# **SERENUS:** Alleviating **Low-Battery Anxiety** Through *Real-time*, *Accurate*, and *User-Friendly* **Energy Consumption Prediction** of Mobile Applications

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# Problem Statement

User feels **low-battery anxiety** when their mobile phone's battery is low

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Pay

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**When the battery drops under 20%,**

**QoE 90%**

# Goal

To alleviate **low-battery anxiety**

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**Why they feel anxiety?**
**What is the root cause of the anxiety?**

# Insight

In psychology,
**anxiety** stems from **uncertainty**

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**anxiety** stems from **uncertainty**

So, we assume
**low battery anxiety** arises from **uncertainty about the availability of a mobile device in the future.**

# Insight

If we help users **eliminate the uncertainty**, users might **alleviate low battery anxiety.**

# Goal

To alleviate **low-battery anxiety**,

we provide **battery information** for users to manage their mobile battery **effectively**

# Approach

## Our new system, SERENUS

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**Our new system, SERENUS**

provides **accurate, real-time predictions**

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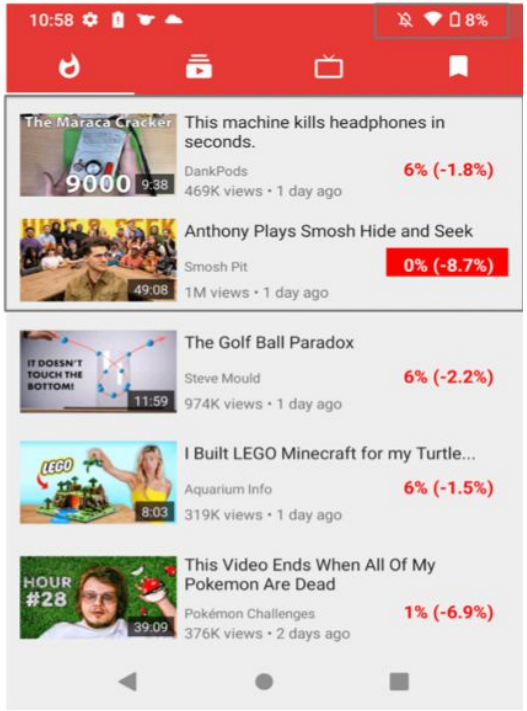
provides **accurate, real-time predictions**
of an application's energy consumption
in a **user-friendly manner**

# Approach

**Our new system, SERENUS**

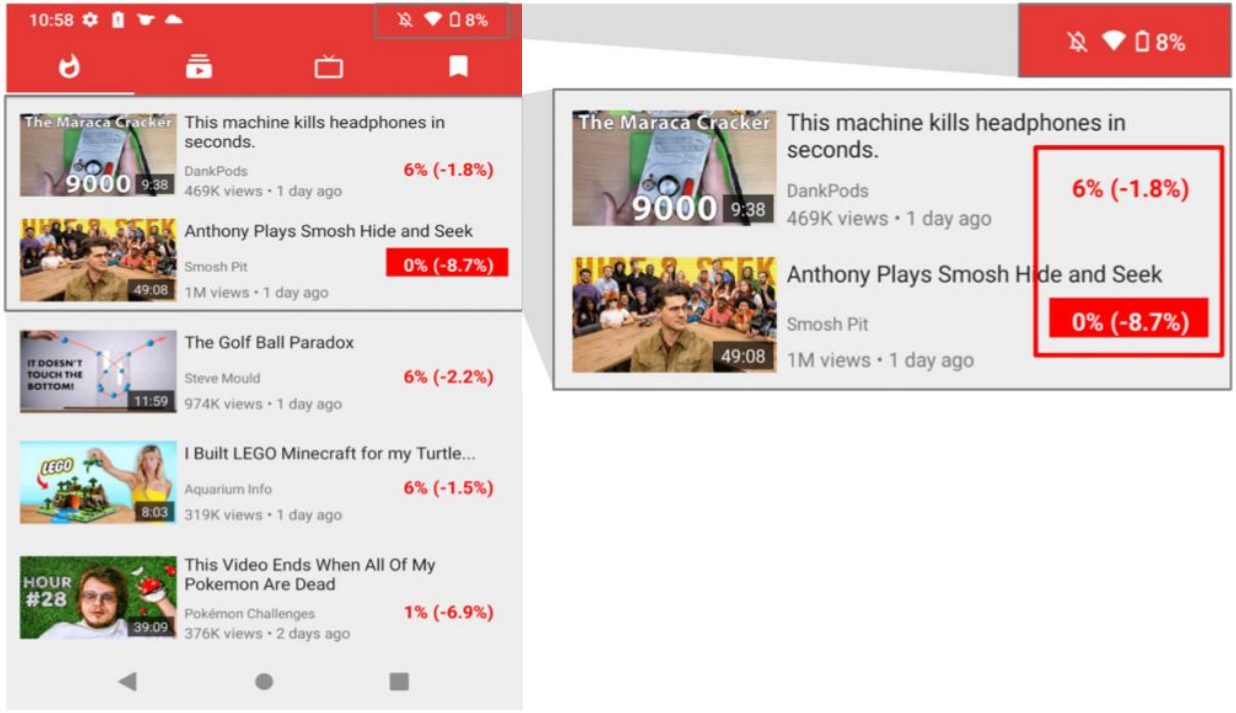
provides **accurate, real-time predictions**
of an application's energy consumption
in a **user-friendly manner**
**right before the user decides** whether
to use the application

