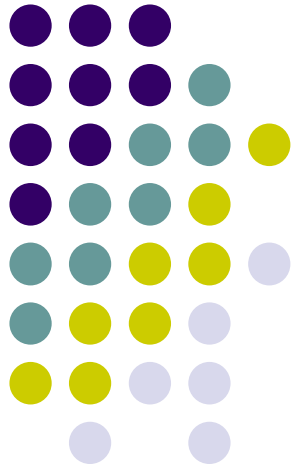
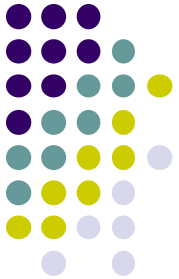
CS 528 Mobile and Ubiquitous Computing

Lecture 10b: Gamification & Energy Efficiency

Emmanuel Agu

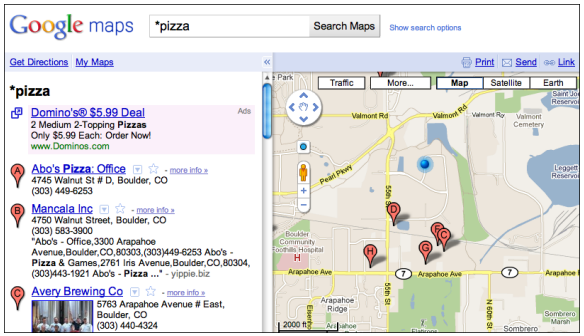




Urbanopoly

The Problem: Curated Datasets

- Location-based recommendations excellent
  - E.g. Best pizza spot near me, ratings pictures



- Gathering such curated (organized) data takes lots of time/money
- Users frequently unmotivated to help
- Very few people (< 10%) rate their experiences

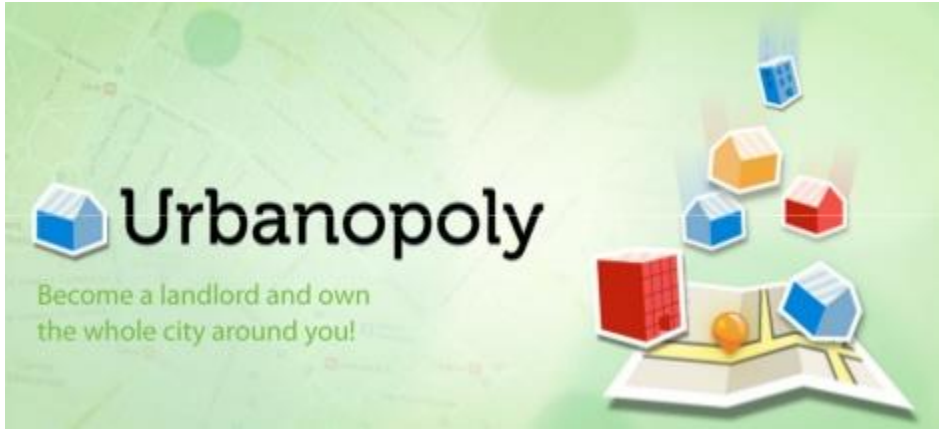
- Can we crowdsource curation? Gamify it? Motivate users

What is Urbanopoly?

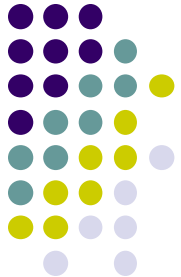
Celino *et al*, Urbanopoly – a Social and Location-based Game with a Purpose to Crowdsource your Urban Data

- A Game With a Purpose (GWP) or “serious games” designed to rate/quality assurance on urban data (e.g. restaurant information) using the user's current location and social graph

- Similar to Monopoly



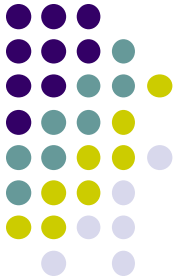
What is Urbanopoly?



- **Urbanopoly:** crowdsource data using an interactive, social monopoly-like mobile game (Urbanopoly)
  - Makes it fun to rate (gamify) reviews of places
  - Players given multiple types of tasks
  - Involve their social network (e.g. Facebook), post update messages

- Try to increase:
  - Number of contributions/player
  - Time each contributor/player spends

Methodology



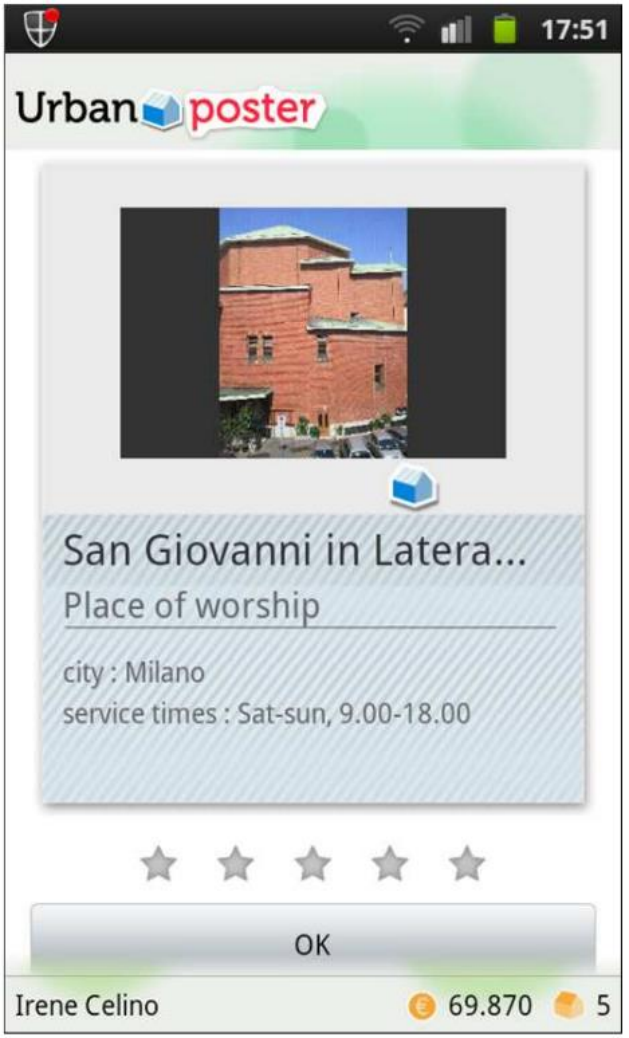
- OpenStreetMap for map data
  - Free geographic info
- Facebook API for social sharing
- **Urbanopoly goal:** crowdsource, pics, reviews, data from users to augment OpenStreetMap data
  - Mini-games to incentivize users

Urbanopoly GamePlay

- User is a landlord, whose aim is to create a "rich portfolio of venues“ (like monopoly)
  - Venues
    - Real places surrounding the user (e.g. shops, restaurants, etc)
    - Venues retrieved from OpenStreetMap
    - Orange venues belong to user, blue venues do not
    - have monetary values
  - Player Budget
    - User pays money to buy venues

