

# Engineering Anatomy of a Search App

*Which can be applicable to any app.....*

Marcelo De Barros

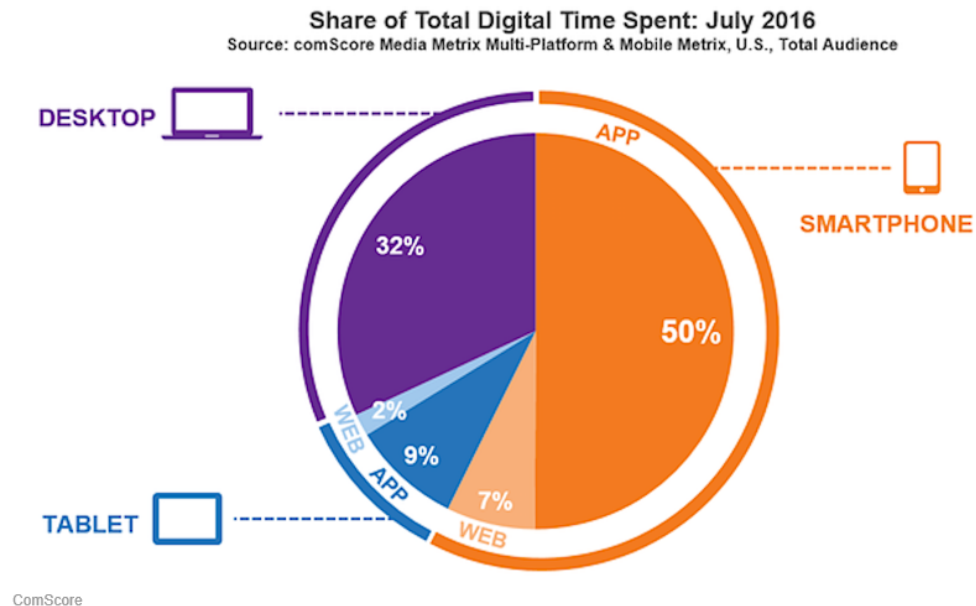
Principal Group Engineering Manager – Bing - Microsoft

# The rise (and potentially fall) of mobile apps!

Huge market with millions of apps (iOS and Android)

The pros: native experience, OS integration

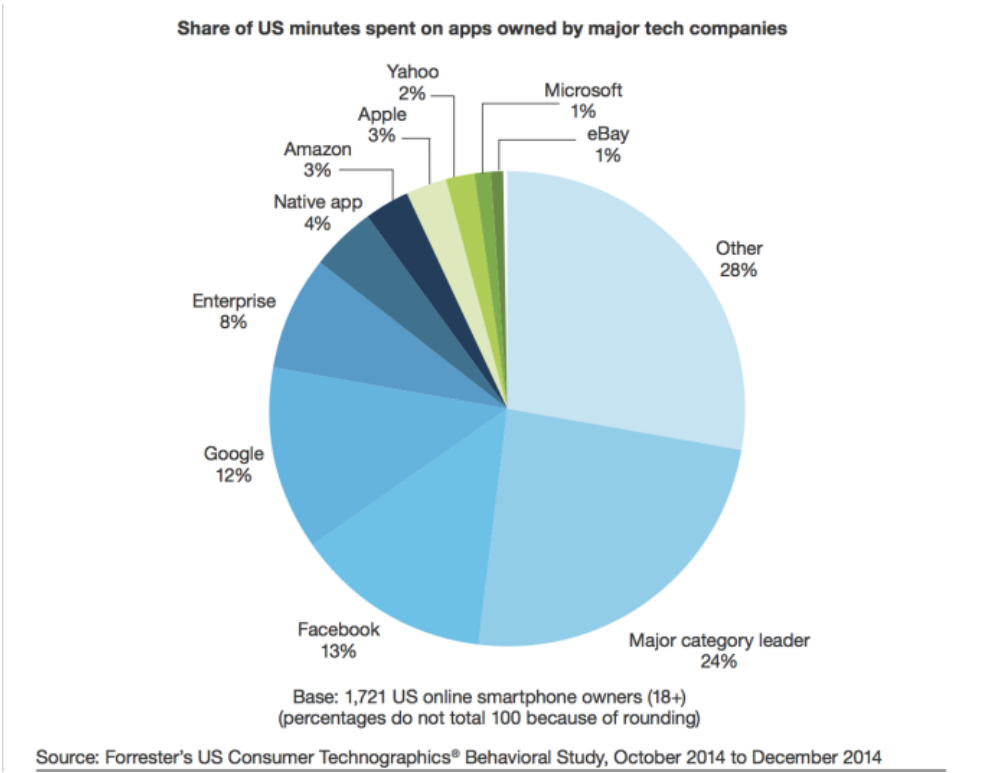
Users are clearly spending more time on Apps than on the Web



# The rise (and potentially fall) of mobile apps!

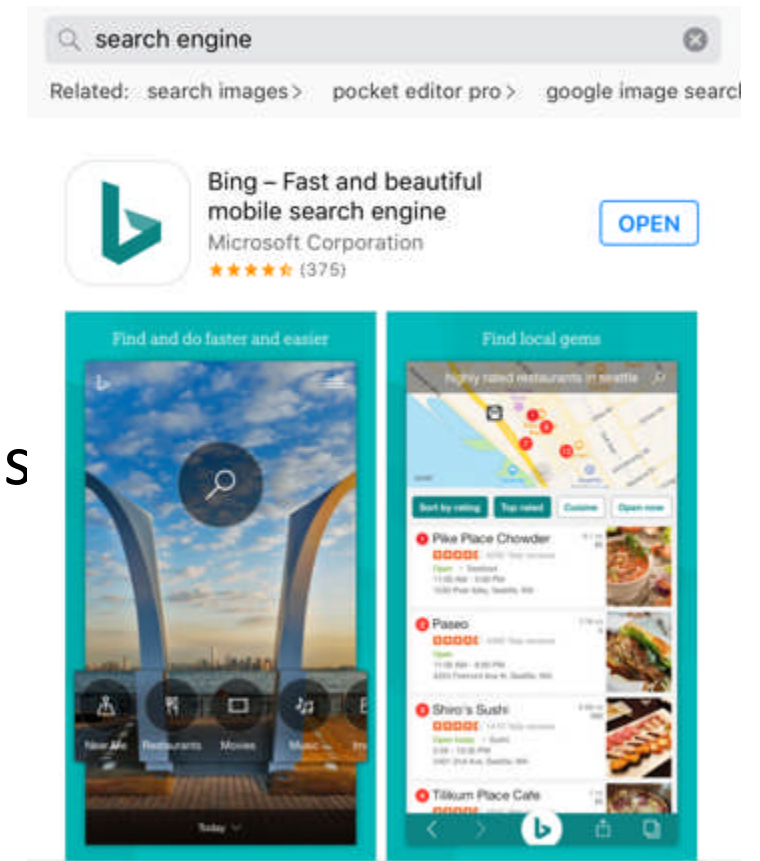
However, users are using fewer apps (basically, they use five apps)

Still, an eco-system that will live for many-many years to come...



