Android Concurrency: The Command Processor Pattern (Part 2)

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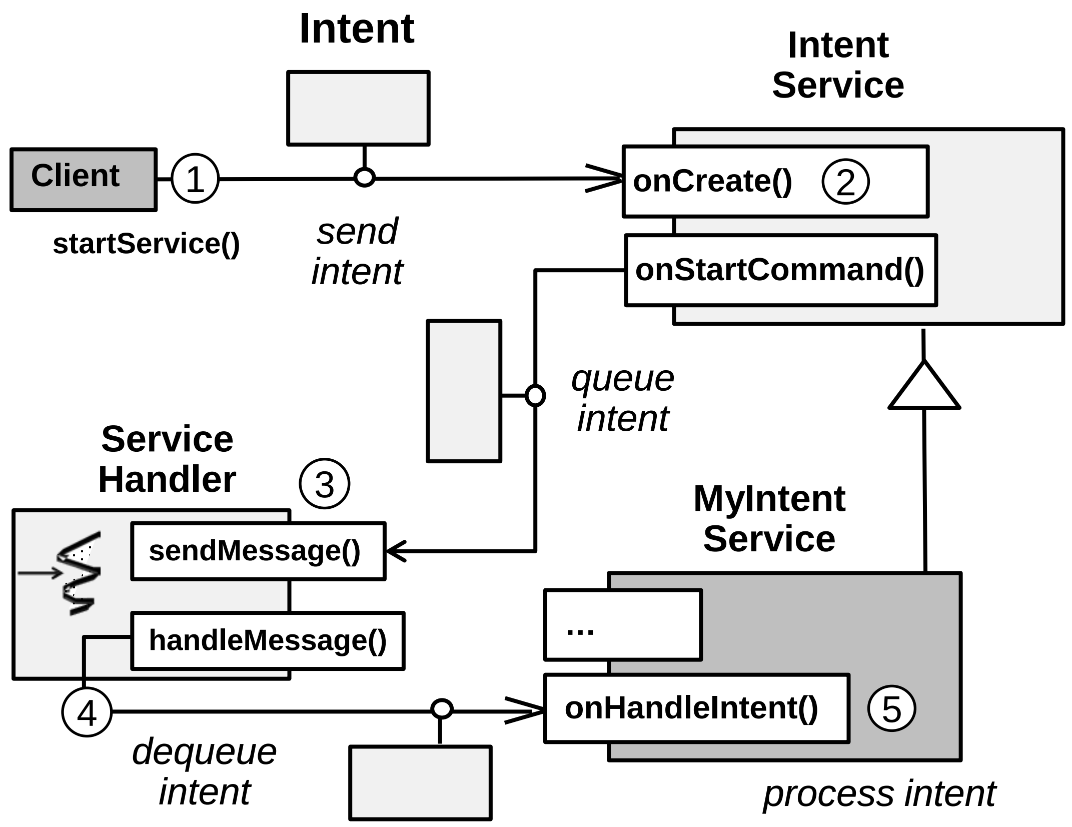
Learning Objectives in this Part of the Module

- Understand how *Command Processor* is applied in Android



Using Handler in Android to Post Runnables

- This example shows how to post Runnables to the UI Thread
- An Android Activity provides a single, focused thing a user can do
  - It contains a Handler associated with the UI Thread's Looper
  - runOnUiThread() uses this Handler to execute a specified action on the UI Thread

```
public class Handler {
  ...
  public final boolean
                post(Runnable r) {
    return sendMessageDelayed
      (getPostMessage(r), 0);
  }
```

frameworks/base/core/java/android/os/Handler.java has the source code

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        Message.obtain();
      m.callback = r;
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```
public class Handler {
  ...
  public final boolean
    sendMessageAtTime
      (Message msg,
       long uptimeMillis) {
    ...
    MessageQueue queue = mQueue;
    ...
    msg.target = this;
    queue.enqueueMessage
      (msg, uptimeMillis);
    ...
```

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```
public class MessageQueue {
  ...
  final boolean enqueueMessage
                   (Message msg,
                    long when) {
    final boolean needWake;
    synchronized (this) {
      Message p = mMessages;
      ...
      if (needWake) {
        nativeWake(mPtr);
    ...
```

Figure how where to enqueue the Message in the doubly-linked list

frameworks/base/core/java/android/os/MessageQueue.java has the source

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frameworks/base/libs/utils/Looper.cpp has the source code