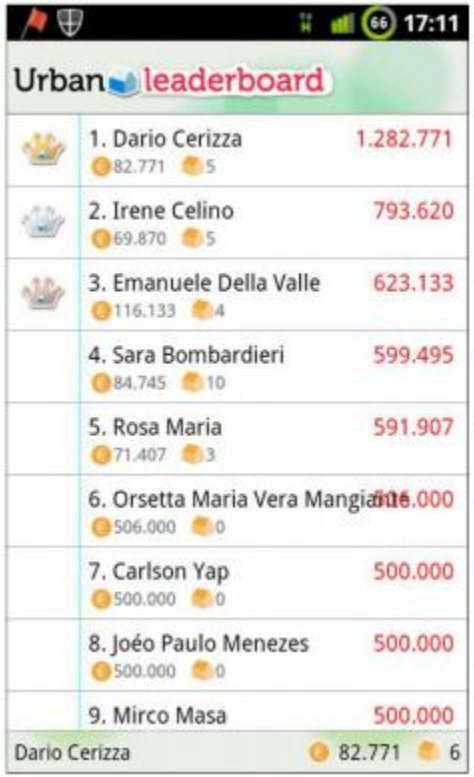
Venue Information

- Location
  - Type
  - Hours
  - Rating
  - Extra info (food served, smoking rules)



Urbanopoly GamePlay

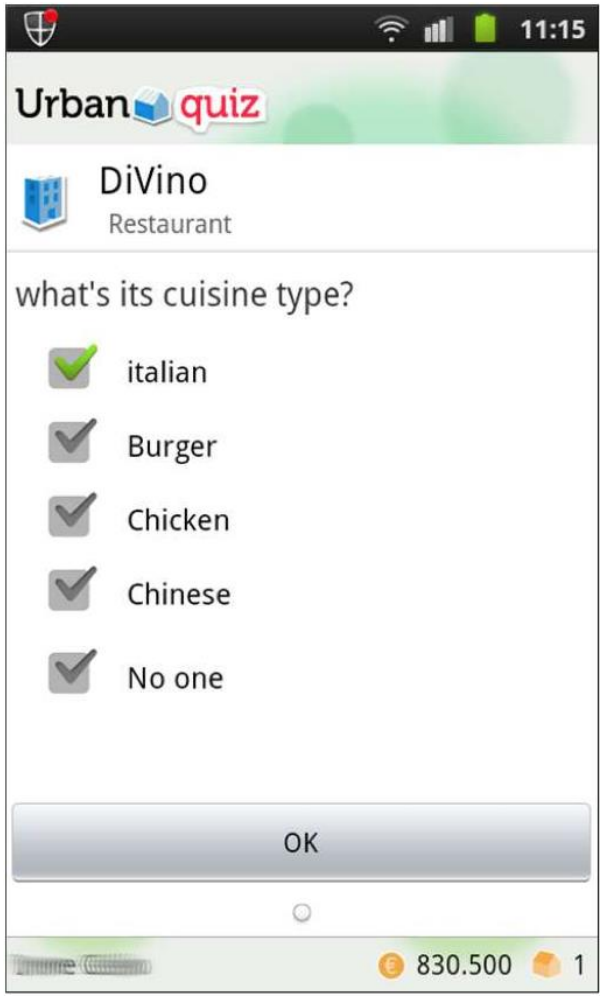
- User can buy venues they visit if not currently owned, they can afford it
- If venue owned, spin a “wheel of fortune”
- Result of wheel spin
  - Solve a puzzle that can give him/her more “money”
  - Quiz about the venue
- Players get daily bonus for participation
- Game maintains leaderboard

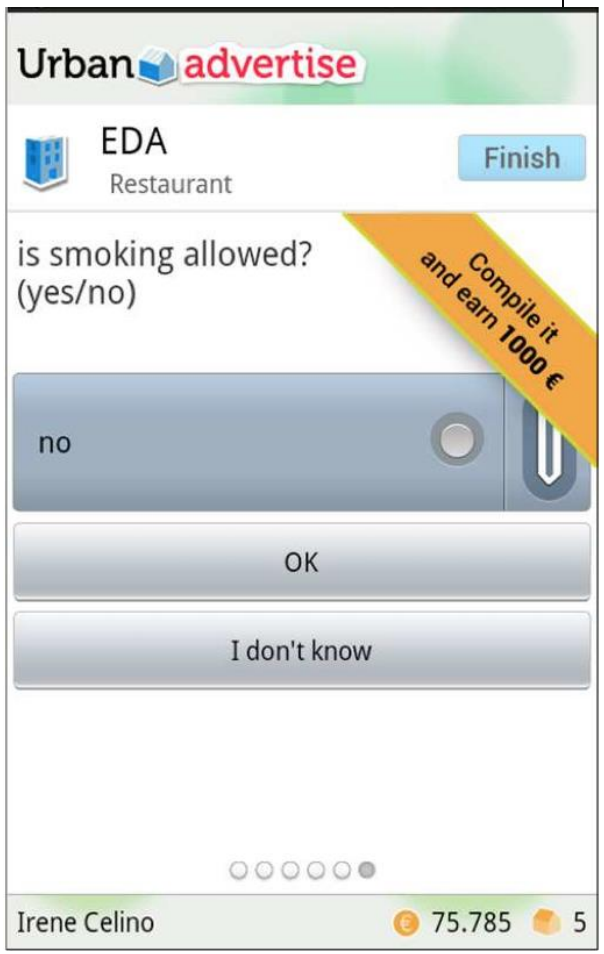


Gameplay

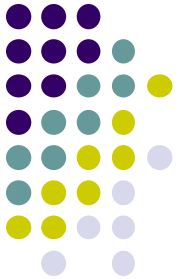
- Data Collection
  - Venue purchase
    - Users required to name venue and specify its type, edit info
  - Venue advertisement
    - If venue already owned, user answers questions about venue (ad)
      E.g. Is smoking allowed?
    - Store owners can grade/rank ads
  - Quizzes
    - Results from spinning wheel
    - Player asked questions about venue

Example Quizzes





Urbanopoly: Other Gaming Features



- Venue trading with other players

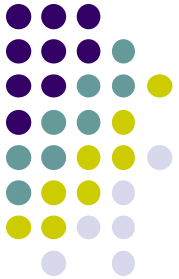
- Mortgage venue:
  - Get immediate cash from bank for venues already owned

Similar Work

- Foursquare
- Yelp
- Google Maps

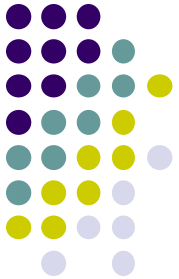
- Urbanopoly differs by gathering data through gamification of data collection
  - Gathers more data types
  - Other apps usually use surveys

Pros Vs Cons



- Pros
  - Social aspect makes it more appealing
  - Gaming aspect makes it very engaging for users; more "fun" than just surveys (e.g. Google Rewards)
  - Leaderboard to compete against friends

- Cons
  - Only available in certain locations in Italy (research prototype?)
  - Possibly slow to get initial critical number of users (classic crowdsourcing issue)



