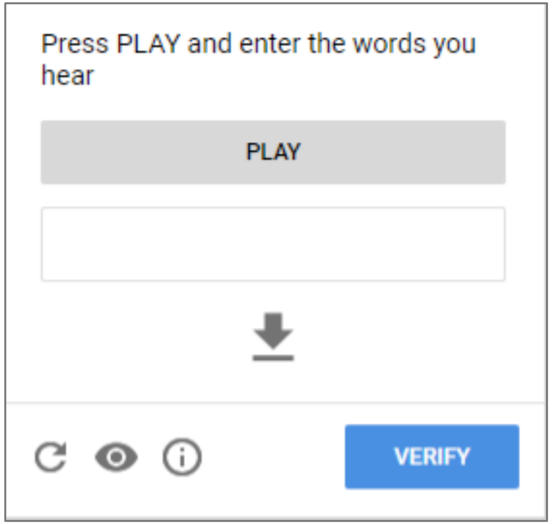
Select all images with
cars
Click verify once there are none left

- Easy for **most** humans, hard for computers
- Data strengthens other services (e.g., street view, image search)

But what about visually impaired users?

reCaptcha Challenges

Audio recognition



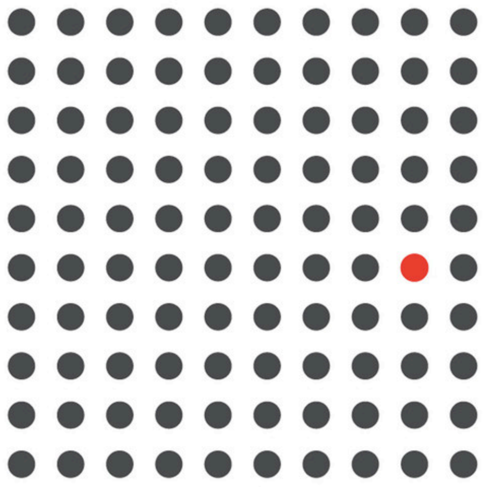
Press PLAY and enter the words you hear

- **Necessary** for visually impaired users
- As of this paper:
  - All digits: “Two… seven… three…”
  - With gaps between numbers
  - And some distortion

Easy for most humans, but
is it hard for computers?

Attacking reCaptcha - Threat Model

- Previous works assumed **well-resourced attackers**
- Solutions/defeats were generally:
  - Offline
  - Requiring training data
  - On powerful computers
- What is “success”?
  - **1%** solving rate can be a “success”



Our Threat Model

- Assume a **low-resource attacker**
  - Need high success rate
  - Minimal training data

- All testing was done on a **free-tier** Amazon Elastic Computing *t2.micro* instance
  - 1GB of RAM
  - 1 virtual CPU
  - 8GB hard-drive

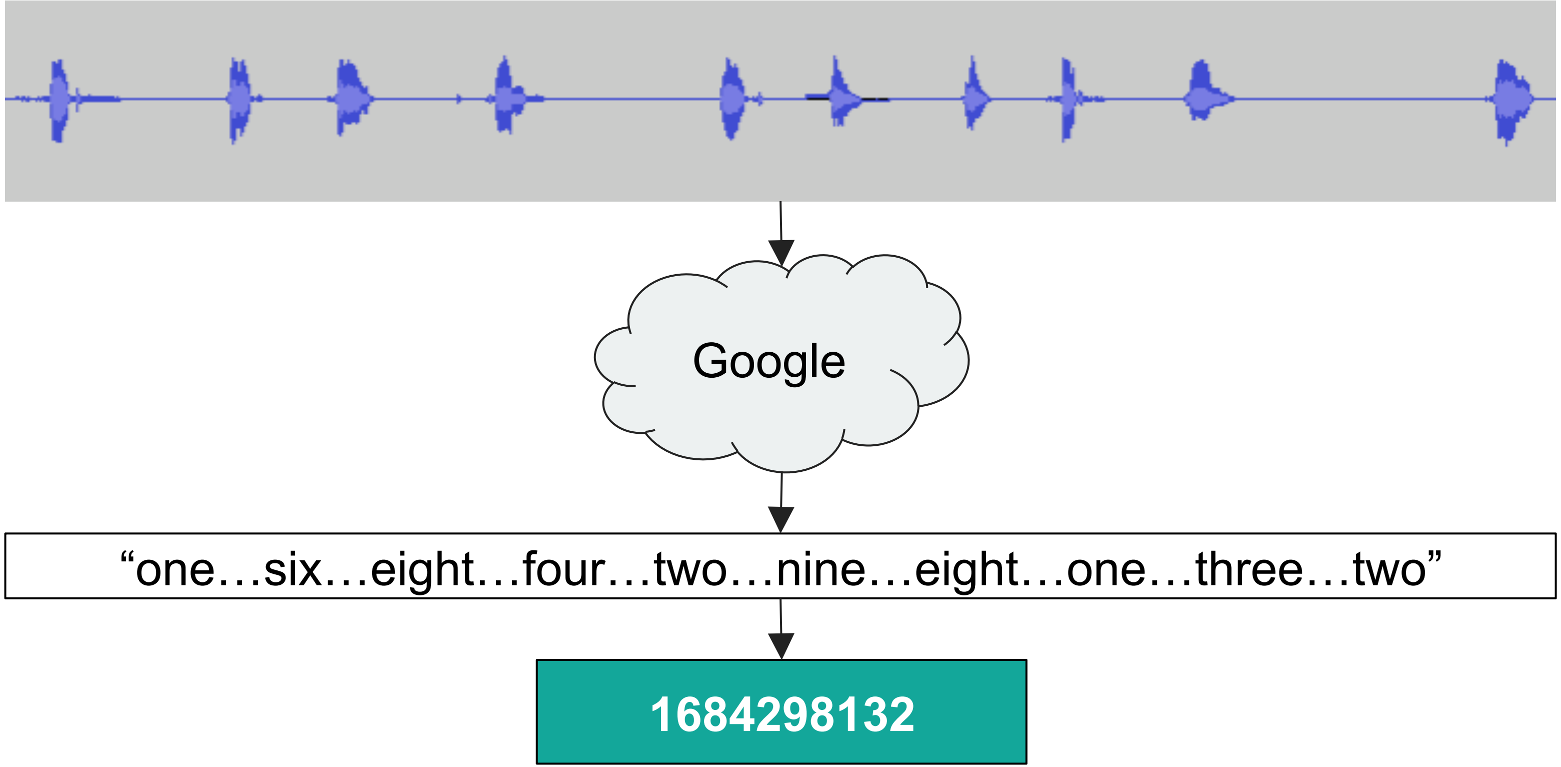
Actual footage of *t2.micro*

Talk is cheap

Why re-invent the wheel when Google, Apple, Amazon, etc. have already done it better?