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public class Looper {
  ...
  final MessageQueue mQueue;

  public static void loop() {
    Looper me = myLooper();
    ...
    MessageQueue queue =
      me.mQueue;

    for (;;) {
      Message msg =
        queue.next();
      ...
      msg.target.
        dispatchMessage(msg);
      ...
```

See previous part on Android Looper

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frameworks/base/core/java/android/os/Looper.java has the source

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```
public class Handler {
  ...
  public void dispatchMessage
                 (Message msg) {
    if (msg.callback != null)
      handleCallback(msg);
    ...
```

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```
public class Handler {
  ...
  public void dispatchMessage
                (Message msg) {
    if (msg.callback != null)
      handleCallback(msg);
    ...

  private final void
              handleCallback
               (Message message)
 {
   message.callback.run();
 }
```

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  public void dispatchMessage
                (Message msg) {
    if (msg.callback != null)
      handleCallback(msg);
    ...

  private final void
                handleCallback
                 (Message message)
 {
   message.callback.run();
 }
```

This particular run() callback is executed in the UI Thread

Command Processor POSA1 Design Pattern

Implementation

- Define a class for Command execution that provides a generic interface used by the Executor
  - Define an execute() operation if processing of a Command can be localized to one method

```
public class Intent implements
                 Parcelable, Cloneable {
   ...
}
```

frameworks/base/core/java/android/content/Intent.java has the source code

Command Processor POSA1 Design Pattern

Implementation

- Define a class for Command execution that provides a generic interface used by the Executor
- Add state Concrete Commands need during their execution
  - Can subclass the abstract Command class or some other means

```
public class Intent implements
         Parcelable, Cloneable {
  ...
  public Intent setData(Uri data)
  { /* ... */ }

  public Uri getData()
  { /* ... */ }

  public Intent putExtra
    (String name, Bundle value)
  {/* ... */ }

  public Object getExtra
    (String name)
  {/* ... */ }
}
```

Command Processor POSA1 Design Pattern

Implementation

- Define a class for Command execution that provides a generic interface used by the Executor
- Add state Concrete Commands need during their execution
- Define & implement the Creator
  - Use patterns like Abstract Factory or Factory Method

```
public class AttachPhotoActivity
  extends ContactsActivity {
 ...
 private void  saveContact
   (ContactLoader.Result contact) {
   ...
   Intent intent =
     ContactSaveService.
       createSaveContactIntent
         (this, deltaList, "", 0,
           contact.isUserProfile(),
           null, null,
           raw.getRawContactId(),
           mTempPhotoFile.
             getAbsolutePath());
   startService(intent);
 }
 ...
```

Create the Intent Command

Command Processor POSA1 Design Pattern

Implementation

- Define a class for Command execution that provides a generic interface used by the Executor
- Add state Concrete Commands need during their execution
- Define & implement the Creator
  - Use patterns like Abstract Factory or Factory Method
  - Determine a mechanism for passing the Command to the Executor

```
public class AttachPhotoActivity
  extends ContactsActivity {
  ...
  private void  saveContact
    (ContactLoader.Result contact) {
    ...
    Intent intent =
      ContactSaveService.
        createSaveContactIntent
          (this, deltaList, "", 0,
            contact.isUserProfile(),
            null, null,
            raw.getRawContactId(),
            mTempPhotoFile.
              getAbsolutePath());
    startService(intent);
  }
  ...
```

Pass the Intent Command to the designated Service via the Binder IPC mechanism

Command Processor POSA1 Design Pattern

Implementation

- Define a class for Command execution that provides a generic interface used by the Executor
- Add state Concrete Commands need during their execution
- Define & implement the Creator
- Define the Execution Context
  - Provide the run-time environment for processing the Command object

```
public abstract class Context {
  public abstract void
   sendBroadcast(Intent intent);

  public abstract Intent
    registerReceiver
      (BroadcastReceiver receiver,
       IntentFilter filter);


  public abstract ContentResolver
    getContentResolver();

  ...

public abstract class Service
       extends ContextWrapper ...
{
  ...
}
```

frameworks/base/core/java/android/content/Context.java has the source code

Command Processor POSA1 Design Pattern

Implementation

- Define a class for Command execution that provides a generic interface used by the Executor
- Add state Concrete Commands need during their execution
- Define & implement the Creator
- Define the Execution Context
- Implement the Executor
  - Receive the Command from the Creator

