

Ubiquitous and Mobile Computing

CS 403x: Falling Asleep with Angry Birds, Facebook and Kindle

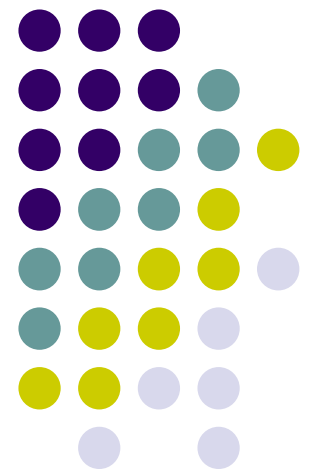
Trevor Behlman

Conor Geary

Alyssa Graham

Computer Science Dept.

Worcester Polytechnic Institute (WPI)

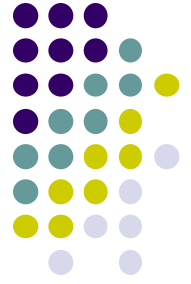




Motivation

- Lack of studies on application usage behavior
- Posed the following questions
 - How long does each interaction with an app last?
 - Does this vary by application category?
 - If so, which categories inspire the longest interactions with their users?
 - How does the user's context affect her app choices?
 - What type of app is opened first?
 - Does the opening of one application predict the opening of another?

Vision – Application Developed



- AppSensor “virtual sensor”
- Part of appazaar application
- App is no longer available through the app store
- Source code still available through github
 - <https://github.com/matboehmer/appsensor>



Related Work

- Paper cited 173 times
- AWARE – Android Mobile Context Instrumentation Framework
- funf Open Sensing Framework
- Behavior
- Cortex Mobile Intelligence by Sense
 - Available for iOS but



Related Work – Behavior



behavio sensing Feb 19, 2012 - 04:22:12pm

walking at 3mph

with you

- Nadav Aharony with Alan 12:33pm to 8:35pm
- Alan Gardner with Cody 12:33pm to 8:40pm
- Cody Sumler with Joi 12:31pm to 8:33pm
- Joi Ito with Alan 04:15pm to 4:32pm

shared photos

apps used this hour

- ee
- Google Maps
- f
- g+
- oo
- checkmark
- location
- glasses

what you were saying

- 12:03pm Off to grab lunch with @codyis and @alan_gardner before exploring the city
- 02:32pm Brilliant brainstorming session over lunch
- 04:59pm @joi Was great running into you on the way back to the conference
- 09:51pm 19 Photos uploaded

moderate talking levels

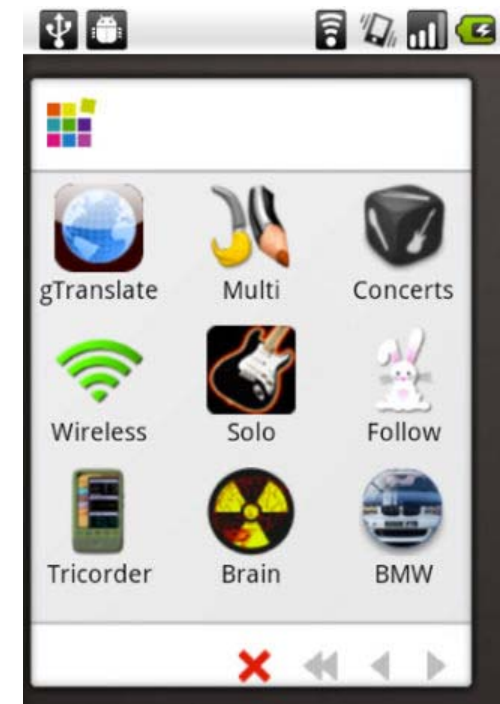
56° F partly cloudy 41% humidity

Photo from <http://www.theverge.com/2013/4/12/4217618/google-purchases-behavio-a-startup-that-makes-predictions-based-on-smartphone-data>



Methodology

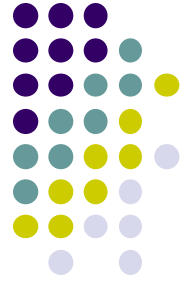
- AppSensor specifically collects app usage statistics in the form of “events”
- Part of appazaar application
- Events
 - Installing apps
 - Updating apps
 - Uninstalling apps
 - Opening/Closing apps
- Each event has metadata from the app sensors