Can we use Google against itself to solve captchas?

Can we leverage Speech-to-Text?

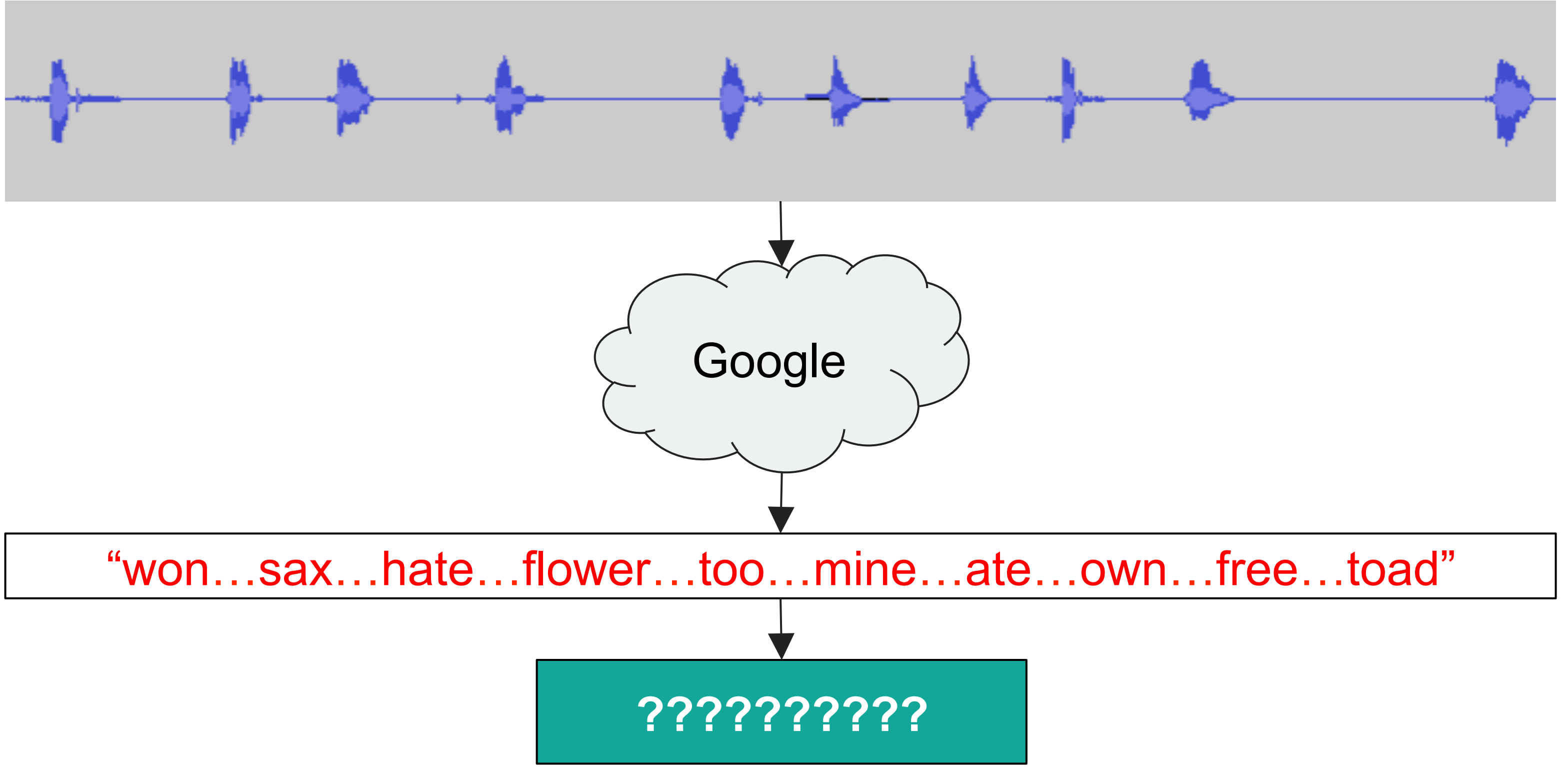


Google

“one…six…eight…four…two…nine…eight…one…three…two”

1684298132

In reality



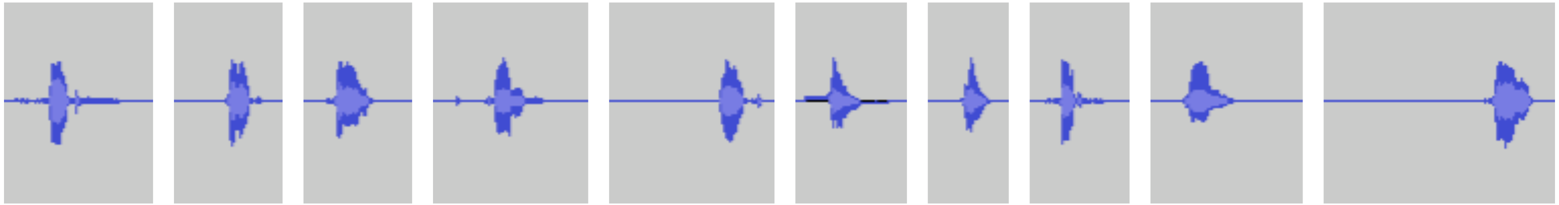
Google

“won…sax…hate…flower…too…mine…ate…own…free…toad”

??????????

