Automating GUI Testing for Android Applications

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Amazon Inc.

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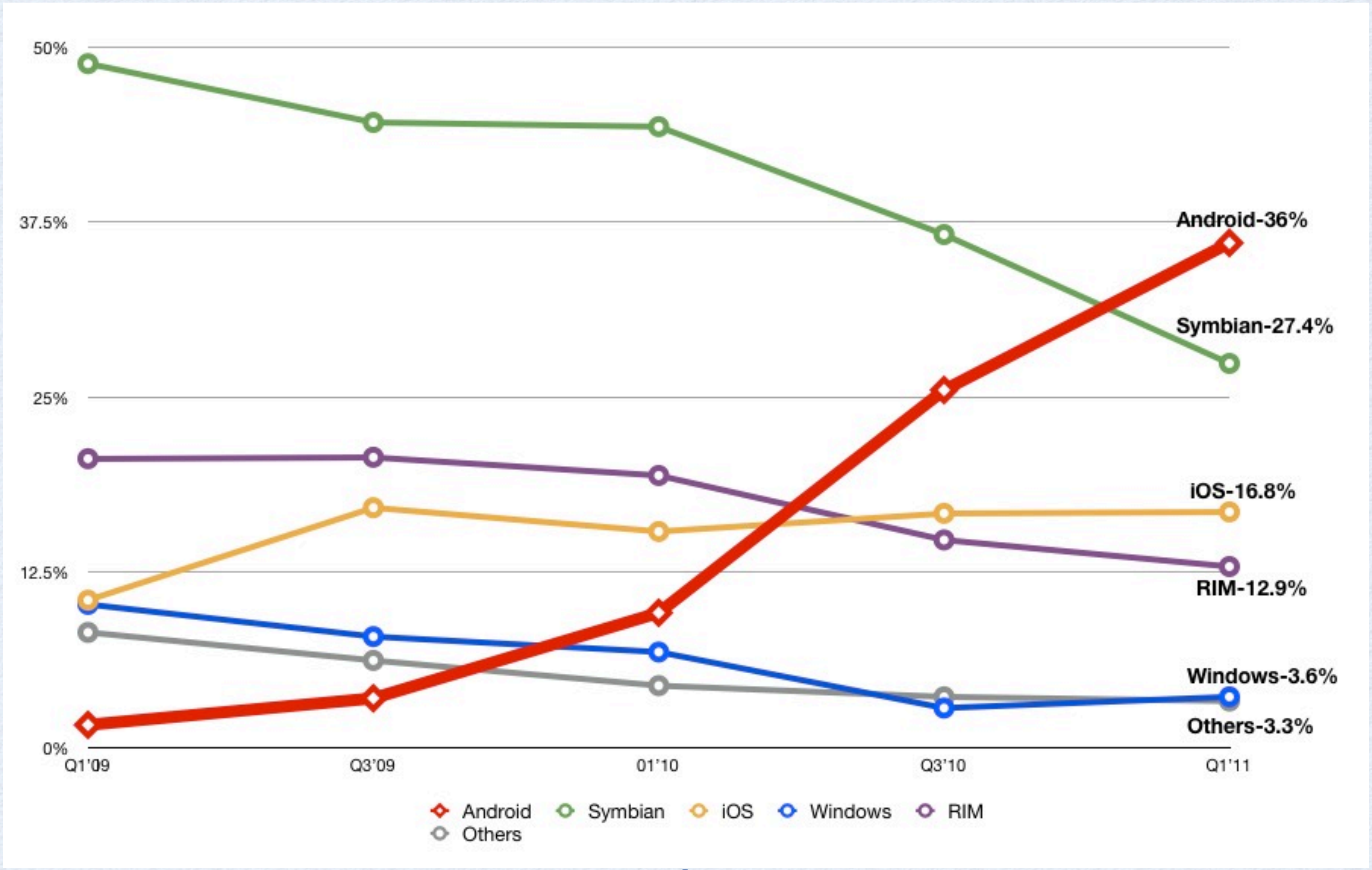
Android Gaining Market Share



