Discovery, Big Data, web analytics, and Bayesian A/B testing at Wikipedia

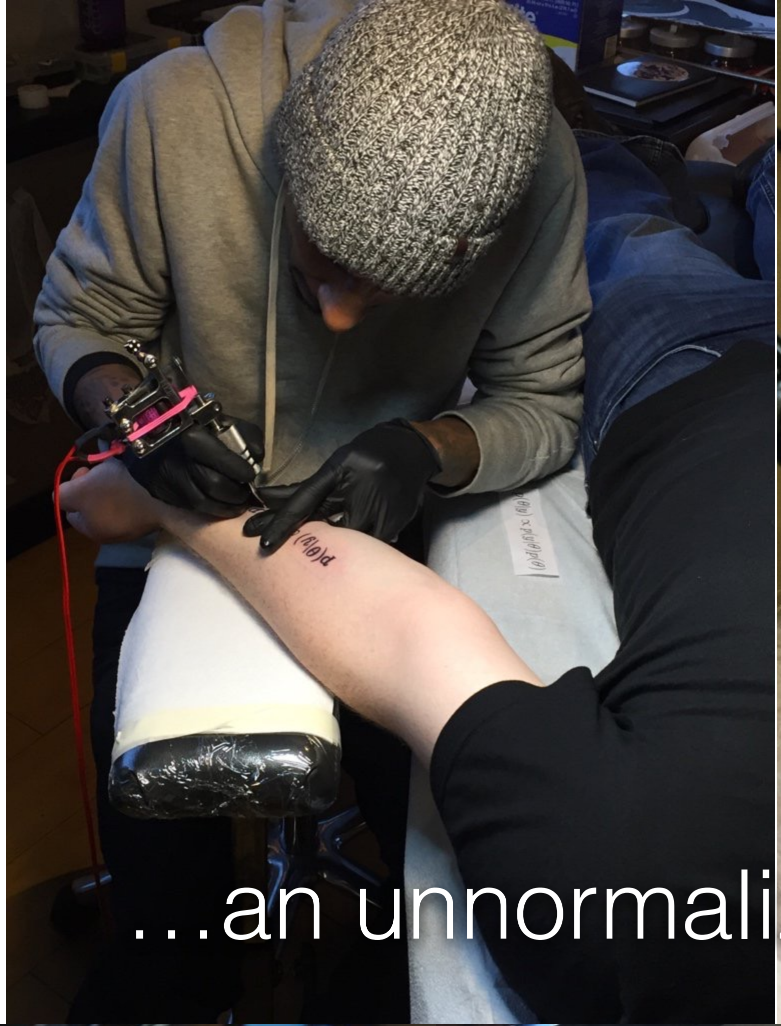
Mikhail Popov (@bearloga)
Data Scientist // Discovery // Wikimedia Foundation

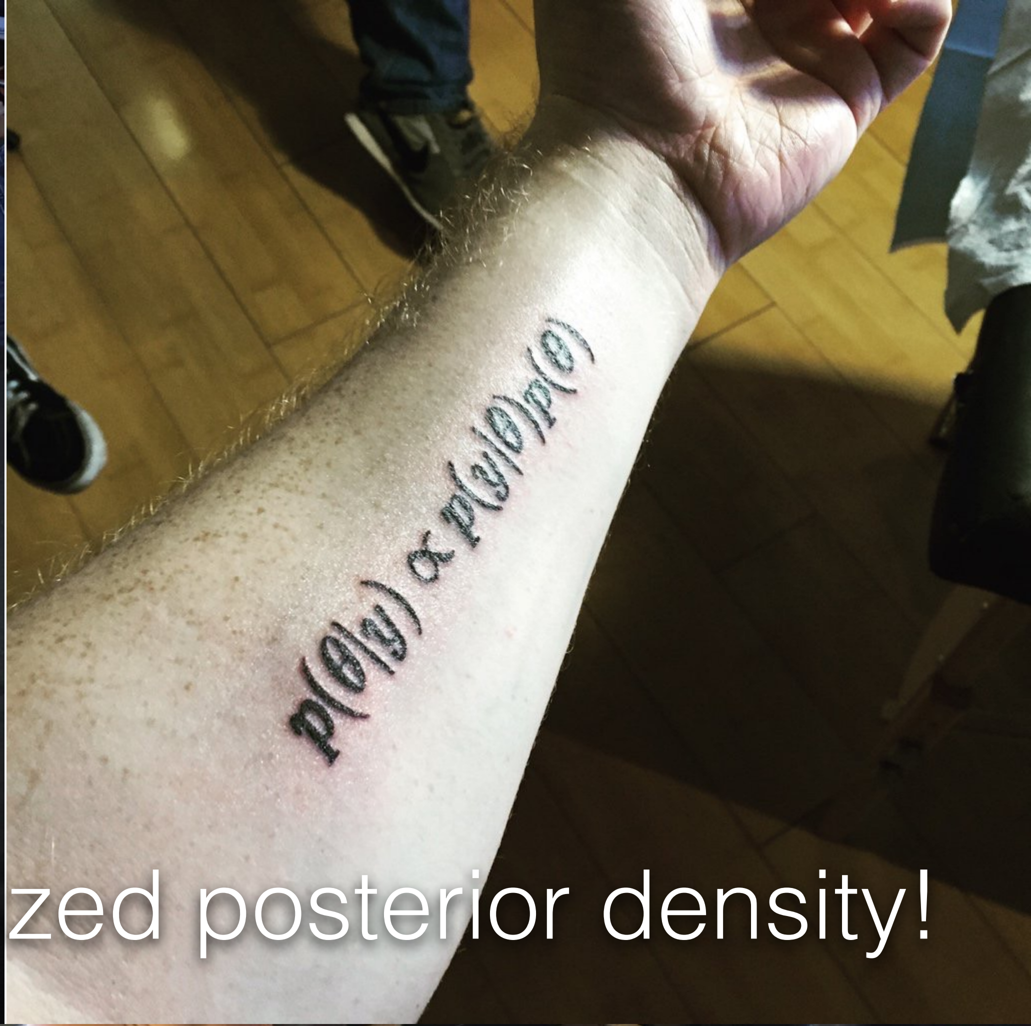
I was/am…

- Bachelor in Mathematics (CSUF NSM, 2012)
- Master in Statistical Practice (CMU, 2013)
- Statistician for a neuropsychology research program at University of Pittsburgh / UPMC for 2 years
- Data Scientist / Data Analyst / Quantitative Analyst / Statistician / why do we have so many names??? 🤔 at Wikimedia Foundation
- Tattoo designer-typesetter (Wait, what?)