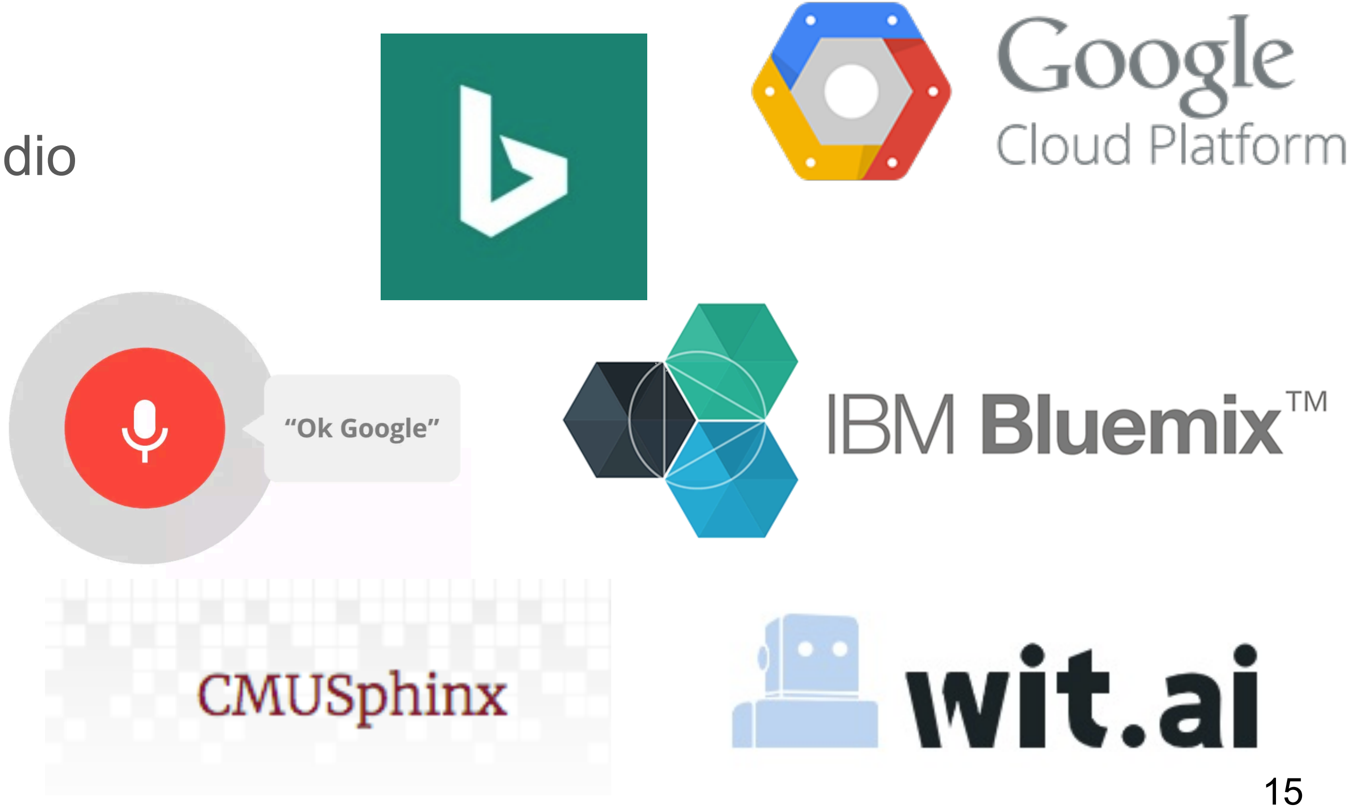
Segmentation

- Simple **amplitude analysis** to find split points
- Divide audio at periods of **silence**