Methodology – Data collected

- Type of event
- Package name of the application
- Start time of event
- Usage time (milliseconds)
- Information of location API
 - ** Longitude ** Latitude **
 - Accuracy ** Altitude **
 - Speed
- Powerstate (connected / unconnected to charger)
- Powerlevel (battery load in percentage)
- Time of last screen on for sessions (UTC timestamp)
- State of headphones (plugged in: yes / no)
- Orientation of device (portrait / landscape)
- WiFi state (turned off / turned on / connected)
- Bluetooth state (turned off / turned on / connected)
- GPS state [implementation planned]
- Identification of device **
 - Hash of IMEI device id (deprecated, unique per device) **
 - Installation id (unique per installation) **
 - Information about device
- Model name
- Screen resolution of Android API Level **
- Version of the *AppSensor* library being used (form AndroidManifest)
- Client IP4 address (only through server script)



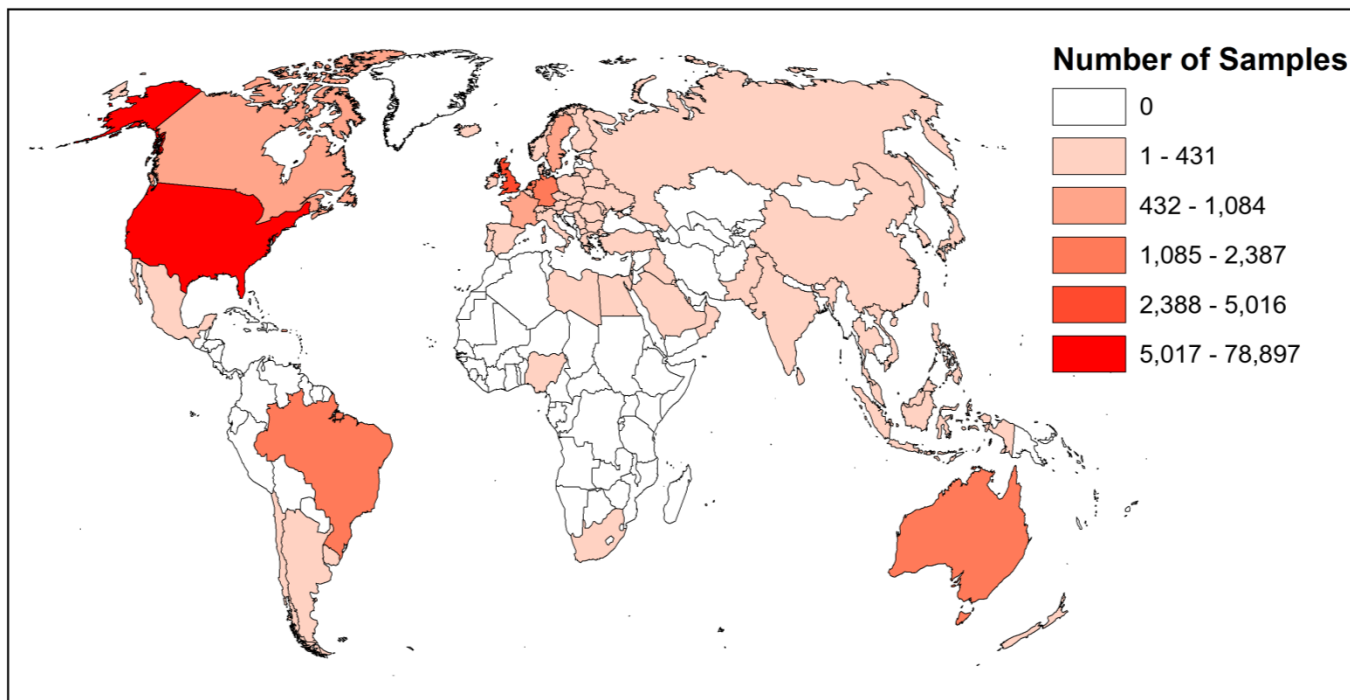
Methodology

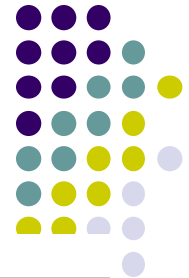
- Personal information is anonymized before data is collected from appazaar app
- Apps were categorized by type to better understand data
- App was advertised as a recommendation service
 - The paper was unclear whether users were aware the data was being used for studies