This hook method is called when a Service is created & spawns a background thread

```
public abstract class IntentService
                        extends Service {
  private volatile Looper
    mServiceLooper;
  private volatile ServiceHandler
    mServiceHandler;
  ...
  public void onCreate() {
    HandlerThread thr = new
      HandlerThread("IntentService["
                  + mName + "]");
    thr.start();

    mServiceLooper = thr.getLooper();
    mServiceHandler = new
      ServiceHandler(mServiceLooper);
  }
```

frameworks/base/core/java/android/app/IntentService.html has source code

Command Processor POSA1 Design Pattern

Implementation

- Define a class for Command execution that provides a generic interface used by the Executor
- Add state Concrete Commands need during their execution
- Define & implement the Creator
- Define the Execution Context
- Implement the Executor
  - Enqueue the Command for subsequent processing

```
public abstract class IntentService
                         extends Service {
  private volatile Looper
    mServiceLooper;
  private volatile ServiceHandler
    mServiceHandler;
  ...
  public void onStart(Intent intent,
                            int startId) {
    Message msg = mServiceHandler.
                        obtainMessage();
    msg.arg1 = startId;
    msg.obj = intent;
    mServiceHandler.
      sendMessage(msg);
    }
  }
```

Enqueue the Intent Command in the ServiceHandler

Command Processor POSA1 Design Pattern

Implementation

- Define a class for Command execution that provides a generic interface used by the Executor
- Add state Concrete Commands need during their execution
- Define & implement the Creator
- Define the Execution Context
- Implement the Executor
  - Dequeue the Command & initiate processing

```
public abstract class IntentService
                                extends Service {
  private volatile Looper
    mServiceLooper;
  private volatile ServiceHandler
    mServiceHandler;
  ...
  private final class ServiceHandler
                               extends Handler {
    public void handleMessage
      (Message msg) {
      onHandleIntent
        ((Intent)msg.obj);
      stopSelf(msg.arg1);
    }
  }
```

Dequeue the Intent Command & dispatch hook method

frameworks/base/core/java/android/app/IntentService.html has source code

Command Processor POSA1 Design Pattern

Implementation

- Define a class for Command execution that provides a generic interface used by the Executor
- Add state Concrete Commands need during their execution
- Define & implement the Creator
- Define the Execution Context
- Implement the Executor
  - Execute the Command in the Execution Context

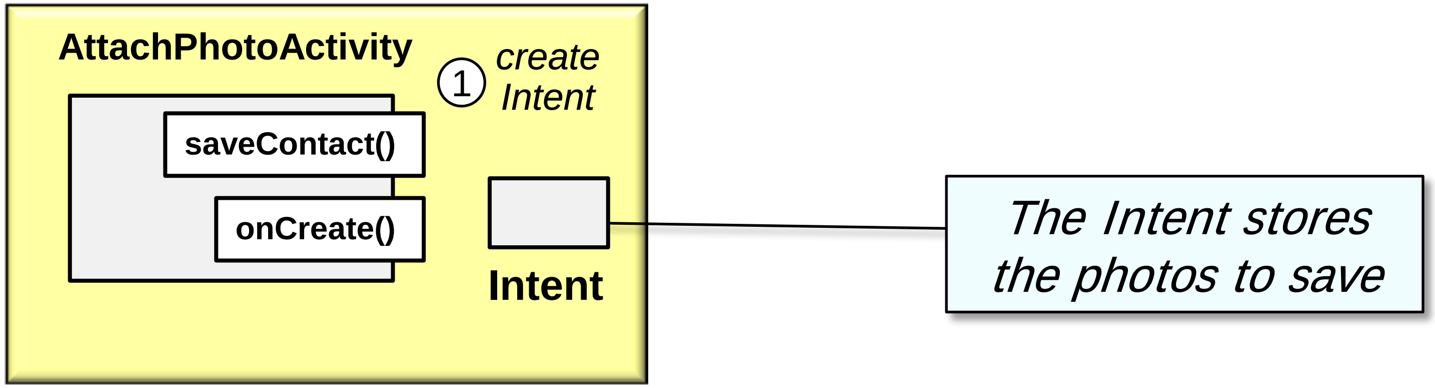
```
public class ContactSaveService
  extends IntentService {

  ...

  protected void
       onHandleIntent(Intent intent)
  {
    ... if (ACTION_SAVE_CONTACT.
              equals(action)) {
     saveContact(intent);
  }

  private void saveContact
                (Intent intent) {
    final ContentResolver resolver
      = getContentResolver();
  ...
}
```

Save the photo in the Contacts content provider

Command Processor POSA1 Design Pattern

Applying the Command Processor pattern in Android

- AttachPhotoActivity allows Apps to attach images to contacts & then use the ContactSaveService to save changes to the Contacts content provider