Multiple Speech-to-Text Services

Submit each audio clip to six **free, public** speech-to-text services



Multiple Speech-to-Text Services

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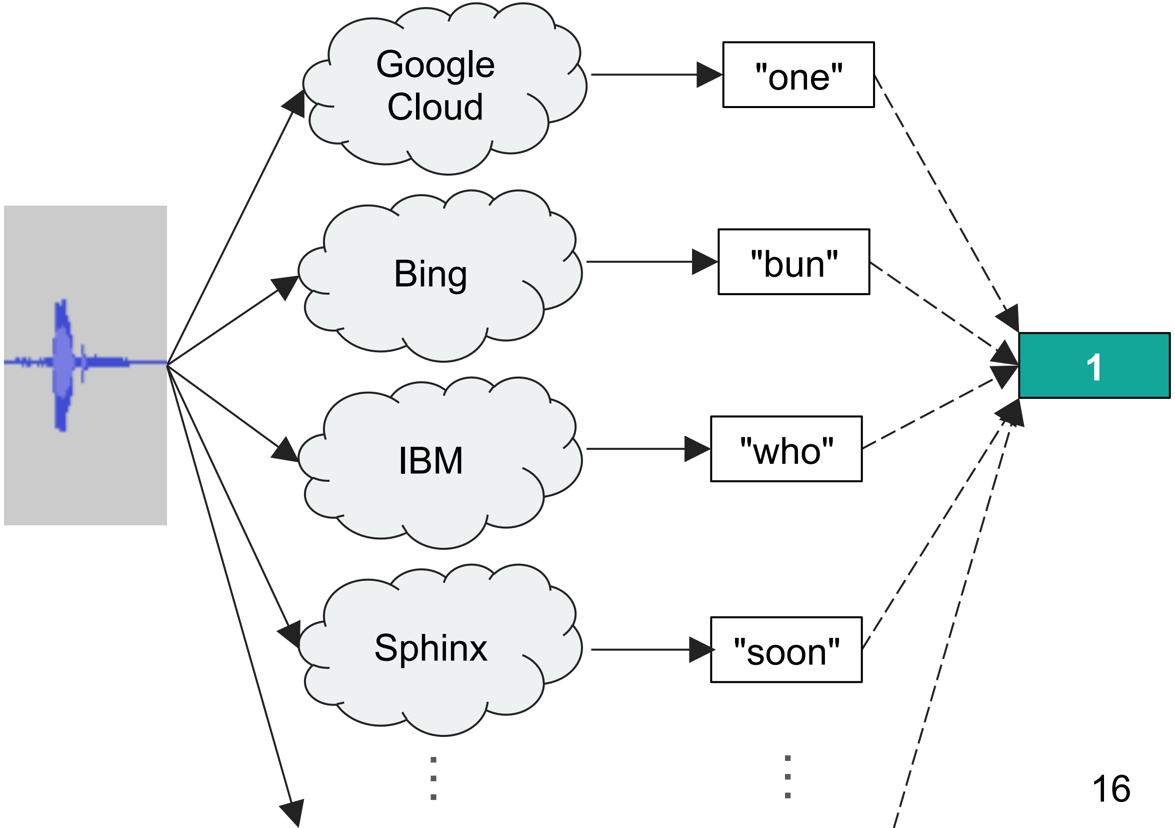
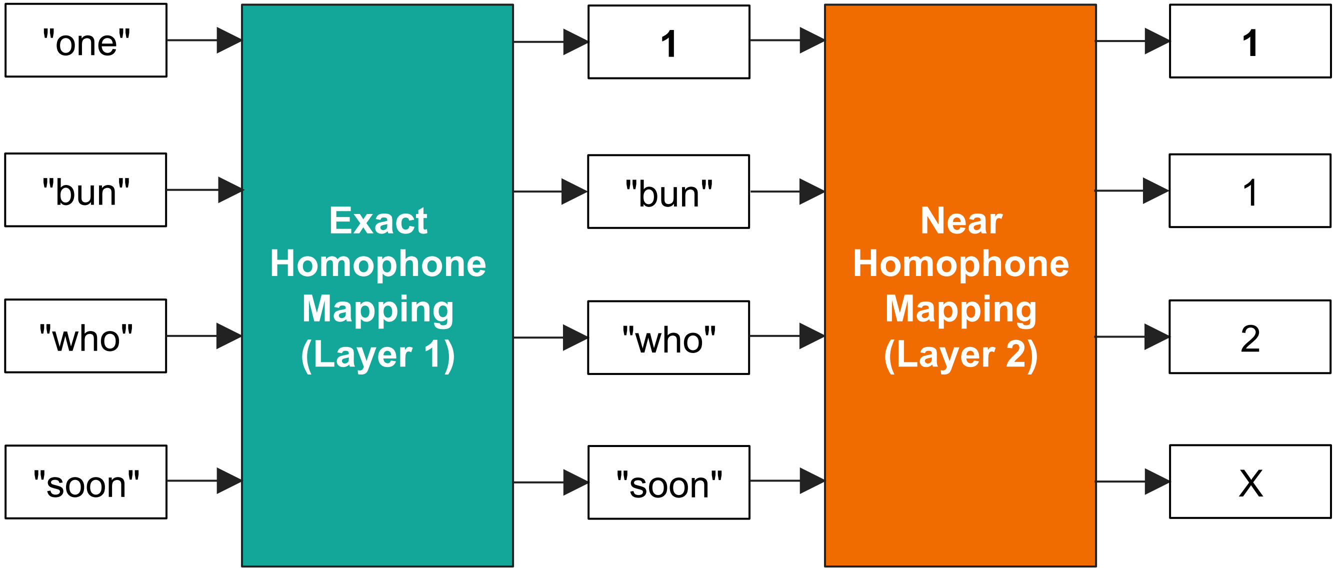
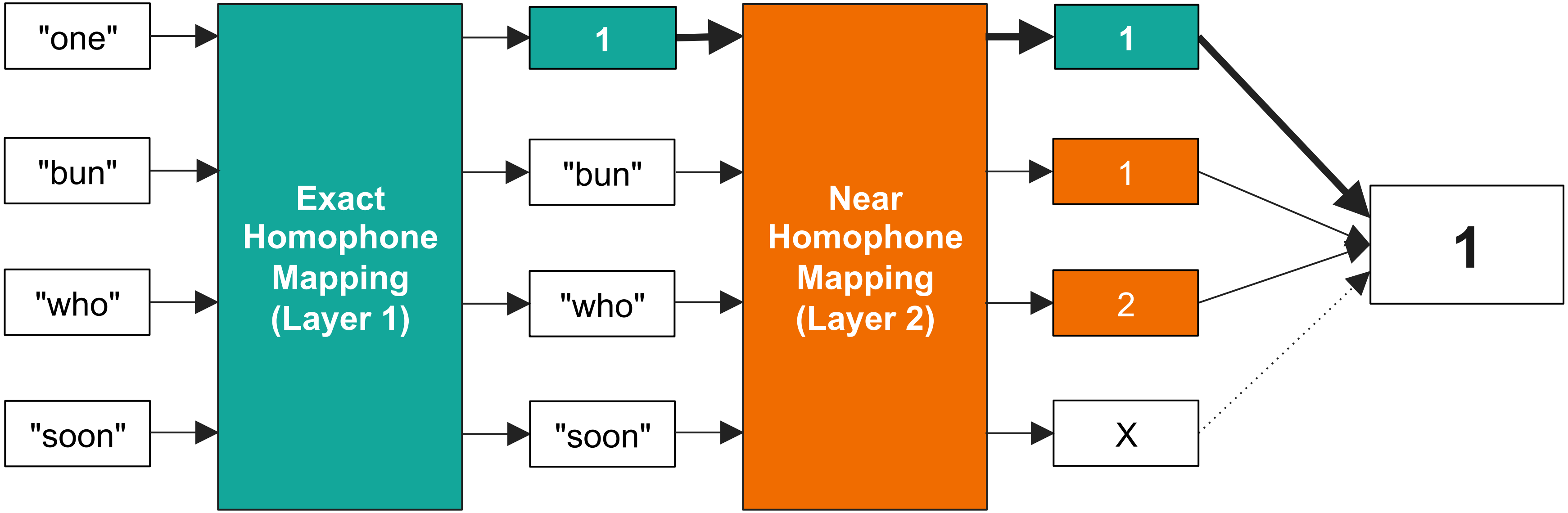


Phonetic Mapping


"one"
"bun"
"who"
"soon"
Exact Homophone Mapping (Layer 1)
1
"bun"
"who"
"soon"
Near Homophone Mapping (Layer 2)
1
1
2
X