Results

- 4125 users between August 2010 and January 2011
- 22,626 different app usage events collected





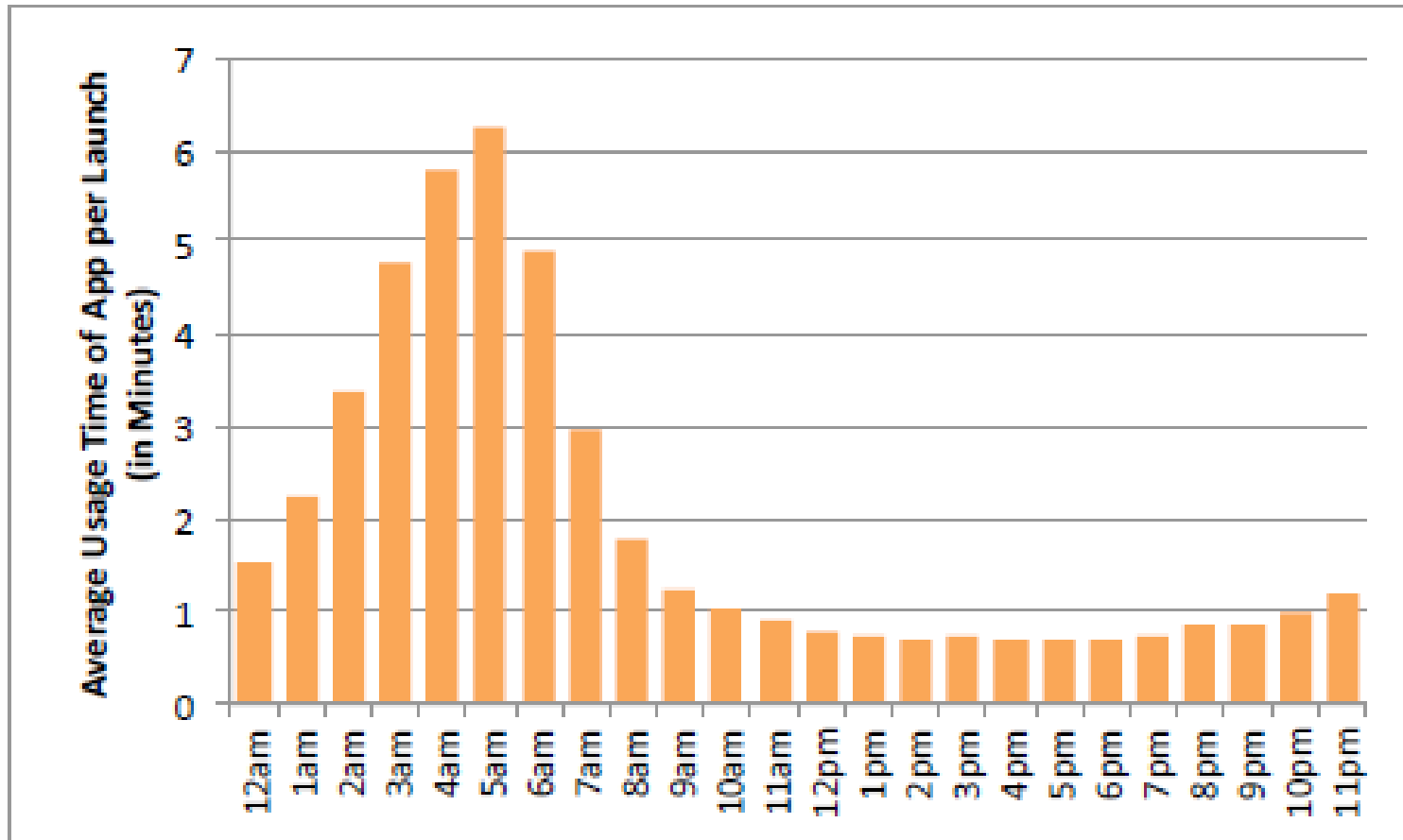
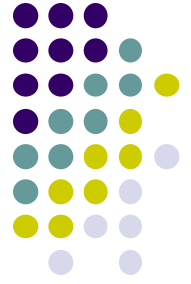
Results