The Intent stores the photos to save

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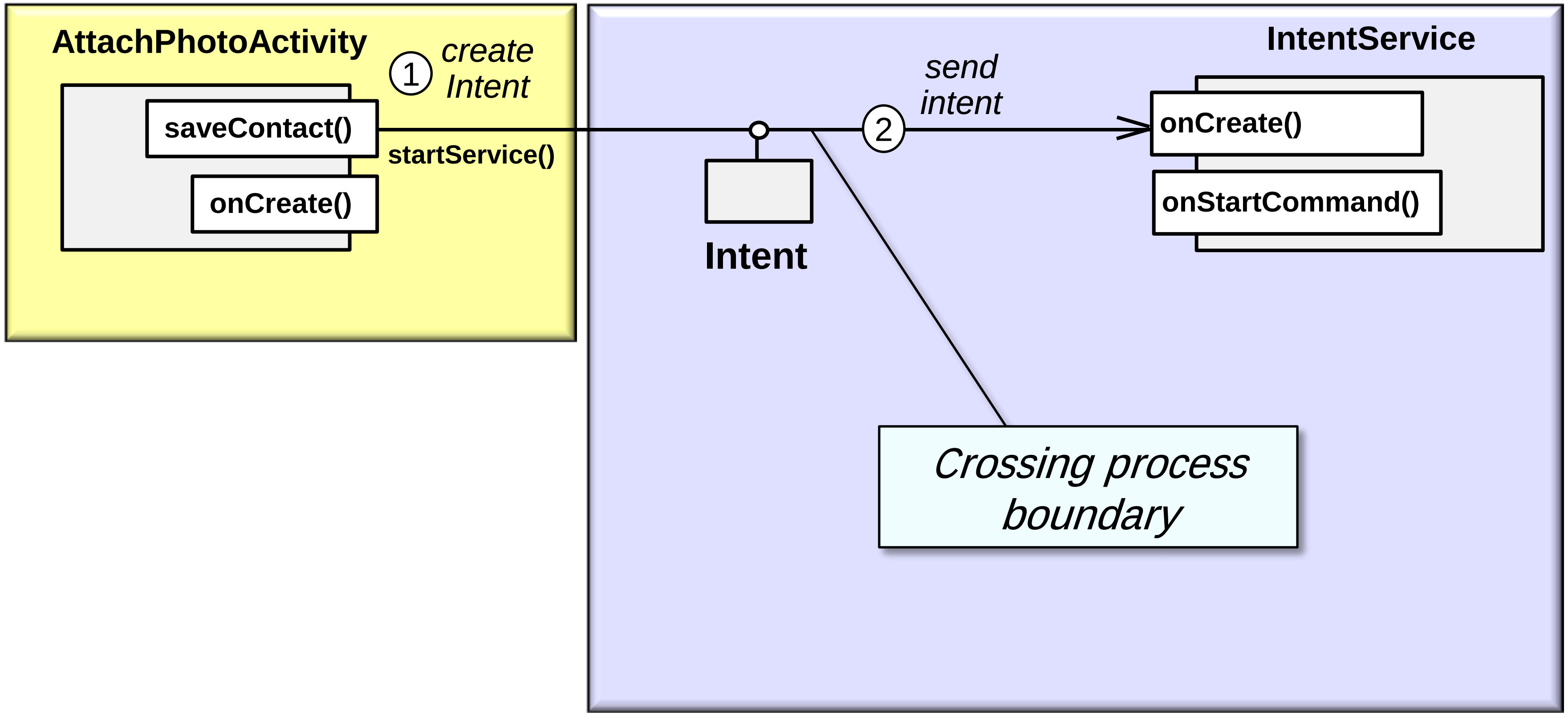