Speech-to-text services are not designed to work for **only** digits

Ensembling


"one"
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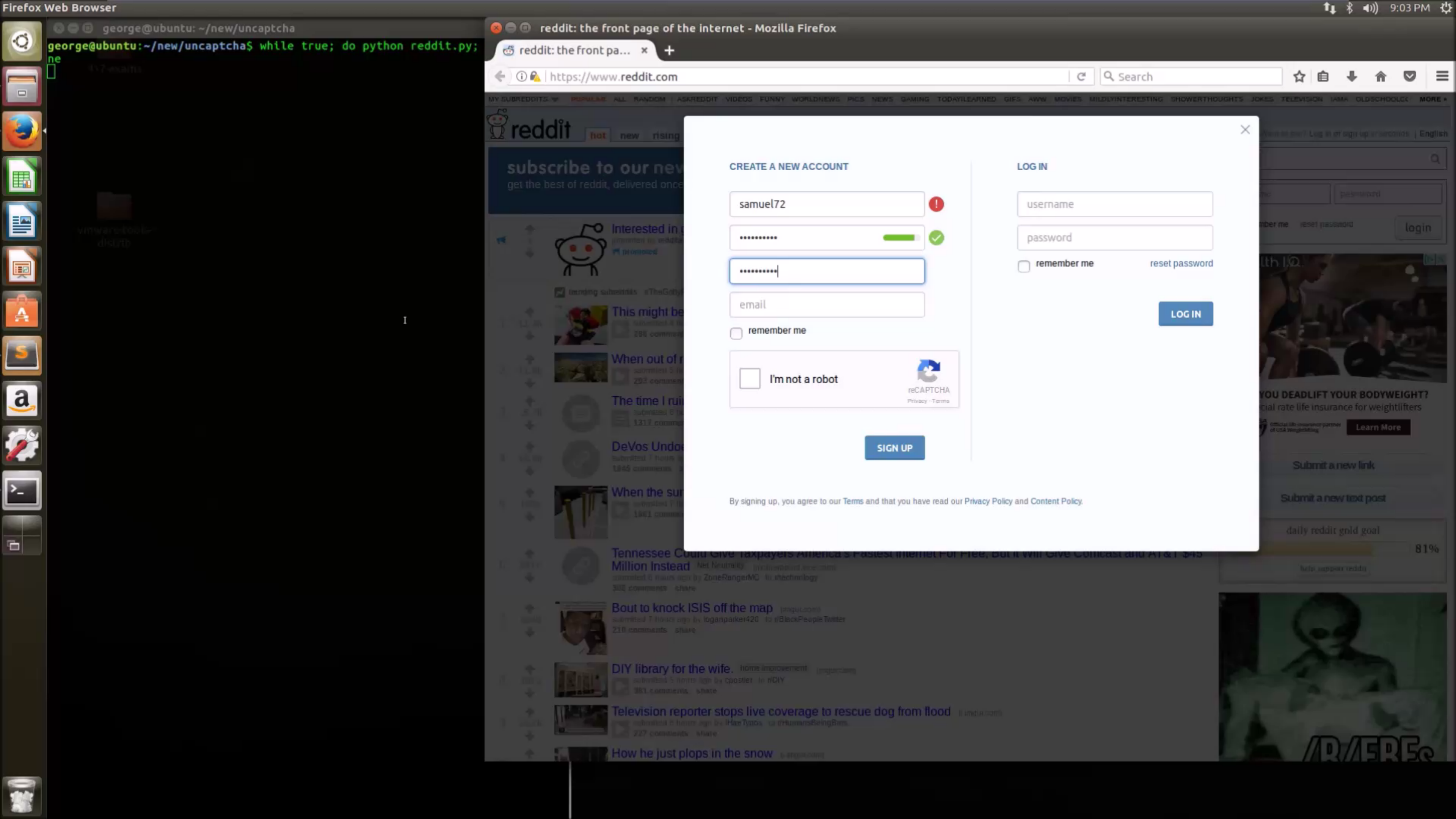
"soon"
Exact Homophone Mapping (Layer 1)
1
"bun"
"who"
"soon"
Near Homophone Mapping (Layer 2)
1
1
2
X
1

Repeat for each digit

Demo



Firefox Web Browser
9:03 PM
george@ubuntu: ~/new/uncaptcha
reddit: the front page of the internet - Mozilla Firefox
reddit: the front pa...
https://www.reddit.com
Search
reddit
hot
new
rising

```
george@ubuntu:~/new/uncaptcha$ while true; do python reddit.py; done
```

CREATE A NEW ACCOUNT

samuel72

••••••••••

••••••••••

email

□ remember me

□ I'm not a robot

reCAPTCHA
Privacy - Terms
SIGN UP

LOG IN

username

password

□ remember me

By signing up, you agree to our Terms and that you have read our Privacy Policy and Content Policy.

subscribe to our nev
get the best of reddit, delivered once
Interested in
This might be
When out of
The time I rui
DeVos Undo
When the sur
Tennessee Could Give Taxpayers America's Fastest Internet For Free, But It Will Give Comcast and AT&T $45 Million Instead
Bout to knock ISIS off the map
DIY library for the wife.
Television reporter stops live coverage to rescue dog from flood
How he just plops in the snow
login
YOU DEADLIFT YOUR BODYWEIGHT?
Learn More
Submit a new link
Submit a new text post
daily reddit gold goal
81%

Experimental Evaluation

459
Audio challenges

10
Digits/challenge

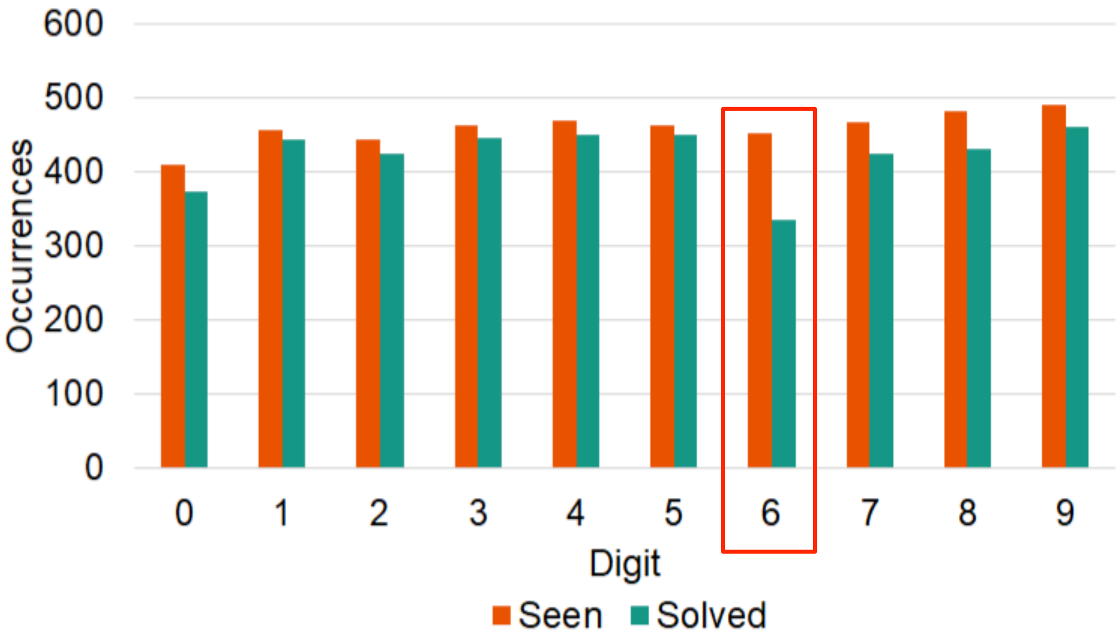
4,590
Audio clips

- Overall accuracy; is it viable for a low-resource attacker?
- Benefits of phonetic mapping and ensembling?
- Limitations?