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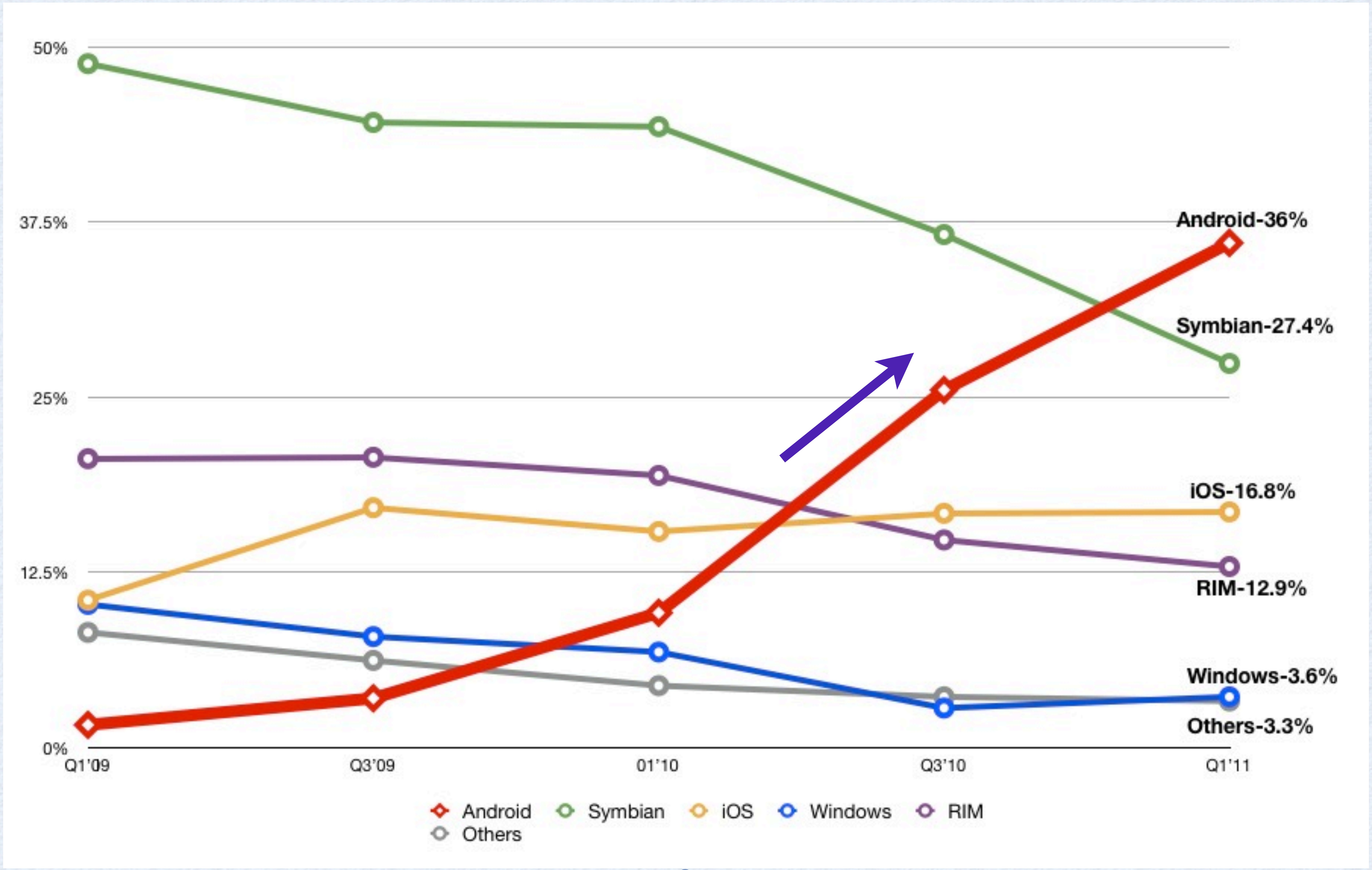
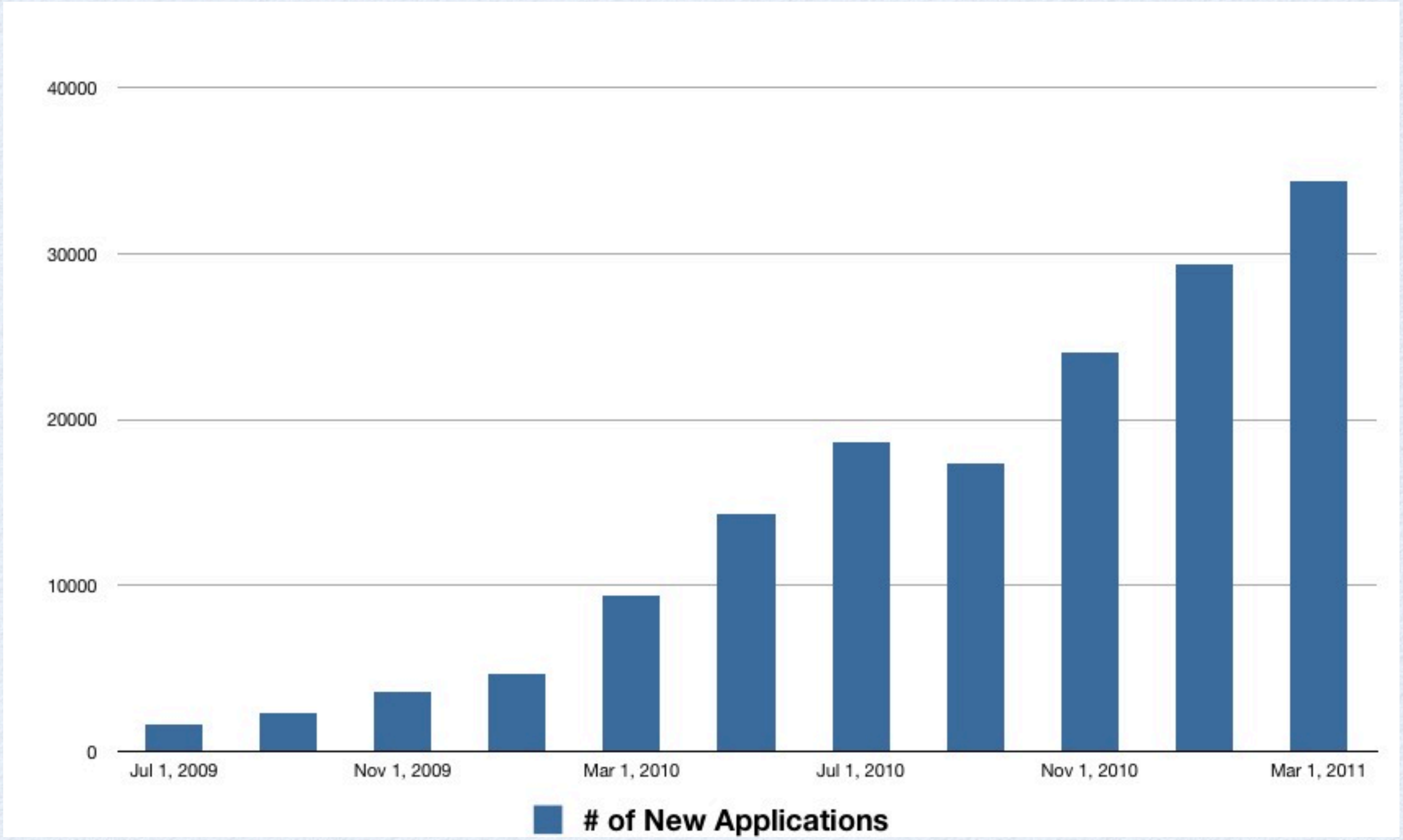