# Who are we?

- Microsoft – Bing – UX Features and Visual System
- Search App
  - Global Search (web documents)
  - Local Search (location-based)
- Heavy focus on entertainment and browser features
- iOS and Android
- Currently in the en-\* market only
- 5-star app\* (*\*changes rapidly though*)



# Characteristics of top search apps

- **Fundamentals**

- Availability/Stability
- Agility
- Instrumentation & Feedback
- Experimentation

- **Performance**

- Progressive Rendering
- Pre-Fetching and Pre-Rendering
- AMP (Accelerated Mobile Pages)
- Poor-Network Detection and Optimization

- **Differentiating Features**

- Offline Mode
- Visual Search
- Embedded Machine Learning (reading mode)

- Discoverability and Distribution Models

# Characteristics of top search apps

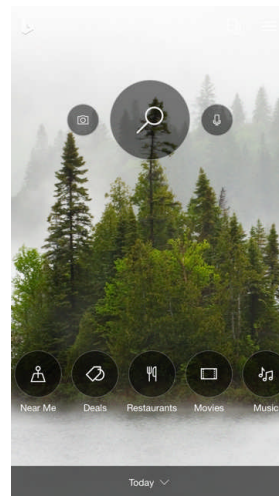
- Availability
  - Memory management
  - **Crashes** are directly related to **reviews** and customer feedback
  - Reviews are directly related to **ranking**
  - Ranking is directly related to **downloads**
  - Shift paradigm to even more defensive techniques

# Characteristics of top search apps

- Agility

- Design decisions:

- **Server-driven** (configs, flights, assets, experiences). Client changes are expensive
    - JSON endpoint, shallow UX (swift/Java) driven by the server changes
    - **ON/OFF features toggle** (server-side)
    - Server-side changes: propagates in **5 min** (7 data centers around the world)



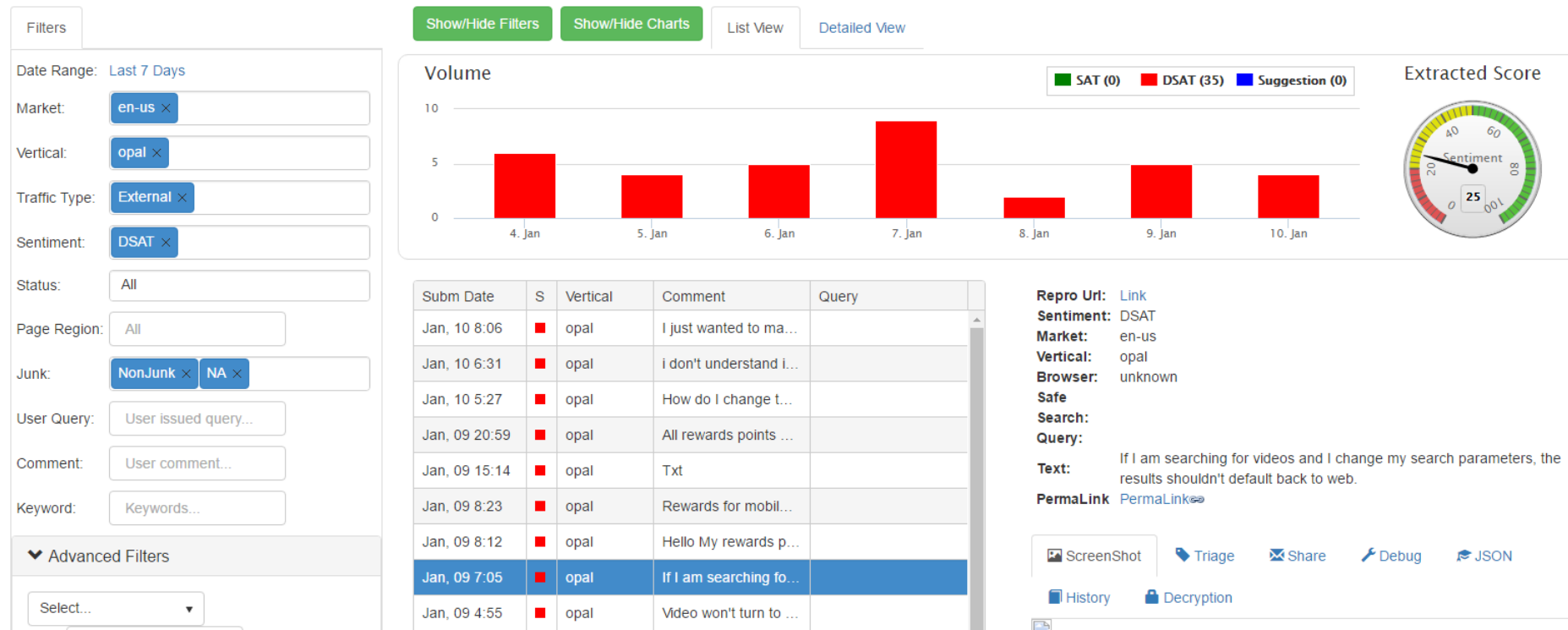
# Characteristics of top search apps

- Instrumentation
  - **Every single aspect:** layout, clicks, dwell time, etc. (**no specific user metric!**)
  - Always learn: learn fast, fail fast (also, good code != pleasant features)
  - Options for instrumentation: custom or generic (e.g., localytics for iOS)



