Capturing Mobile Experience in the Wild: A Tale of Two Apps

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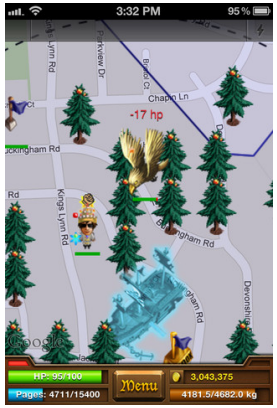
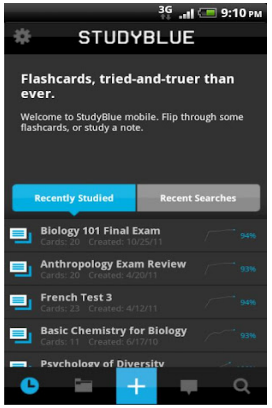
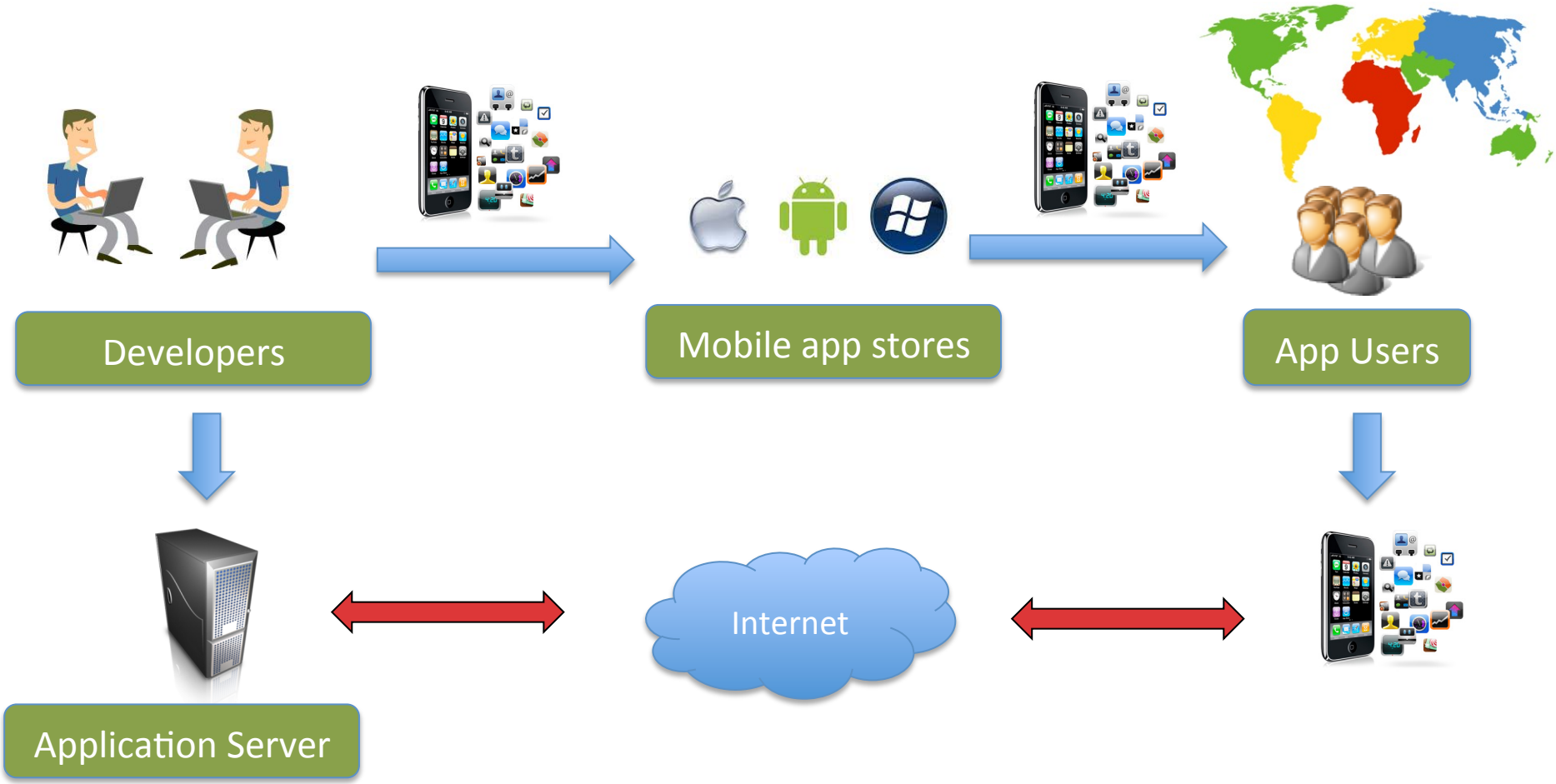




Deploying a mobile application…



What is the "Application Experience"?

Developers

What factors are impacting the users' experience?

What factors are impacting my application revenues?

.....

What is the battery drain of my application across different devices?

Challenge for developers…

Developers

App Users

Example 1: Diverse Devices

Type (tablet, phone) and platform

Screen type/area, OS, features (keyboard), battery capacity, device age

Developers

Application Server

App Users

Example 2: User diversity

Location, time of day, New vs. old users

Network quality (signal, congestion), session durations, revenues

Developers

Application Server

App Users

Example 3: Diverse Networks

802.11, HSDPA, EVDO, LTE → Latency, throughput

Developers

Application Server

App Users

Goal: Capture "application experience"



How can we enable developers to capture the "application experience"?

diversity

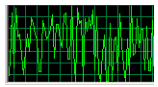
diversity

diversity

Understanding "application experience"

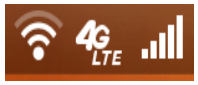
Developers

Device + UI Design (e.g., screen size)

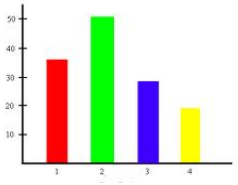


Application Overhead (e.g., Battery, CPU etc.)

