Inside the Android Application Framework

Introduction

- Your host: Dan Morrill, Developer Advocate
- Android is a complete OS, not just a framework
- Even the friendliest abstraction still has “seams”
- Let’s demystify Android’s seams

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Managed Component Lifecycles

- An Android APK is a collection of components
- Components share a set of resources
  - Databases, preferences, file space, etc.
  - Also: a Linux process.
- Every Android component has a managed lifecycle

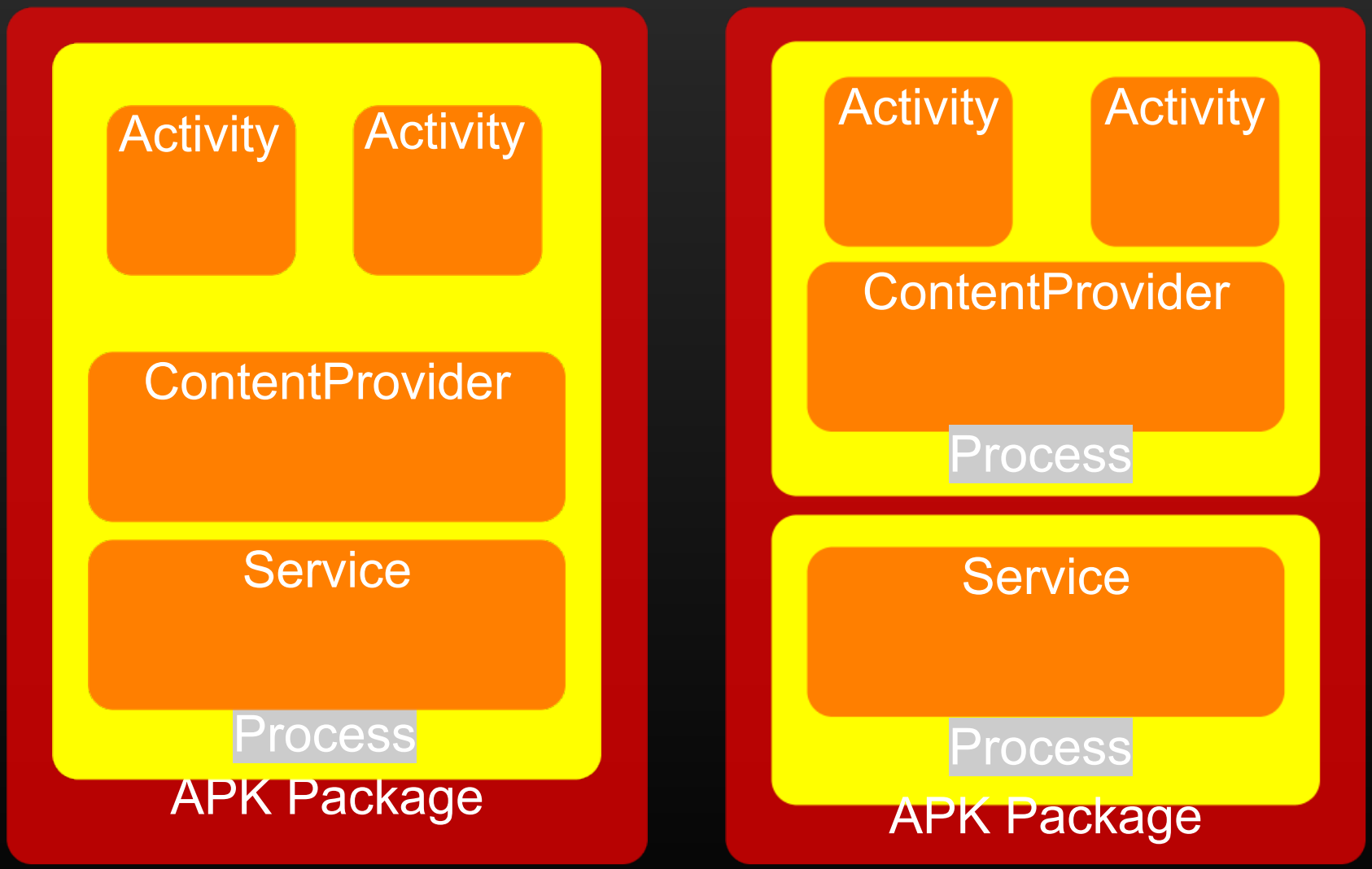
Basics of an Android Application

- Activities
- Tasks
- Processes

Activities and Tasks

- An Activity is a “molecule”: a discrete chunk of functionality
- A task is a collection of Activities
- A “process” is a standard Linux process

Activities and Tasks



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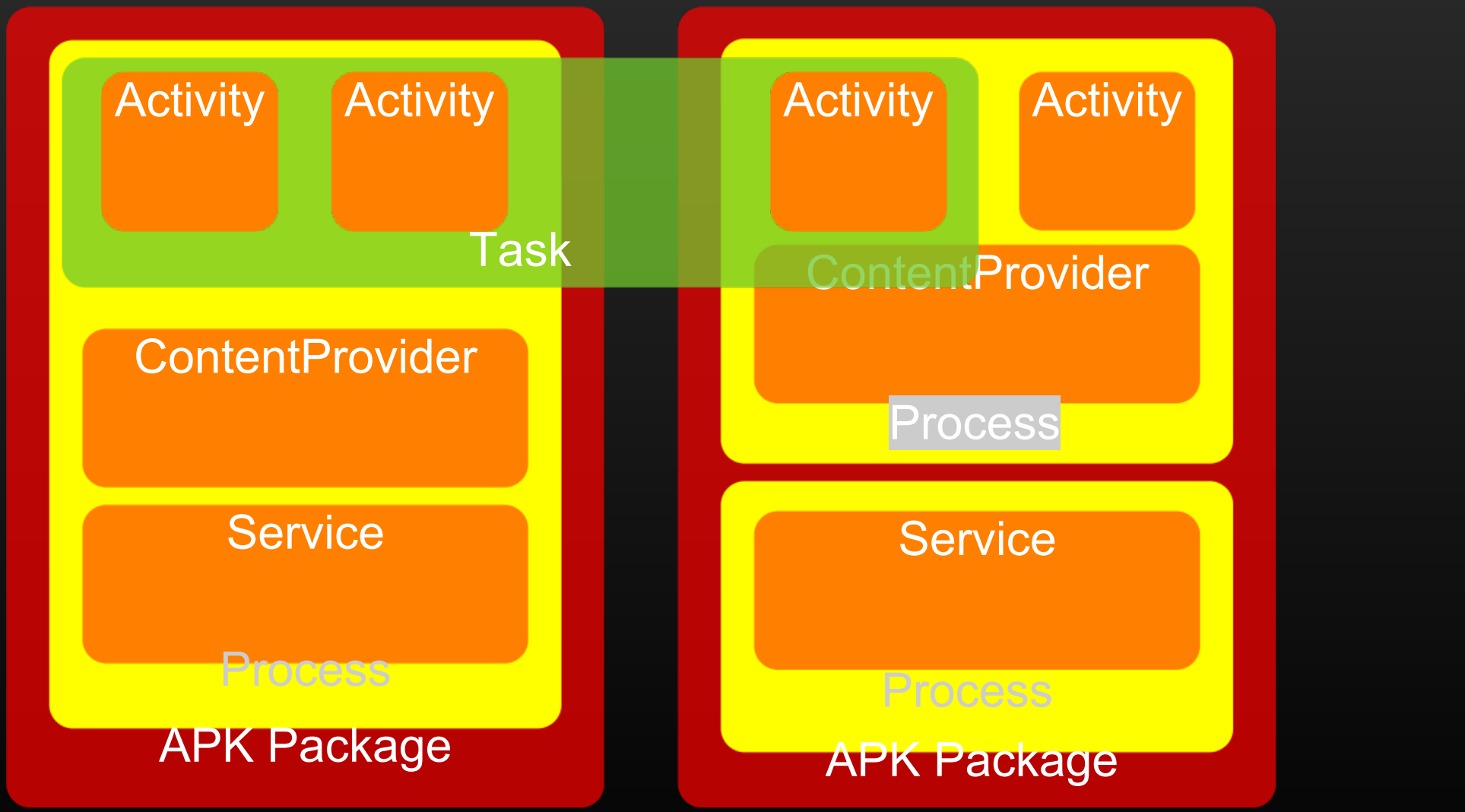
Activities and Tasks