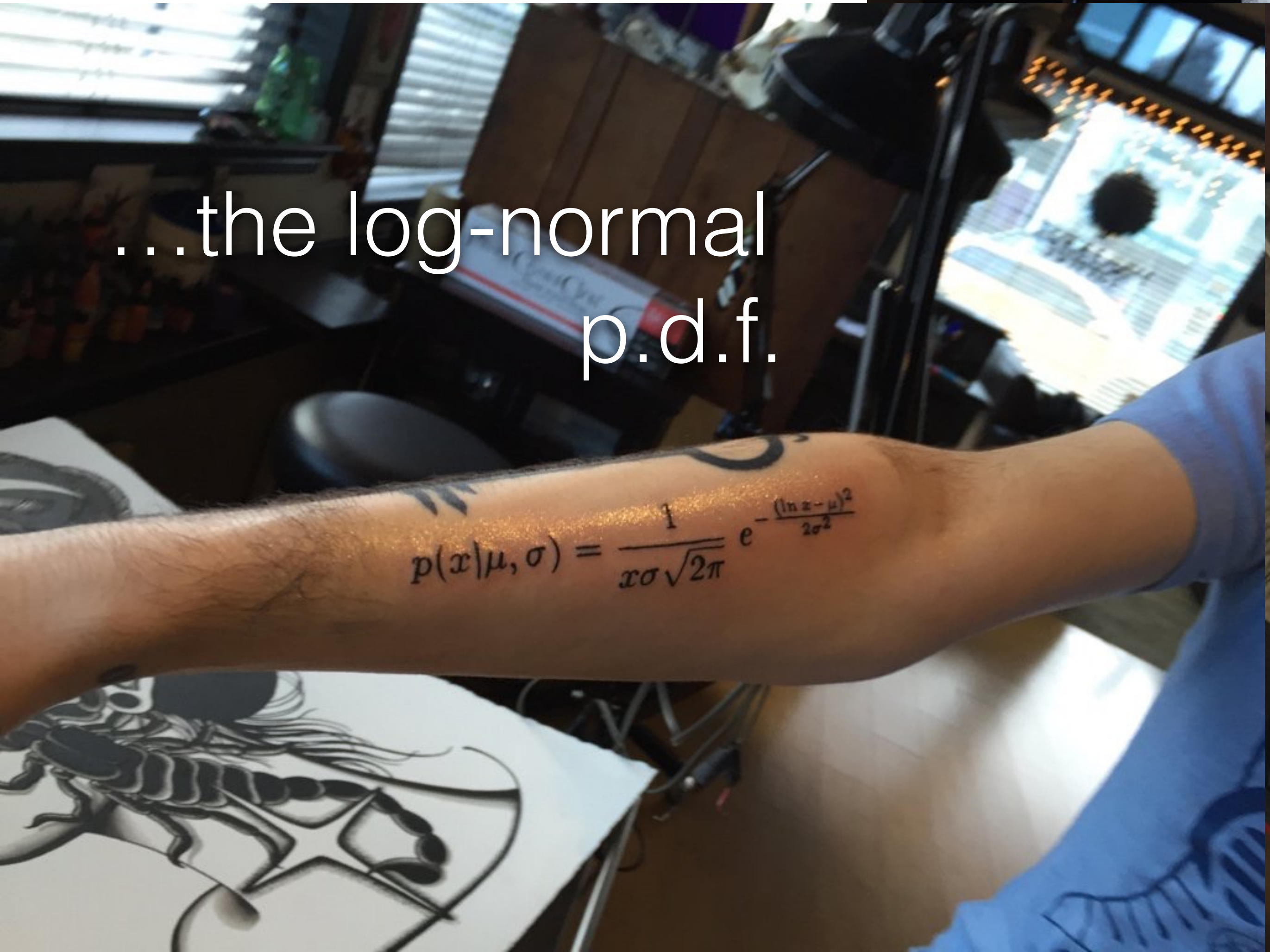
9 January 2016:

Three data science dorks walk into a tattoo parlor in Berkeley, holding LaTeX-typeset formulas for…

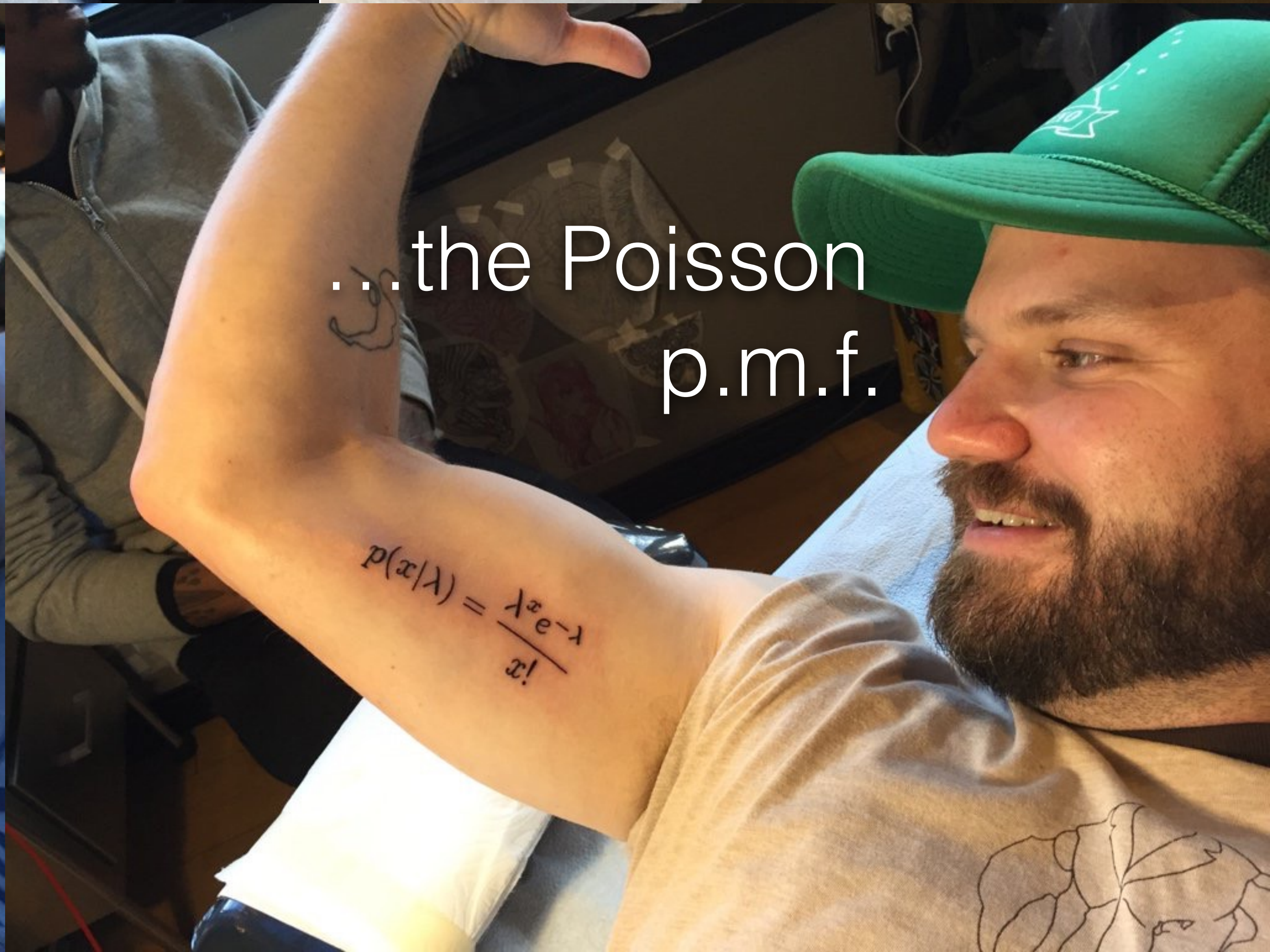




…an unnormalized posterior density!