User types (e.g., old vs. new)



Network performance (e.g., latency)



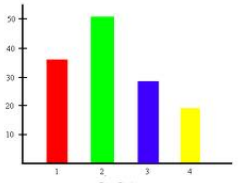
User Engagement (e.g., Session length, interactivity, retention)

Developer Revenues (e.g., virtual currency usage)

Application Experience

Understanding "application experience"

Device + UI Design (e.g., screen size)



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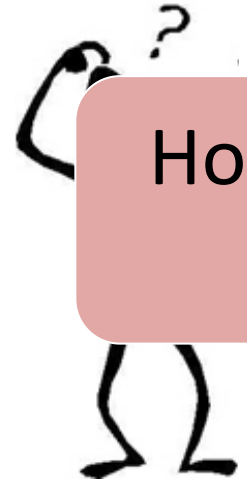
Application Overhead (e.g., (e.g., old vs. new)



Developers

Network performance (e.g., latency)

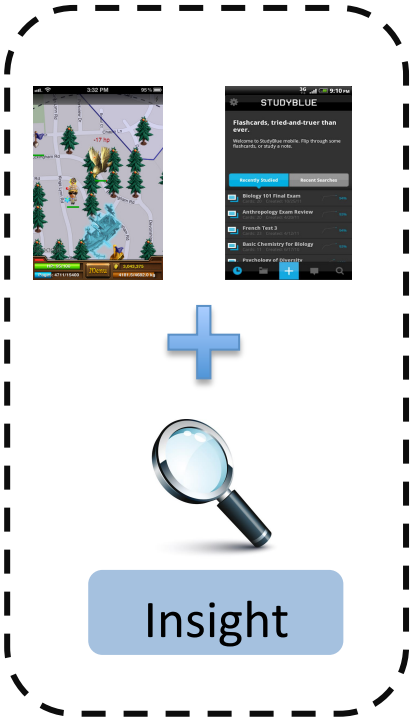
Developer Revenues (e.g., virtual currency usage)

Application Experience

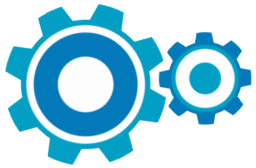
How can we capture these metrics across all users?

Solution: Embedded measurements

- Developed a measurement toolkit: “Insight”
  - Using the application as a vantage point

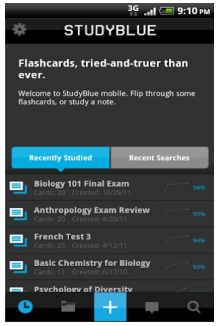


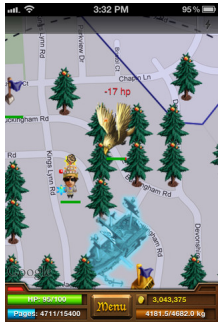
In this talk…



- Insight: Our mobile application analytics toolkit

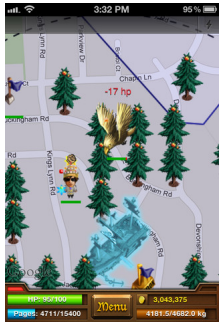
- Study with 2 popular applications
  - MMORPG game: > 1 million users (over 3 years)
  - Study application: > 160,000 users (over 1 year)