# Use Cases



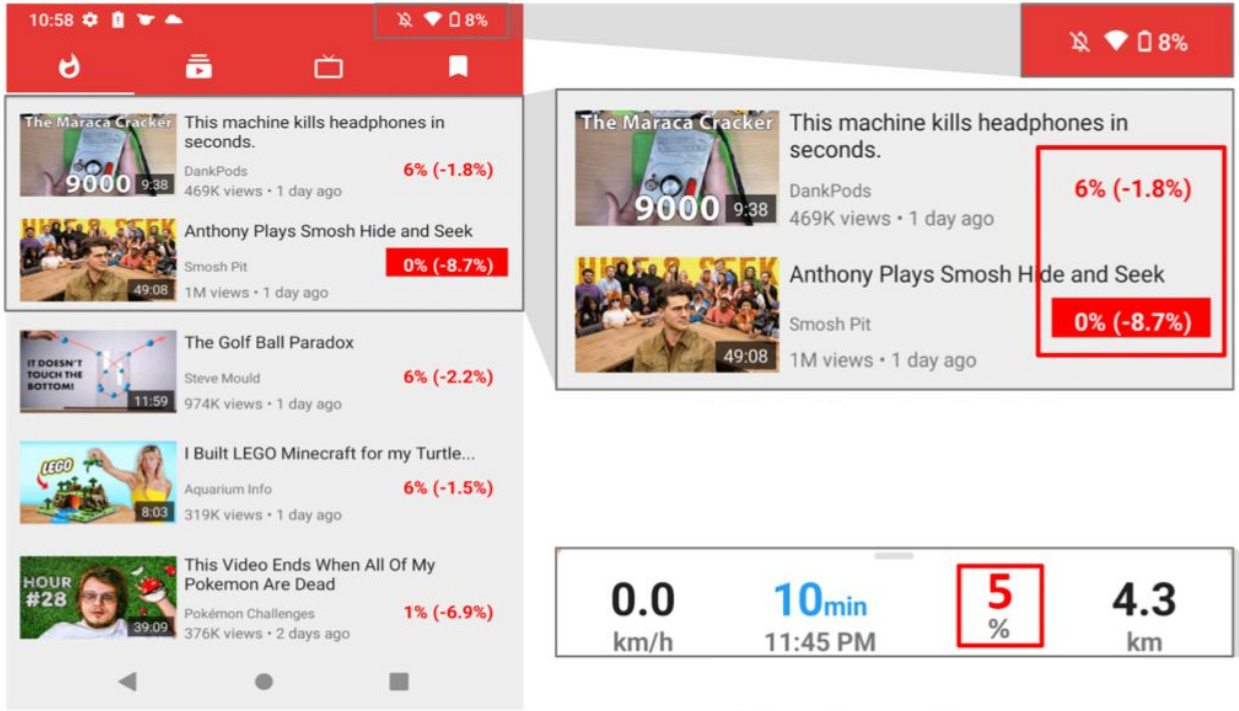

## Streaming

# Use Cases




## Streaming

# Use Cases




Streaming



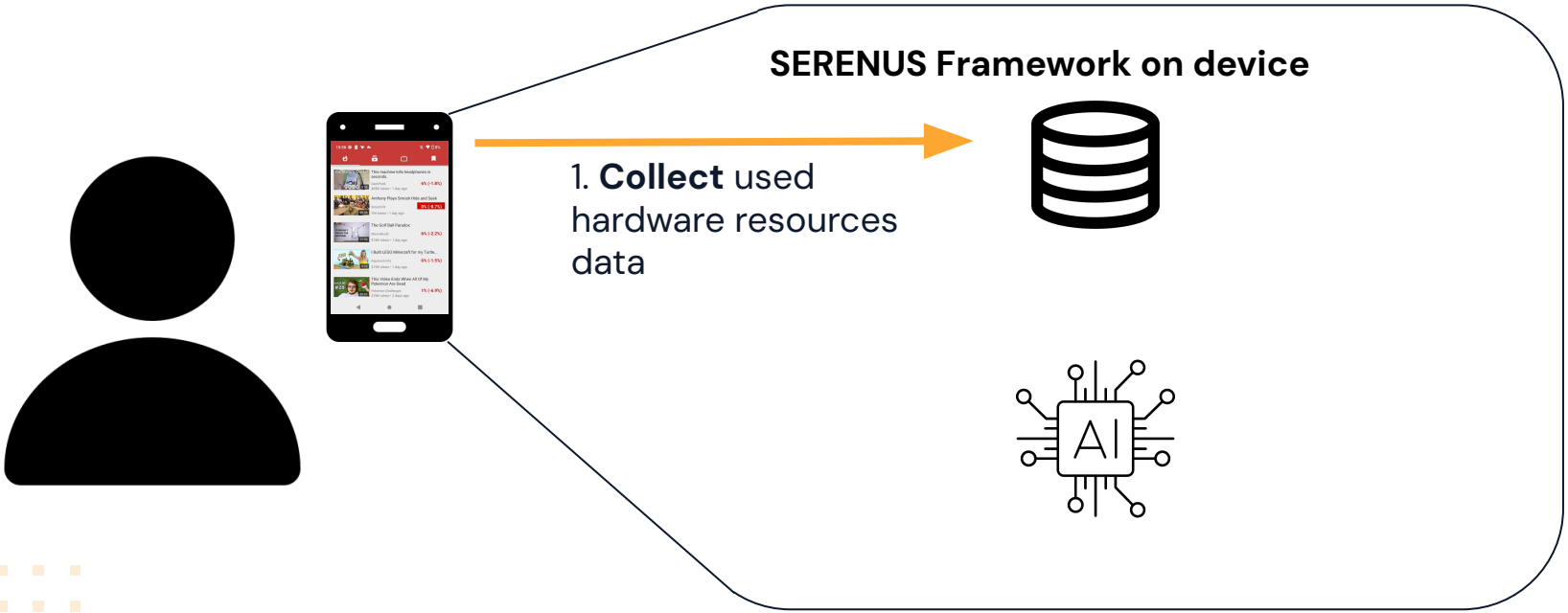