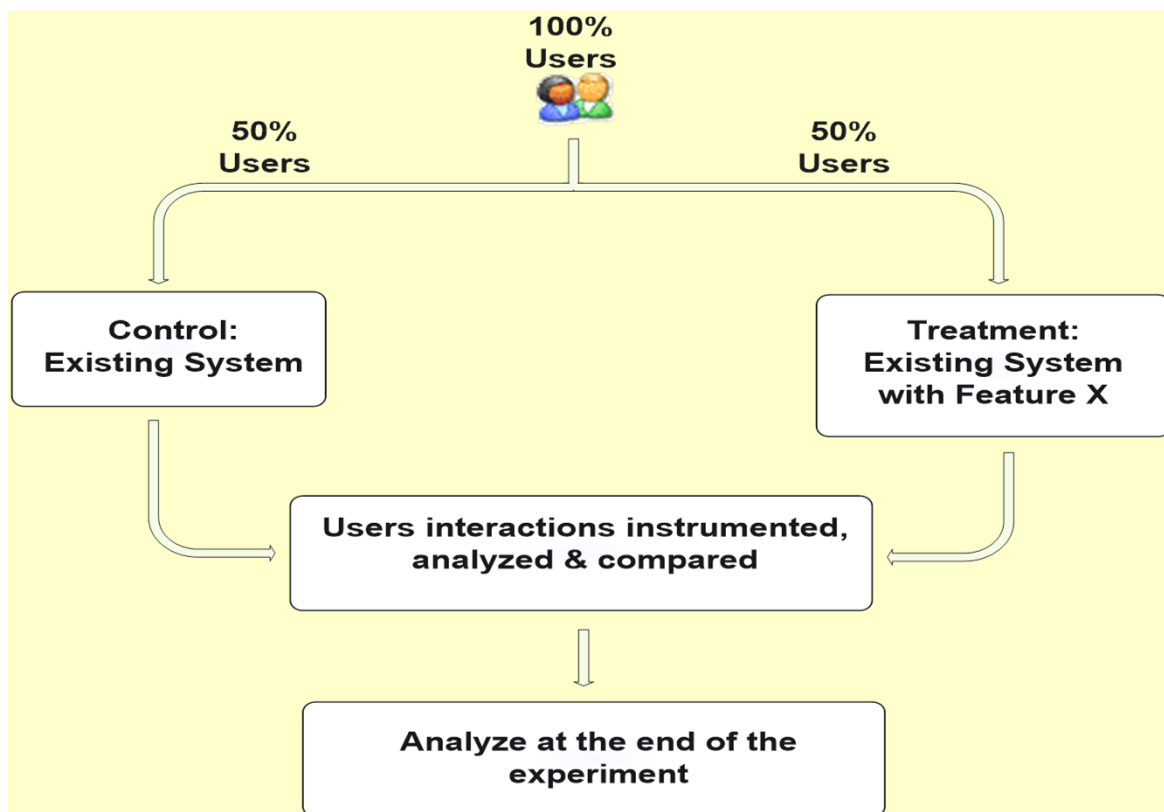
# Characteristics of top search apps

- Feedback: app stores and custom
- Listen-Listen-Listen!!!



# Characteristics of top search apps

## Experimentation



- A/B test is the simplest controlled experiment
- Users are selected randomly into control and treatment (statistics)
- Best scientific way to prove **causality**, i.e., the changes in metrics are caused by changes introduced in the treatment(s)

# Characteristics of top search apps

## Example: True User Intents

### Control

54,900,000 RESULTS Any time ▾

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341 quotes from The Art of War: 'Appear weak when you are strong, and strong when you are weak.'

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For to win one hundred victories in one hundred battles is not the acme of skill. To subdue the enemy without fighting is the acme of skill.


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First published: 1913

Author: Sun Tzu

Series: Seven Military Classics

Genres: Philosophy · Military science · Treatise · Economics · Fiction · Inspirational

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### Treatment

53,600,000 RESULTS Any time ▾

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People also search for



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Feedback

See results for



The Art of War  
2000 Film  
The Art of War is a 2000 American action film directed by ...

# Characteristics of top search apps

## Example: True User Intents

### Control

art of war

54,900 RESULTS

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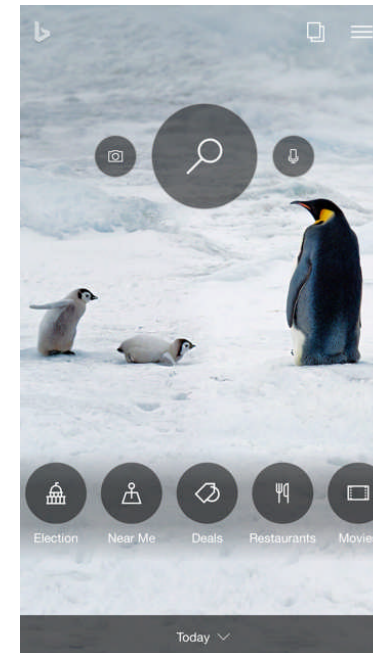
- By modifying the position of the elements on the page (closer/farther from the query box), intent can be inferred through A/B experimentation

➡ Intent: Read the book

➡ Intent: Wikipedia (read about the book)

# Characteristics of top search apps

- Always experiment!
  - Data-driven
  - Majority (> 50%) of your traffic should be experiment
  - Use experimentation to decide intent and subjective info, not to find bugs!
  - Examples:
    - Order of the bubbles
    - Heuristics such as for poor-network detection (sliding window)
    - Colors/Fonts/Spacing/Padding
    - AMP (Accelerated Mobile Pages)



# Embedded Machine Learning

The Reading Mode

# Machine learning is everywhere now!

- From chat-bots to self-driving cars
- From server-side to client-side features

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CIO JOURNAL.