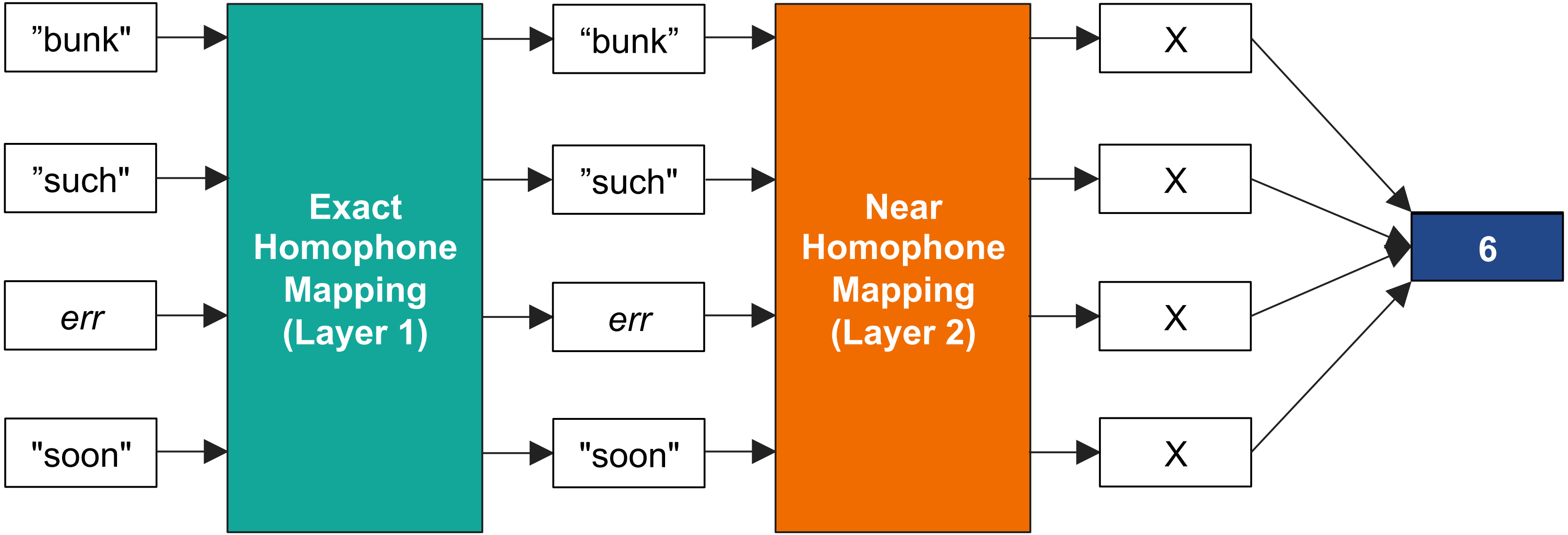
unCaptcha's Overall Performance

91.99%
Digit accuracy

80.31%
Captcha success



Dealing with the poor performance of “6”

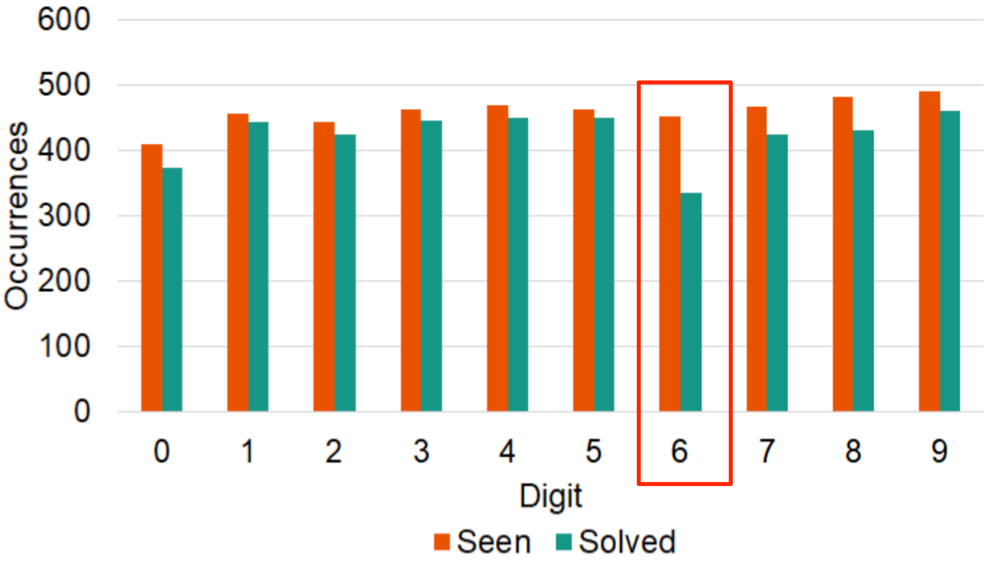

”bunk"
”such"
err
"soon"
Exact Homophone Mapping (Layer 1)
“bunk”
”such"
err
"soon"
Near Homophone Mapping (Layer 2)
X
X
X
X
6

Replace all unknowns (“X”) with a guess of “6”