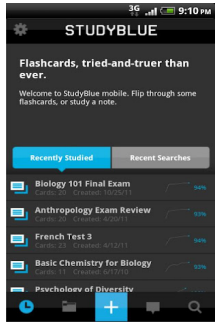


Outline

- **Insight overview and deployment**

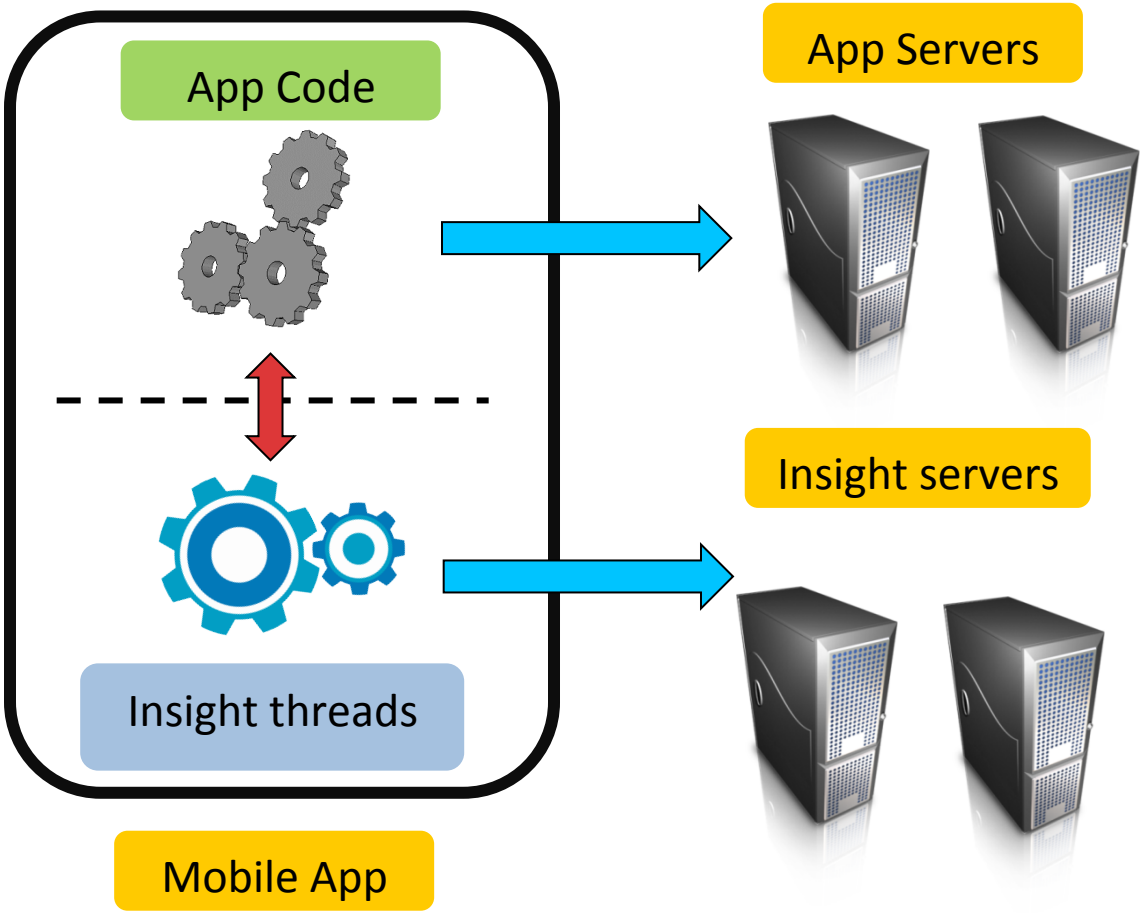


- Understanding application usage
- Impact of network performance

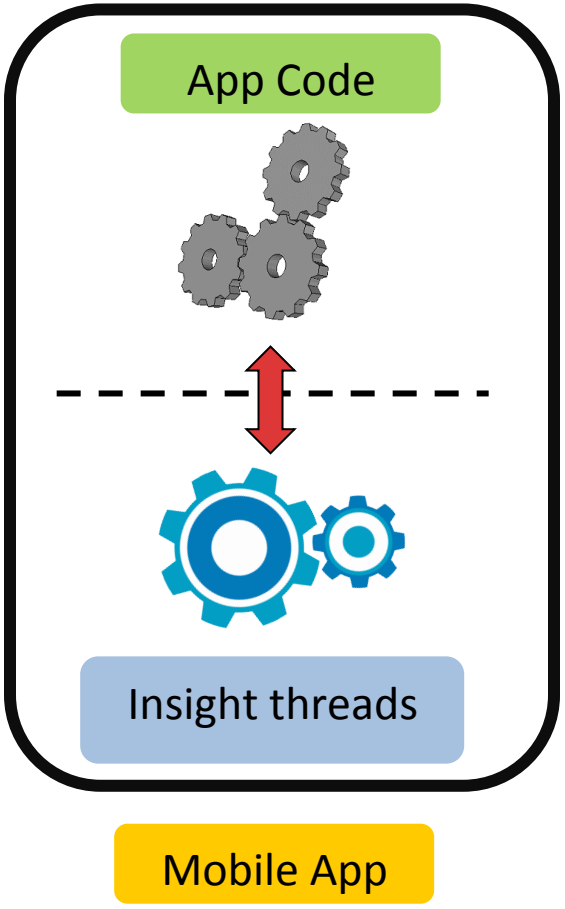


- Related work and summary

Insight measurement toolkit



Insight toolkit advantages

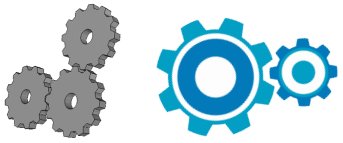


Light-weight library code with easy to use API

Contextual measurements: When desired app is running

No additional overhead for deployment of framework

Insight measurements

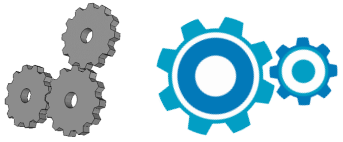


Mobile App + Insight

Insight measurements

User activity

In-app activities



Mobile App + Insight

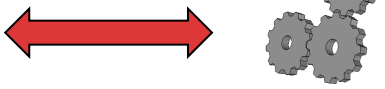
Session durations

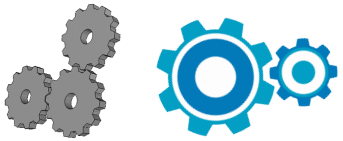
Application specific events (e.g. in-app purchases, fighting monsters)

Insight measurements

Device

Device info





Mobile App + Insight

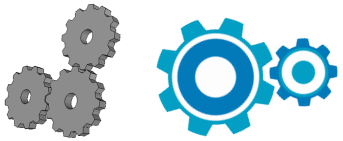
Vendor, screen size,
Platform, OS version

Insight measurements

Application Overhead:
Battery + CPU + Memory usage

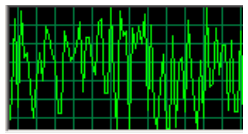
Location: Country, State

Network status: Signal, type (WiFi, HSDPA, EVDO etc.)



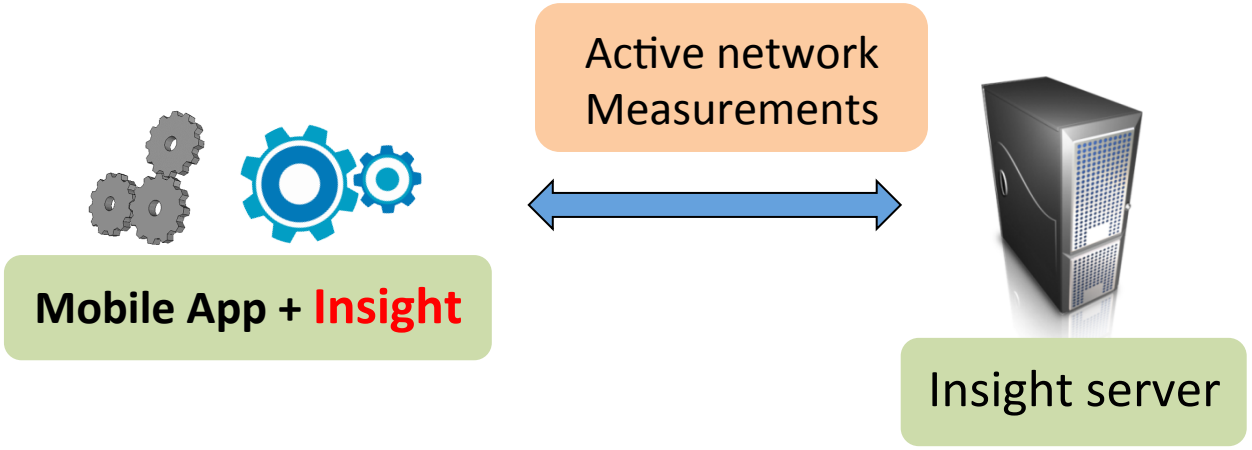
Mobile App + Insight

Status updates



Status Info (Location, Battery, CPU, Network)

Insight measurements



Application level latency: Round Trip Time (RTT) measurements to our server

Insight measurements

User activity

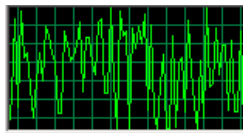
In-app activities
(e.g., in app-purchases)

Active network
measurements

In-situ application vantage point captures a rich set of metrics

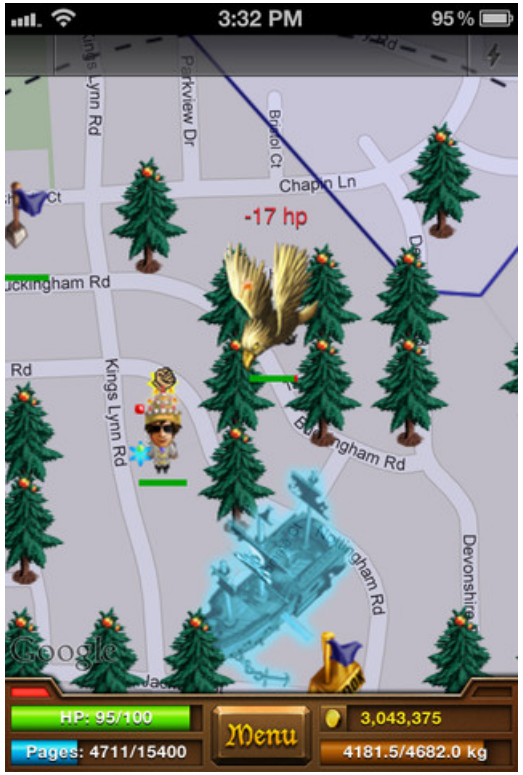
Insight server

Status updates



Status Info (Location, Battery, CPU, Network)

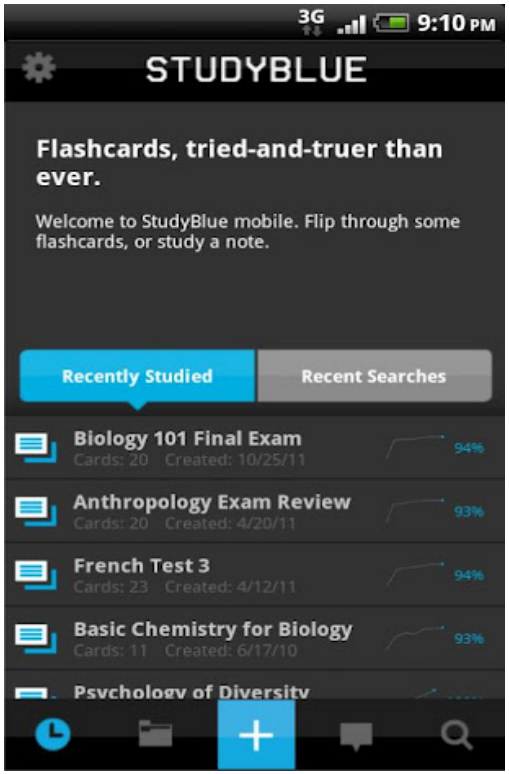
Deployed applications (1)