More and More New Android Applications Released



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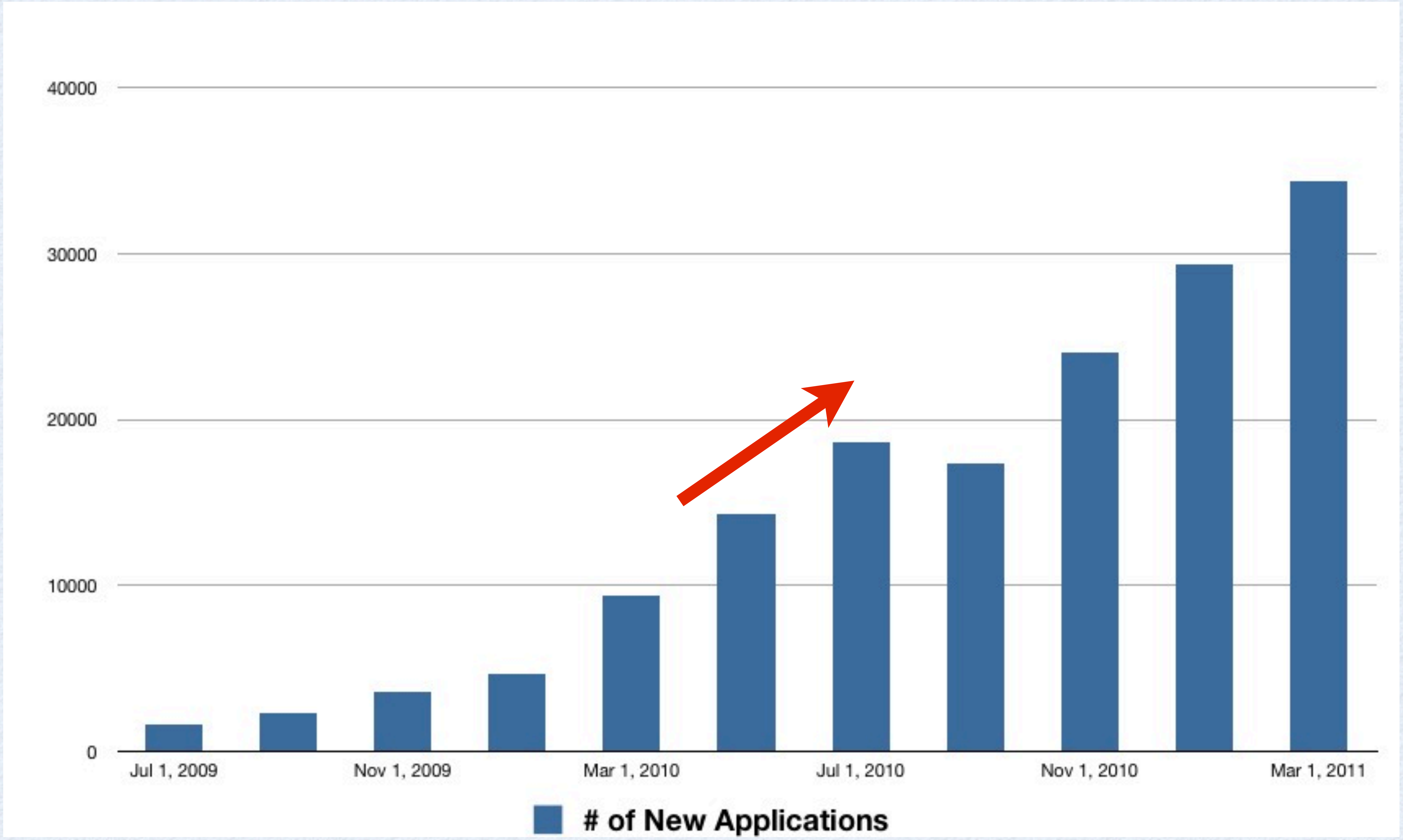

Motivation

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- ✦Android platform gaining traction

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→ Correctness of Android applications is CRITICAL (mobile banking, business mgmt.)

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What's novel about the Android platform?

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✦Novelty of Android development model

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⇨ **Android-specific bug study**

What's novel about the Android platform?