Sandra Helps You Learn: The More you Walk, the More Battery Your phone drains, *Ubicomp 2015*

Problem: Continuous Sensing Applications Drain Battery Power

C Min *et al,* Sandra Helps You Learn: the More you Walk, the More Battery Your Phone Drains, in Proc Ubicomp '15

- Battery energy is most constraining resource on mobile device
- Most resources (CPU, RAM, WiFi speed, etc) increasing exponentially *except* battery energy (ref. Starner, IEEE Pervasive Computing, Dec 2003)

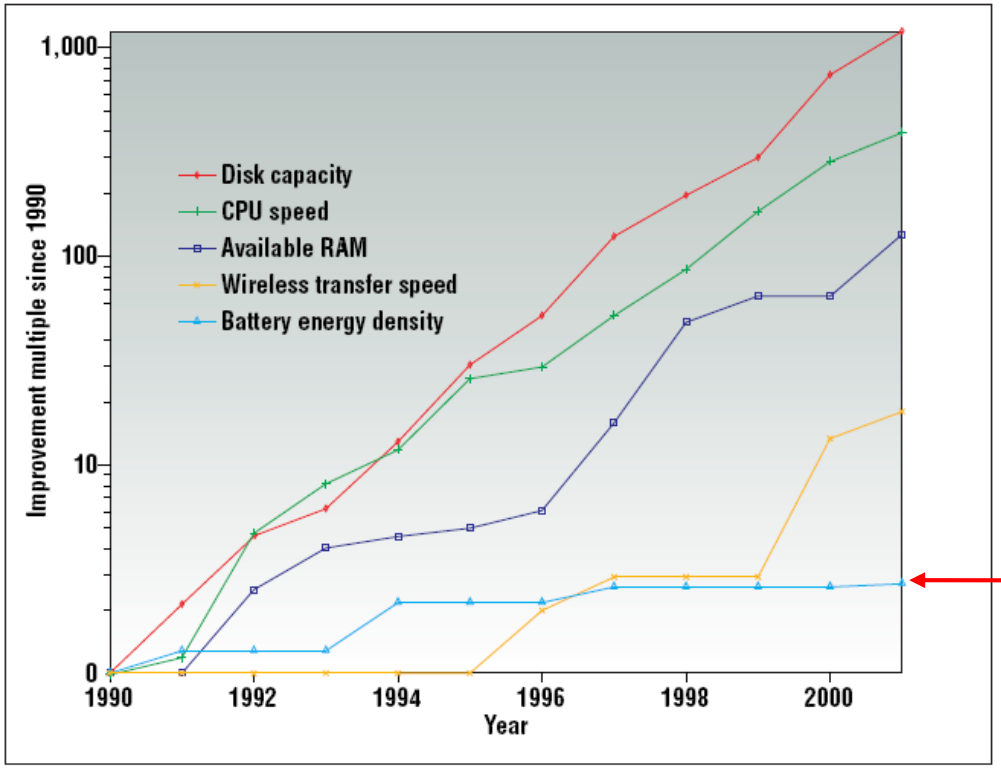


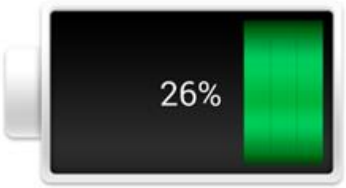
Figure 1. Improvements in laptop technology from 1990–2001.

Battery energy density barely increased

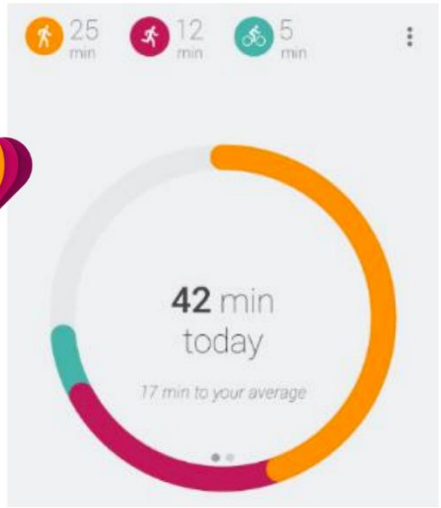
Problem: Continuous Sensing Applications Drain Battery Power

C Min *et al,* Sandra Helps You Learn: the More you Walk, the More Battery Your Phone Drains, in Proc Ubicomp '15

- CSAs (Continuous Sensing Apps) introduce new major factors governing phones' battery consumption
  - E.g. Activity Recognition, Pedometer, etc
- How? Persistent, mobility-dependent battery drain
  - Different user activities drain battery differently
  - E.g. battery drains more if user walks more



Google Fit:
activity tracking

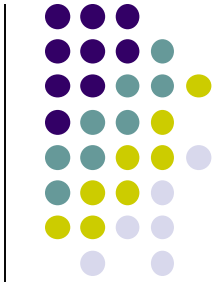


Moves:
activity/place tracking

Accupedo:
pedometer

Dieter:
pedometer

Sandra: Goal & Research Questions



- E.g. Battery at 26%. User's typical questions:
  - How long will phone last from now?
  - What should I do to keep my phone alive until I get home?

- Users currently informed on well-known factors draining battery faster
  - E.g. frequent app use, long calls, GPS, brighter screen, weak cell signal

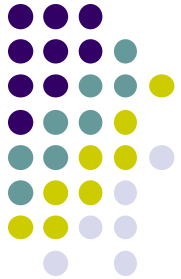
Sandra: Goal & Research Questions

- Users currently don't accurately include CSAs in their mental model of battery drain
  - CSA energy drain sometimes counter-intuitive
  - E.g. CSA drain is **continuous** but users think drain only during activity (e.g. walking)
  - Battery drain depends on activities performed by user

- Paper makes 2 specific contributions about energy drain of CSAs

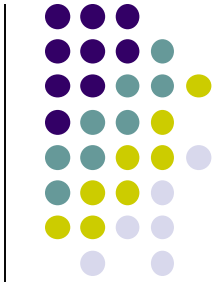
  1. **Quantifies CSA battery impact:** Nonlinear battery drains of CSAs
  2. Investigates/corrects **user's incorrect perceptions** of CSAs' battery behaviors

Sandra: Goal & Research Questions



- **Battery information advisor (Sandra):**
  - Helps users make connection between battery drain (including CSAs) and their activities
  - Forecasts battery drain under different **future** mobility conditions
    - E.g. (stationary, walking, transport) + (indoor, outdoor)
  - Maintains a history of **past** battery use under different mobility conditions