MMORPG Game: Parallel Kingdom (PK)

- Analyzing both iOS and Android users
- Actions: Spend food, trade items, attack players/monsters
- Deployed more than 3 years
  - > 1 million players
  - > 61 million sessions

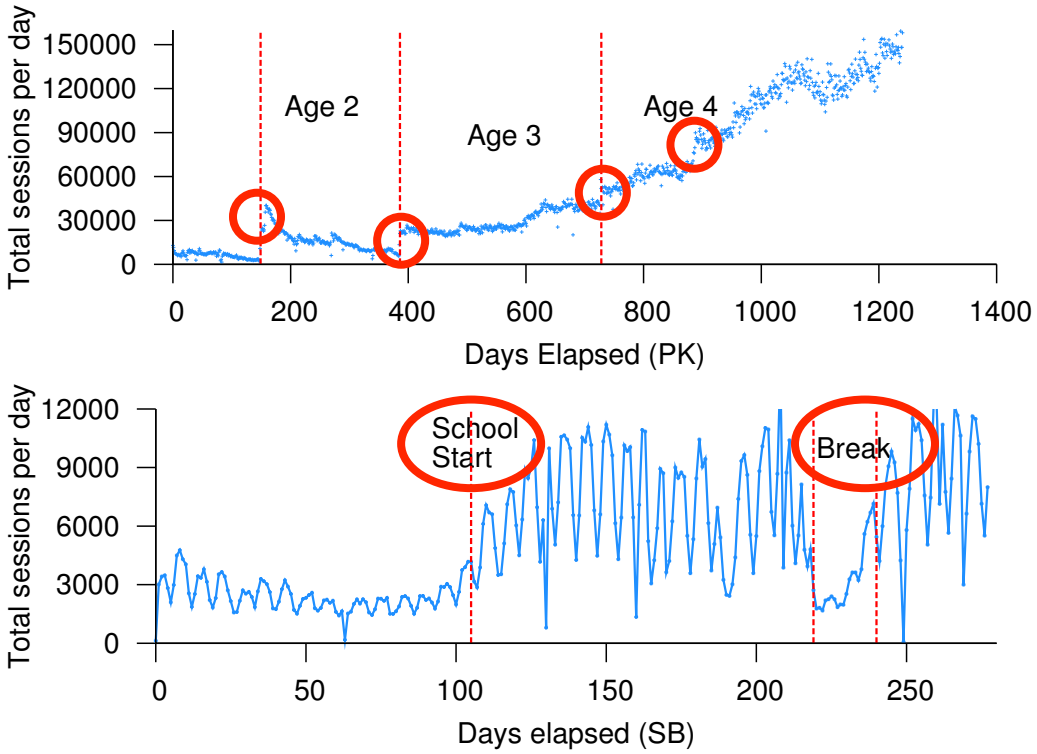
Deployed applications (2)



Study Tool: StudyBlue (SB)

- Analyzed Android users only
- Actions: Study, Create flashcards, quizzes
- Deployed more than 1 year
  - > 160,000 users tracked
  - > 1.1 million sessions

Unique sessions per day



Application usage for PK spikes with new updates while it is highly correlated with time of week and year for SB

Outline

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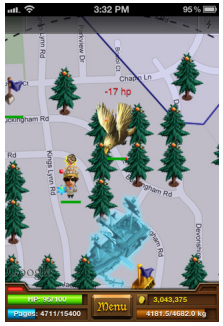
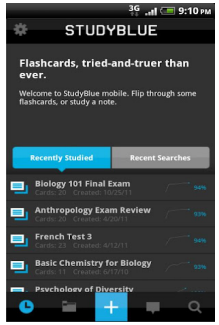


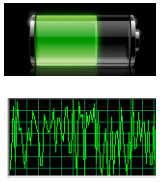
- **Understanding application usage**
- Impact of network performance



- Related work and summary

Understanding "Application Experience"

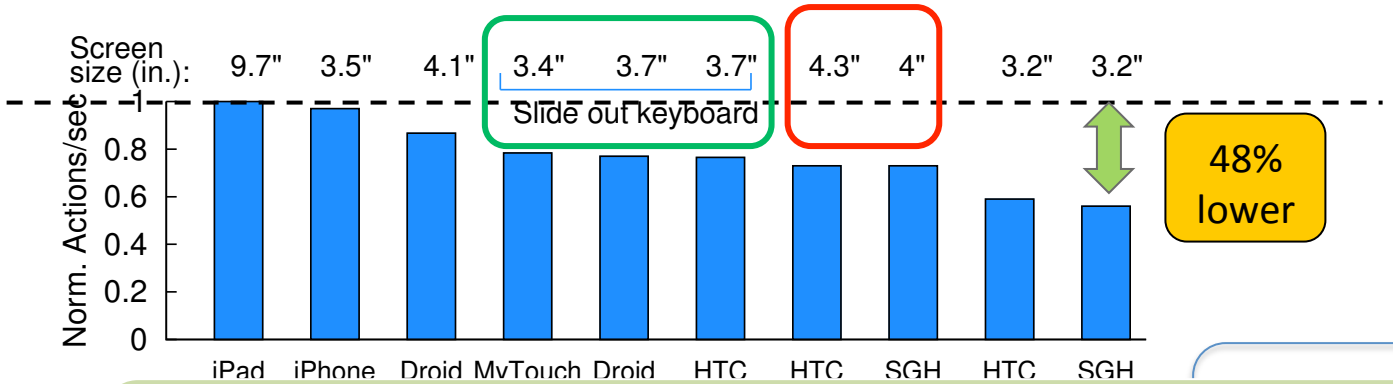
Device + UI Design (e.g., screen size)



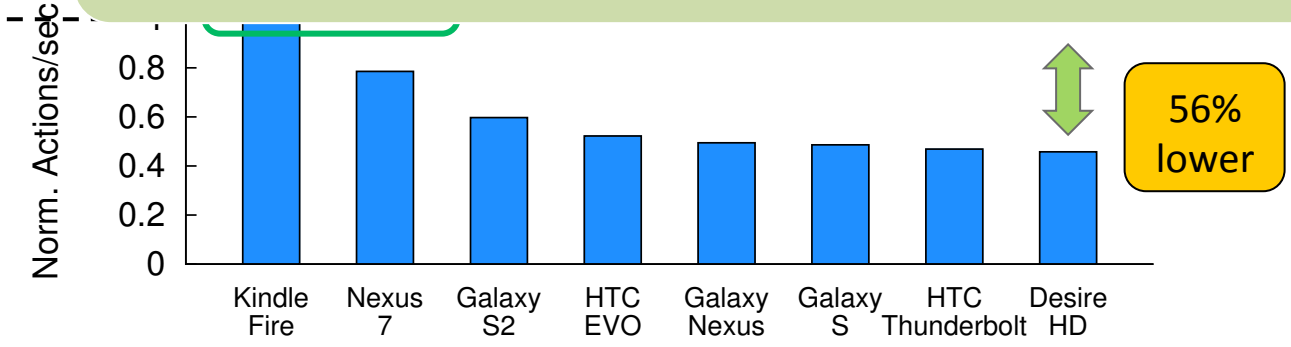
Resource Consumption (e.g., Battery, CPU etc.)