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- ✦Android platform gaining traction
  - Correctness of Android applications is CRITICAL (mobile banking, business mgmt.)
- ✦Novelty of Android development model
  - **Android-specific bug study**
- ✦Android-specific verification tools

What's novel about the Android platform?

Motivation

✦Android platform gaining traction

→ Correctness of Android applications is CRITICAL (mobile banking, business mgmt.)

✦Novelty of Android development model

→ **Android-specific bug study**

✦Android-specific verification tools

→ **Automated approach for test generation and runtime verification for Android applications**

What's novel about the Android platform?

What is Android

- Open source platform for mobile devices, started October 2008
- A complete software stack
  - OS
  - Middleware
  - Applications
- Based on Java

Components of Android Applications

- Activity
    - Control application windows
- Services
    - Run in the background for an indefinite period of time
- Broadcast Receivers
    - React to a broadcast information, i.e., low battery
- Content Providers
    - Store content, allow sharing with other apps

Architecture of Android

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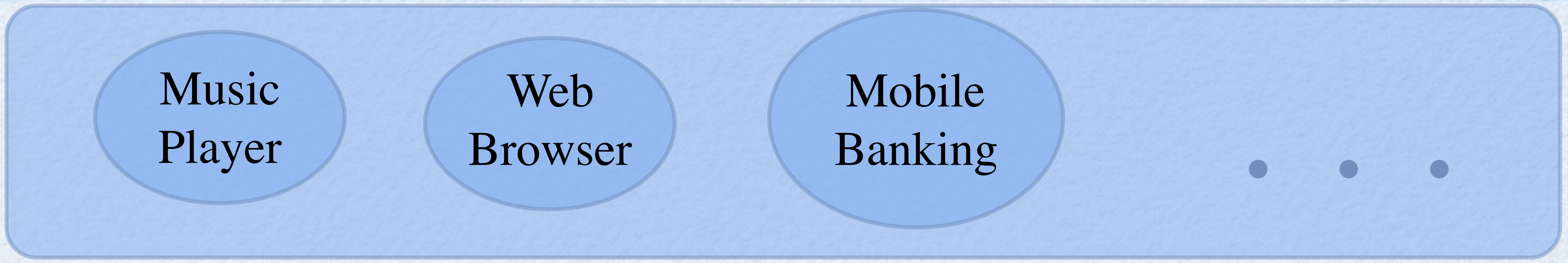
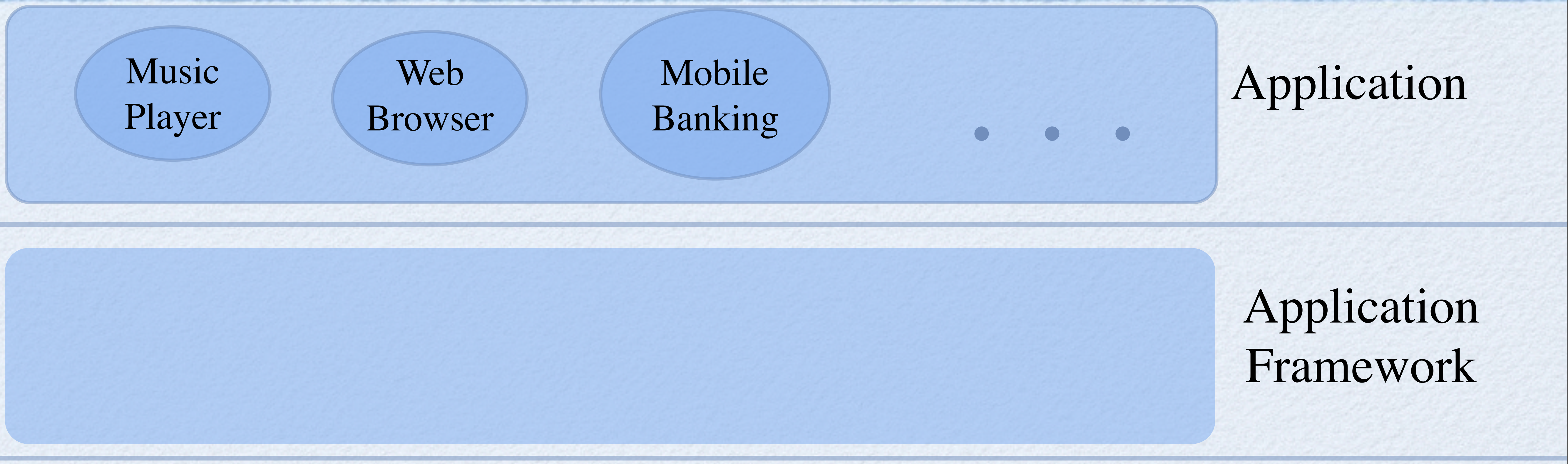