Activities Are...

- ...a concrete class in the API
- ...an encapsulation of a particular operation
- ...run in the process of the .APK which installed them
- ...optionally associated with a window (UI)
- ...an execution Context

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Tasks Are...

- ...more of a notion than a concrete API entity
- ...a collection of related Activities
- ...capable of spanning multiple processes
- ...associated with their own UI history stack
- ...what users on other platforms know as “applications”

Process Basics

- Android process == Linux process
- By default, 1 process per APK
- By default, 1 thread per process
- All* components interleave events into the main thread

*

Most

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Process Lifecycle

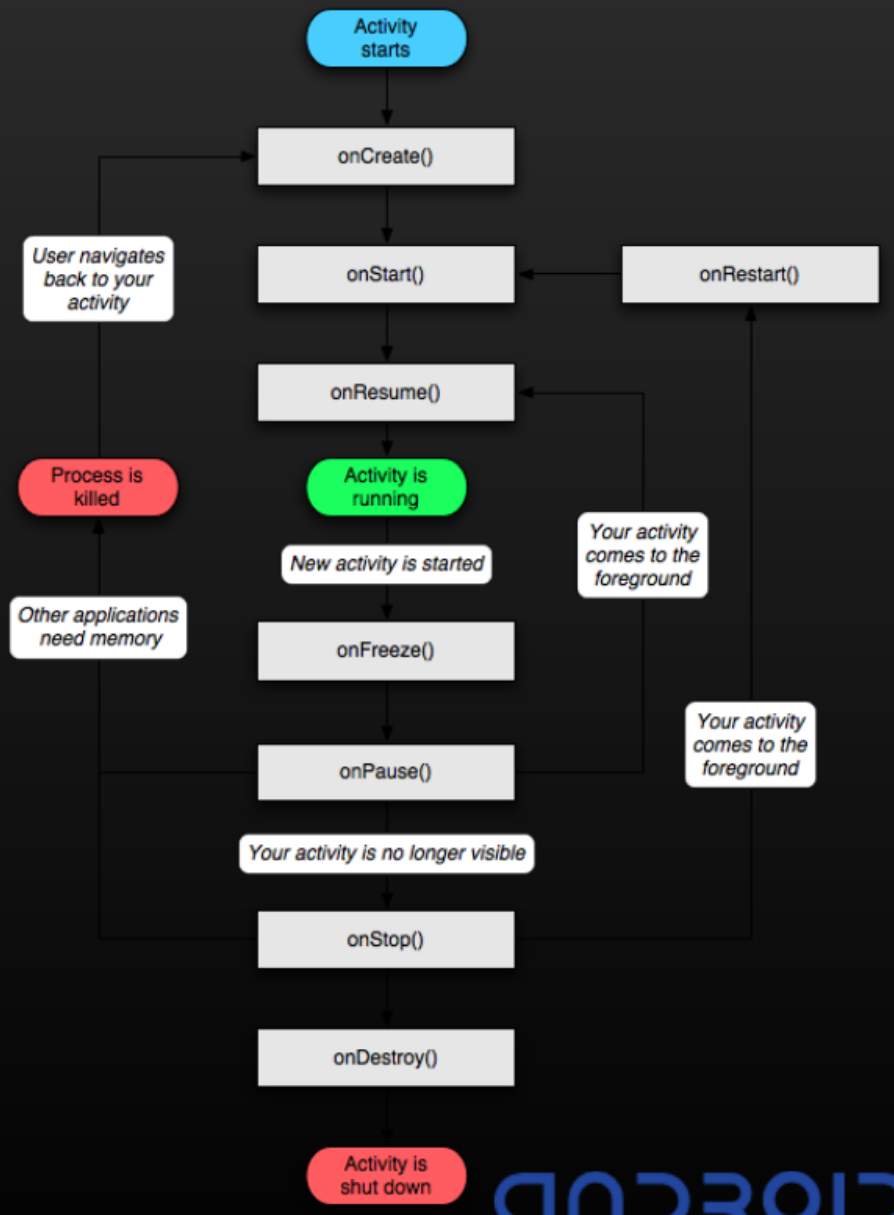
- A process is started for a given user ID when needed
  - Binding to a Service
  - Binding to a ContentProvider
  - Starting an Activity
  - Firing an IntentReceiver
- Remains running until killed by the system