$p(x|\mu,\sigma) = \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{(\ln x-\mu)^2}{2\sigma^2}}$

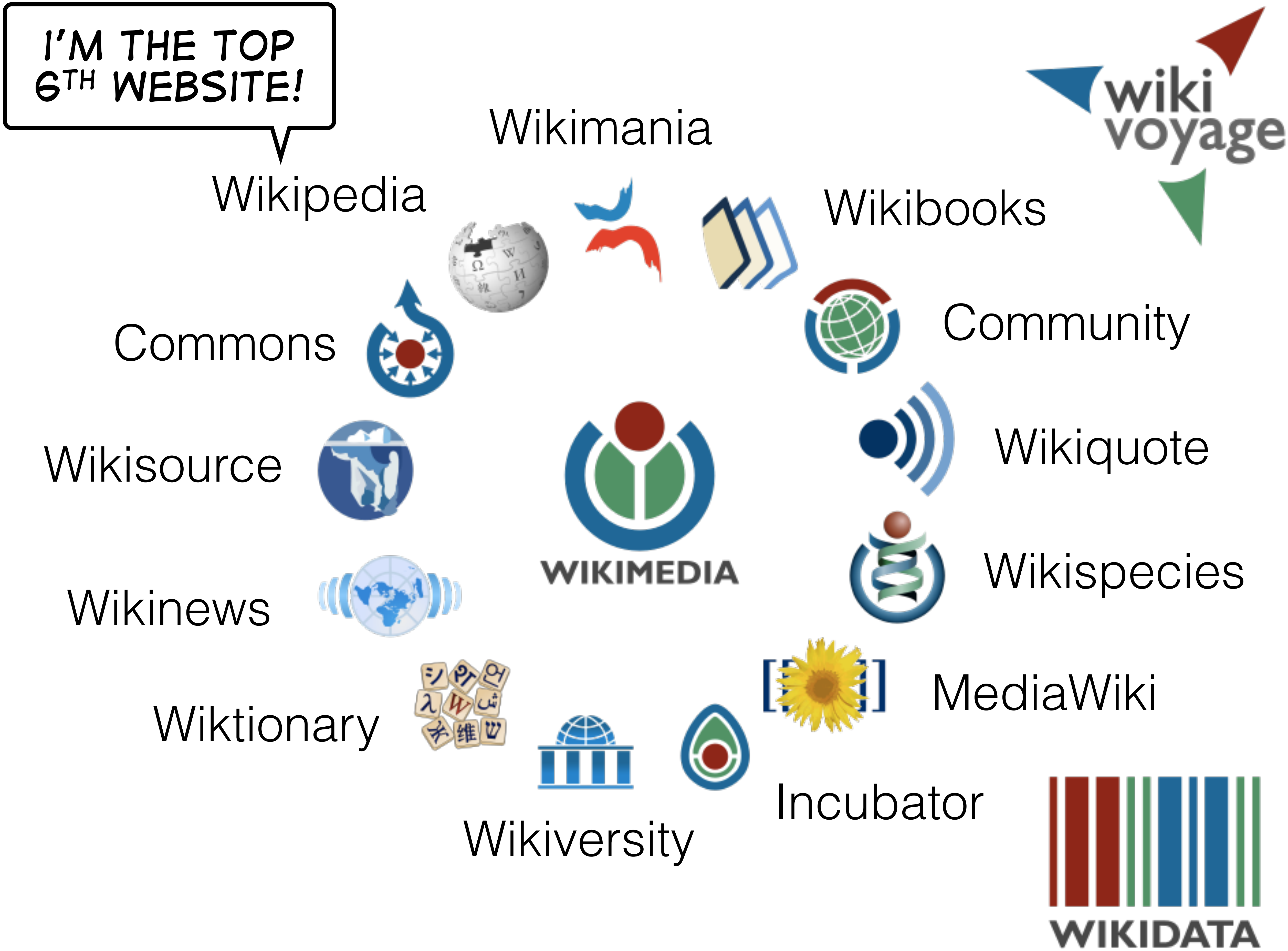
…the log-normal p.d.f.



…the Poisson p.m.f.

The Wikimedia Foundation (WMF)

- A nonprofit charitable organization.
- Committed to creating a world in which every single human being can freely share in the sum of all knowledge (e.g. Wikipedia, Wikipedia Zero).
- Collaborates with users around the world.
- Develops MediaWiki software used by many organizations and companies (e.g. Intel, Wikia, NASA).
- Fights for people's privacy (see *Wikimedia Foundation, et al. v. National Security Agency, et al.* – https://en.wikipedia.org/wiki/Wikimedia_Foundation_v._NSA)



I'M THE TOP 6TH WEBSITE!

Wikimania

Wikipedia

Wikibooks

Commons

Community

Wikisource

Wikiquote

Wikispecies

Wikinews

MediaWiki

Wiktionary

Incubator

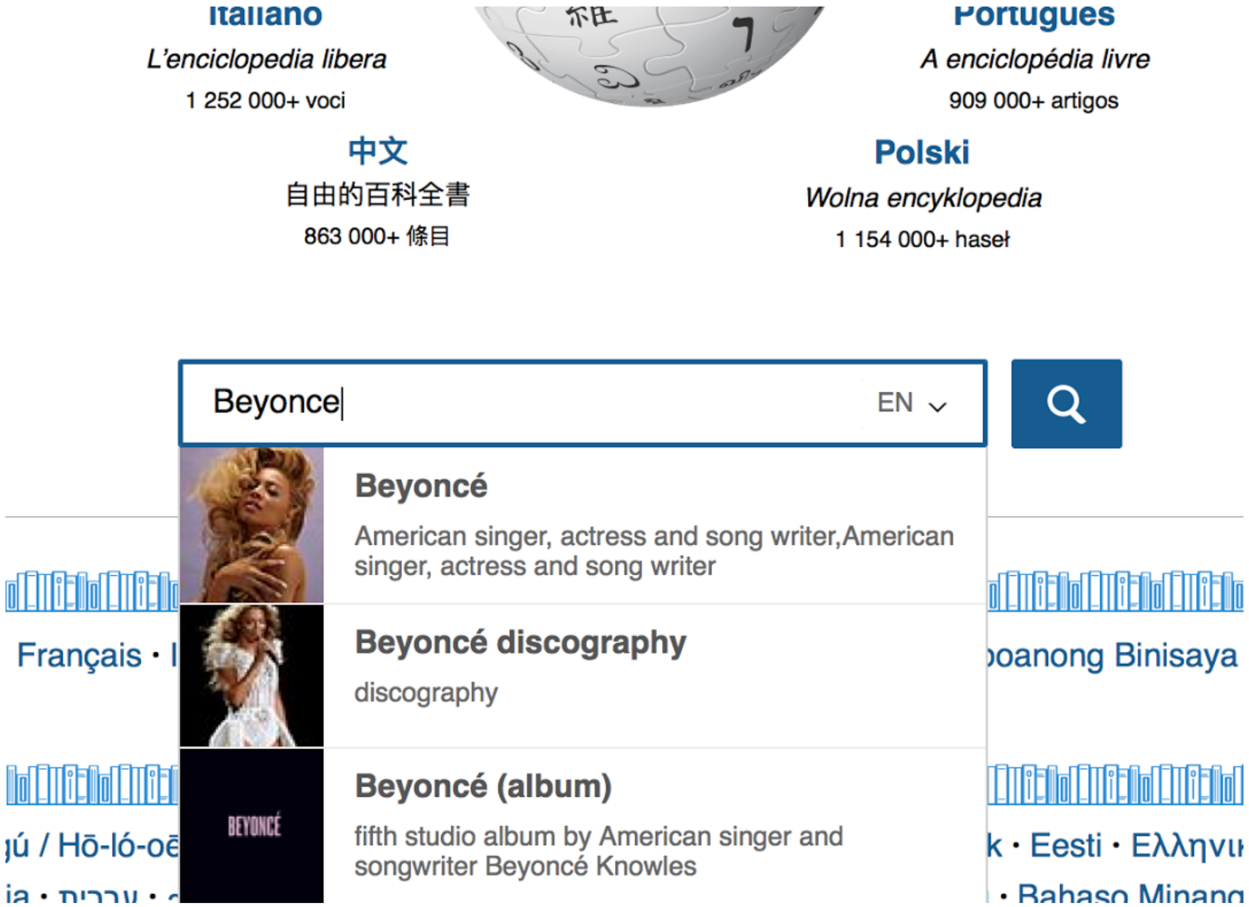
Wikiversity

Discovery Department

Building the anonymous path of discovery to a trusted and relevant source of knowledge.