Application

Architecture of Android



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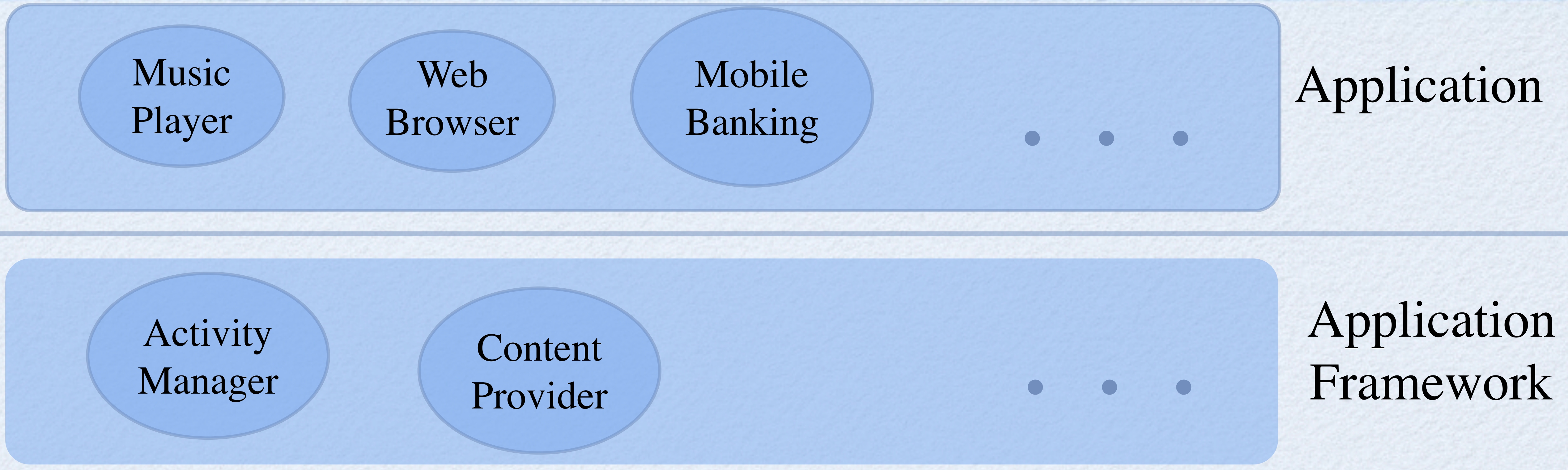

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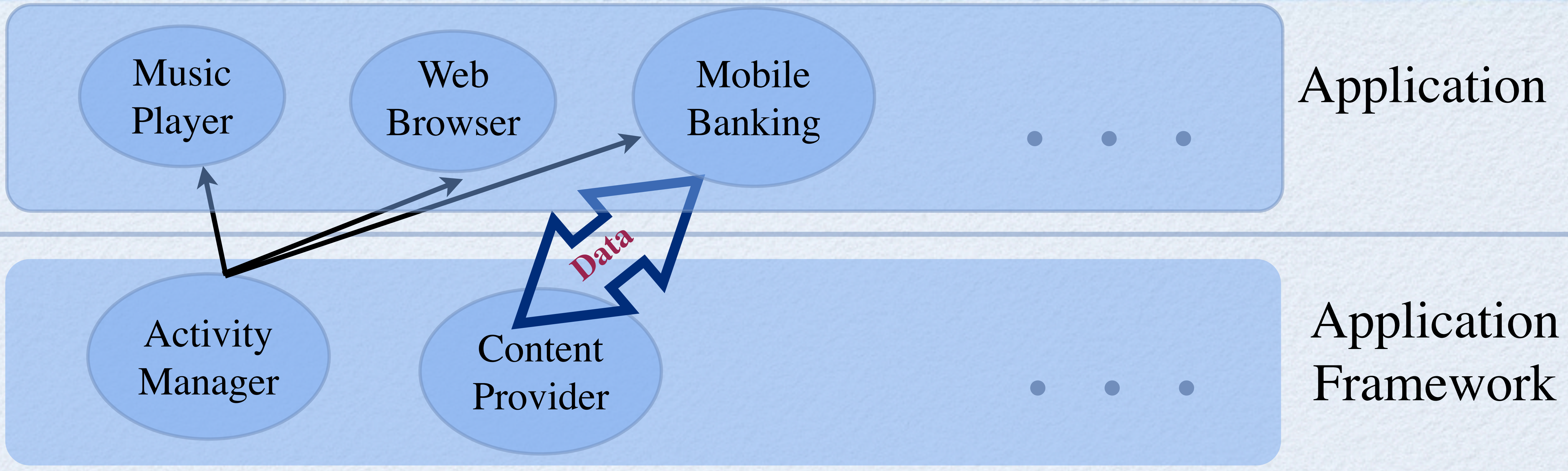