More on Activities

- Activity Lifecycle
- Examples of Common Use Cases

The Directed Cyclic Graph of Life

- Activities have several states
- Lifecycle methods are called on transitions
- You typically don't need to use them all, but they are there
- http://code.google.com/android/reference/android/app/Activity.html



Activity Lifecycle

- Three general “phases”
- Starting up
  - onCreate(): first method called during lifetime, with prior state
  - onStart()/onRestart(): signal that execution is beginning
  - onResume(): signals that a previous pause is being undone

Activity Lifecycle

- Normal execution
  - onFreeze(): save UI state (NOT intended to save persistent data)
  - onPause: signals loss of focus and possible impending shutdown

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Activity Lifecycle

- Shutting down
  - onStop()/onDestroy(): final shutdown and process termination
  - Not guaranteed to be called (and usually not, except on finish()...)

Activity Lifecycle Examples

- Starting a Child Activity
- Child Activity + Process Shutdown
- Returning to the Home Screen
- Calling finish() Explicitly
- Displaying a Dialog Box
- Semi-Transparent Windows
- Device Sleep

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Example: Child Activity Launched

- Call sequence:
  - onCreate()
  - onStart()
  - onResume()
  - onFreeze()
  - onPause()
  - onStop()
  - onRestart()
  - onStart(), onResume(), ...

This is the “classic” scenario.

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Example: Child Activity + Process Death

- Call sequence:
  - onCreate() (empty state)
  - onStart()
  - onResume()
  - onFreeze()
  - onPause()
  - *onStop() (maybe)*
  - *onDestroy() (maybe)*
  - onCreate() (with state), ...

Like the basic case, but onCreate() is called again, with the state saved in onFreeze().

Example: User Hits 'Home'

- Call sequence:
  - onCreate()
  - onStart()
  - onResume()
  - onFreeze()
  - onPause()
  - *onStop() (maybe)*
  - *onDestroy() (maybe)*

Identical to the basic case -- that is, the Home key is not a special case.

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Example: finish() Called

- Call sequence:
  - onCreate()
  - onStart()
  - onResume()
  - onPause()
  - onStop()
  - onDestroy()

Because the Activity has been explicitly told to quit and is being removed from the task (and history stack), onFreeze() is not called, and onDestroy() **is** reached.

Example: Dialog Box

- Call sequence:
  - onCreate()
  - onStart()
  - onResume()

Despite appearances, dialog boxes are Views, and not Activities, so they have no effect on the owning Activity's lifecycle.

Example: Transparent/Non-fullscreen Child

- Call sequence:
  - onCreate()
  - onStart()
  - onResume()
  - onFreeze()
  - onPause()
  - onResume()

The new partial-screen window leaves a portion of the previous window visible, so onPause() is followed by onResume() (without onStop()) when the child closes.