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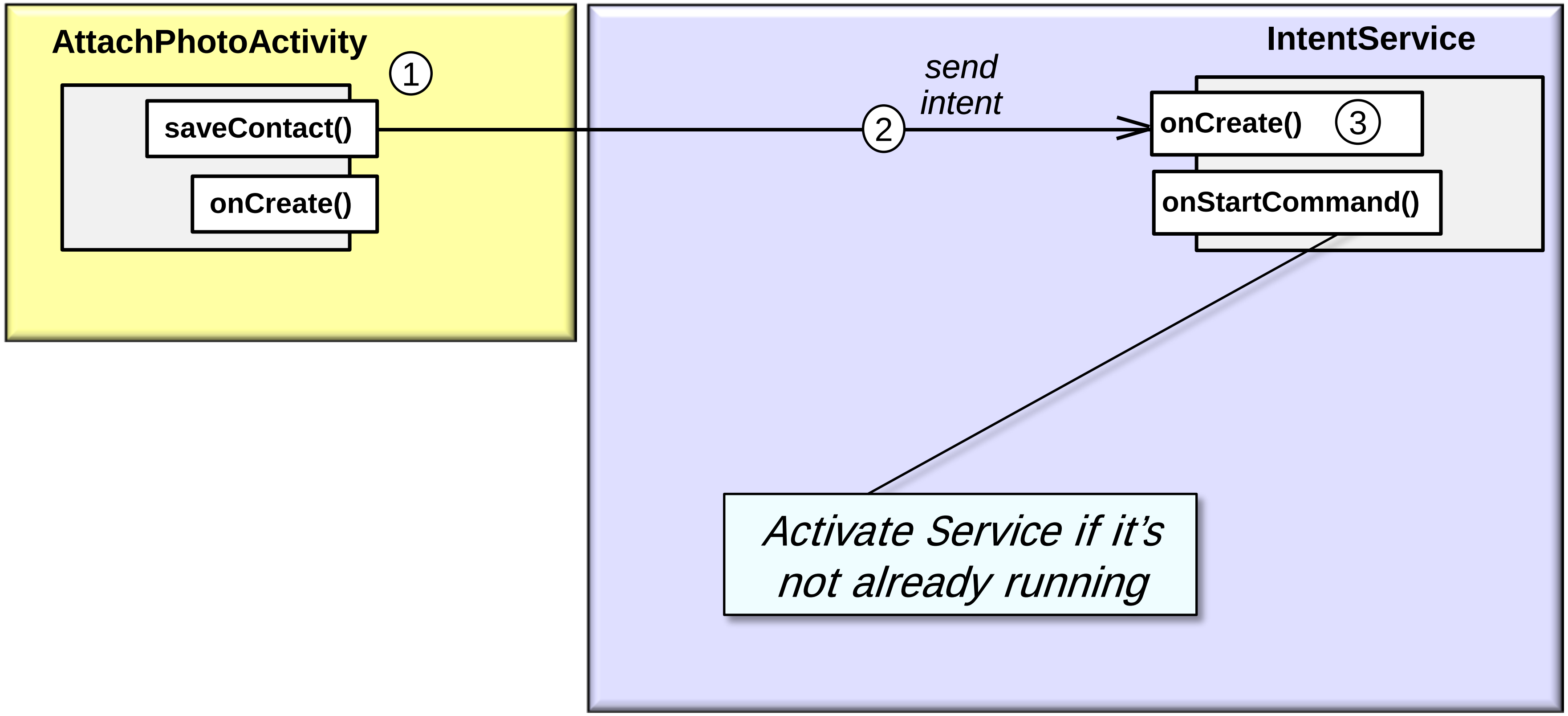

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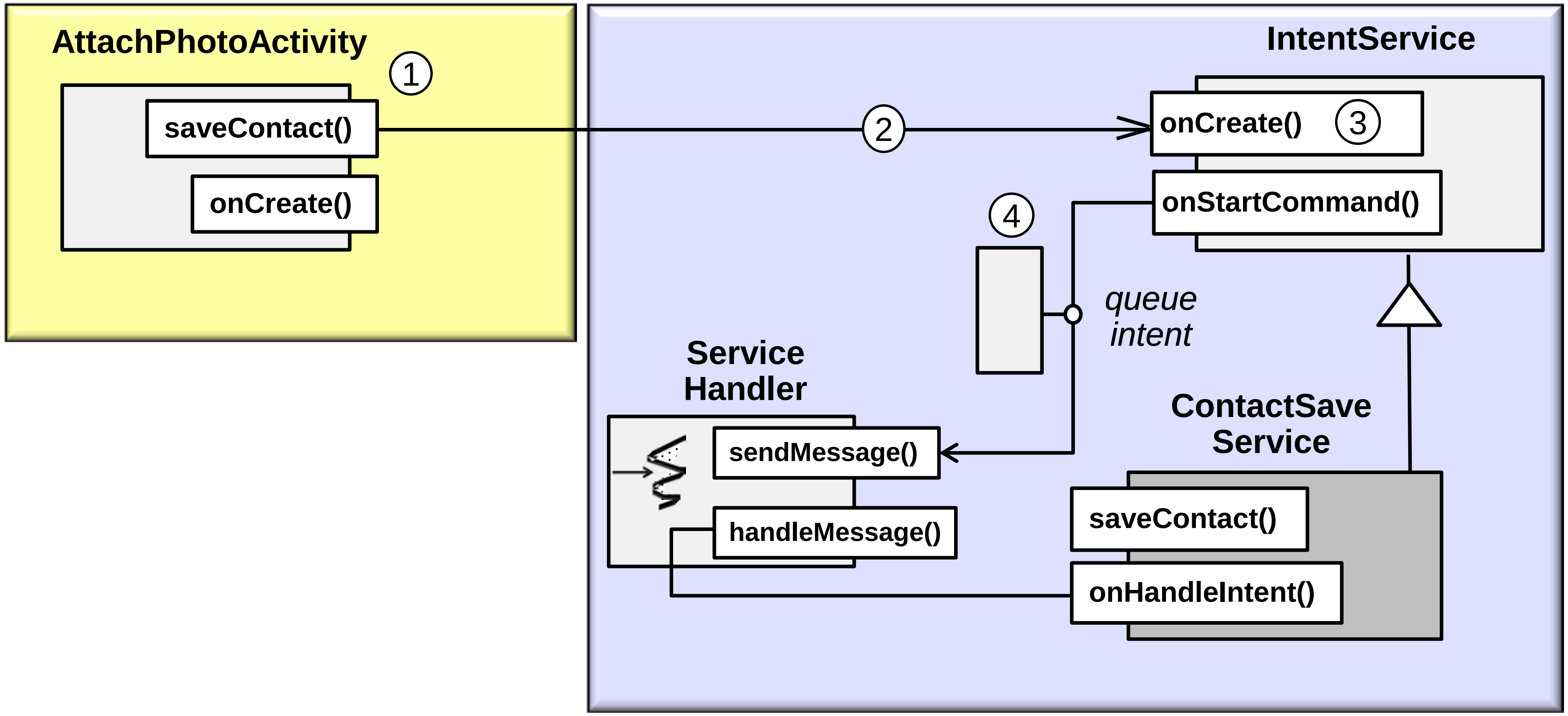