User types (e.g., old vs. new)

Impact of device on user interactivity



User interactivity varied by 2x based on device types and hardware features (screen size and slide out keyboards).

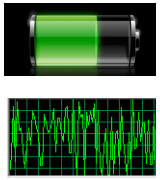


SB: Device Model

Understanding "Application Experience"

Device + UI Design (e.g., screen size)

Device form factor and platform impacted interactivity (upto 2x).

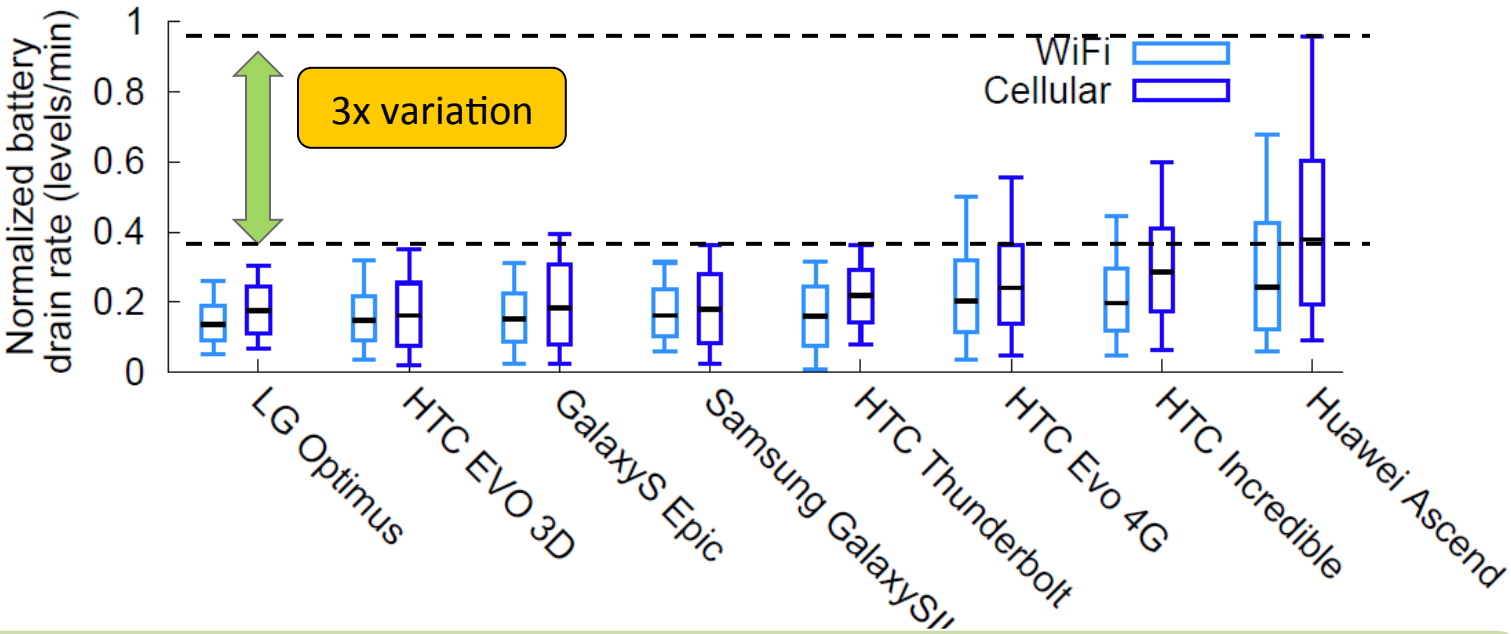


Resource Consumption (e.g., Battery, CPU etc.)

User types (e.g., old vs. new)

Battery consumption in the wild (PK)

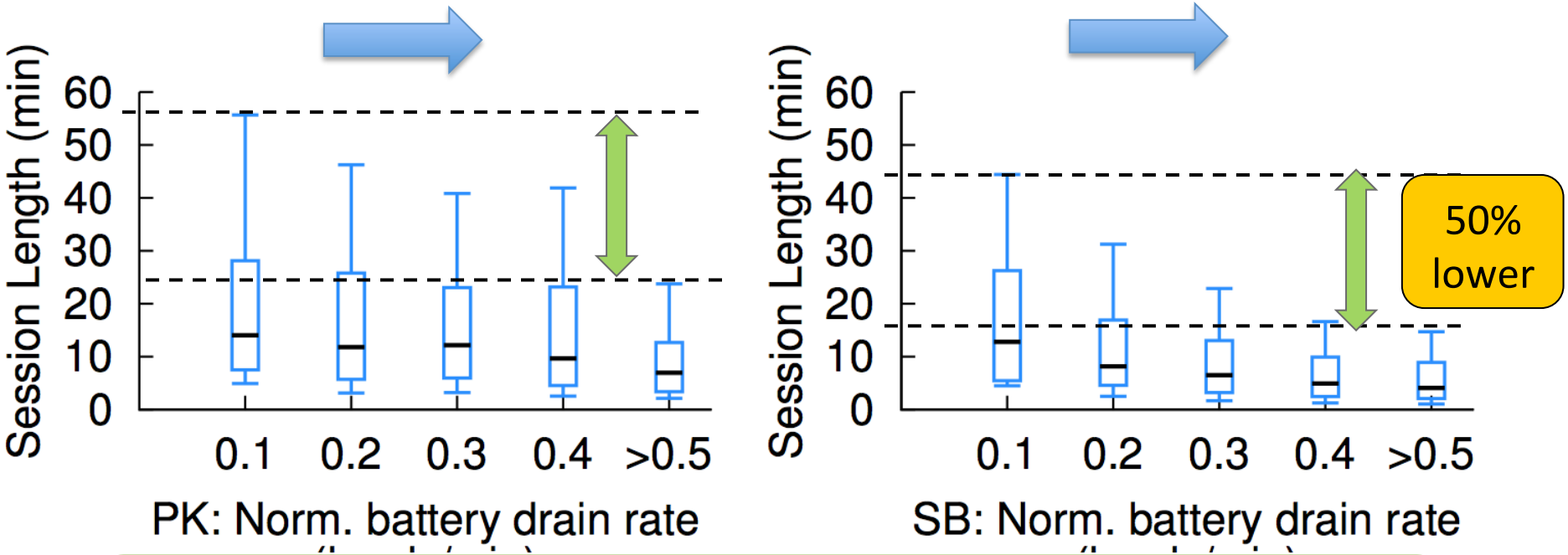
Battery drain = % usage/ time



High variation in application footprint (battery usage) due to diversity of devices