unCaptcha’s Overall Performance

91.99%
Digit accuracy

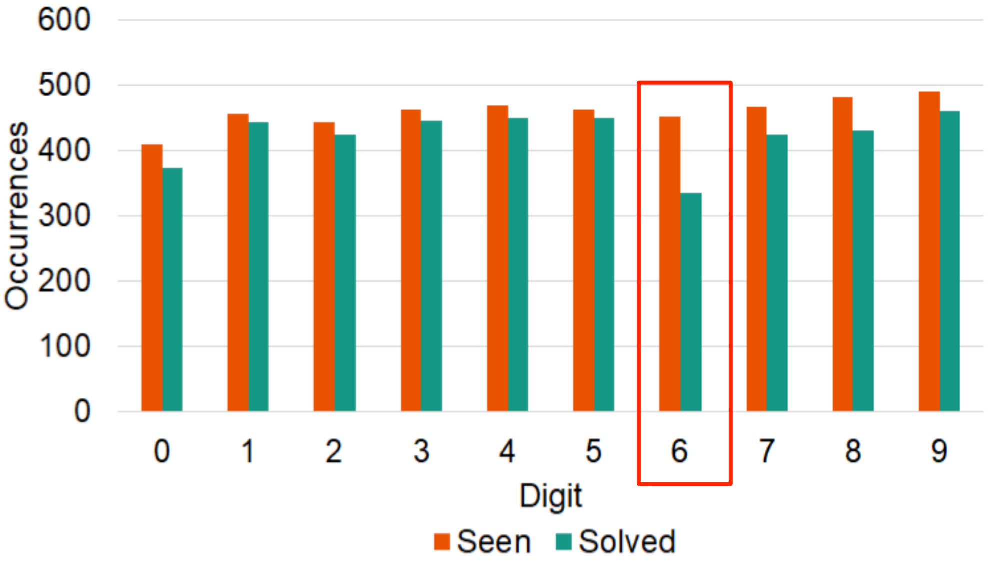
80.31%
Captcha success



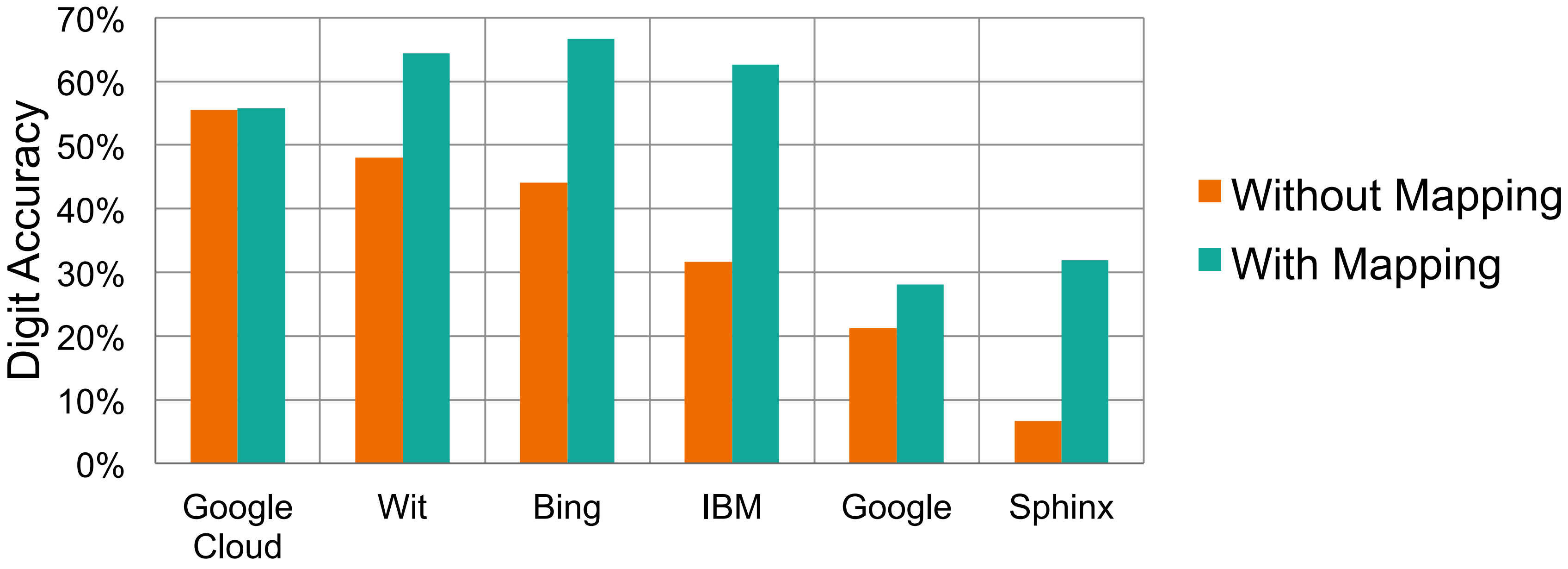
unCaptcha’s Overall Performance

93.41%
Digit accuracy

85.15%
Captcha success

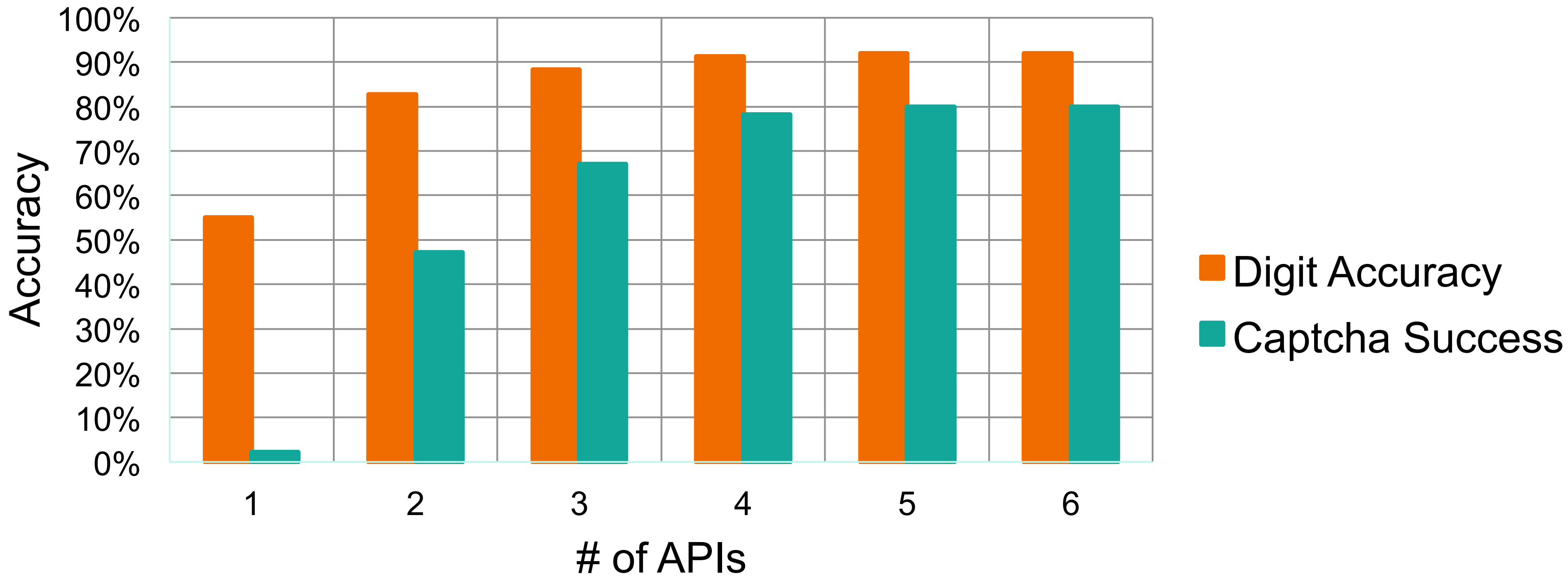


Benefit of Phonetic Mapping



Increased digit accuracy by **17% overall**

Benefit of Ensembling



Increased captcha success by **78%**

unCaptcha’s Speed

22.24 sec

Avg. time to solve

Main bottleneck: Service response time

Trade-off for a low-resource attack

19.22 sec

Avg. audio challenge

reCaptcha accepts answers

before a human could listen to the challenge

unCaptcha’s Speed

5.42 sec
Avg. time to solve

Main bottleneck: Service response time
Trade-off for a low-resource attack

19.22 sec
Avg. audio challenge

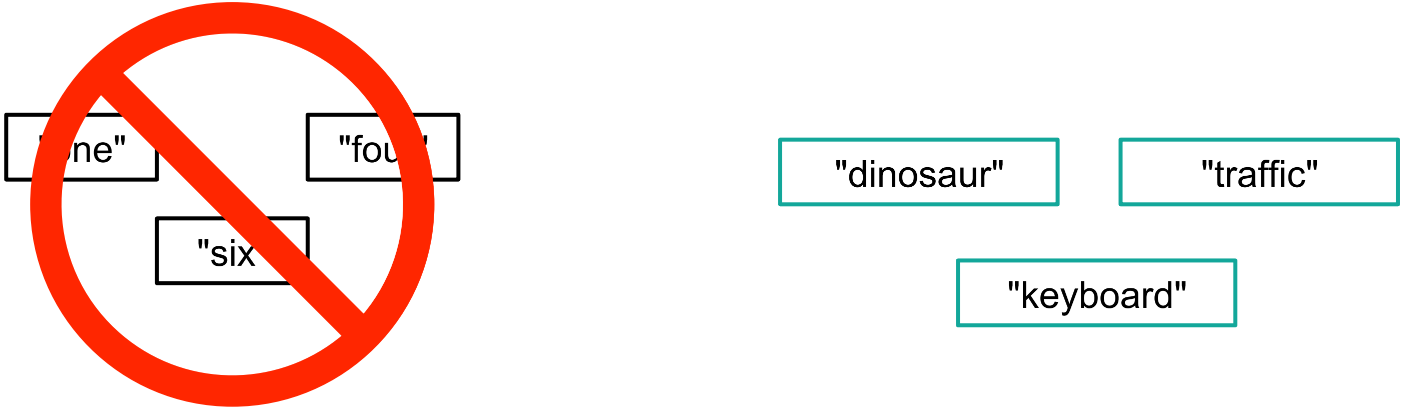
reCaptcha accepts answers
before a human could listen to the challenge

Limitations

- Services are free, but have API limits
- ...yet reCaptcha is the **sole defense** against creating a new account on many of these services
- unCaptcha could theoretically be made **self-sufficient**

Future Recommendations

- Increase **vocabulary size**
  - Mitigate the boost of the phonetic mapping



ne"

"fou

"six