Example: Device Goes to Sleep

- Call sequence:
  - onCreate()
  - onStart()
  - onResume()
  - onFreeze()
  - onPause()
  - onResume()

The device going to sleep is identical to a non-fullscreen Activity being launched on top.

Threads on Android

- Overview
- Loopers
- Multi-thread Considerations

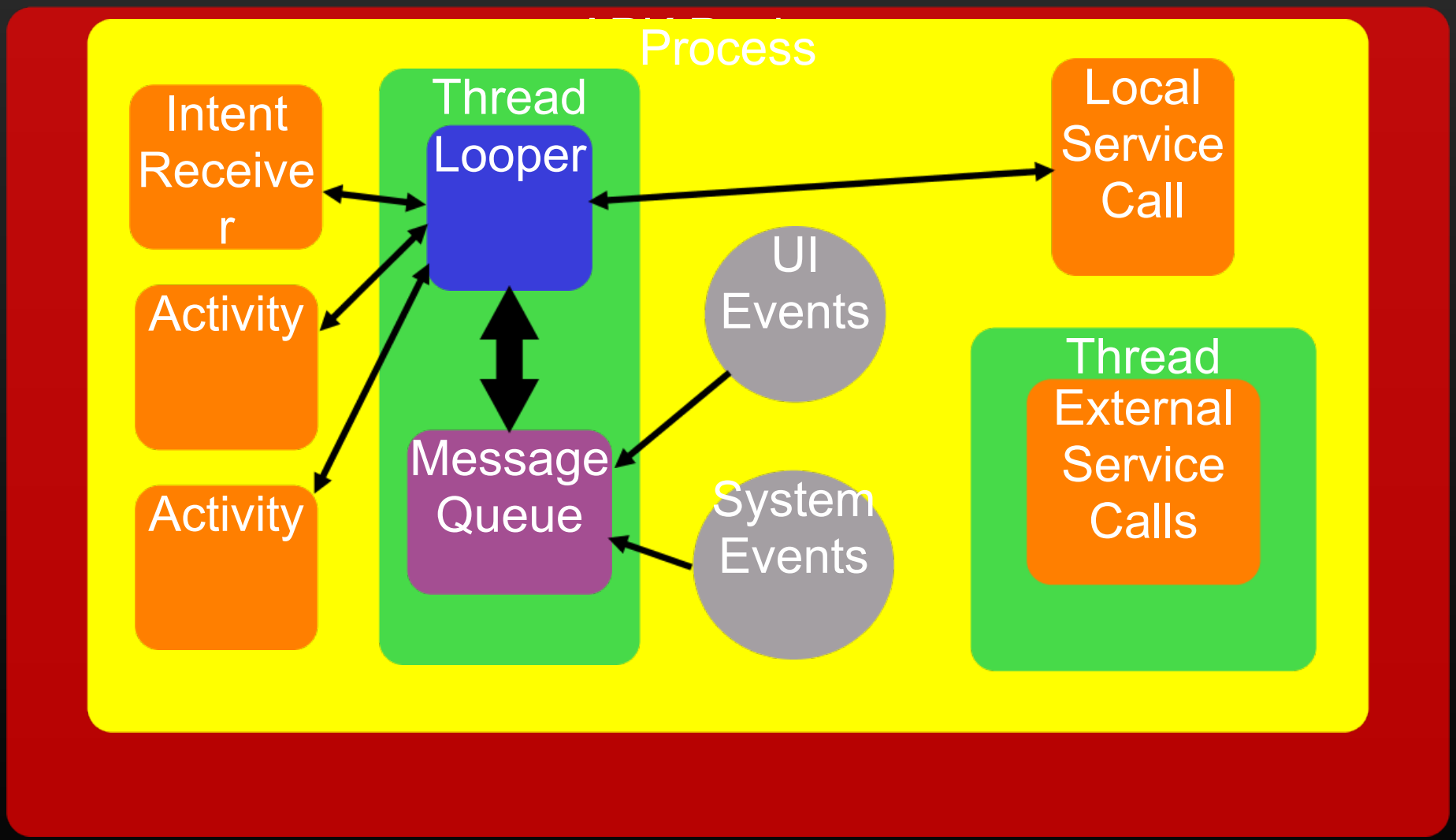
Threading Overview

- Each process has one thread (by default)
- Most components share the single thread
- Services and ContentProviders sometimes do not

Threads and Loopers

- Each thread has a Looper to handle a message queue
- Events from all components are interleaved into Looper
  - e.g. View UI events, IntentReceivers firing, etc.
- Loopers cannot accommodate multi-threaded access
  - They are designed to play nicely with MessageHandlers

Threads and Loopers



Threads and Views

- Views use Looper messages to fire events
- Since Loopers are 1:1 with threads, the View tree is too
- Threads you create cannot directly touch a View
- But, you can create a new Looper for your own thread

Threads in Other Contexts

- Services & ContentProviders sometimes run in their own threads
  - ...but still in the same process
- Components can create threads, but must handle thread-safety

Service Lifecycle

- Started by some other Component
  - Either explicitly, or implicitly by binding to it
- Explicitly-started Services run until explicitly shut down
  - (or killed by the system during a memory crunch)
- Implicitly-started Services run til the last client unbinds

More on Processes

- Resource Management
- Processes & Security
- Controlling Processes

Process Resource Management

- Spawned by the special “Zygote” process
  - Process + pre-warmed Dalvik VM == responsiveness
- Process runs under user ID unique to system
  - Process + User ID == security

Processes & Security

- Each application is given a unique user ID
  - No exceptions!
  - ...except these: init, Zygote, and the main runtime
- Each application has direct access only to its own data
- Other apps' resources are available only via defined, explicitly-exposed APIs
  - i.e. Issuing Intents, binding to Services or ContentProviders

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Inter-Process Communication

- Why??
- Process Transparency
- Binder in 30 Seconds
- IPC using Parcelables
- IPC using Bundles
- Android IDL