Projects:

- 🔍 Search feature & APIs
- 🔍 Wikipedia Portal (wikipedia.org)
- 🔍 Maps, in collaboration with OpenStreetMap
- 🔍 Wikidata Query Service



Italiano
L'enciclopedia libera
1 252 000+ voci

Português
A enciclopédia livre
909 000+ artigos

中文
自由的百科全書
863 000+ 條目

Polski
Wolna encyklopedia
1 154 000+ haseł

Beyonce EN

Beyoncé
American singer, actress and song writer,American singer, actress and song writer

Beyoncé discography
discography

Beyoncé (album)
fifth studio album by American singer and songwriter Beyoncé Knowles

Français · l

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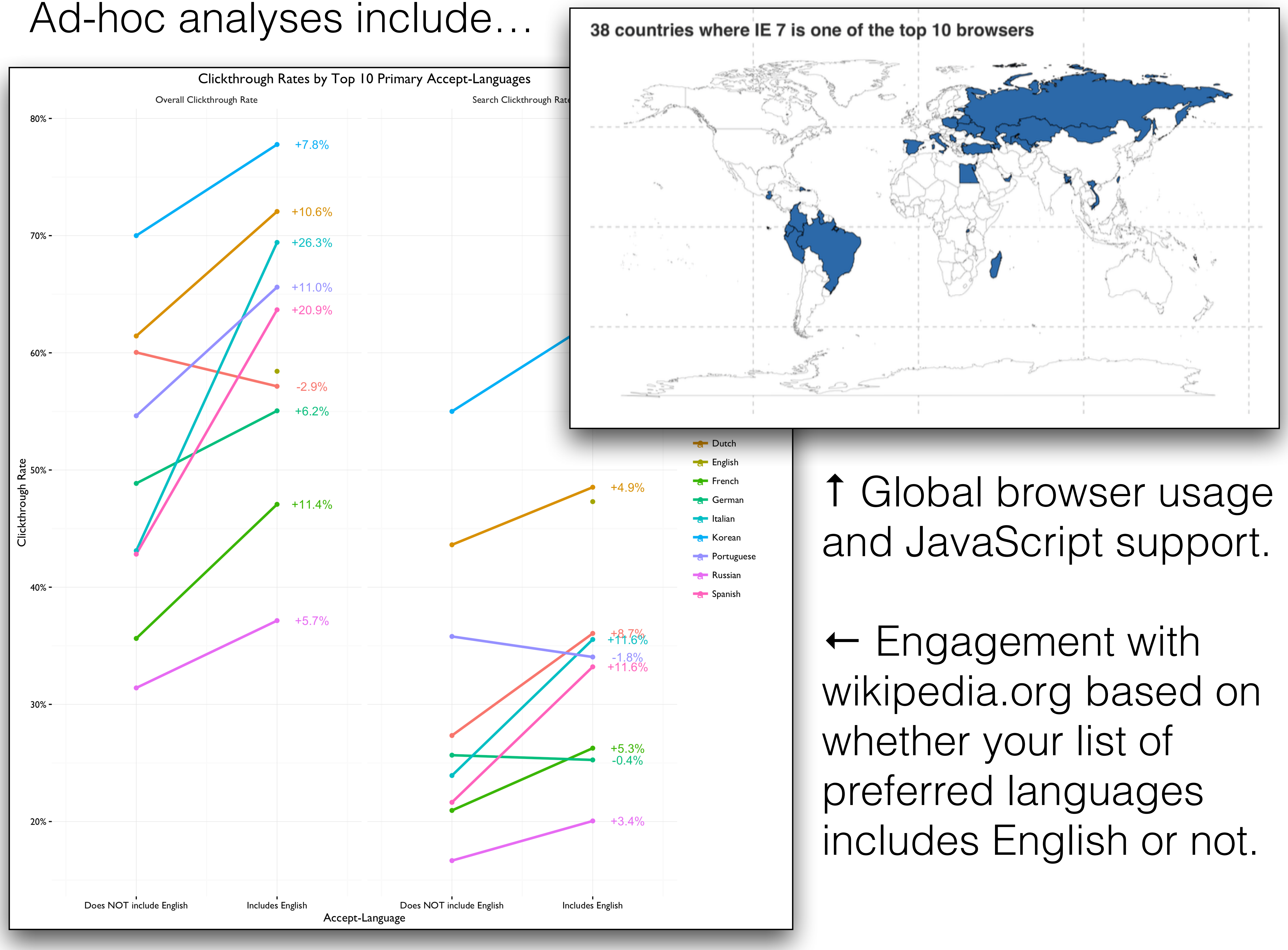
k · Eesti · Ελληνι

· Bahasa Minang

Discovery’s Analysts

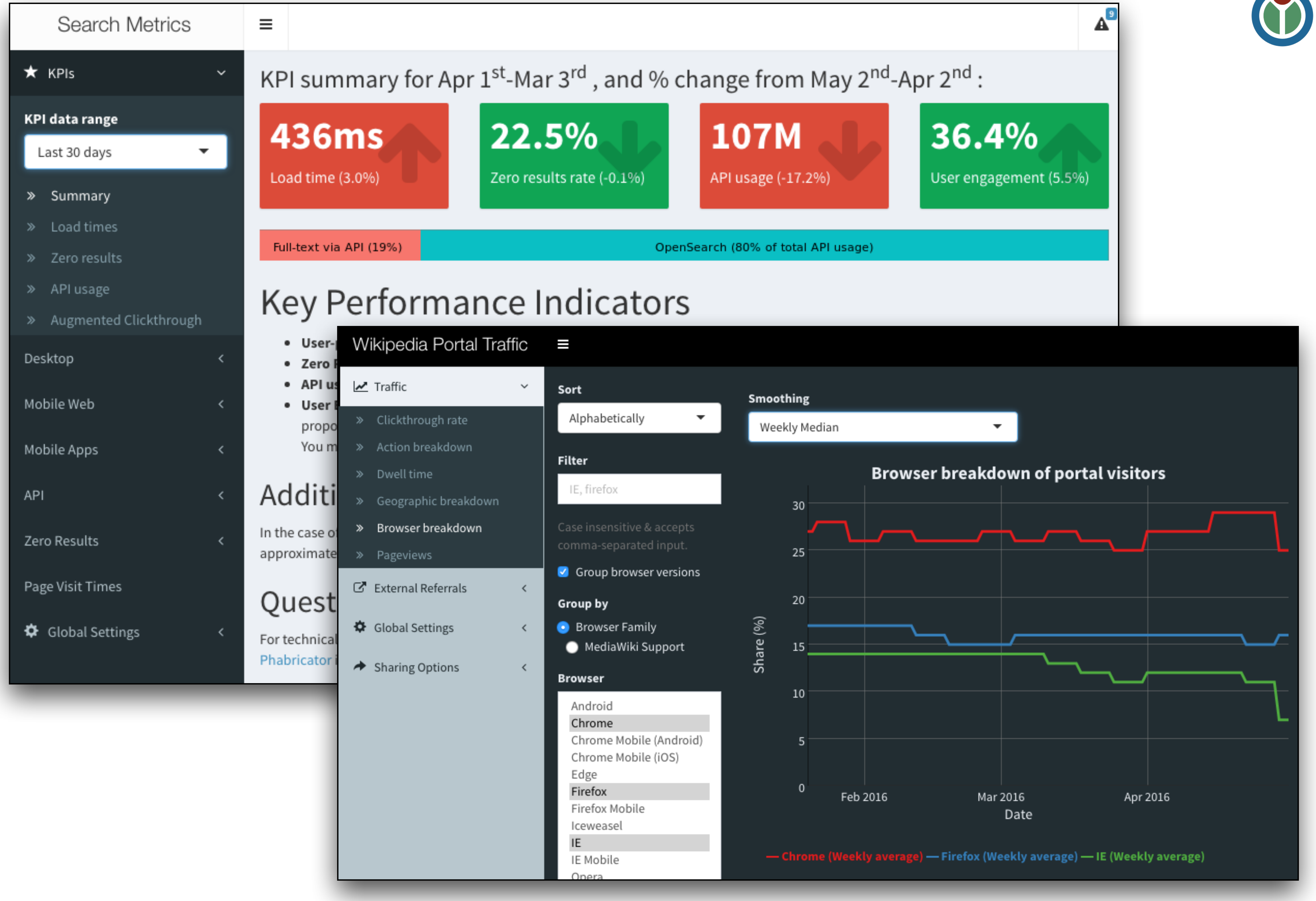
- 📊 Integrated within department instead of separate dep’t
- 📊 Provide ad-hoc analyses and reports as needed
- 📊 Build and maintain dashboards for tracking *key performance indicators* (KPIs) and other metrics
- 📊 Consult with teams in design of experiments – “A/B tests” – e.g. narrowing down affected population
- 📊 Work with engineers to design event logging schemas

