DarkReader: Bridging the Gap Between Perception and Reality of Power Consumption in Smartphones for Blind Users

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Blind users do not need screens.
Screen consumes over 20% battery

[Chen et al., MobiCom 2015]
Prone to shoulder-surfing
Sleep Mode
Our Contribution

• Understanding the perception of power consumption of blind users

• DarkReader: realizing those perceptions in practice for blind users
Study 1: Research Questions

• RQ1: Usability issues with the power-saving settings in smartphones?

• RQ2: Are you aware of privacy-preserving curtain mode?

• RQ3: How do you react to battery indicators?

• RQ4: How to deal with the limited battery capacity of smartphones?
Study 1: Participants

• 10 Blind Participants (from Mailing List)

• **Gender**: 6 males, 4 females

• **Age**: $\text{Mean}= 40.8$, $\text{SD}=12.8$, $\text{Min}=27$, $\text{Max}= 60$

• **iPhones**: more than 3 years old (except for one)

• **Daily usage**: from 1 to 8 hours

• **Recharging frequency**: 1.8 times/day (avg)
Findings: Usability Issue

- Screen reader *cursor* is *lost* in Sleep Mode
- Causes serious usability concern

**Cursor resets to the first element**

**Cursor is at “October 10th”**
• 6/10 participants disabled auto-lock

• Others set longer interval (e.g., 5 minutes)
Findings: Misconception

• 9/10 participants were aware of screen curtain mode

• 6/9 who disabled auto-lock, used curtain mode frequently

• Others did not use curtain mode frequently
  • Forgot the gesture to enable/disable it
  • Often show the screen to sighted persons
  • Stay-at-home

• All 9 participants believed curtain mode saves power
Findings: Anxiety

• All participants experienced anxiety hearing the “Low Battery” message

• Routinely used power-hungry apps
  • E.g., BeMyEyes, Seeing AI, Blind Square, Access Ride

• Carried external battery packs
  • E.g., Juice Box, Morphie

• Preferred to know the remaining usage time (e.g., 1 hour and 20 minutes)
Dark Reader
DarkReader: Low-Power Screen Reader

• Built on top of Android’s screen reader, TalkBack

• Sleep mode + Curtain mode = DarkReader mode
  • Keeps screen reader and apps interactive, as if they were in curtain mode
  • Keeps the screen truly off, as it were in sleep mode
  • Users can use any gesture to enable/disable it

• Reports remaining usage time in discrete intervals (in-progress)
Technical Challenges

• Deliver *user inputs* to the *hardware driver* (ULPM)

• Deliver *user inputs to screen readers*

• *Update* applications’ *UI* (UIWear)

• *Retain* the screen reader *cursor*
UI changes

TalkBack

Cached UI Tree

Accessibility

Manager Service

Add New Filter

Input Filter

Text-to-Speech (TTS)

Cached Buffer for TTS

Accessibility events

UI changes

User App (background)

NON-STOP

[UIWear, MobiCom'17]

User App

[ULPM, UIST'18]

Hardware Composer

Pixel rendering

Input events

Hardware Layer

Framework Layer

Application Layer

User
Study 2: Evaluation of DarkReader

- Another study with 10 blind participants
  - User experience
  - Power saving

- 3 regular tasks:
  - T1: Making a phone call
  - T2: Reading an article
  - T3: Watching YouTube
Results: Task Completion Time

No statistically significant difference in completion time
Results: Power Consumption in different Screen Conditions

Drastically saves power consumption, up to 50%
Conclusion

• Sleep mode has usability concern for screen reader users
• Blind users incorrectly assume curtain mode saves power

• DarkReader truly switches the screen off, yet interactive
• We hope smartphone vendors will incorporate DarkReader