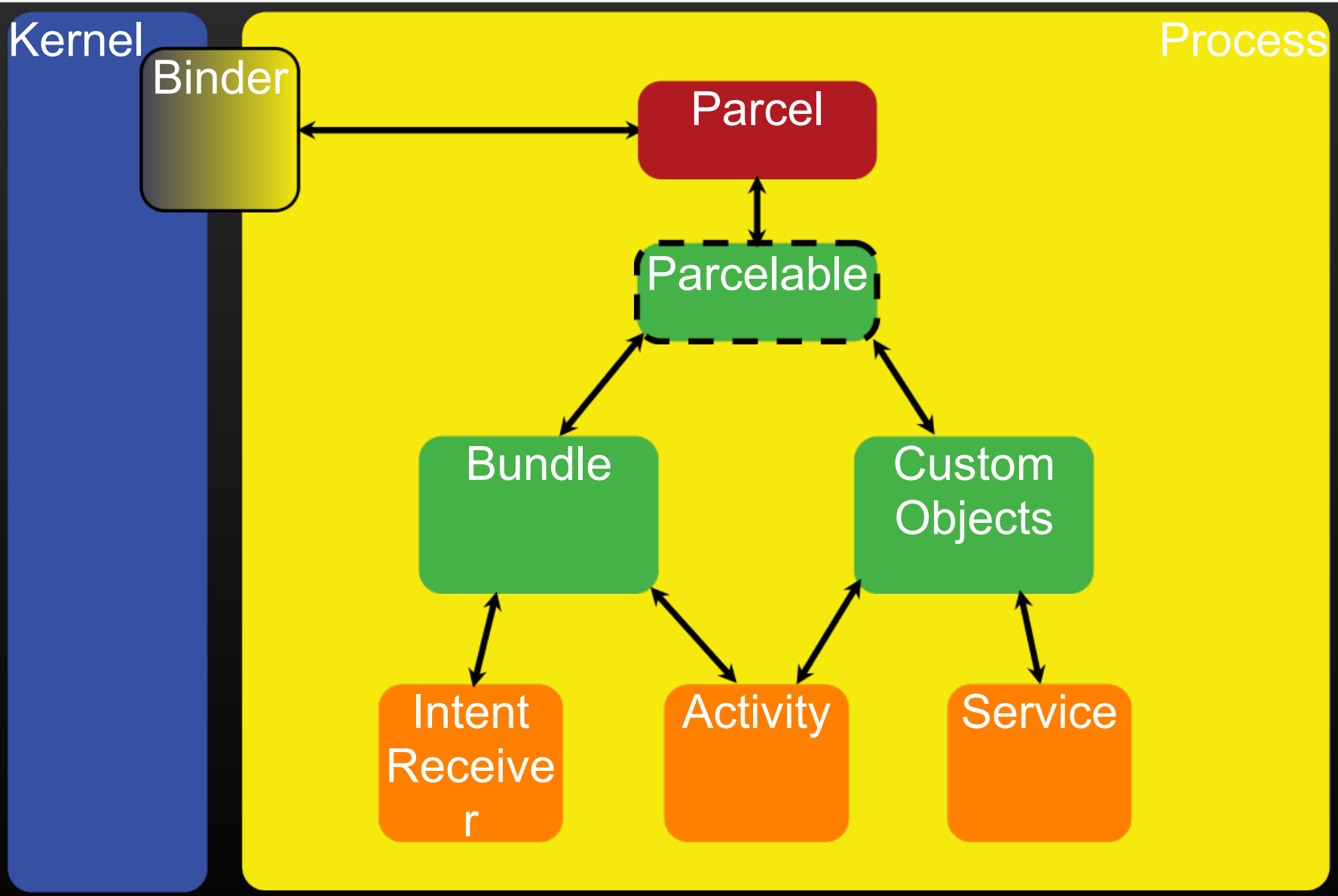
Why??

- All this process/Activity/task stuff is confusing... why?
- It’s all for the noble goal of efficiency (i.e. speed.)
- Serialization is slooow; memory transfers are slooow.
- CPU is not the bottleneck: think memory & bandwidth.

Process Transparency

- Process management is transparent to code.
- ...almost. In some cases, it's unavoidably visible.
- *Lifecycle* is seamless, but *data* sometimes isn't.
- Specific APIs send data across process boundaries.

IPC Overview



Binder in 30 Seconds

- All IPC goes through “The Binder”
  - Binder is implemented as a kernel module + system lib
  - Supports sophisticated cross-process data transport
- The framework APIs “know” how to use Binder
- Generally two entry points: Bundles & Parcelables

IPC - Parcelables

- A Parcelable is a class which can marshal its state to something Binder can handle -- namely, a “Parcel”
- Standard Java serialization has semantics Parcelables don’t need
  - Supporting full serialization would mean wasting CPU cycles

IPC - Bundles

- Bundles are typesafe containers of primitives
  - That is, C-like primitives: ints, strings, etc.
- Simple data-passing APIs use Bundles
  - Think of onFreeze() as passing data to your future self
- Flat structure permits optimizations like memory-mapping

IPC - AIDL

- “Android Interface Definition Language”
- Used to build developer-friendly APIs using Parcelables
- Preferred way to expose structured, complex-typed APIs
- Compromise between efficiency and Java usability

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Wrapping Up

- APKs are loose collections of components
- Tasks (AKA apps) are bags of component instances that span processes & APKs
- Managed lifecycles & IPC join the “seams”

Questions?