Pixelsior: Photo Management as a Platform Service for Mobile Apps

Kyungho Jeon, Sharath Chandrashekhara, Karthik Dantu and Steven Y. Ko

University at Buffalo, The State University of New York
Photo data is exploding

- 2 billion mobile devices with cameras were sold in 2014 [Evans 2014]
- 3+ billion photos were shared on Facebook, Snapchat, Instagram, and WhatsApp every day in 2015
Photo apps are so popular

- Many popular apps have photo-related features
  - Google Photos, Snapchat, Instagram, Facebook, WhatsApp, ...

- Popular features including...
  - Sharing, Editing, Sync, Image analysis
Popular feature #1: Sharing photos over messaging apps
Popular feature #2: Editing a photo and synchronizing

Applying "Monochrome" filter
Popular feature #3: Image analysis

- E.g., Face recognition
- Use the information to organize and search photos
- Managed as metadata

Source: Google Photos
How do current apps provide these features and what are the problems?
Sharing photos over *multiple* messaging apps
Sharing photos over *multiple* messaging apps
Sharing photos over *multiple* messaging apps

Alice

Bob

Chris

Resize

Resize
Sharing photos over *multiple* messaging apps
Sharing photos over *multiple* messaging apps

Repeated resizing and duplicate resized image files
Editing synchronized photos with content adaptation

"Adapted": Reduced size image

Smartphone

Synchronized

Cloud

Original size image
Editing synchronized photos with content adaptation

"Adapted": Reduced size image

Smartphone

I want to apply a filter!

Cloud

Synchronized

Original size image

14
Editing and synchronizing with content adaptation

I want to apply a filter!

Download

Smartphone

Original size

Reduced size

Cloud

Original size image
Editing and synchronizing with content adaptation

I want to apply a filter!
Editing and synchronizing with content adaptation

Smartphone

Original size

I want to apply a filter!

Sync

Cloud

Original size image
Editing and synchronizing with content adaptation

I want to apply a filter!

Sync
Editing and synchronizing with content adaptation

Smartphone

Original size

Reduced size

Cloud

I want to apply a filter!
Editing and synchronizing with content adaptation

Smartphone

Done!

Cloud

Original size image

Reduced size
Editing and synchronizing with content adaptation

Unnecessary network and computing operations
Impossible to edit a photo without a network connectivity
Image analysis: managing semantic information
Image analysis: managing semantic information

Repeated image analyses and individual management of metadata

App A runs face recognition algorithm

App B runs face recognition algorithm

File

Per-app Metadata

Per-app Metadata
Summary of current problems

● **Sharing photos**
  ○ Repeated resizing computation and redundant resized images

● **Editing synchronized, adapted photos**
  ○ Propagating updates on adapted photos requires careful implementation

● **Image analysis and metadata management**
  ○ Repeated analyses from multiple apps and individual metadata management
Summary of current problems

● Sharing photos
  ○ Repeated resizing computation and redundant resized images

Every app implements photo related features individually!

○ Propagating updates on adapted photos requires careful implementation

● Image analysis and metadata management
  ○ Repeated analyses from multiple apps and individual metadata management
Research question

What is a better way to manage mobile photo data?
Pixelsior

A new platform for mobile photo data

- A consolidated shared service, provided by a mobile platform
- An efficient mechanism for photo management functionality
Before
Sharing photos over messaging apps

Alice

Pixelsior

Request: width 800px

Chris

Bob
Sharing photos over messaging apps

Alice

Bob

Chris

Pixelsior
Sharing photos over messaging apps
Sharing photos over messaging apps

Alice

Bob

Chris

Request:
width 800px

Pixelsior
Sharing photos over messaging apps

Alice

Bob

Chris

Pixelsior
Sharing photos over messaging apps

Alice

Bob

Chris

Pixelsior
Editing synchronized photos with content adaptation
Editing synchronized photos with content adaptation

Smartphone

Reduced size image

“Grayscale” filter

Cloud

Full size image

Pixelsior

Pixelsior
Editing synchronized photos with content adaptation

Smartphone

Reduced size image

"Grayscale" filter

Cloud

Apply "Grayscale"

Pixelsior

Full size image
Editing synchronized photos with content adaptation

Smartphone

Reduced size image

"Grayscale" filter

Cloud

Apply "Grayscale"

Full size image

"Grayscale" filter

Pixelsior

Pixelsior
Semantic information management

App A runs face detection algorithm and updates metadata

App B retrieves not only photo but also its metadata

Pixelsior

metadata
Design Space

- Data model
- API: a developer’s point of view
- Transformation management
Design: data model

Pixelsior Photo store
Design: APIs

- **read** and **write**
  - Retrieve a resize depending on app-specific policy (quFile, FAST ‘10)

- **search** and **query**
  - Organize and search photos with attributes (Semantic File Systems, SOSP ‘91)
  - Query a photo’s metadata and transformation history
Design: transformation management

- **Built-in primitive image transformations**
  - e.g., blur, brightness, contrast, grayscale, ...

- **Customized transformations**
  - Can be developed as a sequence of primitive transformations
  - Can be plugged into the platform so that other apps can use
Design: transformation management

Tablet

Brightness & Contrast: -40%

Phone
Design: transformation management

Tablet

Brightness & Contrast: -40%

Phone

Download

Resize
Design: transformation management

Tablet

Phone
Open questions and thoughts (1/2)

● Access control
  ○ Letting apps access a View, e.g., Earp (NSDI ‘16)

● Legacy apps
  ○ Leveraging application rewriting frameworks
    ■ e.g. BlueMountain (HotStorage ‘15)
Open questions and thoughts (2/2)

- Other data types, e.g., video, voice mail, ...
  - Provide a layered design:
    - Primitive interface layer
    - Data type specific layer

- Consistency
  - Operation-based synchronization can result in inconsistency
  - Handle each transformation case by case
    - Phan et al., MobiSys ‘04
Summary

● We identified mobile photo management problems
● To address the problems, a new platform service, Pixelsior, is proposed
● Currently, we are implementing it!