Map

# SERENUS Workflow

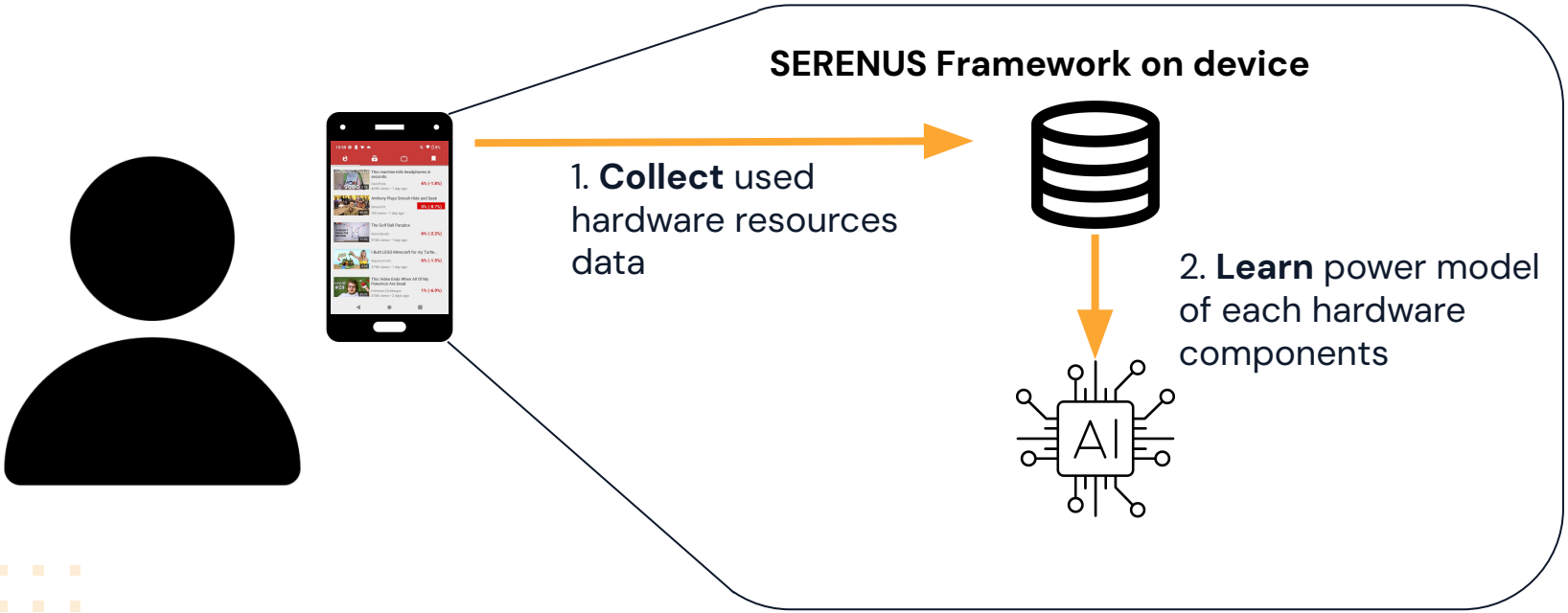
1. Collect Data
2. Construct Power Model
3. Predict in real-time