### The Year Ahead: Artificial Intelligence Drives CIO Agendas

Managing emerging technologies can help IT chiefs lead 'digital transformation' efforts

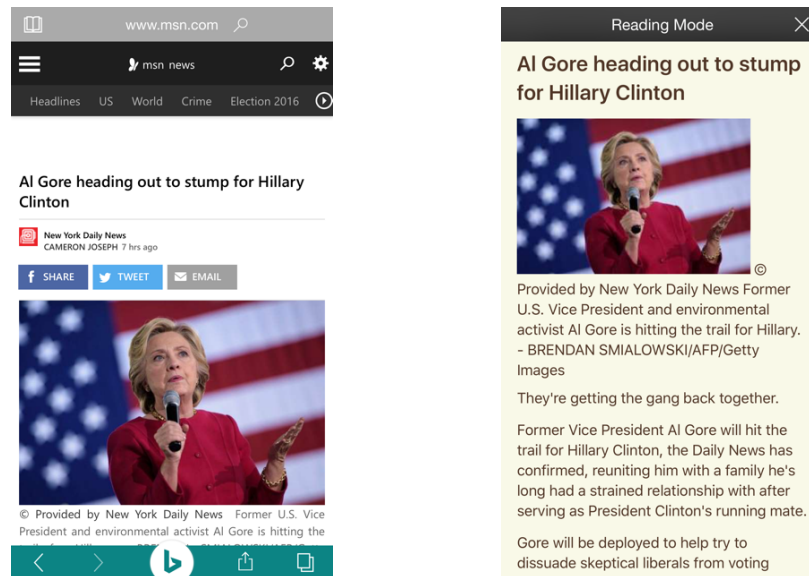
By [STEVEN NORTON](#)

Jan 2, 2017 10:56 am ET

CIOs are putting a generation of cheaper and more powerful artificial intelligence to use in a range of corporate applications, automating work that people have performed and making it possible to do things that weren't possible before. The applications range from practical, highly targeted chatbots to broad-based artificial intelligencesuch as Watson,

# Reading mode

- Problem Statement: *given an HTML page, which elements to keep and which elements to throw away in order to maximize readability?*



- Typical supervised machine learning problem:
  - Training data (laborious)
  - Features selection (images, videos, source, tags, etc.)
  - Select the machine learning model (Neural-Net, Decision Trees, **Custom Clustering**)
  - Training → Test → Repeat



# Entity Extraction

```
▶<header>...</header>
▼<div class="row two-columns-fixed-rr">
  ::before
  ▼<section class="column">
    ▼<article class="module">
      ▼<div id="storycontent">
        <!--storytext-->
        ▼<div id="storytext">
          ▶<div id="js-ie-storytop" class="ie--storytop" style="height: auto;">...</div>
          ▶<div class="share-tools share-tools--floater" id="js-sharebar-floater" style="top:
            <h2>OPEC is finally agreeing to cut oil production.</h2>
            ▶<p>...</p>
            ▶<div id="ie_column">...</div>
            <p> Oil prices surged more than 5% in reaction. </p>
            ▶<p>...</p>
            ▶<p>...</p>
            ▶<p>...</p>
            ▶<p>...</p>
            ▶<p>...</p>
            <div id="storyFooter"></div>
            ▶<div class="clearfix">...</div>
            ▶<div class="storytimestamp">...</div>
            </div>
            <!--/storytext-->
            ▶<div class="foot">...</div>
            </div>
            <!-- main -->
            <div class="share-tools pull-left" id="js-sharebar-main"></div>
          </article>
        ▶<div class="cnnoutbrain outbrain-recommended" id="js-outbrain-recommended">...</div>
```

- Idea: find the grouping of **tags that define an article**, while ignoring ads/social/etc.
- **Score reader friendly tags higher** (p, div, article, h5)
- Score tags that contain **large bodies of text higher**
- **Penalize** certain tags/phrases: **ad, share, social, sidebar**
- Apply **scoring** over the DOM tree (**clustering with thresholds**)

# Performance Characteristics

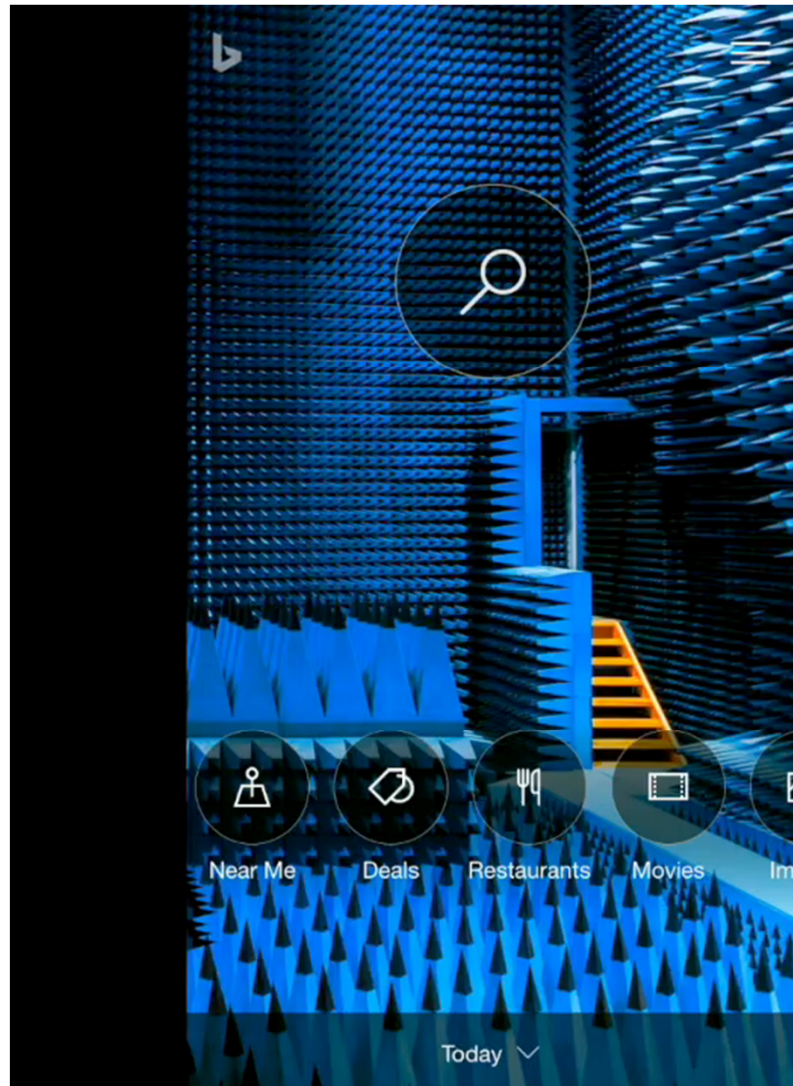
# Performance Characteristics

- App benefits: memory (but that can also be the problem...)
- Core ideas:
  - Progressive Rendering (JSON → render above the “fold” → render the rest)
  - **Pre-fetch and Pre-render content**
  - **Detect poor-network** and adjust based on it
  - “Perceived” performance (which is what users care....)