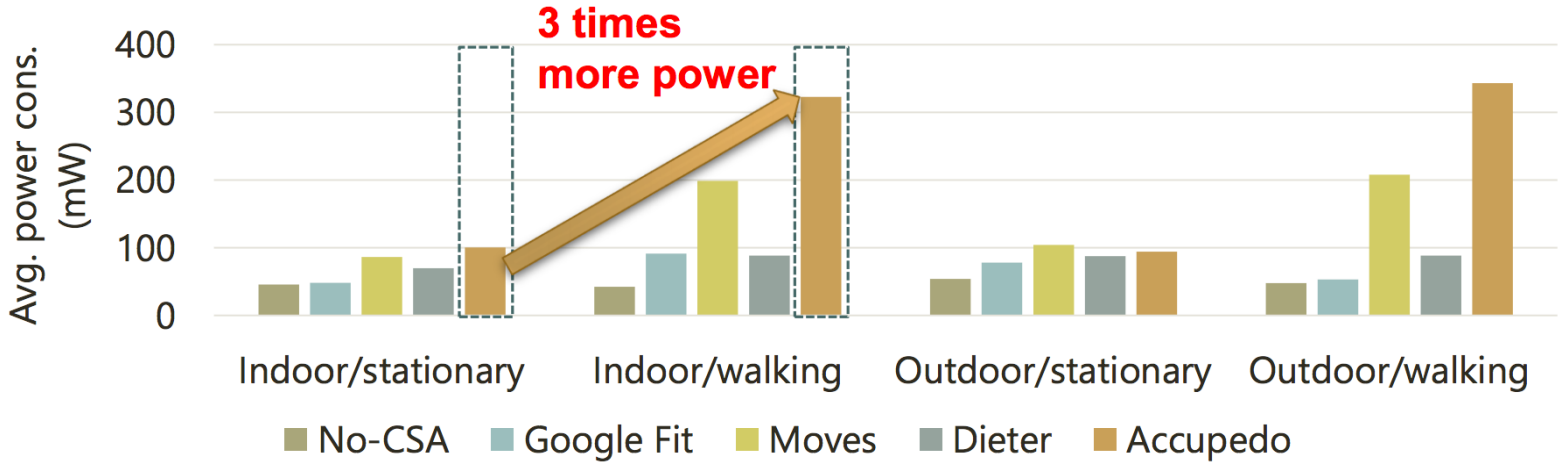
First Step: Measure Battery Consumption of 4 CSAs



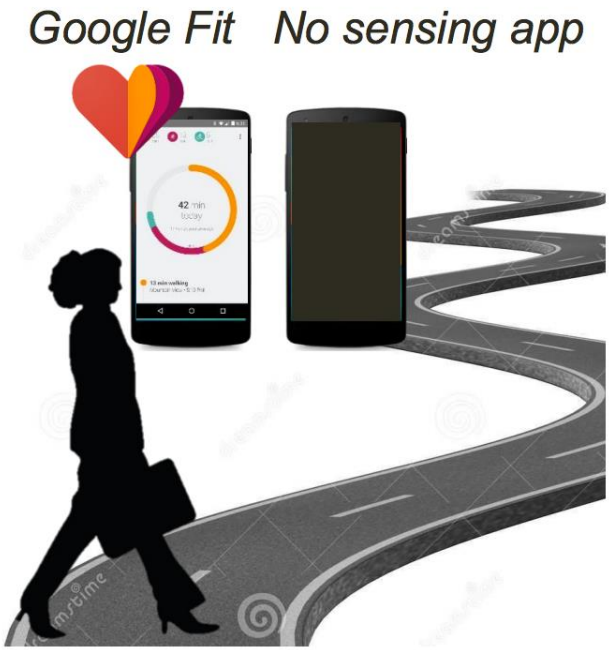
- **Google Fit:**
  - Tracks user activity continuously (walking, cycling, riding, etc)
- **Moves:**
  - Tracks user activity (walking, cycling, running), places visited and generates a storyline
- **Dieter:**
  - Fitness tracking app in Korea
- **Accupedo:**
  - Pedometer app

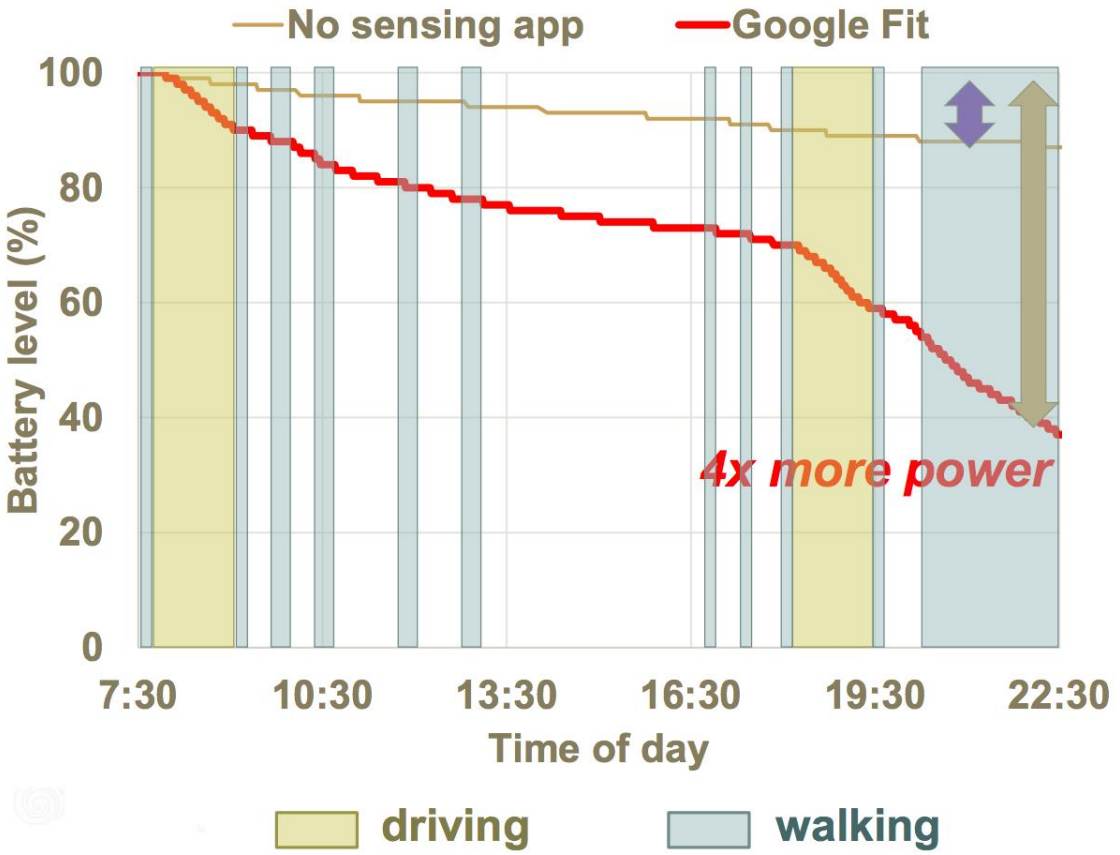
Energy Consumed by CSAs under different mobility conditions

- CSAs drain extra stand-by power
- Average increase in battery drain: 171% vs No-CSA
- Drains 3x more energy when user is walking vs stationary