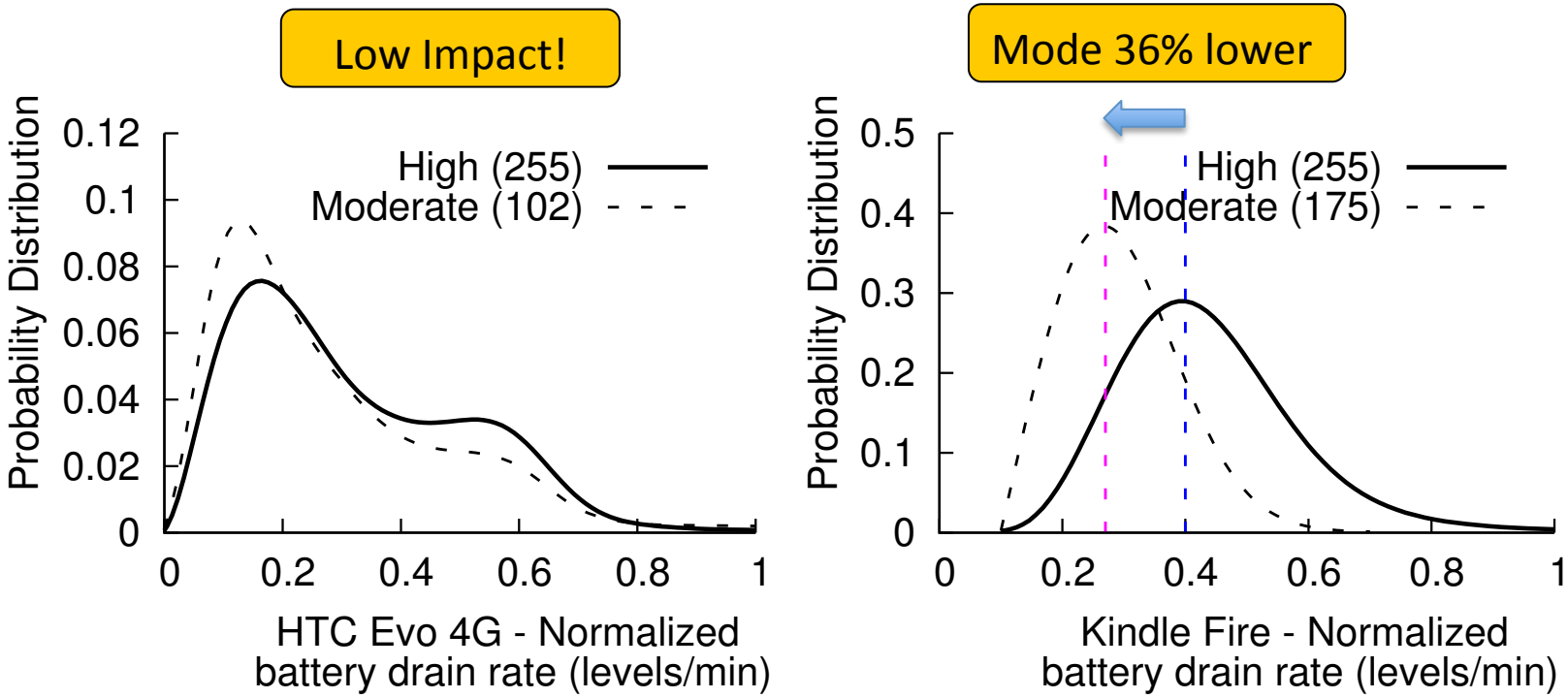
Battery drain vs. session duration (Evo 4G)

Increase in battery drain



Sessions with high battery drain exhibited upto 2x times lower durations

Conserving battery consumption…

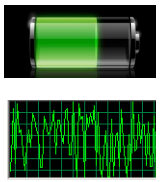


Device specific optimizations (e.g., screen brightness, GPS frequency) can help, but variable gains per device

Understanding "Application Experience"

Device + UI Design (e.g., screen size)

Device form factor and platform impacted interactivity (upto 2x).

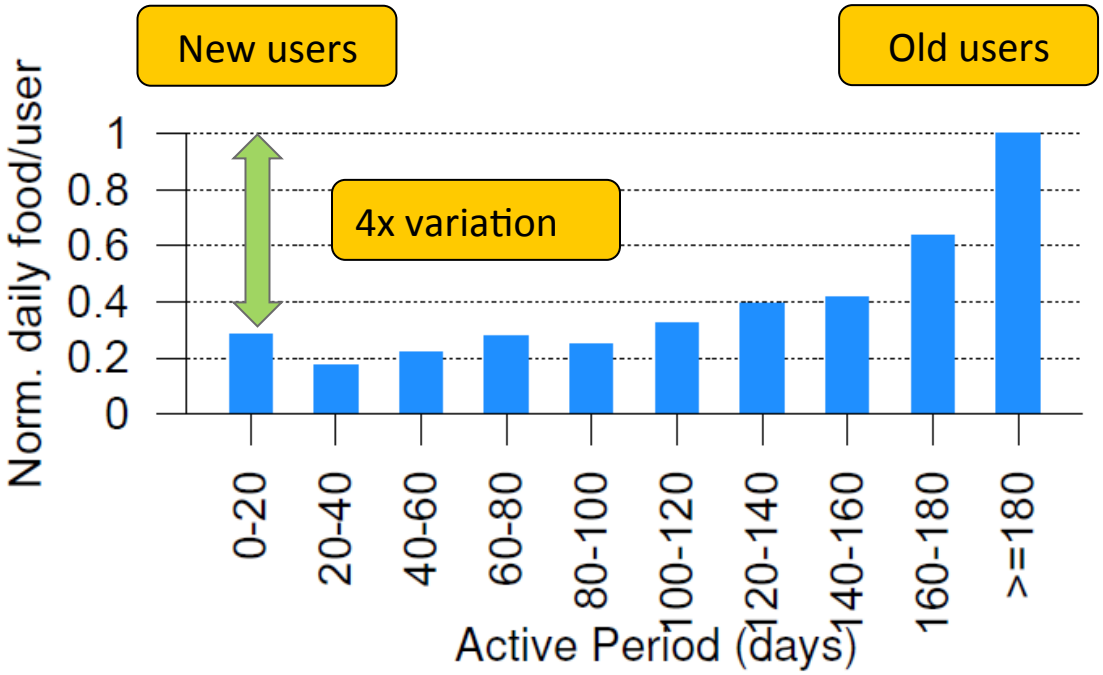


Resource Consumption (e.g., Battery, CPU etc.)