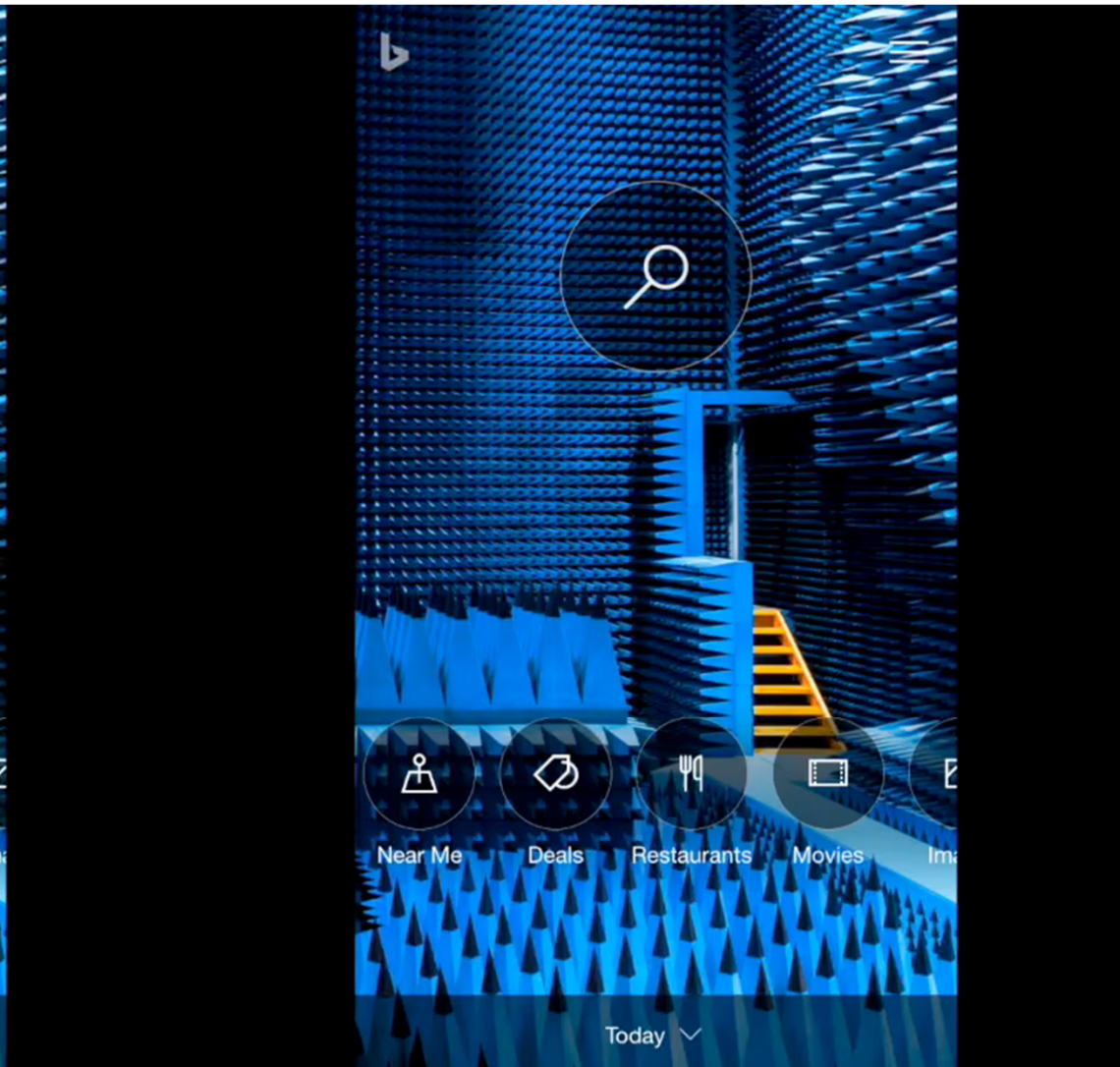
# Content Prefetch - Design

# Example-1: auto-suggest pre-fetch comparison

No pre-fetch

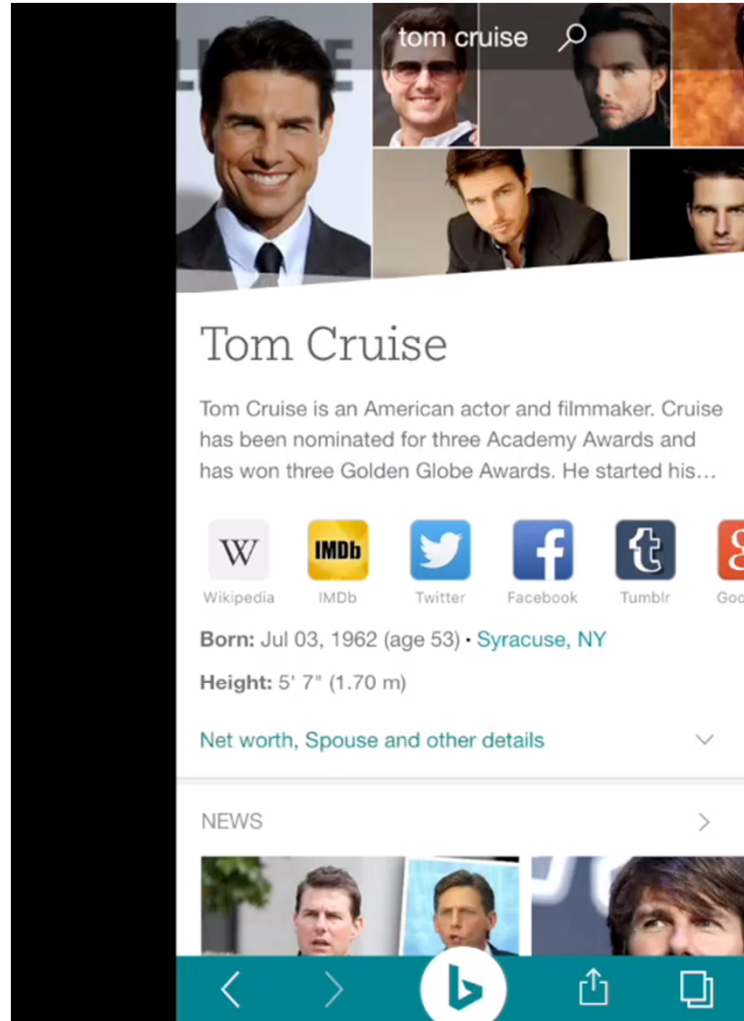


With pre-fetch

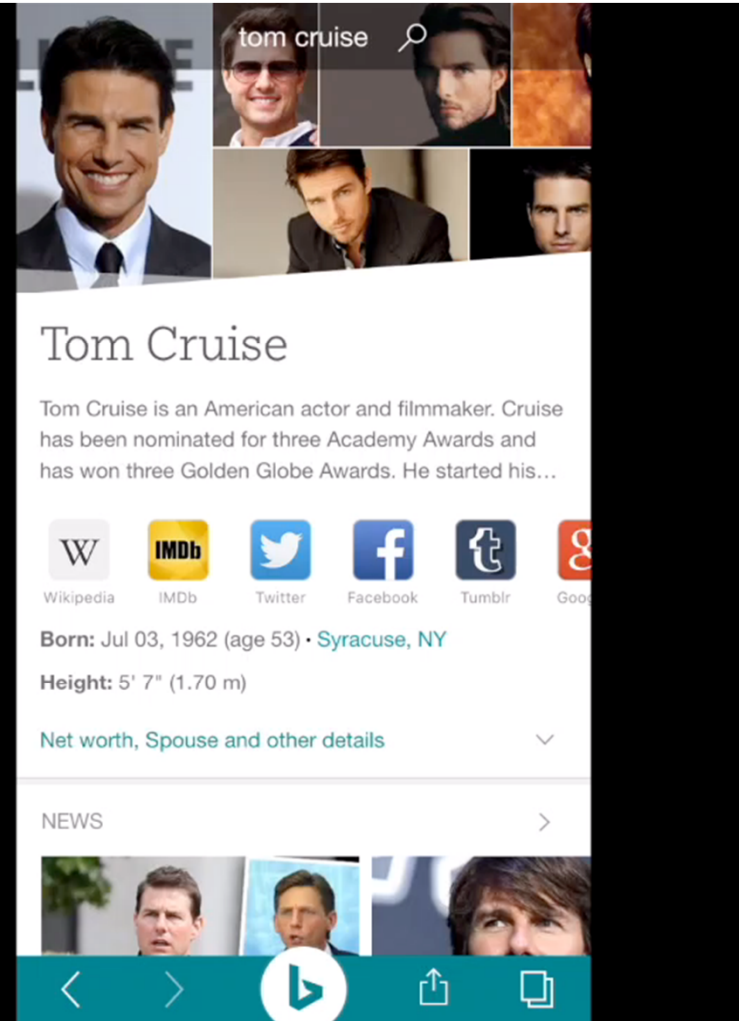


# Example-2: related entities pre-fetch comparison

No pre-fetch

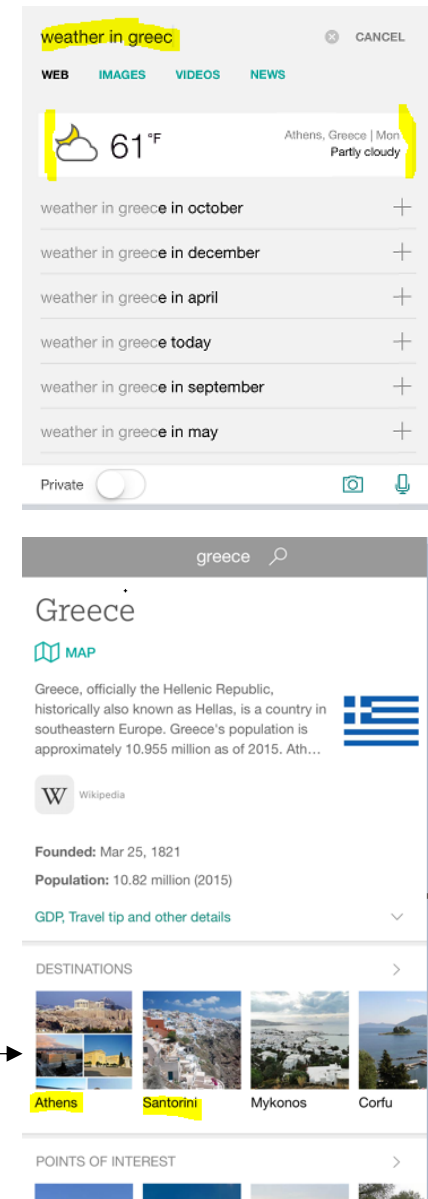


With pre-fetch



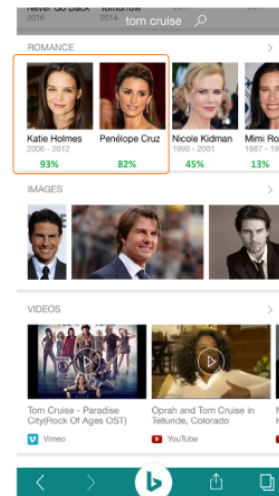
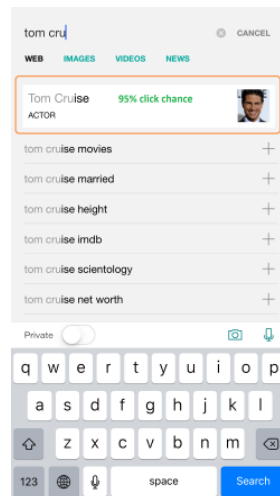
# Feature Principles

- 2 target scenarios
  - Answer Autosuggest
    - **High confidence** on user intent
  - Top 2 Related carousel's first entity
    - Chance of clicking on first entity of top 2 related entity carousel is high
      - **Over 96% probability** (for the carousel items)
    - Carousel count to pre-fetch = 2 ( server side configurable)
- Can individually turn off different aspects
  - Autosuggest pre-fetch
  - Related entities pre-fetch
  - Entire pre-fetch feature



# Pre-Fetch Principles

- Spin off a background thread to download (pre-fetched) content
- Determination of content to pre-fetch:
  - Network considerations:
    - Good network (heuristic)
    - WiFi (data plan consideration)
    - Not “in-private” mode (privacy consideration)
  - Scenarios where the user will be likely to engage (heuristic-based)
  - Server-configured