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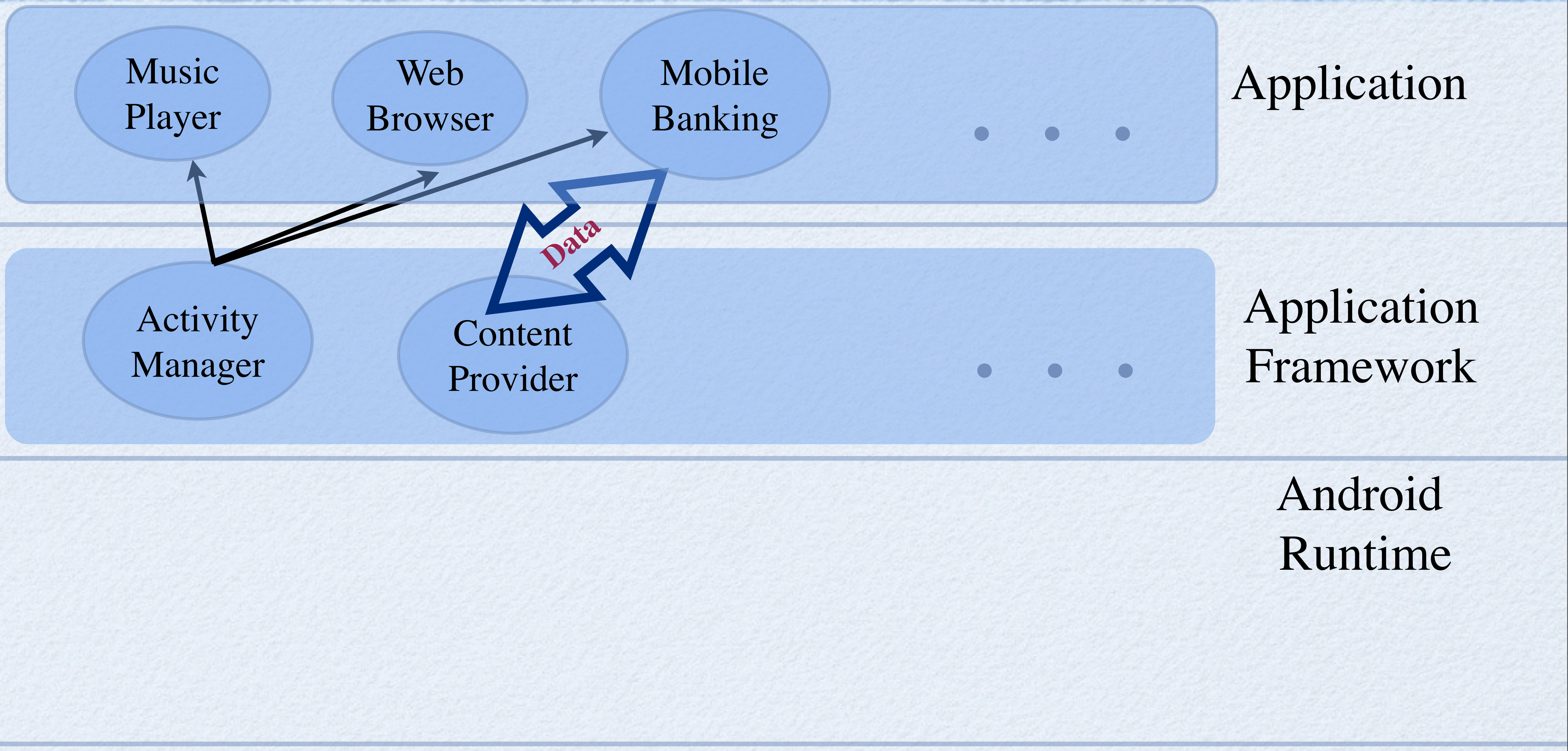

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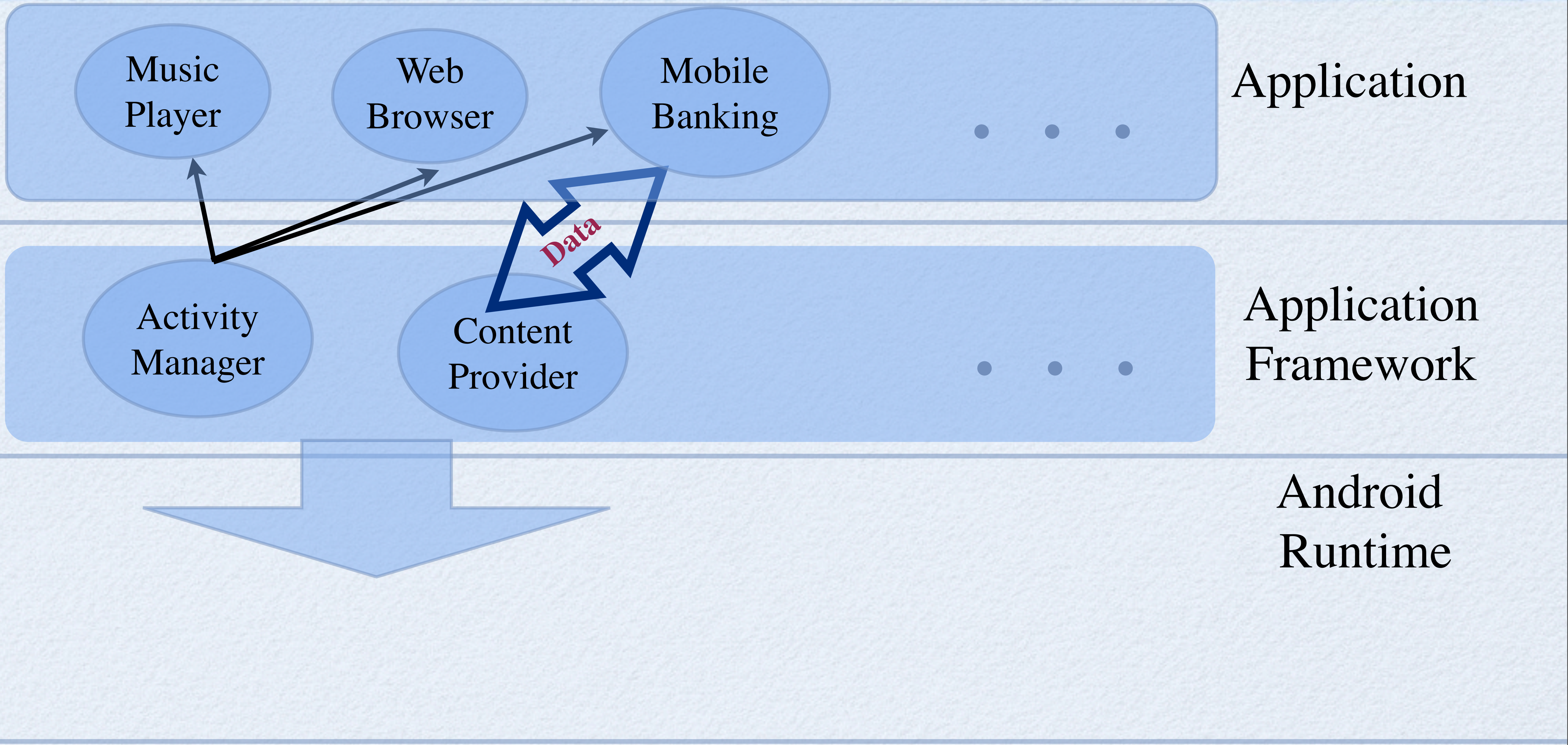