High variability in battery overhead (3x)
Gains from device optimizations can vary

User types (e.g., old vs. new)

Impact of retaining users on revenue (PK)



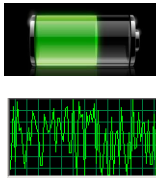
Over a period of 7 months (Age 2 of the game)

Old users tend to spend more money daily (4x more than new users)

Understanding "Application Experience"

Device + UI Design (e.g., screen size)

Device form factor and platform impacted interactivity (upto 2x)



Resource Consumption (e.g., Battery, CPU etc.)

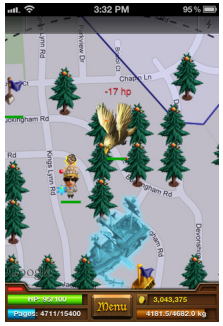
High variability in battery overhead (3x)
Gains from device optimizations can vary

User types (e.g., old vs. new)

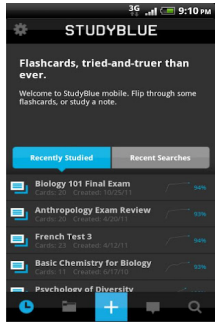
User retention is important: Upto (4x) more daily revenues per user

Outline

- Insight overview and deployment

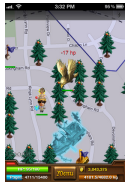


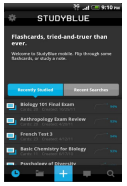
- Understanding application usage
- **Impact of network performance**



- Related work and summary

Impact of network performance





Mobile App + Insight

Network latency measurements

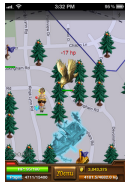
Insight server

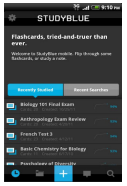
User Interactivity

Network type usage

Developer revenues

Impact of network performance





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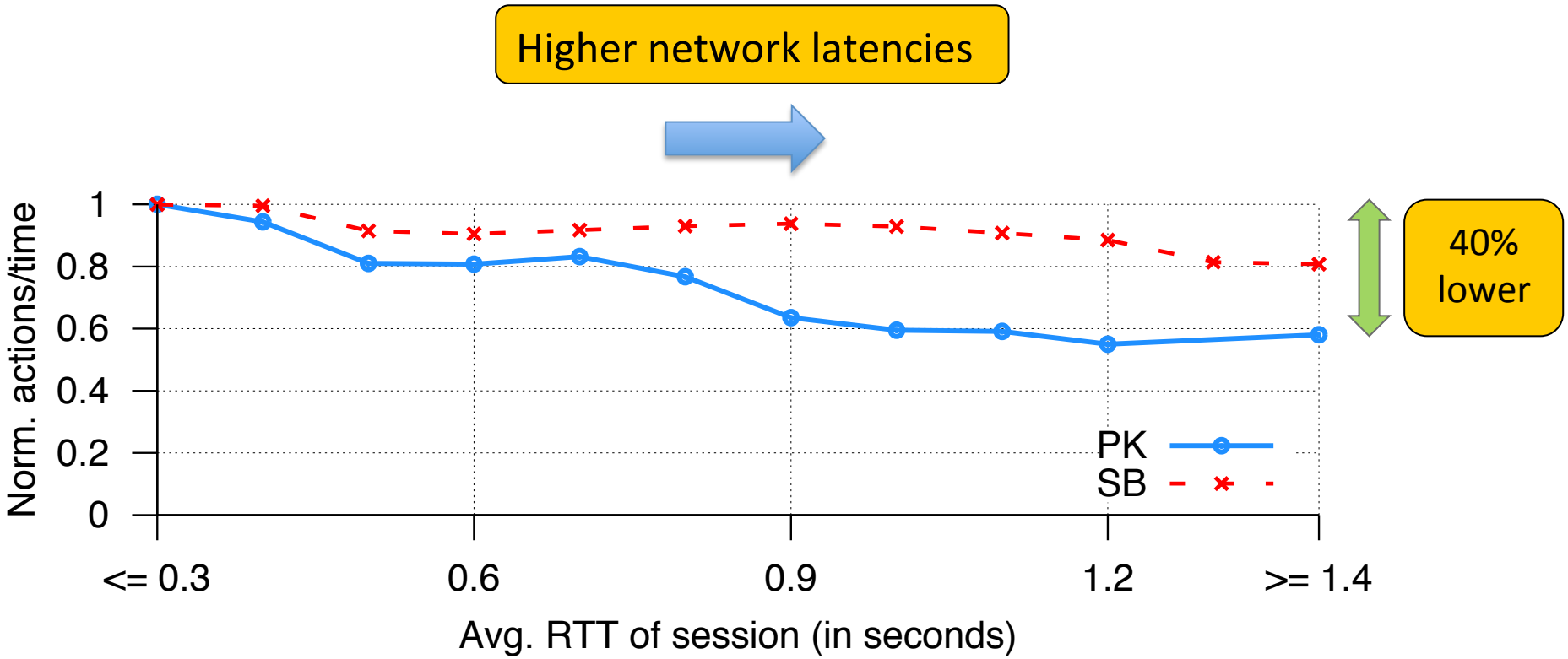
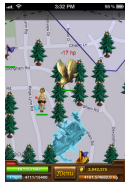
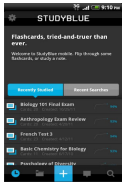
Impact of latencies on user interactivity



40% drop in user interactivity for MMORPG at high latencies (900ms). Lower impact on study application.

Impact of network performance

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Insight server

User Interactivity

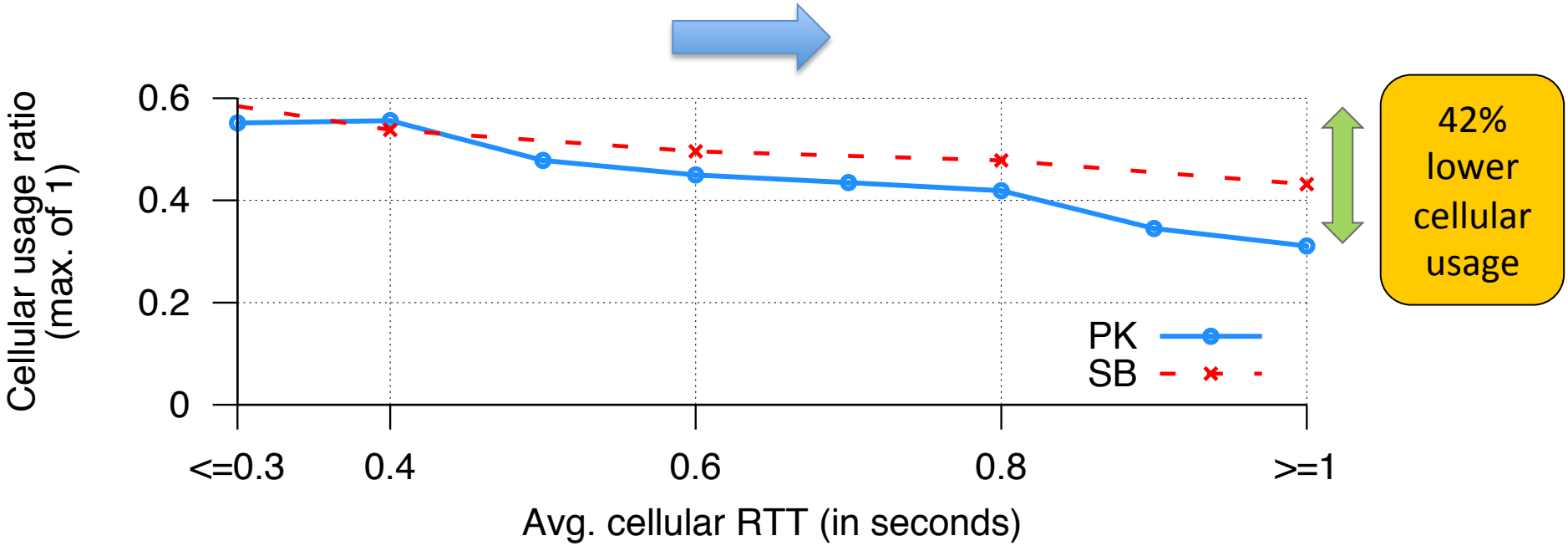
Higher drop in interactivity for **MMORPG (40%)** at poor latencies