**All steps work within the device**

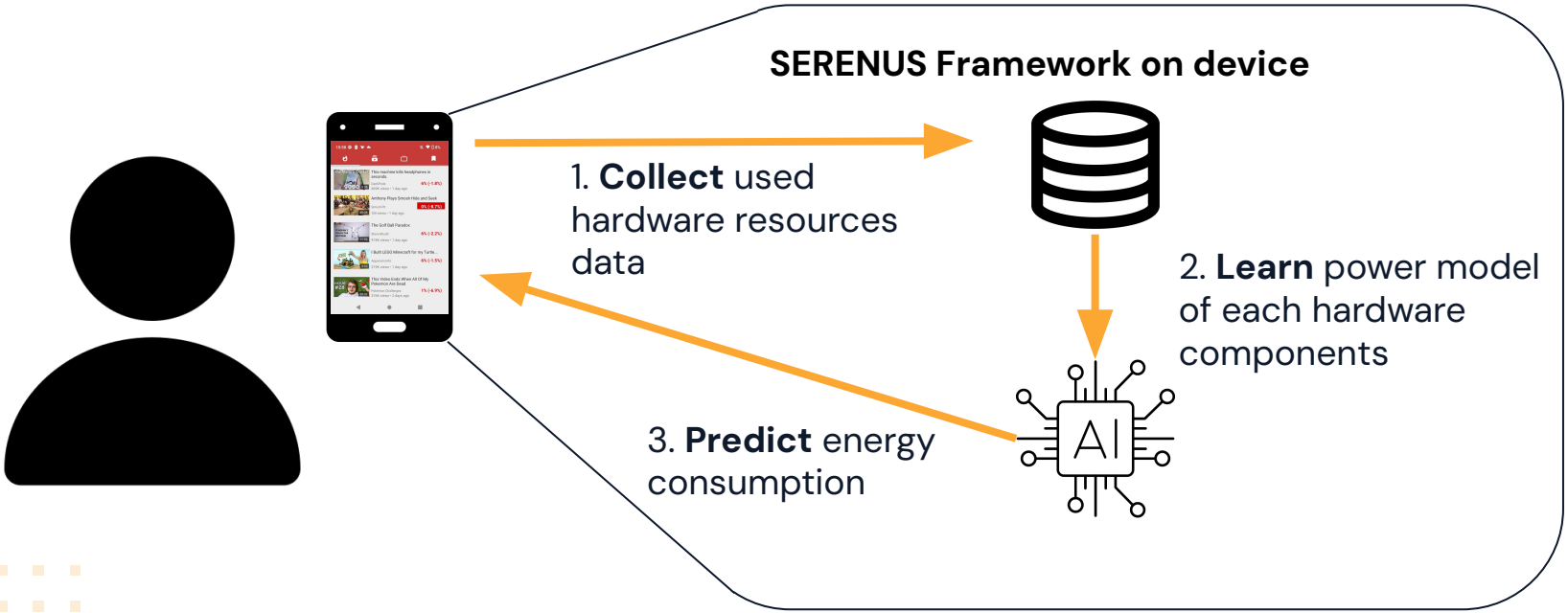
# SERENUS Workflow



# SERENUS Workflow

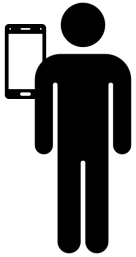


# SERENUS Workflow



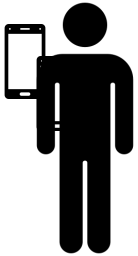
# User Study

## Two in lab condition



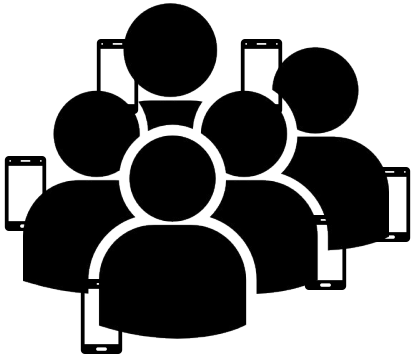
Existing System
(N=17)