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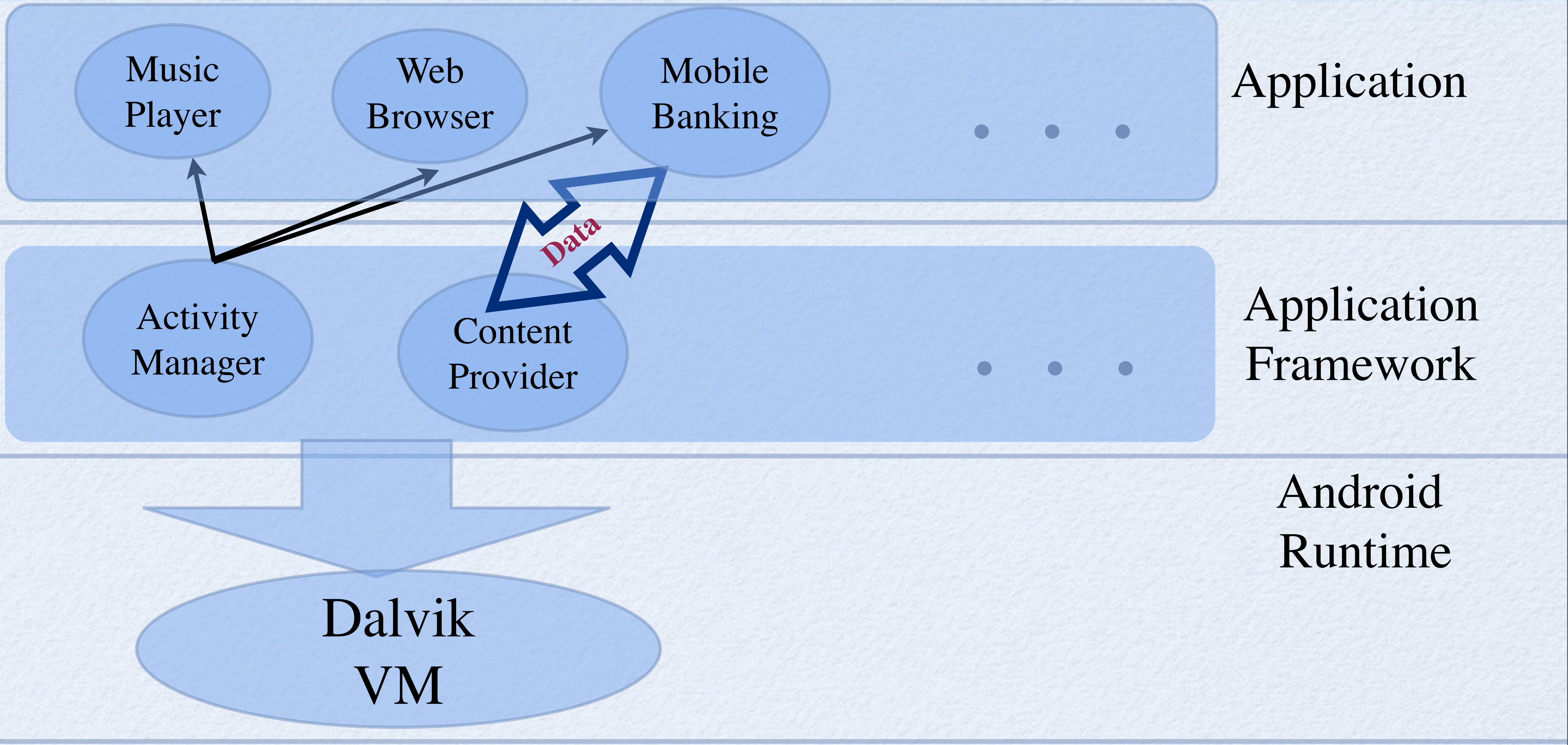