Network type usage

Developer revenues

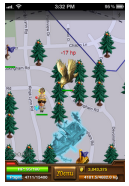
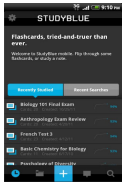
Impact of latencies on cellular usage

Higher **average cellular** latencies



High cellular latencies correlated with higher preference for WiFi networks for both apps

Impact of network performance

Mobile App + Insight


Network latency measurements

Insight server

User Interactivity

Higher drop in interactivity for **MMORPG (40%)** at poor latencies

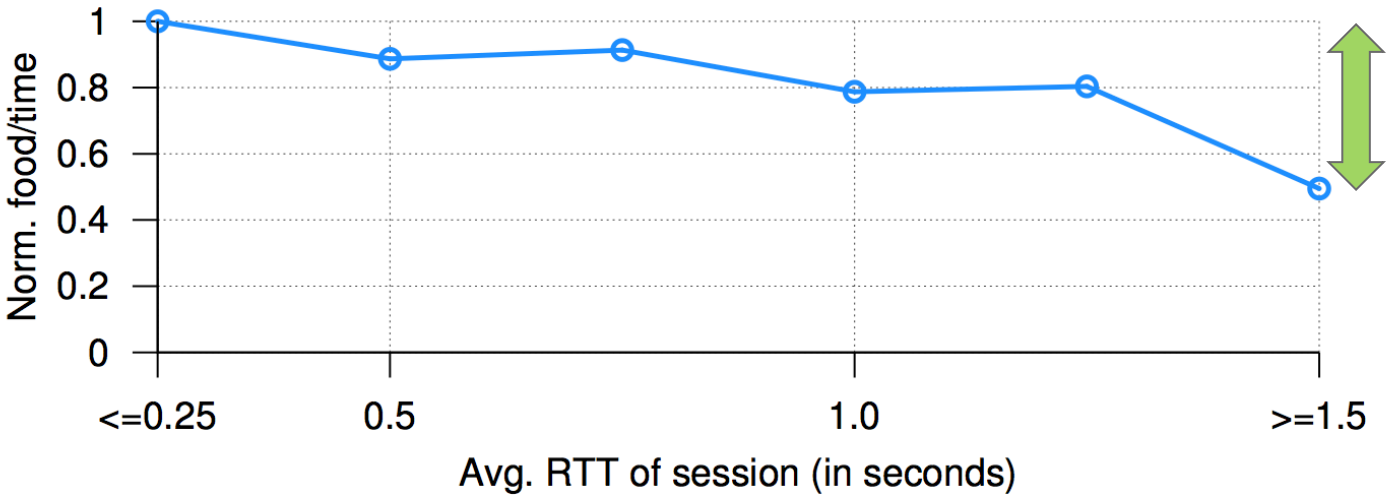
Network type usage

Greater user preference for WiFi networks at high cellular latencies across both apps

Developer revenues

PK: Impact of latencies on revenues

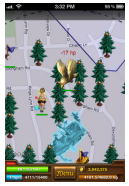
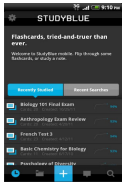
Latency vs. Revenue / time



52% lower revenue

High network latencies caused upto a 50% drop in developer revenues

Impact of network performance

Mobile App + Insight


Network latency measurements

Insight server

User Interactivity

Higher drop in interactivity for **MMORPG (40%)** at poor latencies

Network type usage

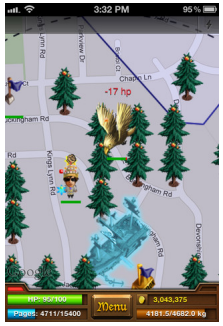
Greater user preference for WiFi networks at high cellular latencies.

Developer revenues

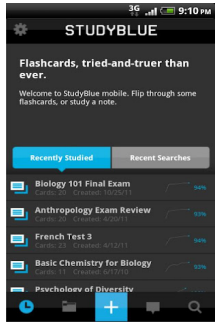
Upto **50% drop in developer revenues** (MMORPG) due to poor network performance

Outline

- Insight overview and deployment



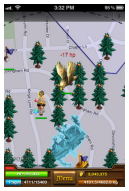
- Understanding application usage
- Impact of network performance



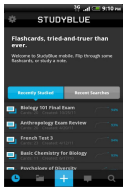
- **Related work and summary**

Related work

- Commercial Tools: Android/iOS, Flurry
- Understanding network performance (MobiSys'10)
  - 3G Test: Standalone mobile app. to measure cellular and WiFi performance
- Smartphone usage studies (MobiSys'11)
  - Falaki *et al.* : Application, network and device usage study across 255 users
- Mobile application usage characteristics (IMC'11)

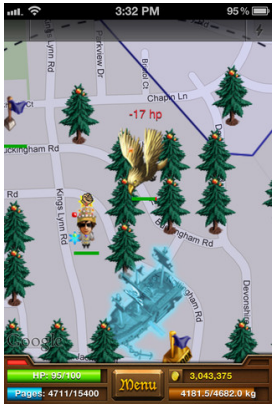


Summary



- Presented “Insight”, a measurement framework for mobile applications
  - >3 year deployment on 2 popular apps
- High variance (3x) in resource usage across devices
  - Device specific optimizations can help (gains vary)
- User retention is critical for applications revenue generation and engagement: 4x variability
- High latencies lowered both revenues (52%) and user-engagement (40%) (more for MMORPG)

Thanks!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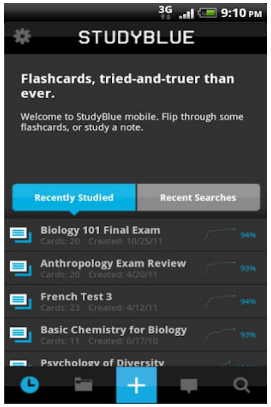
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