Ad-hoc analyses include…



↑ Global browser usage and JavaScript support.

← Engagement with wikipedia.org based on whether your list of preferred languages includes English or not.



Search Metrics

KPI summary for Apr 1^{st}-Mar 3^{rd} , and % change from May 2^{nd}-Apr 2^{nd} :

436ms Load time (3.0%)	22.5% Zero results rate (-0.1%)	107M API usage (-17.2%)	36.4% User engagement (5.5%)

Full-text via API (19%) OpenSearch (80% of total API usage)

Key Performance Indicators

- User-
- Zero R
- API us
- User E

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Wikipedia Portal Traffic

Sort: Alphabetically

Filter: IE, firefox

Case insensitive & accepts comma-separated input.

☑ Group browser versions

Group by

● Browser Family

○ MediaWiki Support

Browser

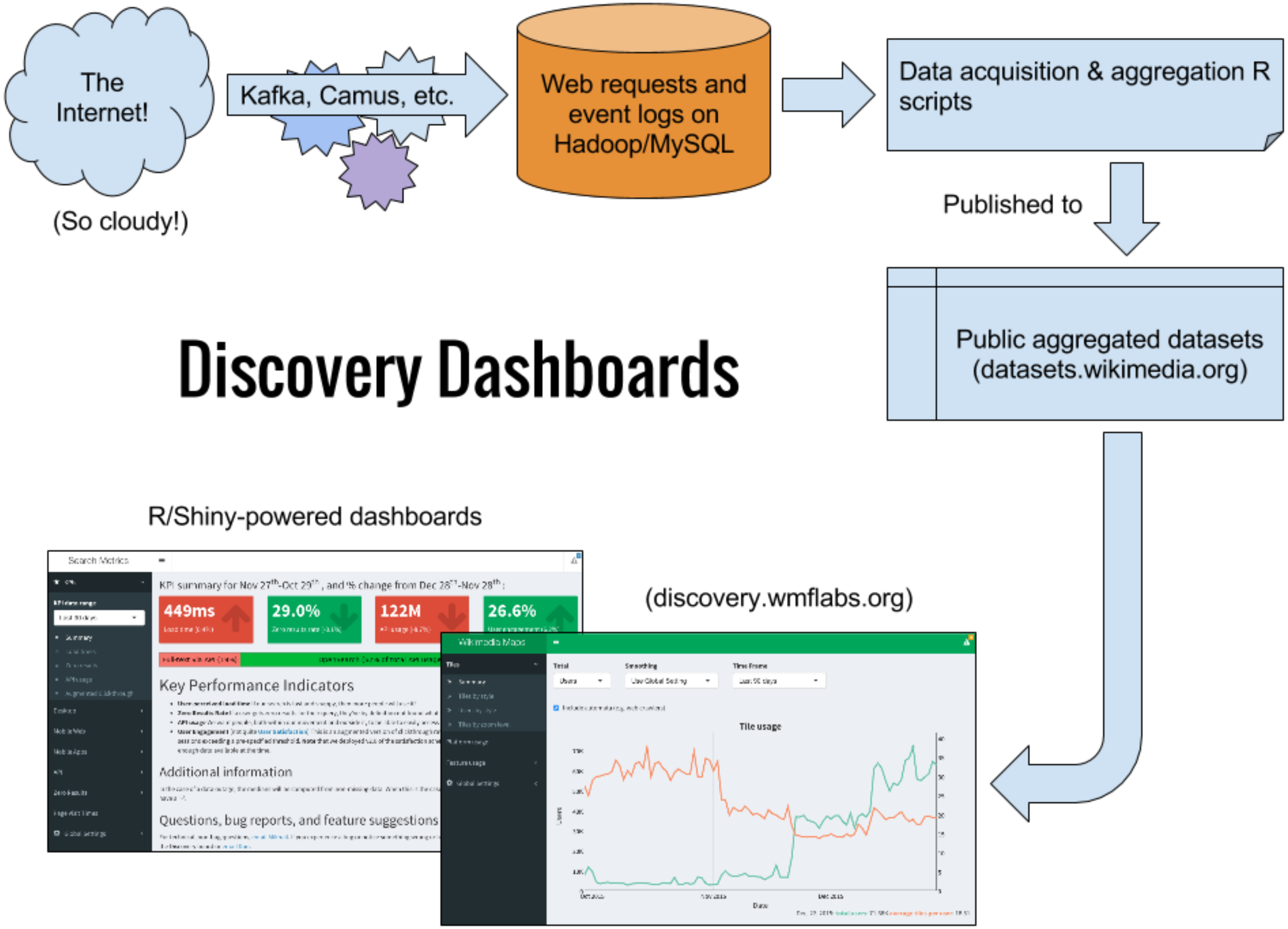
- Android
- Chrome
- Chrome Mobile (Android)
- Chrome Mobile (iOS)
- Edge
- Firefox
- Firefox Mobile
- Iceweasel
- IE
- IE Mobile
- Opera

Smoothing: Weekly Median

Browser breakdown of portal visitors

30
25
20
15
10
5
0
Share (%)
Feb 2016
Mar 2016
Apr 2016
Date
— Chrome (Weekly average) — Firefox (Weekly average) — IE (Weekly average)

discovery.wmflabs.org



The Internet!
(So cloudy!)
Kafka, Camus, etc.
Web requests and event logs on Hadoop/MySQL
Data acquisition & aggregation R scripts
Published to
Public aggregated datasets (datasets.wikimedia.org)
Discovery Dashboards
R/Shiny-powered dashboards
(discovery.wmflabs.org)

Search Metrics

KPI summary for Nov 27th-Oct 29th, and % change from Dec 28th-Nov 28th:

449ms | 29.0% | 122M | 26.6%

Key Performance Indicators

Additional information

Questions, bug reports, and feature suggestions

Wikimedia Maps

Total: Users | Smoothing: Use Global Setting | Time Frame: Last 90 days

Tile usage

Database-to-Dashboard Pipeline

Data & Technologies

Web & Search Requests

- 📈 *MapReduce* with Hadoop Distributed File System (HDFS)
- 📈 Kafka (log buffer) → HDFS via LinkedIn's Camus pipeline
- 📈 Includes IP addresses, request referrers, user agents, queries
- 📈 Retrieve and aggregate data with HiveQL and User-defined functions (UDFs) written in Java