- Average of 59.23 minutes/day using their phone
- Average application session: 71.56 seconds

Category	Apps	Avg. usage	Exemplary Apps
unknown	4,823	36.37 sec	-
Finance	307	37.01 sec	Mint.com Personal Finance, Bank of America, Google Finance, iStockManager
Travel	782	44.72 sec	Google Maps, Yelp, Waze
Communication	881	46.92 sec	Google Mail, Handcent SMS, K-9 Mail
Productivity	1,062	61.49 sec	Calendar, Evernote, GTasks
Shopping	326	61.71 sec	Market, Barcode Scanner, Craigslist
Social	538	62.69 sec	Facebook for Android, Twitter, TweetDeck
Sports	385	65.98 sec	Yahoo! Fantasy Football '10, ESPN ScoreCenter, NFL Mobile
News	784	68.11 sec	NewsRob, reddit is fun, BBC News
Settings	1	68.71 sec	Default Settings App
Browser	10	74.01 sec	Default Browser, Skyfire Browser, Dolphin Browser
Entertainment	84	76.90 sec	IMDb Movies & TV, TV Guide Mobile, PhotoFunia
Multimedia	130	82.79 sec	Pandora Radio, Music, Camera
Comics	3,242	91.33 sec	DailyStrip, XkcdViewer, Dilbert Mobile
Games	2,822	114.25 sec	Angry Birds, Wordfeud FREE, Solitaire
Health	424	153.80 sec	CardioTrainer, Sleep Bot Tracker Log, Baby ESP
Lifestyle	956	167.77 sec	DailyHoroscope, Gentle Alarm, Epicurious Recipe
Reference	764	176.28 sec	Kindle for Android, Aldiko Book Reader, Audible
Tools	3,004	206.26 sec	AppBrain App Market, Apps Organizer, Google Goggles
Themes	1,061	258.28 sec	Zune Home, Fingerprint Screensaver, HomeChange
Libraries & Demos	240	274.23 sec	Google Services Framework, default Updater, Motorola Updater, Bubbles Demo, Ride Logger Demo, ES Task Manager

Table 2. Number of apps investigated in our study and average usage time of every categories' apps from opening to closing.