Day-long Battery Drain under real Life Mobility

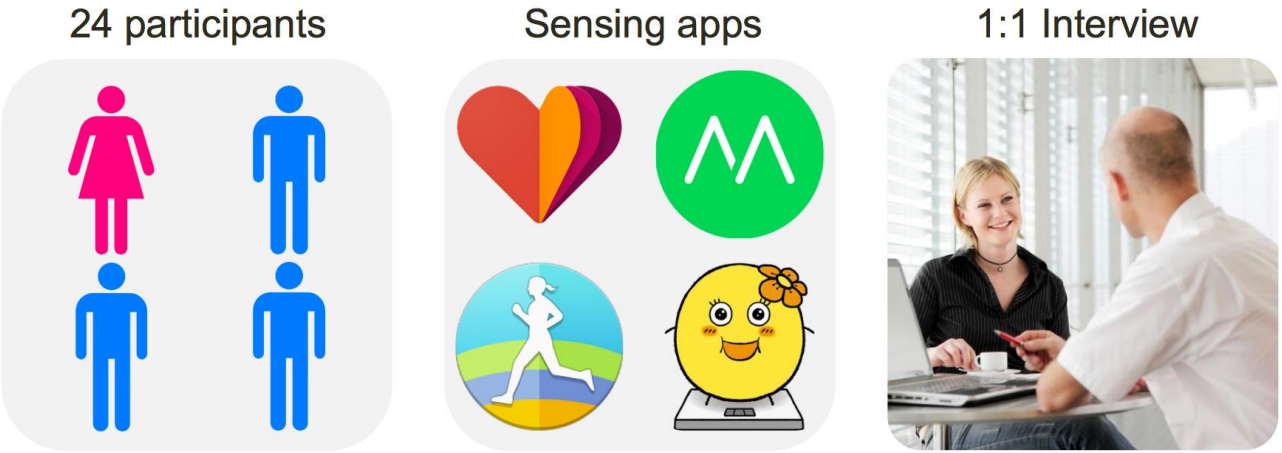




Also steeper battery drain when user is walking

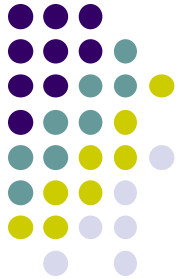
Users may focus on only battery drain caused by their foreground interactions

Next: Investigate User perceptions of CSAs' Battery Consumption



- Interviewed 24 subjects to understand factors influencing phone's battery life
- Questions included:
  - Do you feel concerned about phone's battery life?
  - Have you suspected that CSAs reduce battery life?

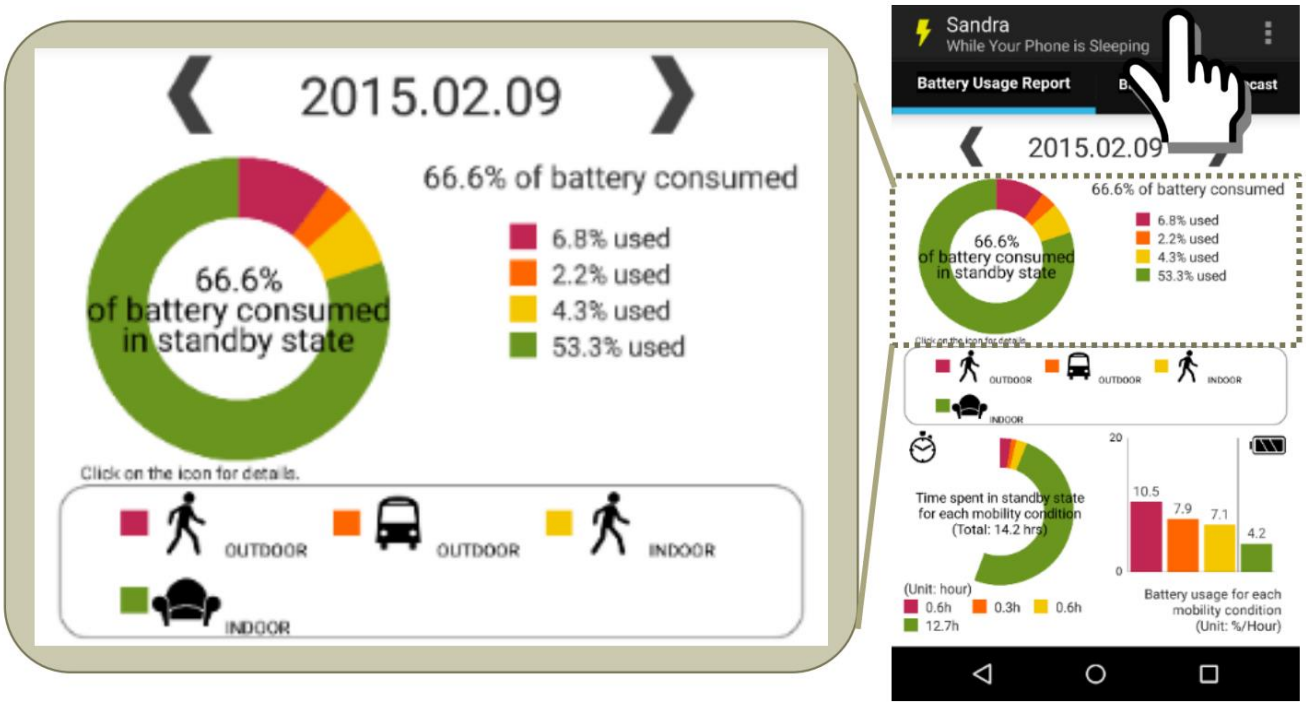
Findings: Investigate User perceptions of CSAs' Battery Consumption



- Subjects
  - Already knew well-known sources of battery drain (display, GPS, network, voice calls, etc)
  - Felt battery drain should be minimal when phone is not in use
  - Were very concerned about battery life. E.g. kept multiple chargers in office, home, car, bedside, etc
  - Had limited, sometimes inaccurate understanding of details of CSA battery drain
  - Disliked temporarily interrupting CSAs to save battery life.
    - E.g. Users kill battery hungry apps, but killing step counter misses steps, 10,000 step goals

Sandra Battery Advisor Design

- **Goal:**
  - Educate users on mobility-dependent CSA battery drain
  - Help users take necessary actions in advance
- Sandra Interfaces show breakdown of past battery use
- Battery usage information retrieved using Android system calls