# Pre-Fetch + Pre-Render

- Extra trick: pre-fetch and *pre-render*
- Pre-Render: set of Hidden WebViews (HWV)
- Upon pre-fetch, **content is pre-render in one of the HWV**
- On click, swap the views
- Pros:
  - Speed (immediate)
- Cons:
  - Memory pressure (potential “silent” crashes)
  - Technical nuances (such as “sound”)
  - Privacy (sharing cookies with “unseen” pages)

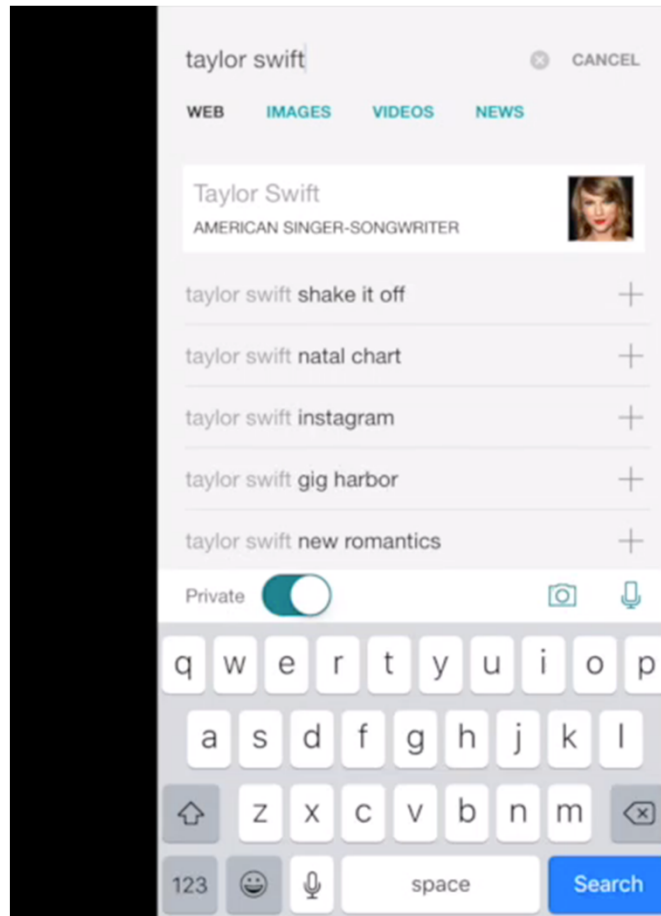
# Detection and Optimizations for Poor Networks

# Motivation

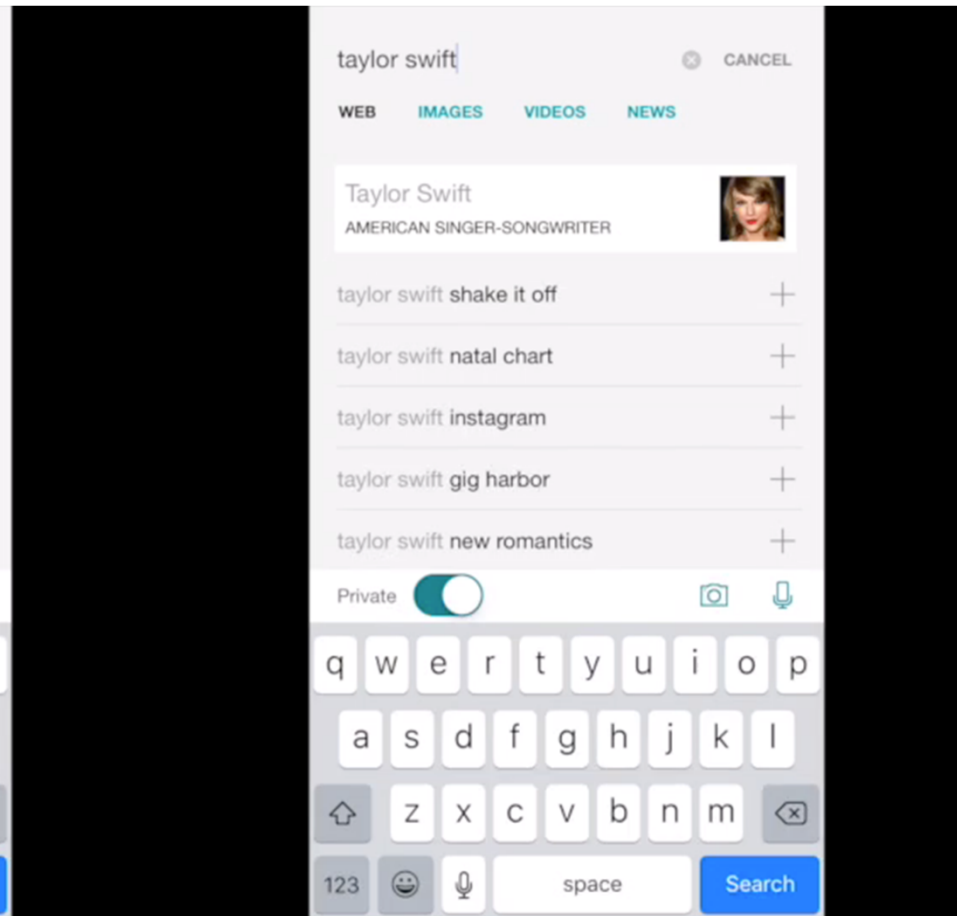
- iOS apps in general are **painful in slow/high-latency networks**
- These poor networks are everywhere
  - 3G with poor signal
  - Public WiFi (bus/coffee shop/airport)
  - Crowded environments
- If we could **detect our network speed ...**
- ... we could **tailor our actions** to improve the experience!
  - Use less data & decrease load times