Results – Average usage time by hour





Results – Usage by hour of the day

	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm	% of Total Launches	Users	Apps	
Browser	7.9%	7.7%	7.8%	7.6%	7.3%	7.4%	7.0%	7.9%	8.1%	8.0%	7.7%	7.3%	7.0%	6.9%	6.8%	6.4%	6.6%	6.6%	6.4%	6.6%	7.0%	7.4%	7.5%	7.4%	6.83%	2,398	9	
Comics	4.5%	5.2%	5.4%	5.8%	5.8%	5.6%	5.5%	5.2%	5.4%	5.1%	4.7%	4.3%	4.3%	4.2%	4.2%	4.3%	4.4%	4.0%	4.4%	4.2%	4.1%	4.1%	4.1%	4.4%	4.31%	2,151	1,810	
Communication	44.9%	41.1%	38.3%	35.4%	31.6%	31.8%	32.7%	34.7%	39.4%	44.8%	49.0%	52.6%	54.8%	55.2%	55.2%	56.1%	55.7%	56.8%	57.1%	56.1%	54.8%	53.3%	52.0%	49.0%	49.50%	2,769	550	
Entertainment	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.02%	126	43	
Finance	0.2%	0.3%	0.3%	0.2%	0.1%	0.1%	0.1%	0.2%	0.3%	0.3%	0.4%	0.5%	0.3%	0.3%	0.4%	0.3%	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.25%	604	164
Games	3.2%	3.0%	3.0%	2.7%	2.5%	2.3%	2.2%	1.7%	1.9%	1.9%	2.0%	2.1%	2.2%	2.2%	2.2%	2.3%	2.3%	2.2%	2.2%	2.4%	2.7%	3.0%	3.0%	3.2%	2.30%	1,716	1,702	
Health	0.3%	0.4%	0.4%	0.4%	0.6%	0.6%	0.7%	0.6%	0.4%	0.3%	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.3%	0.2%	0.3%	0.2%	0.3%	0.26%	540	227	
Libraries & Demo	0.4%	0.5%	0.6%	0.7%	0.9%	0.8%	0.7%	0.6%	0.5%	0.4%	0.3%	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.3%	0.3%	0.3%	0.3%	0.30%	1,267	117	
Lifestyle	0.8%	0.9%	1.0%	1.4%	1.3%	1.5%	1.4%	1.4%	1.1%	0.9%	0.6%	0.6%	0.5%	0.5%	0.5%	0.5%	0.6%	0.5%	0.3%	0.4%	0.4%	0.5%	0.5%	0.5%	0.60%	2,132	451	
Multimedia	2.1%	2.1%	2.4%	2.4%	2.7%	2.4%	1.8%	1.8%	1.9%	1.7%	1.8%	2.0%	2.0%	2.0%	2.2%	2.1%	2.2%	2.4%	2.3%	2.3%	2.2%	2.1%	1.9%	2.0%	2.03%	1,713	76	
News	2.6%	2.5%	2.6%	2.5%	2.5%	2.7%	3.3%	3.7%	4.1%	3.6%	3.0%	2.6%	2.5%	2.7%	2.5%	2.4%	2.2%	2.1%	2.3%	2.2%	2.3%	2.2%	2.3%	2.3%	2.46%	1,777	440	
Productivity	3.6%	5.0%	5.0%	5.8%	6.3%	6.5%	6.0%	5.4%	4.8%	5.1%	4.9%	4.3%	4.2%	4.0%	4.0%	3.7%	3.4%	3.4%	3.0%	3.1%	3.1%	3.0%	2.9%	3.2%	3.76%	2,190	648	
Reference	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.6%	0.6%	0.7%	0.5%	0.5%	0.5%	0.4%	0.4%	0.4%	0.4%	0.3%	0.4%	0.4%	0.4%	0.5%	0.5%	0.5%	0.6%	0.47%	903	346	
Settings	1.3%	1.6%	1.5%	1.3%	1.6%	1.2%	1.2%	1.1%	1.3%	1.4%	1.4%	1.4%	1.2%	1.3%	1.2%	1.2%	1.3%	1.1%	1.1%	1.2%	1.2%	1.3%	1.3%	1.4%	1.23%	2,178	1	
Shopping	3.9%	4.5%	3.7%	3.4%	3.2%	3.2%	3.1%	3.0%	3.1%	3.3%	3.2%	3.2%	3.2%	2.8%	2.9%	2.9%	2.7%	2.7%	2.7%	2.7%	2.8%	3.1%	3.6%	3.5%	2.96%	2,556	198	
Social	5.7%	5.0%	4.9%	4.3%	4.2%	4.0%	4.4%	5.1%	5.3%	5.4%	5.2%	5.0%	4.7%	4.8%	4.9%	4.5%	4.5%	4.6%	4.6%	4.9%	5.2%	5.4%	5.8%	5.7%	4.77%	1,902	342	
Sports	0.5%	0.3%	0.3%	0.2%	0.3%	0.3%	0.2%	0.3%	0.3%	0.3%	0.3%	0.4%	0.4%	0.6%	0.7%	0.8%	0.9%	0.8%	0.6%	0.6%	0.7%	0.8%	0.7%	0.7%	0.56%	571	215	
Themes	0.2%	0.1%	0.2%	0.3%	0.4%	0.4%	0.4%	0.2%	0.2%	0.2%	0.1%	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%	0.2%	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%	0.14%	249	231	
Tools	10.9%	12.2%	14.6%	17.6%	20.3%	21.5%	21.4%	18.6%	14.7%	10.4%	8.4%	6.8%	6.1%	5.9%	5.9%	5.9%	6.0%	6.1%	5.8%	6.0%	6.3%	6.8%	7.4%	9.1%	7.89%	2,512	1,688	
Travel	1.4%	1.6%	2.1%	2.2%	2.4%	2.6%	2.2%	1.9%	2.0%	2.1%	2.0%	1.8%	1.9%	1.9%	1.9%	1.8%	2.0%	1.9%	2.2%	2.2%	1.9%	1.7%	1.6%	1.4%	1.86%	1,752	407	
Unknown	4.7%	5.3%	5.1%	5.0%	5.3%	4.4%	5.0%	5.9%	4.6%	4.4%	4.1%	3.8%	3.5%	3.8%	3.7%	3.7%	4.0%	3.6%	3.7%	3.7%	3.7%	3.9%	4.1%	4.5%	3.88%	2,284	1,796	
Total Launches per Hour	103,604	77,053	53,633	40,332	33,438	30,949	38,161	56,895	83,488	109,550	127,069	142,642	158,876	168,082	169,018	172,935	173,963	179,801	184,012	176,050	163,080	153,835	141,303	123,639				