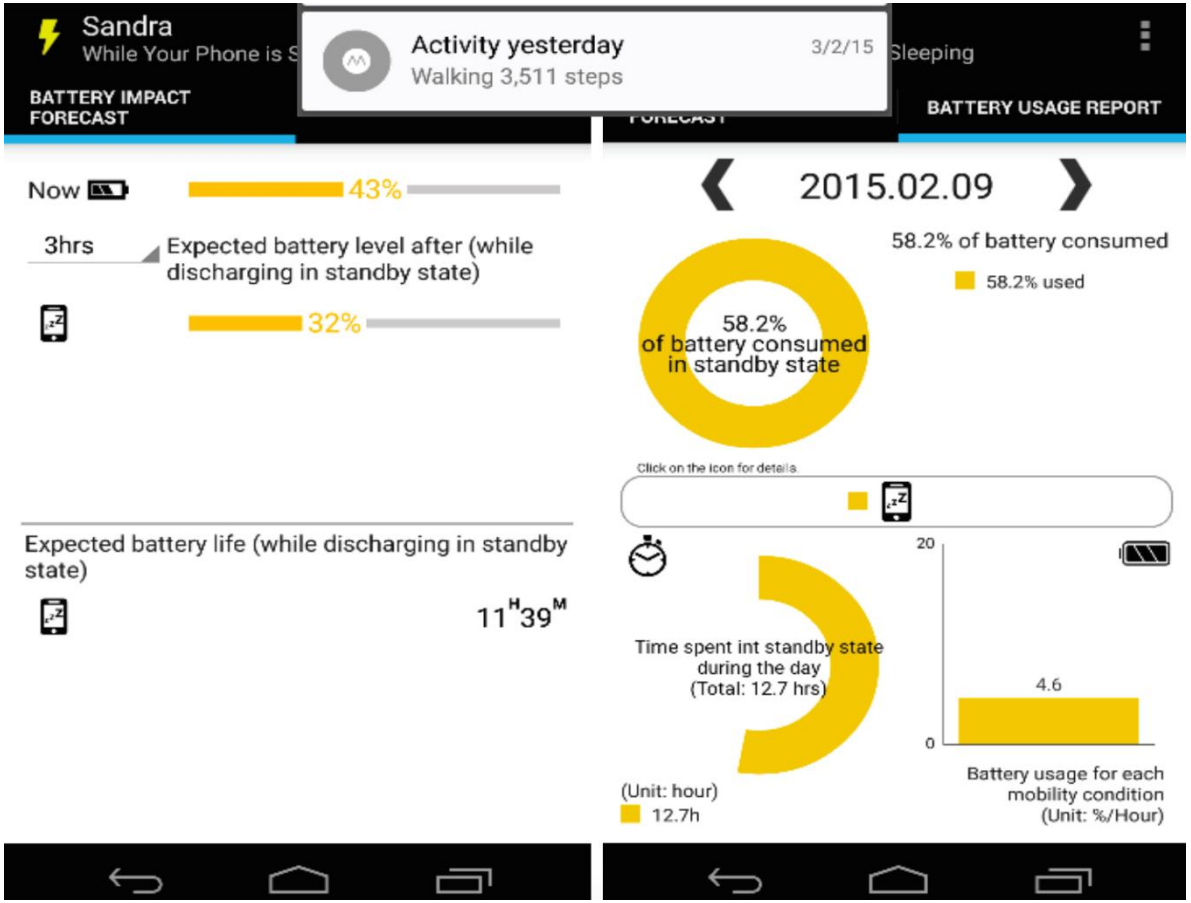


Sandra Battery Advisor Design

- Sandra interfaces that forecasts expected standby times for a commonly occurring mobility conditions
  - E.g. Walking indoors/outdoors, commuting outdoors, etc

Sandra Battery Advisor Design

- Sandra-lite version: less detailed
  - No mobility-specific breakdown of battery drain
  - Single standby life expectation



Forecast of Future

Breakdown of Past battery usage

Sandra Evaluation

- Experimental Setup

24 participants

30-day deployment

18 Google Fit, 6 Moves

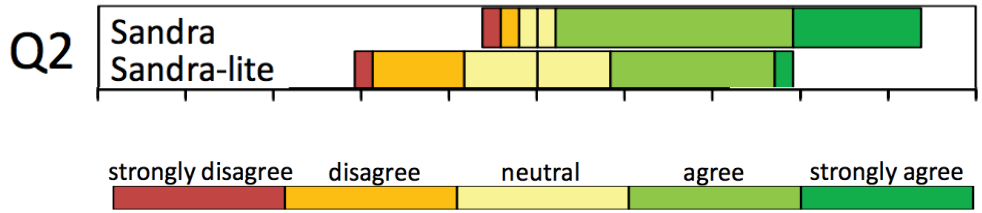
Real devices

- First 10 days Sandra just gathered information (no feedback)
- Last 20 days gave feedback (forecasts, past usage breakdown)
- Surveyed users using 2 questionnaires for using Sandra and Sandra-lite
  - 5-point Likert-scales (Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree)

Sandra Evaluation

- Q1: “Did it bring changes to your existing understanding about your phone’s stand-by battery drain? ”

- Q2: “Do you think the provided information is useful”



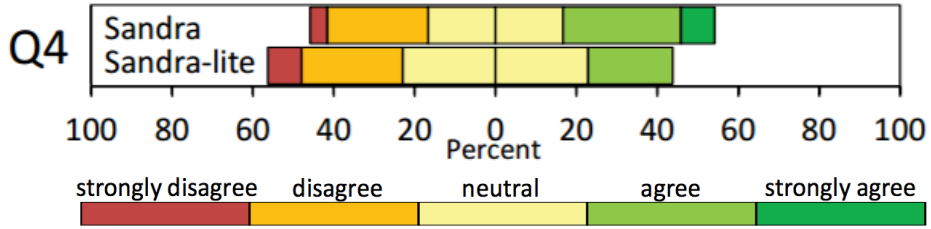
Sandra vs Sandra-lite: Mobility-aware battery information of Sandra increased users’ existing understanding(p-value 0.023)

Realizing that the phone consumes different power

Sandra Evaluation

- Q3: “Did you find it helpful in managing your phone’s battery?”

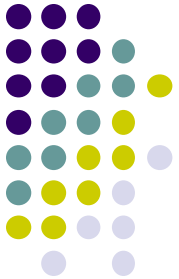
- Q4: “Did you find it helpful in alleviating your battery concern?”



Mobility-aware battery information was perceived as useful (p-value= 0.005)

Acquiring
new everyday practices:
Turning off GoogleFit on driving

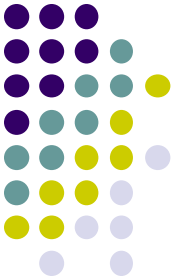
Feeling less nervous
under limited battery:
Before sleeping



Focus: A Usable & Effective Approach to OLED Display Power Management

Wee *et al*, Ubicomp 2013

Introduction

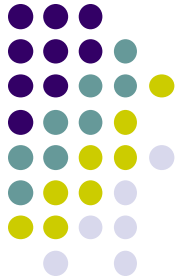


- OLED is technology used in creating smartphone screens
  - Lower power consumption than LCD, does not require backlight,
  - Better image quality

- **Problem:** OLED still consumes up to 67% of the total device power consumption.
-
- *Focus:* a system for reducing power consumption of OLED displays on smartphones.

- Larger displays such as the 4 inch iPhone 5, 4.8 inch Galaxy S III, 5 inch Galaxy S IV, and the 5.3 inch Galaxy Note II

How Focus Reduces Energy Consumption



Focus Goal: reduce power consumption, while preserving user experience.