VS



SERENUS
(N=18)

## Field Study



1 WEEK
w/ SERENUS
(N=7)

# User Study

- **The degree of anxiety**
  - **STAI-6** score
  - **Content analysis**
    - The frequency of anxiety-related keywords on participants' answers
- **The degree of planning their application usage**
  - **7 likert scale**

# Evaluation

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**Max 40%** ⬇

Reducing the anxiety
regarding energy consumption

# Evaluation

**Max 40%** ↓

Reducing the anxiety
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**Max 27%** ↑

Improving the application usability
in low battery situation

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**77 /100**

SUS Score
(System Usability Score)

# Evaluation

**Max 40%** ↓

Reducing the anxiety
regarding energy consumption

**Max 27%** ↑

Improving the application usability
in low battery situation

**77 /100**

SUS Score
(System Usability Score)

**Avg 90%**

Prediction Accuracy
(4 device models &
12 real world applications)

# What we found

**The uncertainty** comes from

# What we found

**The uncertainty** comes from

- **To use desired applications with the current battery level**
- **Remained battery lifetime**
- **Unexpected future events (Sudden call)**

# Thanks!

**Do you have any questions?**

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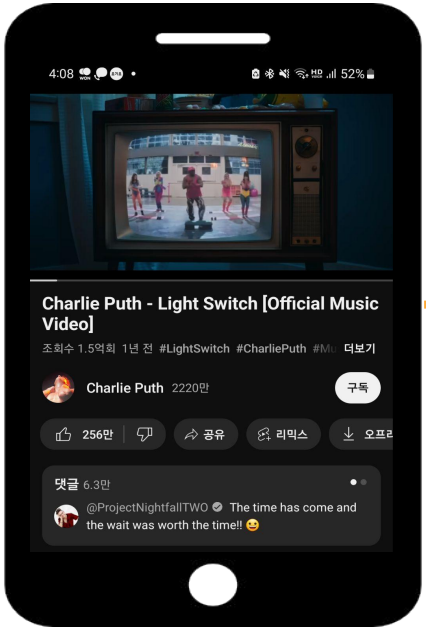
# Appendix

# Energy Consumption Estimation




Audio

Display

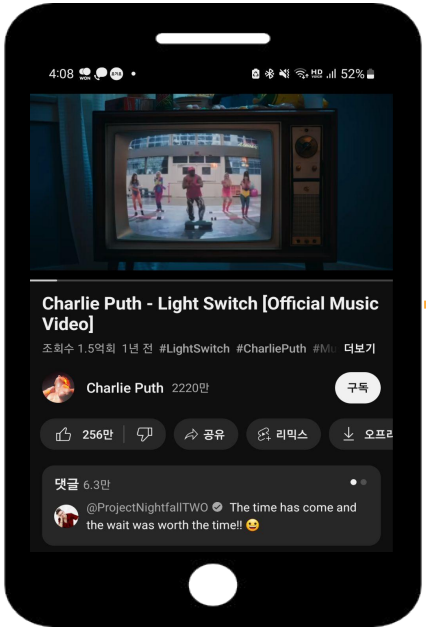
CPU

CPU

GPU

GPU

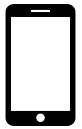
# Energy Consumption Estimation




Audio

Audio Power Model

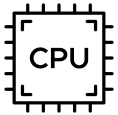
8 mAh



Display

Display Power Model

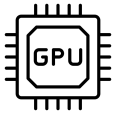
50 mAh




CPU

CPU Power Model

7 mAh

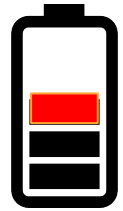



GPU

GPU Power Model

15 mAh

80 mAh



# Energy Consumption Estimation

Power model of each hardware estimates the energy consumption of the application based on **hardwares' resource usages**

$$E^{app} = \sum_{i=0}^{\#of\,hardware} \beta_i \times d_i^{app}$$

$\beta_i$ → Power coefficient value (energy consumption per time)

$d_i^{app}$ → Activated duration