Figure 5. Hourly relative app usage by category in terms of launches. Each cell value refers to the percentage of app launches done by our users within each hour for each category. Colors are normalized by row, with green indicating each category's maximum percentage of application time, and white indicating each category's minimum. For example, games reach their peak in the evening (green) and trough in the morning (white).

Results – Transitioning between apps



	Browser	Comics	Communication	Entertainment	Finance	Games	Health	Libraries & Demo	Lifestyle	Multimedia	News	Productivity	Reference	Settings	Shopping	Social	Sports	Themes	Tools	Travel	Unknown	Samples	Users	Apps
Browser	2.4%	3.6%	33.8%	0.0%	0.3%	3.5%	0.2%	0.2%	0.4%	1.5%	11.8%	3.8%	0.6%	1.7%	3.6%	15.6%	0.5%	0.3%	8.1%	2.2%	6.1%	48,379	2,193	9
Comics	6.5%	9.4%	36.1%	0.0%	0.2%	4.8%	0.6%	0.2%	0.6%	5.2%	2.7%	4.1%	0.6%	2.2%	5.2%	4.3%	0.6%	0.4%	8.4%	2.7%	5.0%	31,258	1,754	1,220
Communication	5.7%	2.7%	65.5%	0.0%	0.2%	1.5%	0.1%	0.1%	0.2%	1.3%	2.1%	2.5%	0.3%	1.0%	1.7%	4.8%	0.4%	0.1%	5.0%	1.4%	3.2%	434,974	2,839	449
Entertainment	6.7%	6.1%	26.1%	0.0%	0.0%	3.3%	0.6%	0.0%	0.6%	5.6%	0.6%	2.8%	0.0%	3.3%	7.2%	3.3%	3.3%	0.0%	8.3%	5.6%	16.7%	180	65	28
Finance	10.3%	3.7%	37.3%	0.0%	1.8%	2.9%	0.2%	0.3%	0.2%	1.5%	8.6%	3.5%	0.1%	1.5%	5.5%	6.1%	0.7%	0.1%	10.6%	1.9%	3.1%	1,496	347	117
Games	11.8%	5.9%	30.4%	0.0%	0.3%	15.1%	0.3%	0.4%	0.7%	1.0%	2.1%	4.2%	0.7%	1.5%	6.5%	4.0%	0.8%	0.1%	8.3%	1.7%	4.2%	8,620	1,077	995
Health	3.8%	4.8%	34.3%	0.0%	0.3%	2.5%	6.1%	0.6%	1.2%	6.1%	2.9%	3.1%	1.6%	2.3%	6.0%	4.9%	0.8%	0.0%	12.4%	2.3%	3.9%	1,466	328	130
Libraries & Demo	6.0%	3.7%	23.3%	0.0%	0.2%	2.3%	0.3%	2.6%	0.8%	1.3%	1.7%	3.2%	0.3%	16.2%	11.9%	3.7%	0.3%	0.1%	13.4%	3.2%	5.5%	3,936	1,082	90
Lifestyle	8.2%	5.3%	17.3%	0.0%	0.1%	4.0%	0.5%	0.6%	3.0%	0.9%	2.3%	4.3%	0.7%	2.3%	28.7%	3.1%	0.2%	0.4%	10.2%	2.2%	5.5%	4,673	1,383	303
Multimedia	6.2%	10.5%	38.2%	0.0%	0.2%	1.4%	0.6%	0.2%	0.4%	2.5%	2.5%	6.2%	0.3%	2.0%	1.8%	4.4%	0.3%	0.4%	9.5%	3.2%	9.1%	12,451	1,376	53