Event Logging (User Actions)

- 📉 JavaScript event triggers (e.g. clickthroughs, edits, pings)
- 📉 Kafka → MariaDB (MySQL)
- 📉 Varying degrees of privacy (anonymized → containing PII) & sampling (all vs. 1 in n users)
- 📉 Retrieve and aggregate using Structured Query Language

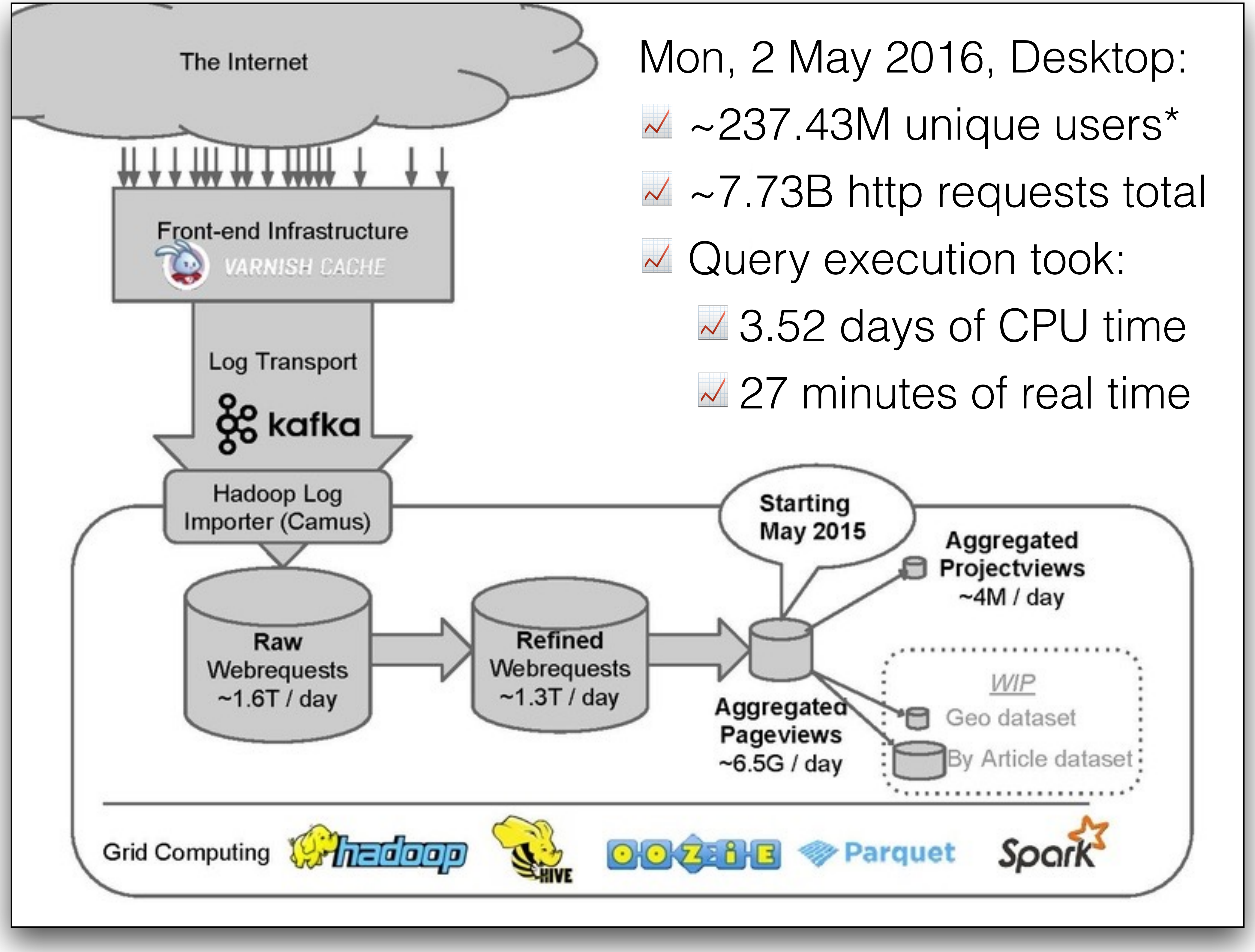
Event Logging Volume

- Only 0.5% of sessions (users) get selected for anonymous tracking
- Monday, 2 May 2016, on Desktop: 23K sessions (users) recorded

event	total events	average per user
search results page	226K	9.93
opened a result	2.8K	1.37
“I’m alive!” check-in	14K	8.04
clicked	22K	1.73

Mon, 2 May 2016, Desktop:

- ~237.43M unique users*
- ~7.73B http requests total
- Query execution took:
  - 3.52 days of CPU time
  - 27 minutes of real time



My team only uses R

Development: devtools, testthat, roxygen2, Rcpp, RStudio + GitHub

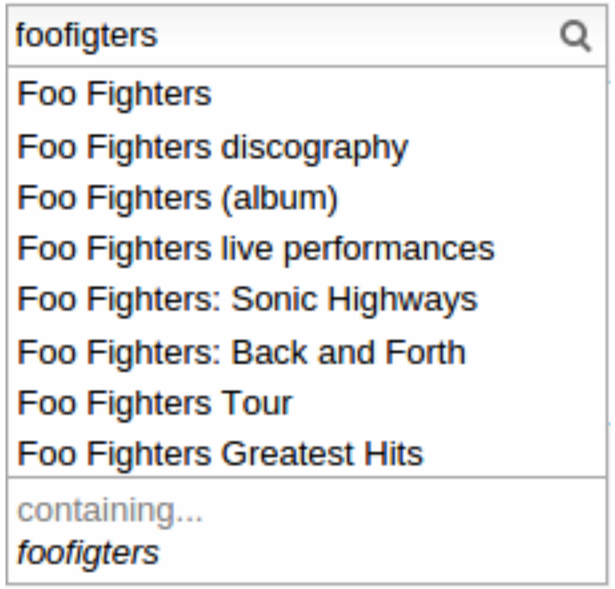
Data Manipulation & Analysis

- ⚒ Data wrangling: readr, dplyr, tidyr, data.table, lubridate, xts
- ⚒ Web analytics: urltools, rgeolocate, iptools, uaparser
- ⚒ Bayesian analysis of categorical data: BCDA

Data Visualization & Reporting

- 🖍 ggplot2 + ggthemes + ggally
- 🖍 RMarkdown + knitr for reproducible reporting
- 🖍 shiny + shinydashboard + dygraphs (for time series)
- 🖍 All code (but not data) is public at github.com/wikimedia-research