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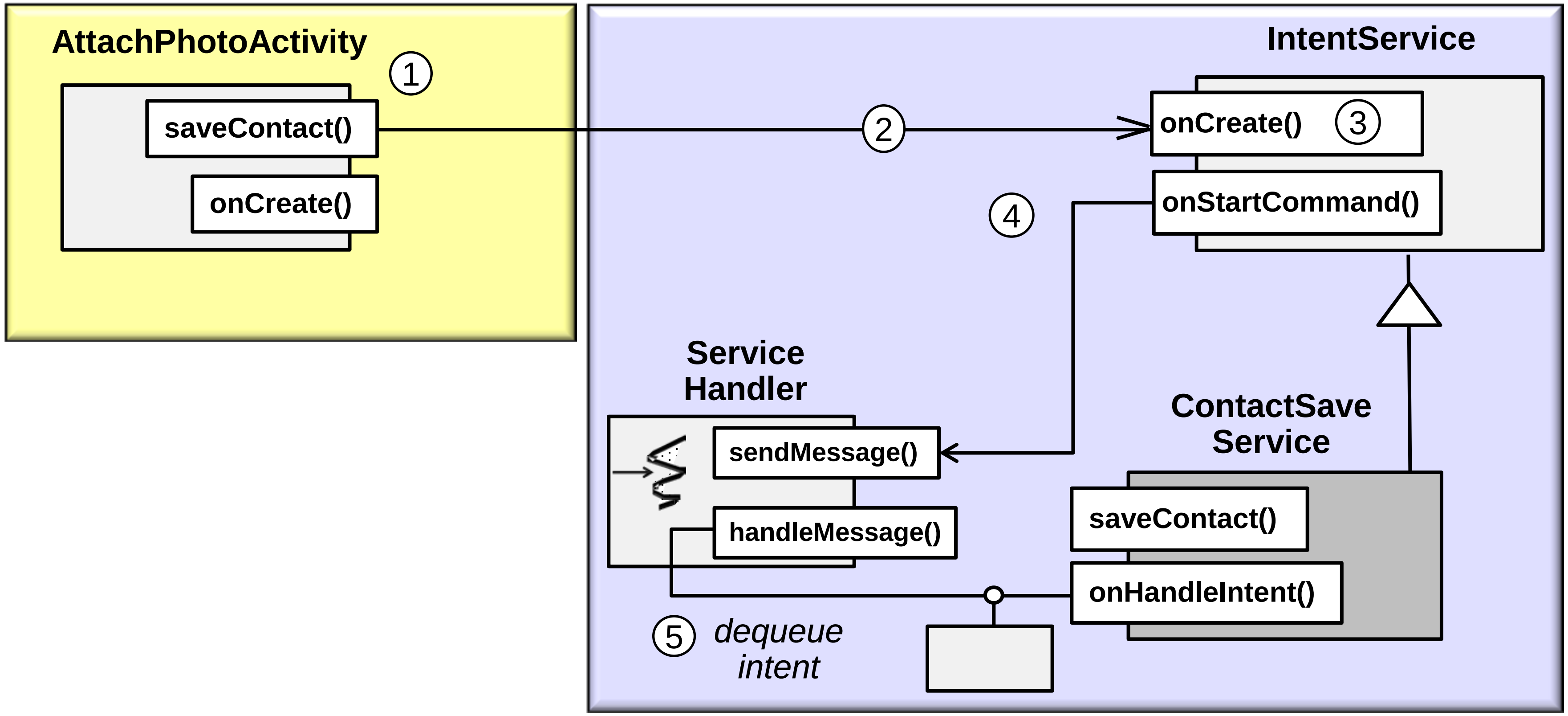