News	33.6%	3.3%	33.3%	0.0%	0.5%	1.6%	0.2%	0.1%	0.2%	1.4%	3.9%	2.9%	0.4%	1.4%	3.0%	3.7%	0.4%	0.0%	6.5%	1.0%	2.4%	25,131	1,440	312
Productivity	7.4%	5.0%	38.5%	0.0%	0.4%	2.6%	0.4%	0.2%	0.6%	2.8%	2.8%	7.2%	1.1%	3.8%	4.8%	5.1%	0.6%	0.3%	9.7%	2.4%	4.4%	31,113	1,954	498
Reference	13.1%	4.5%	34.3%	0.0%	0.2%	7.5%	0.6%	0.3%	1.0%	1.0%	2.5%	4.6%	2.9%	1.7%	5.2%	4.1%	0.4%	0.2%	9.8%	1.7%	4.4%	2,611	552	199
Settings	8.9%	5.6%	26.3%	0.1%	0.2%	1.8%	0.4%	5.2%	0.7%	2.0%	2.6%	6.9%	0.5%	0.0%	5.6%	4.7%	0.6%	0.5%	11.6%	4.8%	11.1%	13,576	1,863	1
Shopping	8.5%	7.8%	23.2%	0.0%	0.4%	4.8%	0.4%	0.9%	9.6%	0.9%	2.8%	5.2%	0.7%	3.0%	4.7%	4.3%	0.5%	0.5%	16.6%	1.6%	3.8%	21,788	2,207	132
Social	24.1%	3.0%	35.3%	0.0%	0.3%	2.3%	0.2%	0.2%	0.3%	1.2%	2.9%	2.8%	0.3%	1.5%	2.7%	12.4%	0.7%	0.1%	5.3%	1.2%	3.3%	35,086	1,593	239
Sports	7.4%	4.3%	43.3%	0.1%	0.4%	2.5%	0.4%	0.2%	0.3%	1.3%	3.0%	4.8%	0.5%	2.4%	3.8%	5.4%	7.6%	0.0%	7.0%	1.5%	3.9%	2,793	387	135
Themes	8.5%	10.2%	37.2%	0.0%	0.2%	2.4%	0.1%	0.2%	1.4%	3.2%	0.4%	4.7%	0.4%	3.3%	6.5%	3.6%	0.1%	1.2%	8.6%	3.3%	4.6%	1,929	175	175
Tools	11.0%	5.1%	36.1%	0.0%	0.2%	2.7%	0.3%	0.4%	0.6%	2.1%	2.4%	4.2%	0.6%	2.1%	5.5%	4.1%	0.4%	0.2%	15.7%	2.8%	3.5%	88,911	2,384	1,310
Travel	6.7%	9.1%	36.2%	0.1%	0.2%	2.3%	0.3%	0.5%	0.7%	1.9%	1.6%	6.7%	0.4%	5.0%	2.9%	4.4%	0.3%	0.2%	10.2%	6.6%	3.6%	12,556	1,403	281
Unknown	10.7%	4.4%	40.8%	0.1%	0.2%	2.1%	0.2%	0.3%	0.6%	3.9%	1.8%	3.2%	0.3%	3.9%	2.9%	4.7%	0.3%	0.2%	6.4%	1.5%	11.6%	48,379	1,972	1,277

Figure 9. Transition probabilities in app chains. The transitions are from categories in a row to categories in a column. The diagonal indicates transitions between apps in the same category. The probability ranges from yellow (low) to green (high).



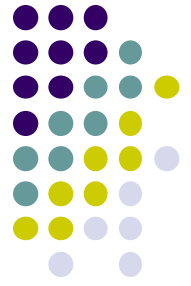
Conclusion

- They concluded brief sessions were correlated to poor success. Citing Mint as being a popular app in the finance category which had brief average sessions.
 - We're not certain if this is a fair assessment.
 - Mint currently has 5-10 million installs
- They collected a lot of interesting data which was the focus. They did not analyze the data too intensely in this study.