Testing Completion Suggester's Impact on Zero Results Rate

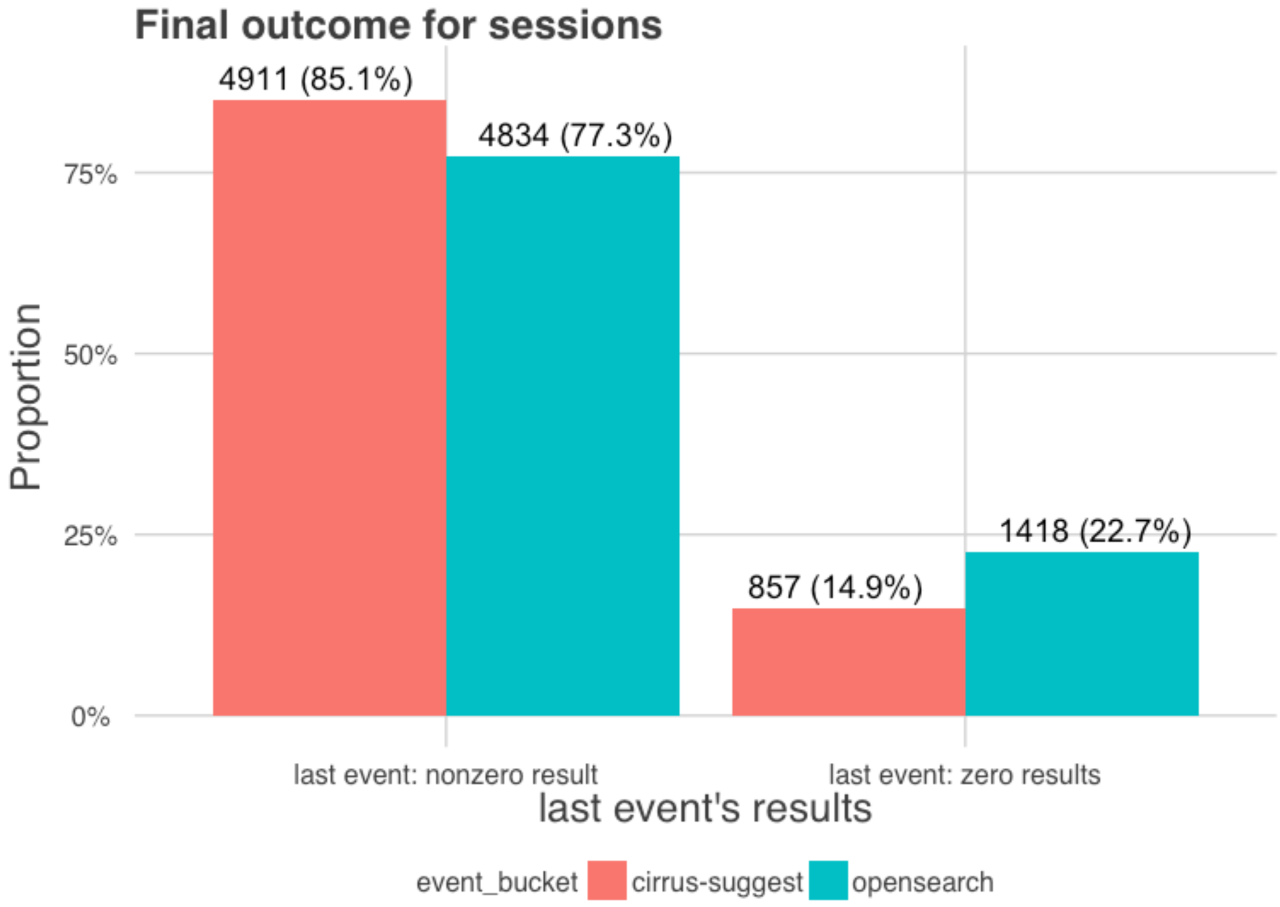


foofigters

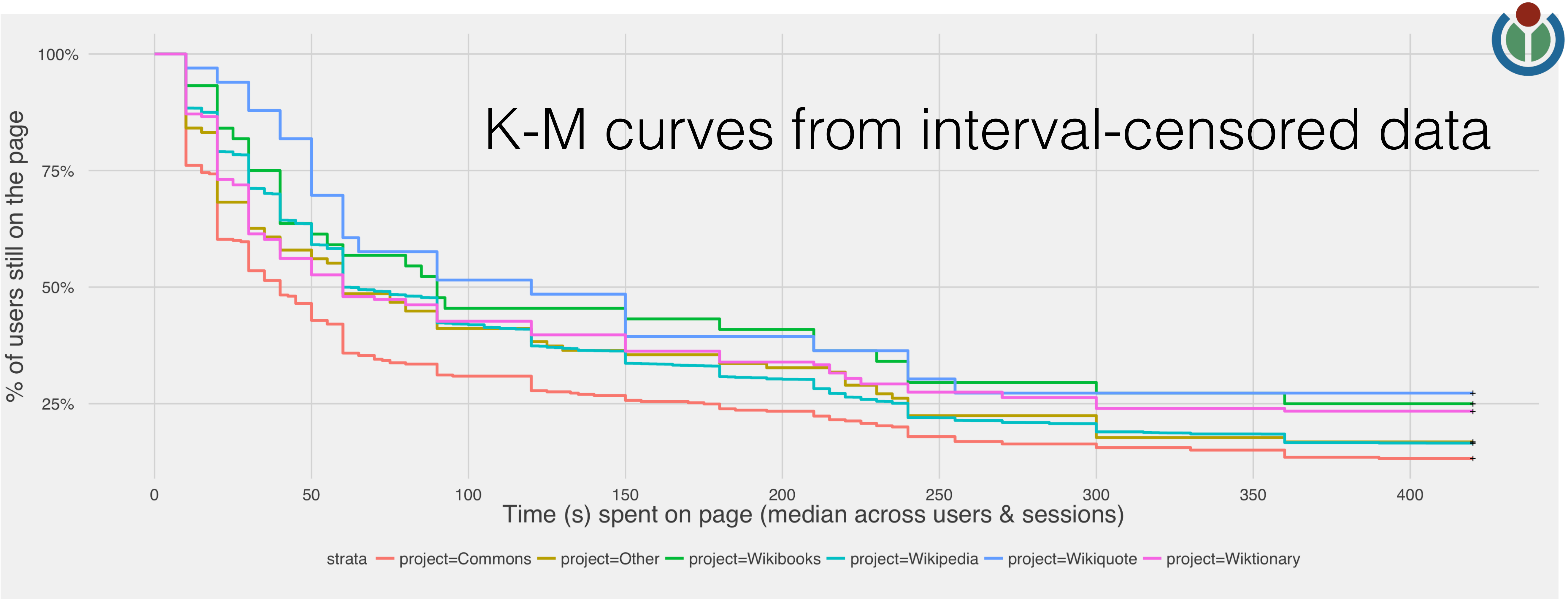
Foo Fighters
Foo Fighters discography
Foo Fighters (album)
Foo Fighters live performances
Foo Fighters: Sonic Highways
Foo Fighters: Back and Forth
Foo Fighters Tour
Foo Fighters Greatest Hits

containing...
foofigters

- Tolerance for typos and stop words
- Fewer typos suggested (e.g. searching for *Airton Senna* will properly suggest *Ayrton Senna*)



- Used Bayesian methodology (Beta-Binomial model) to compute difference, relative risk, and credible intervals.
- Deployed as opt-in beta → deployed to production!