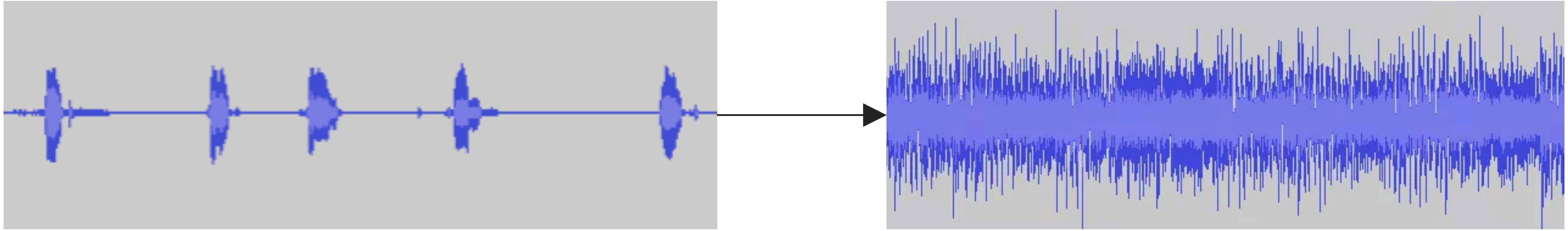
"dinosaur"

"traffic"

"keyboard"

Future Recommendations

- Increase **distortion**
  - Negatively affect segmentation and accuracy



Future Recommendations

- Increase **complexity** of task
  - Semantic over syntactic

“**draw** a circle”

“type ‘car’ but **not** ‘dog’”

“type only the **English words** in the following list…”

“type **every other word** in the following phrase…”

“type only the **animals** in the following list…”

“type ‘bus’ **three times**”

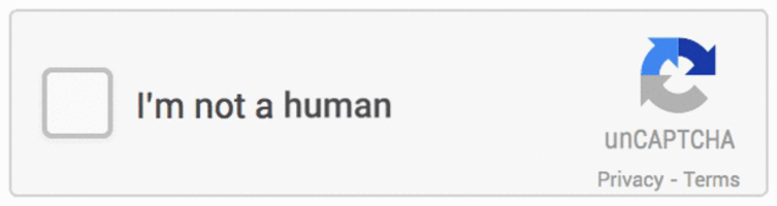
“type only the words that **rhyme** in the following list…”

New reCaptcha Updates

- Disclosed to Google in March
  - Already “aware of the issue” as of April
- English **phrases** instead of **digits**
- Uses static instead of silence
- Better browser automation detection

“and also total in”

Summary



- Boosts **per-digit accuracy** and **overall captcha success** by
  - **Ensembling** 6 online speech-to-text services
  - **Phonetically Mapping** their output to digits

85.15%
Captcha sucess

5.42 sec
Avg. time to solve

- unCaptcha proves that a **low-resource, high-accuracy** defeat of Google's reCaptcha system is possible

Check out project website at **http://uncaptcha.cs.umd.edu**

unCaptcha