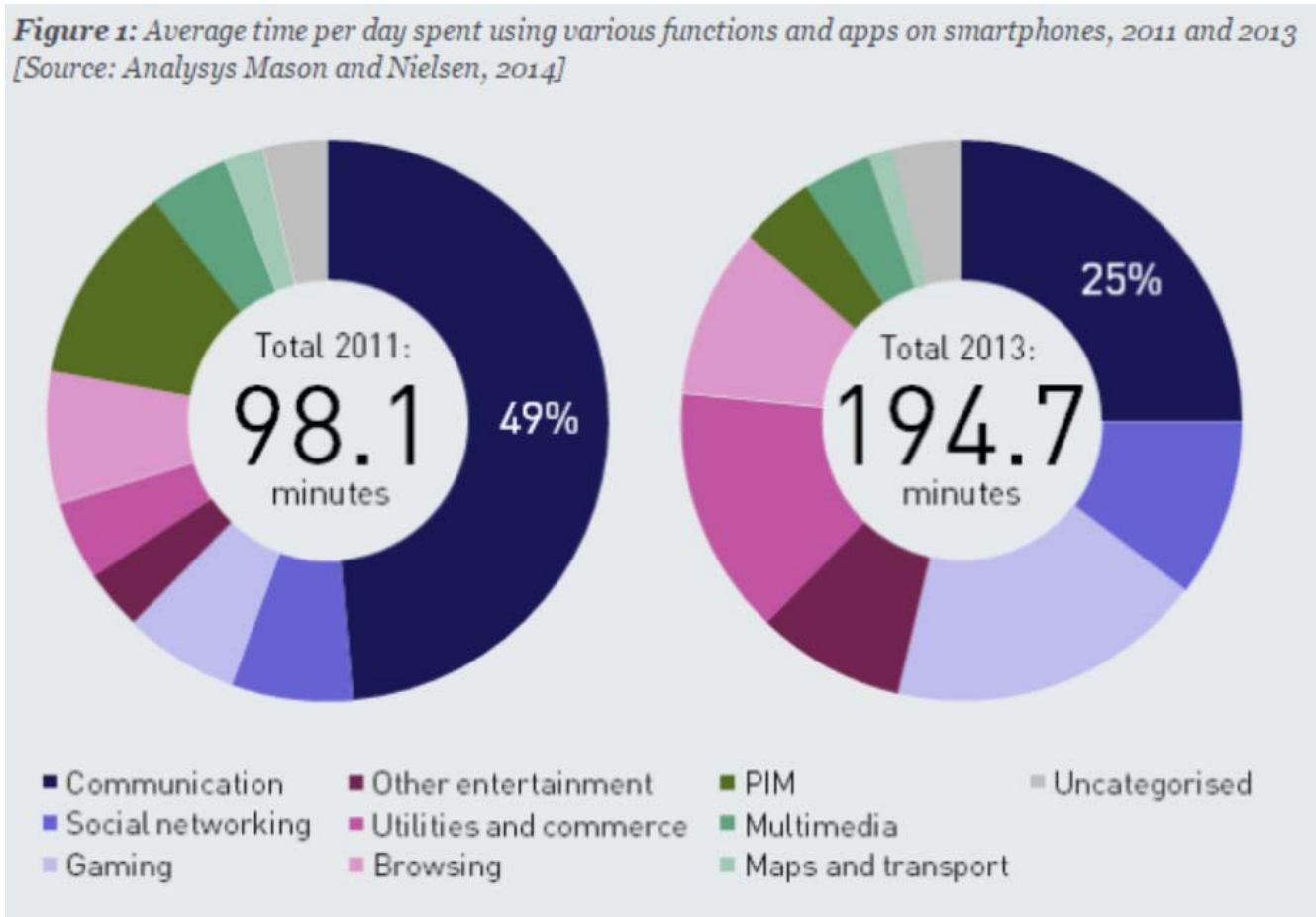
Conclusion

- Proved they could acquire quality data
- Because the data was collected in 2010-2011 we feel the data is no longer a good representative of current usage
- The found users were using their phones an average of 59.23 minutes/day



Conclusion

*Figure 1: Average time per day spent using various functions and apps on smartphones, 2011 and 2013
[Source: Analysys Mason and Nielsen, 2014]*





Future Work

- Better understanding of location-based results
- Improving Appazaar recommender system
- Back to the App: The Costs of Mobile Application Interruptions
 - Continued studying data collected from AppSensor



References

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QUESTIONS?