Human-Computer Interaction Research: User Satisfaction

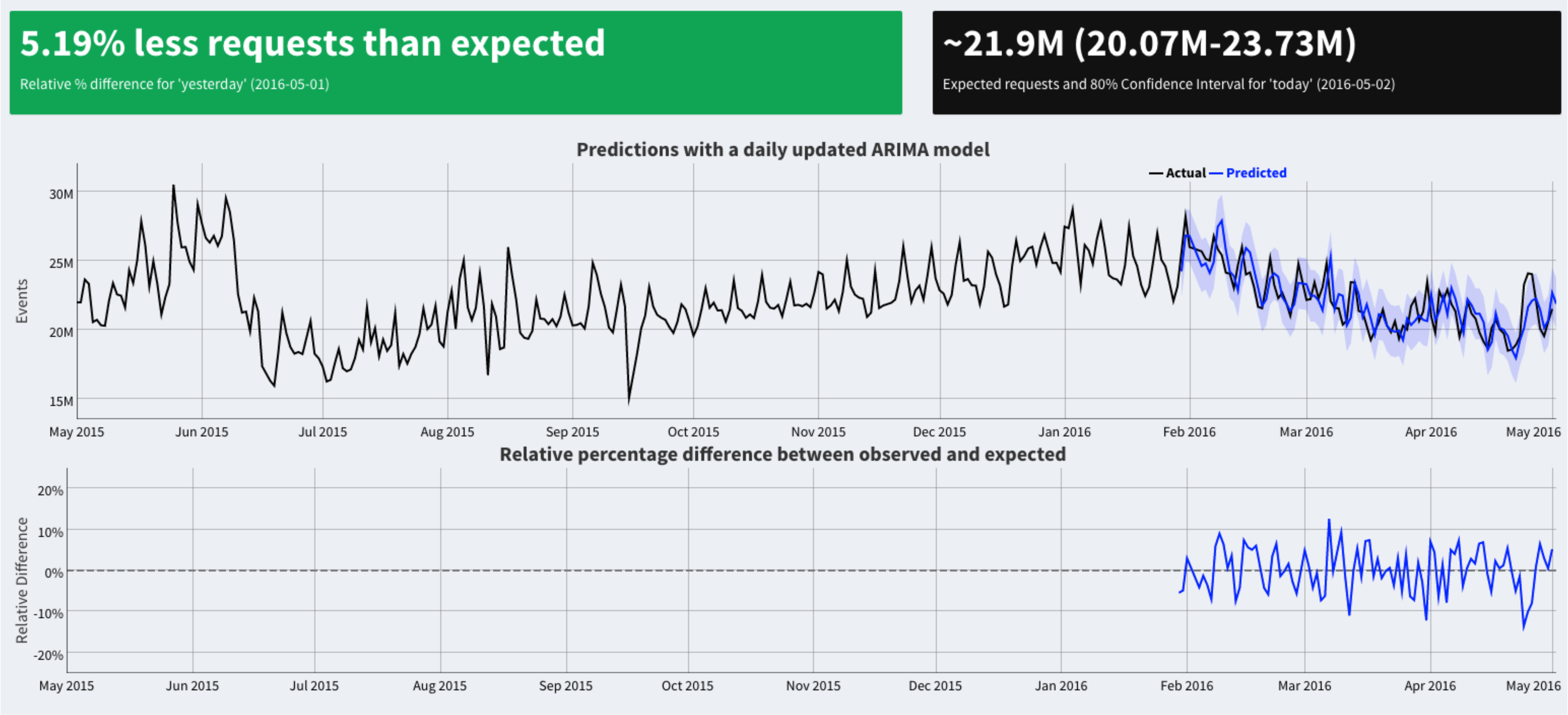
Scenario 1: Find out Barack Obama's birth date.

Scenario 2: Learn about Black Lives Matter movement.

Scenario 3: I search for Lin-Manuel Miranda's *Hamilton*, stay there for 5s, and then decide I want to read about Aaron Burr.

Scenario 4: I search a vague term with no specific task in mind.

Project: daily forecasts to detect anomalies & abuse of service



5.19% less requests than expected

Relative % difference for 'yesterday' (2016-05-01)

~21.9M (20.07M-23.73M)

Expected requests and 80% Confidence Interval for 'today' (2016-05-02)

Predictions with a daily updated ARIMA model

Relative percentage difference between observed and expected

Prototype using ARIMA: http://discovery-experimental.wmflabs.org/forecast/

Future work will probably focus on Bayesian Structural Time Series Modeling

Thank you!

Got additional questions?

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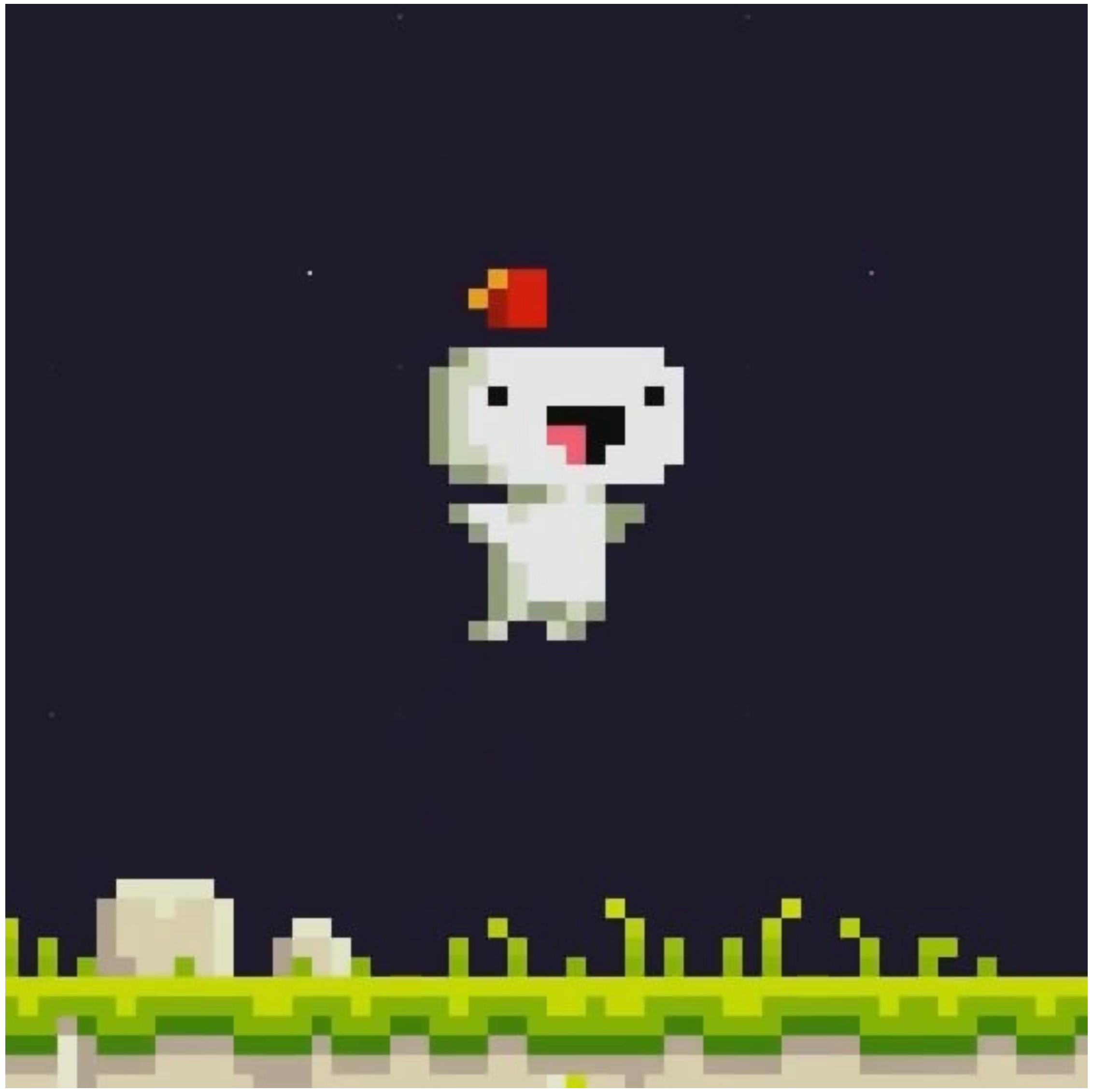

We're hiring data analysts!

See the jobs page at WMF:
https://wikimediafoundation.org/wiki/Work_with_us