Two main approaches in literature:

1. Convert displayed colors into colors that consume less energy.

2. Darken or turn off portions of the displayed contents that are less interesting to the user ★

FOCUS uses option 2

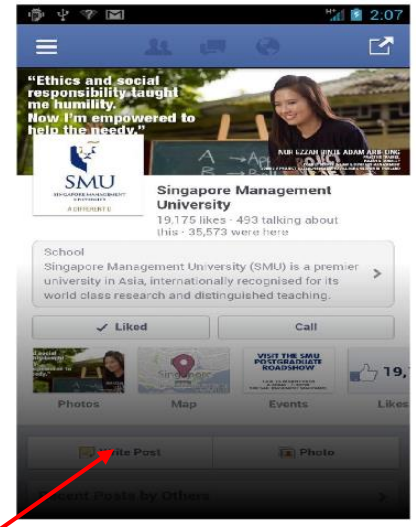
Examples of FOCUS Operation

- Top 50% unmodified
- Bottom 50% dimmed

(a) BBC News (Original)

(b) With Focus "Default" Profile

(c) Facebook (Original)



(d) With Focus "Default" Profile

With FOCUS Default Profile

Approach

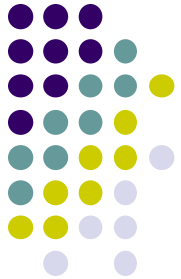
- **General Approach:** Darken “less important” parts of screen
- *Question:* Which portion can be dimmed?
- Study 520 Android applications in 26 categories.
- Use the concept of *saliency* to identify Regions of Interest (ROI) for each of these categories, based on user interaction

- Findings

  64% of Apps place new content at the top /bottom.

  69% of Apps use scrolling to access new content.

  77% of Apps are read-only.



Approach

- Result: Most Apps use half of screen to display NEW content.
  - Simple ROI model: Dim top/bottom.
- Alpha blending to achieve dimming
- Implement Focus Inside The Android Framework

FOCUS Application-Specific Profile

- Different dimming for different applications
- E.g Facebook has different dimming pattern from BBC app

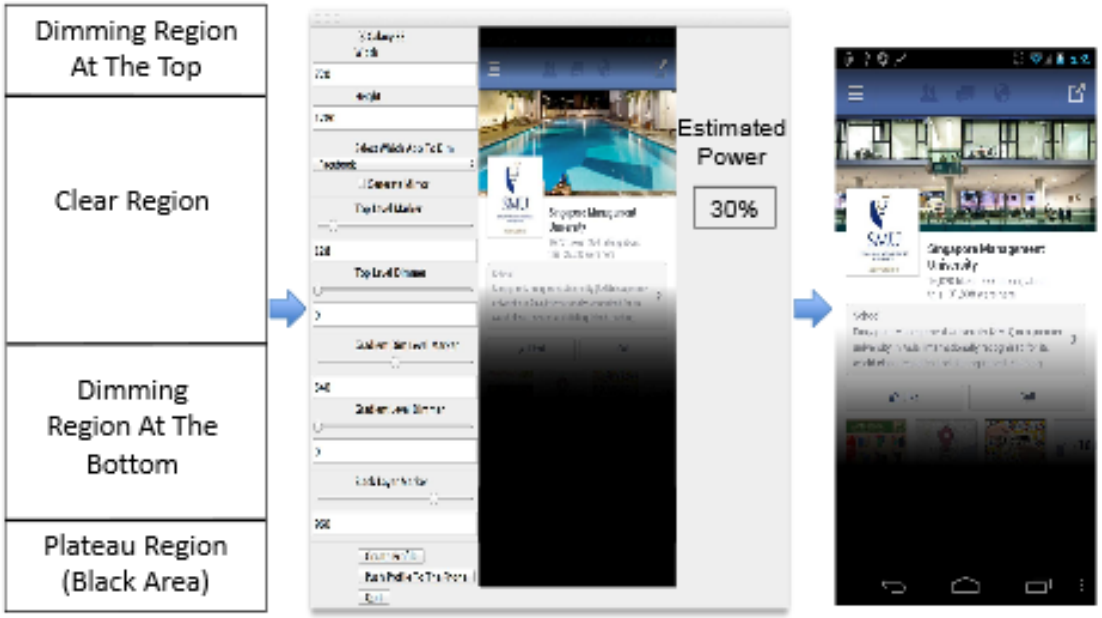


Figure 2. Applying Application-specific Profiles In Focus

Evaluation: App-Specific Dimming

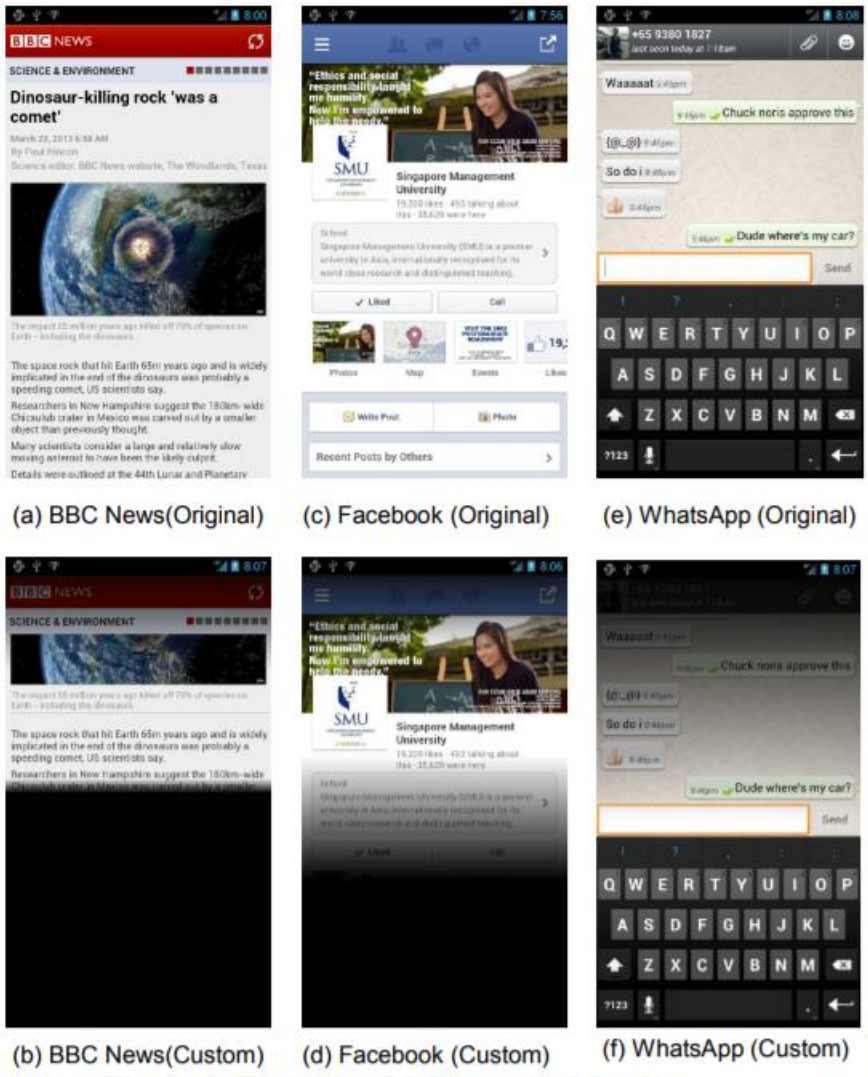
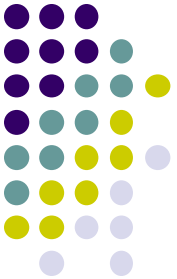


Figure 3. Examples Of Customised Profiles

Evaluation

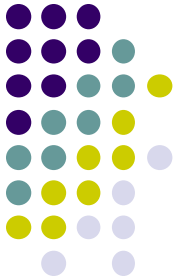


- **The evaluation is done to answer the following questions:**

- 1)How effective is *Focus* in saving power?