packages/apps/Contacts/src/com/android/contacts/activities/AttachPhotoActivity.java

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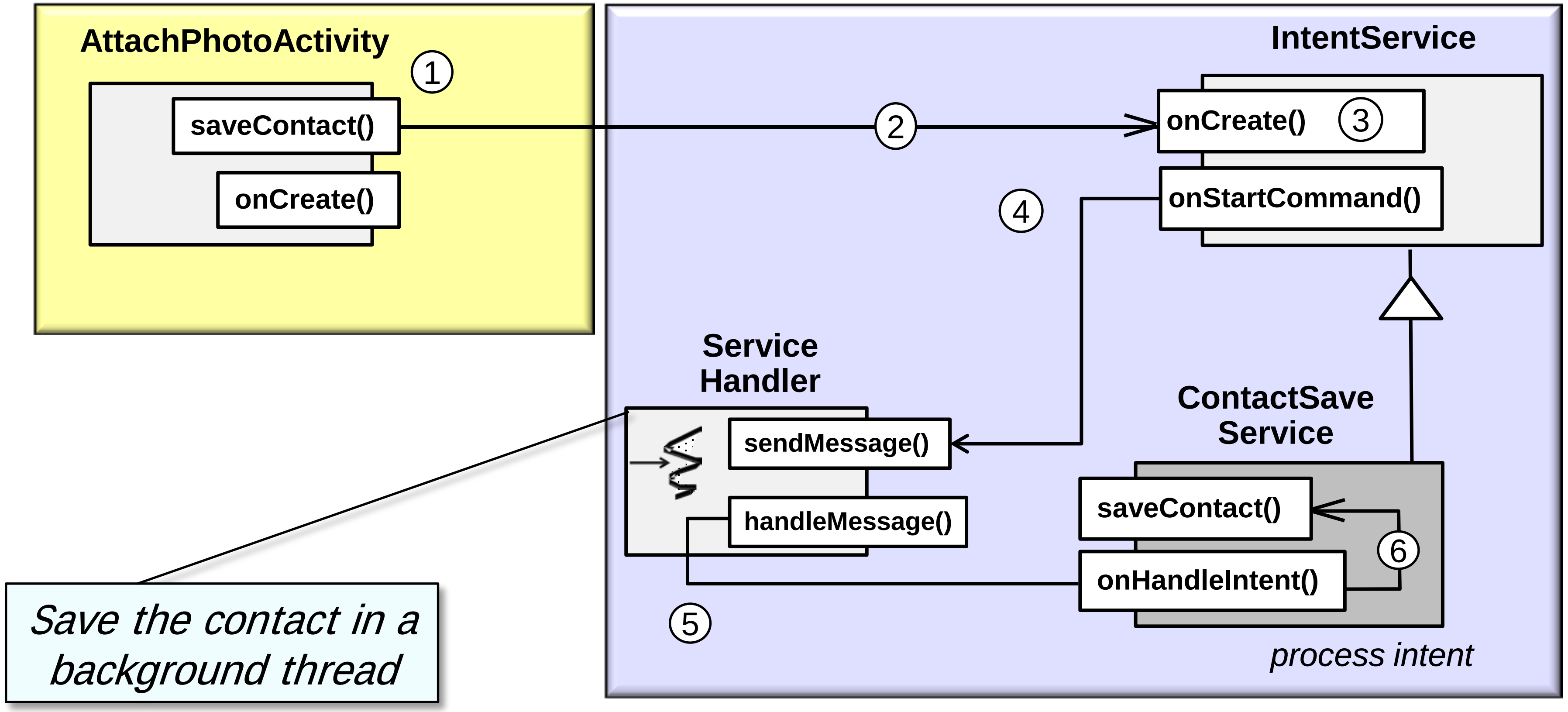
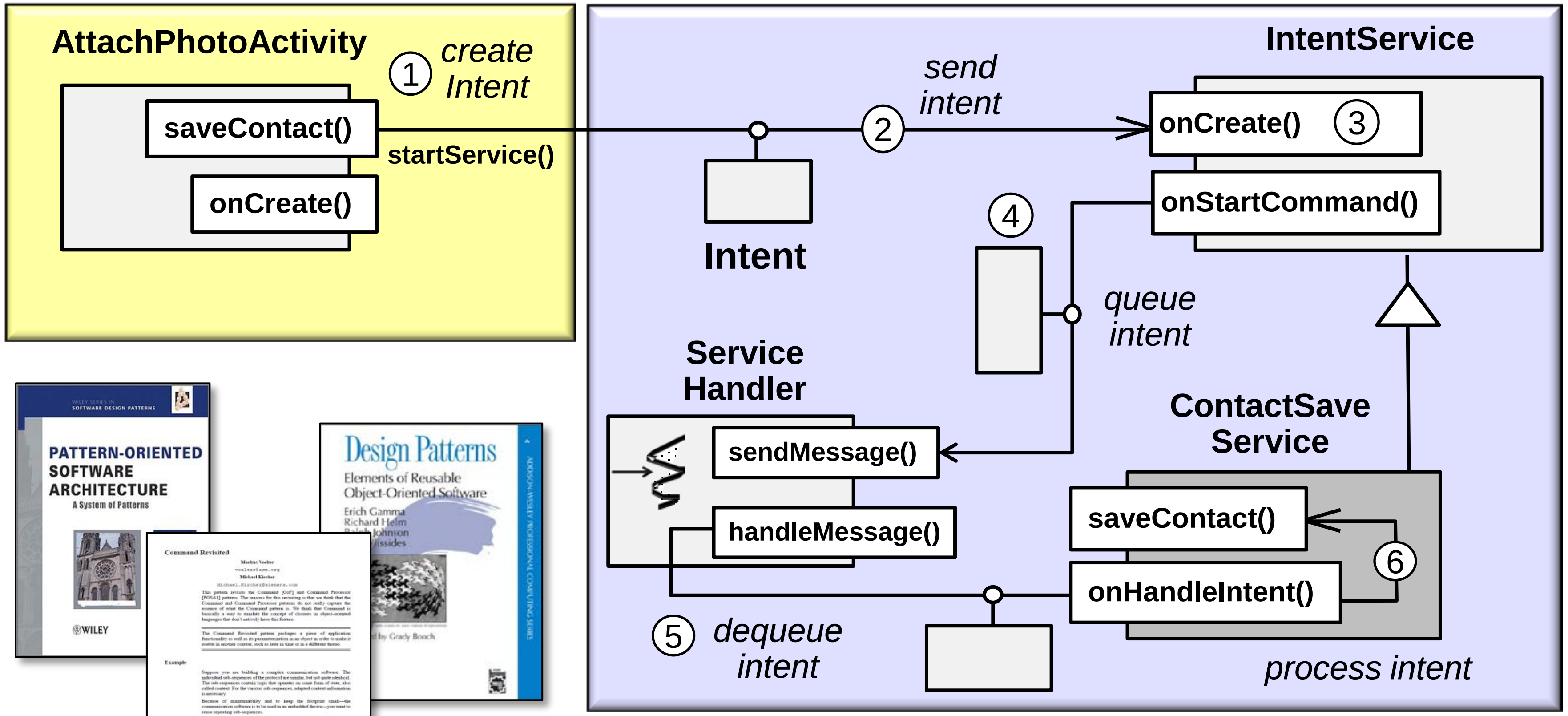
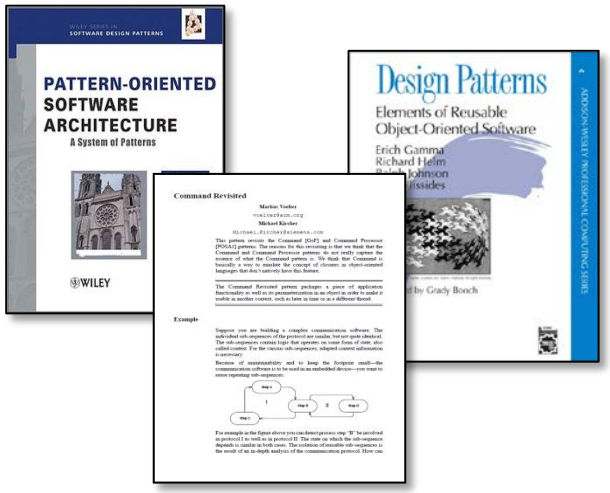


Summary

- The Android Intent Service framework implements the *Command Processor* pattern & processes Intent Commands in a background Thread





Other patterns are involved here: *Activator*, *Messaging*, *Result Callback*, etc.