# Demo

Dynamic Quality On



Dynamic Quality Off

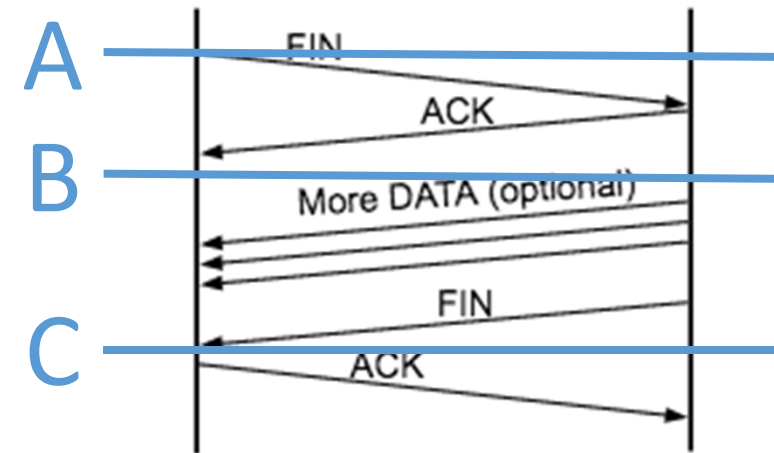


# Core Concepts

- Goal: Detect all forms of slow connections
- Idea: Use past connections to predict future ones
- Requirement: Accomplish everything client side!
- How: Track latency, bandwidth, and failed connections
- How: Sliding window to smooth the detection

# Detection for Poor Networks (iOS)

- A – `dataTask.start()`
- B – first call of `didReceiveData()`
- C – connection completed callback
- Latency is estimated by B – A
- Bandwidth is estimated by  $\text{size} / (C - B)$
- Store connection data in circular queue



#	9	6	7	8
Latency	0.50s	1.02s	0.37s	0.78s
Bandwidth	131k	035k	208k	154k



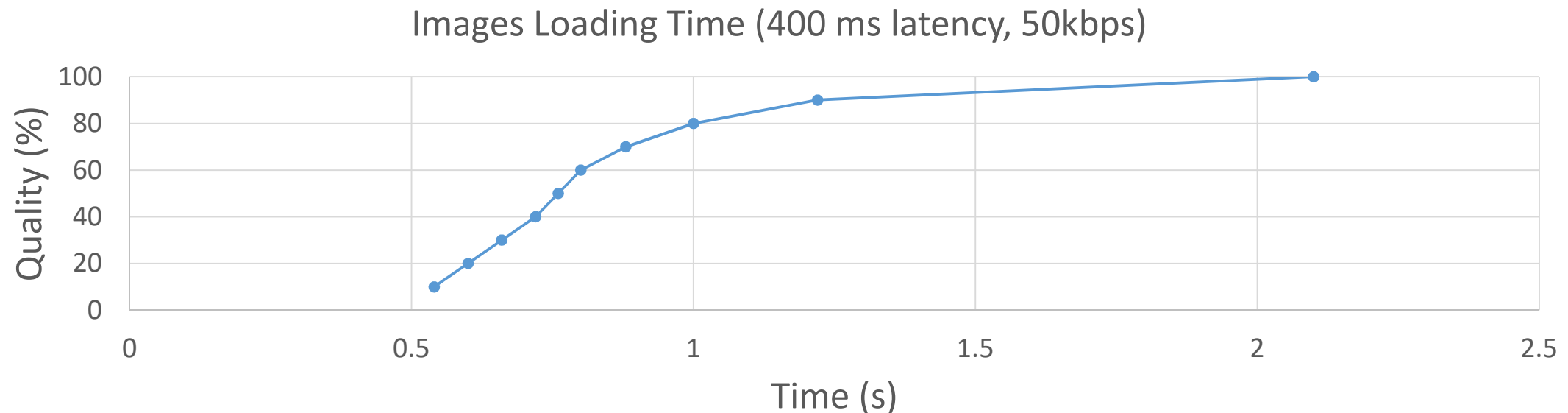
Avg Latency: 0.668s  
Avg Bandwidth: 132k

# Detection Considerations

- Existing solutions (FB's Network Connection Class for Android)
- Should reset on network changes (ex: 3G -> WiFi)
- Tune circular queue size
  - Too high -> fail to respond to changes
  - Too low -> susceptible to noise in network
- Latency dependent on connection setup
- Doesn't help cold queries
  - Pre-fetch/Config/Instrumentation can warm the queue!
- Handle caching gracefully (ignore cached content in the calculation)

# Optimizations for Poor Networks

- Based on network status, **customize the actions**:
  - Reduce size of paginated entries (no pagination)
  - Use lower quality images (gradually improve the quality)
  - Change timeout/retry policy for requests (lower the bar)
  - Stop requests from auxiliary features (such as “auto-suggest”)



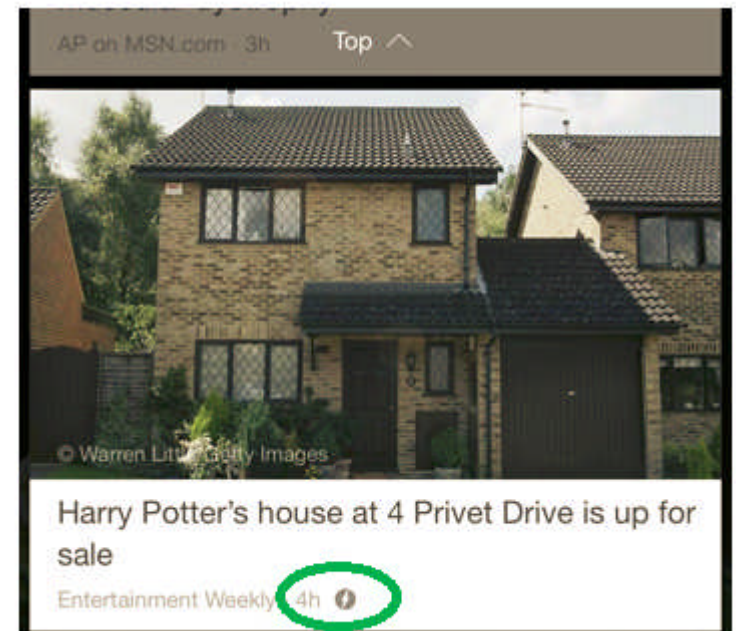


# AMP Integration

AMP: Accelerated Mobile Pages

# AMP: Accelerated Mobile Pages

- Subset of HTML heavily optimized for Mobile
  - Light: restriction on libraries
- Open Source (Google, Microsoft, Other Companies)
- 80% faster (based on Bing App data)
- 40% adoption (en-us, based on Bing App data)
- <http://blogs.bing.com/search/September-2016/amp-open-source-effort>



# In Summary...

- Apps ecosystem are being challenged, but it still in ascendance
- Fundamentals (availability, stability, agility, instrumentation) matters
- Performance is paramount – or else your app will be uninstalled...
- Machine Learning and AI must be part of your app
- Invest on discoverability, upselling and distribution models