- 2)What is the impact on task completion time?

Methodology of Evaluation



- **Tool:** Monsoon external hardware power monitor

  - **Apps**: 15 popular applications with various categories

- **Approach**: Running application with “main” page without *Focus* for one minute and with *Focus* for one minute.

Result: Effectiveness

Application	One Minute Continuous Usage Scenario						
	Power Consumption (mW)			% Improvement			
	Base (1)	"Default" (2)	"Customised" (3)	(2) over (1)	(3) over (1)	(3) over (2) (% & Diff.)	
Aldiko Book Reader	1952.30	1337.65	1236.27	31.48	36.68	16.52	(5.20)
Documents To Go 3.0	1620.04	1357.11	1267.67	16.23	21.75	34.01	(5.52)
Gmail	1707.48	1243.77	1006.59	27.16	41.05	51.14	(13.89)
Firefox Browser	1703.89	1255.24	1047.32	26.33	38.53	46.33	(12.20)
WhatsApp Messenger	1237.10	1218.18	952.98	1.53	22.97	1401.31	(21.44)
OCBC Banking	1696.96	1249.17	1036.19	26.39	38.94	47.56	(12.55)
YouTube	1452.80	1113.60	787.30	23.35	45.81	96.18	(22.46)
BBC News	1550.99	1118.97	881.51	27.85	43.11	54.79	(15.26)
Adobe Reader	1923.19	1437.42	1261.15	25.26	34.42	36.26	(9.16)
Dropbox	1921.80	1358.99	1284.40	29.29	33.17	13.25	(3.88)
ES File Explorer	889.71	790.46	768.43	11.16	13.63	22.13	(2.47)
Calendar	1520.55	1149.23	1092.58	24.42	28.15	15.27	(3.73)
eBay	1766.78	1259.86	1238.60	28.69	29.90	4.22	(1.21)
Facebook	1557.35	1288.49	1041.78	17.26	33.11	91.83	(15.85)
Twitter	1823.38	1230.84	1020.18	32.50	44.05	35.54	(11.55)

Percentage Improvement In Energy Consumption

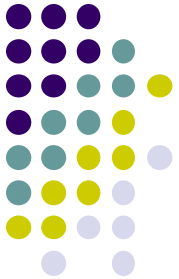
User Study

- **User study is designed to answer the following questions:**

1. Are the “Default” and “Customised” profiles usable?

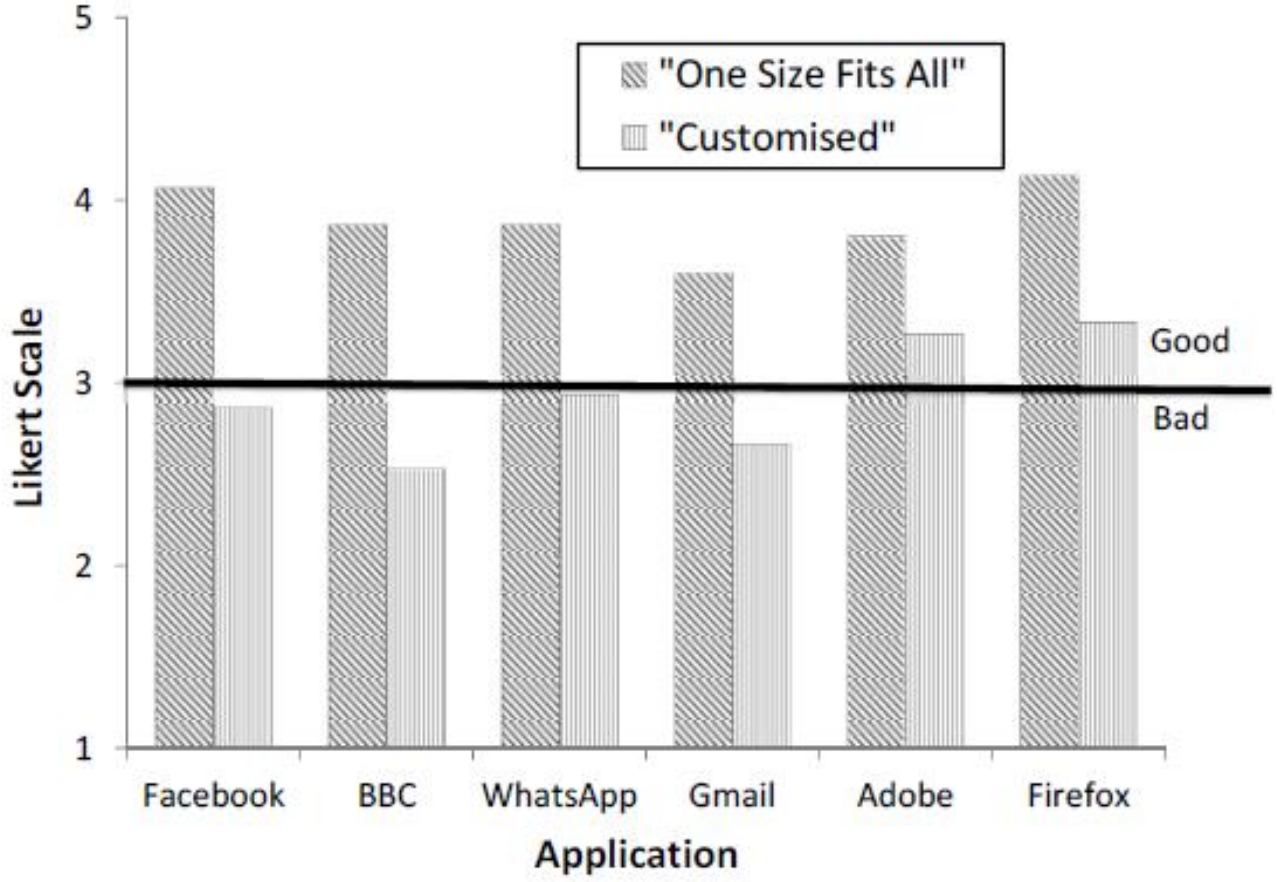
2. Are Supplied Profiles Good Enough?:

2nd User Study: Usability



- **Participants:** 30 undergraduate participants from SMU's Information Systems school
  - **Apps:** 6 popular apps, 4 apps each participant
- **Approach:** Participants use unmodified version first then modified versions.
- **Evaluation:** Participants answer two questions using a 5-point Likert scale

Result: Usability



Default profile generally preferred to app-specific customizations