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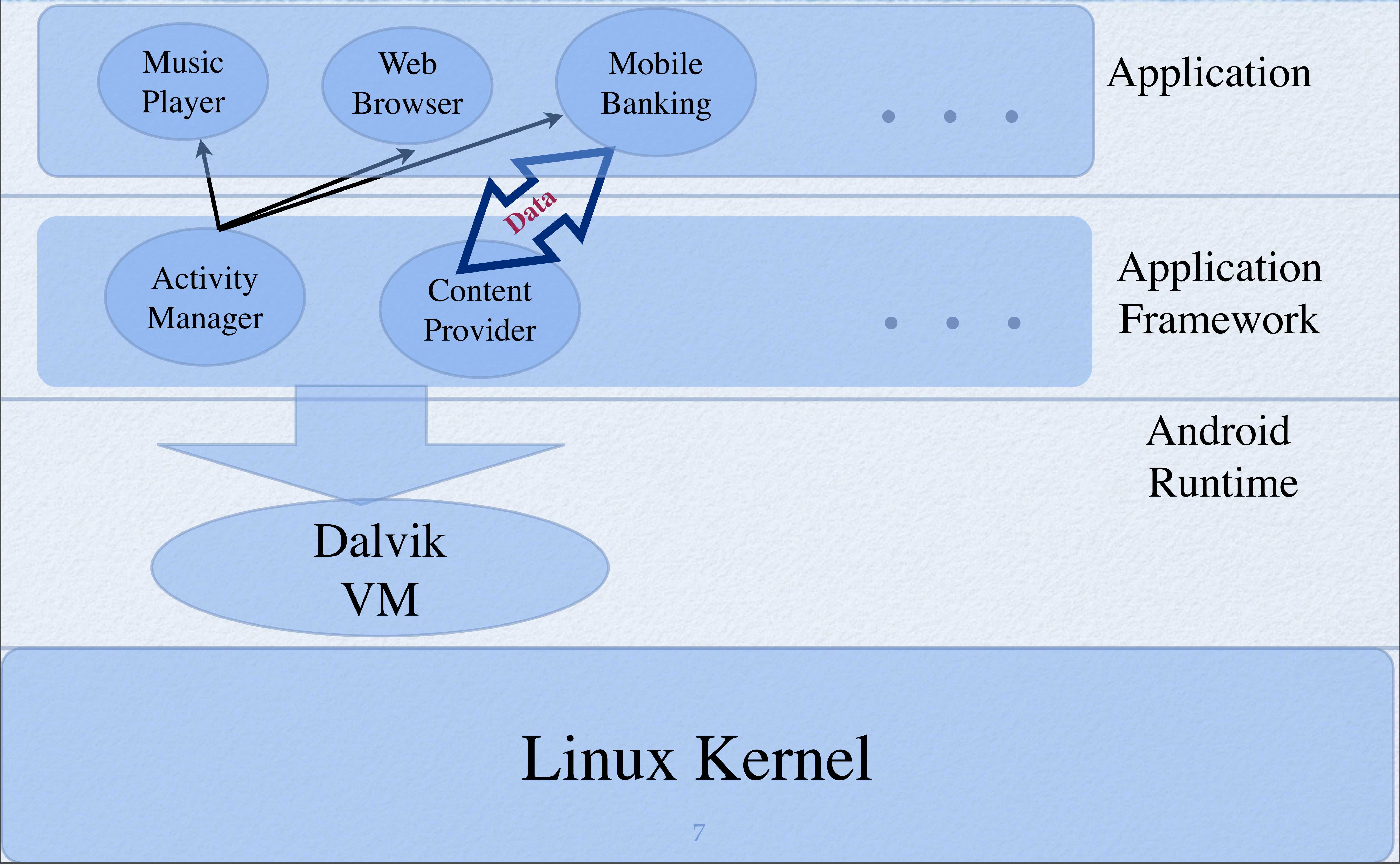

Roadmap

Roadmap

Android development model is unique

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Android development model is unique

$\Downarrow$

Android-specific, novel kinds of bugs

Roadmap

Android development model is unique

Android-specific, novel kinds of bugs

Bug study and bug categorization

Applications Examined

Program	First Release	# of updates	# of bugs
Andoku	06/2009	382	1
GuessTheNumber	02/2009	71	2
Delicious	02/2009	60	5
MonolithAndroid	11/2008	167	7
Opensudoku	04/2009	393	7
CMIS	01/2010	41	8
DealDroid	03/2009	164	10
Skylight1	09/2009	709	10
Rokon	09/2009	362	29
ConnectBot	08/2008	508	79

Bug Study Results

Program	Bug Category								
	Activity	*Event*	*Type*	*Unhandled Exception*	*API*	*I/O*	*Concurr-ency*	*Other*	**Total**
Skylight1	3	2	0	1	0	0	0	4	**10**
CMIS	0	0	0	2	0	0	0	6	**8**
Delicious	0	0	0	0	1	0	0	4	**5**
ConnectBot	2	8	2	5	1	3	1	57	**79**
DealDroid	1	1	0	0	0	0	0	8	**10**
Rokon	0	6	2	3	0	4	0	14	**29**
Andoku	0	0	0	0	0	0	0	1	**1**
Opensudoku	1	1	0	0	0	0	0	5	**7**
GuessTheNumber	1	1	0	0	0	0	0	0	**2**
MonolithAndroid	0	2	0	0	2	0	0	3	**7**
Total	**8**	**21**	**4**	**11**	**4**	**7**	**1**	**102**	**158**

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Bug Study Results

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Testing Techniques

Combination of multiple methods:

1. Automatic event generation
2. Test case generation
3. Post-run application performance monitoring

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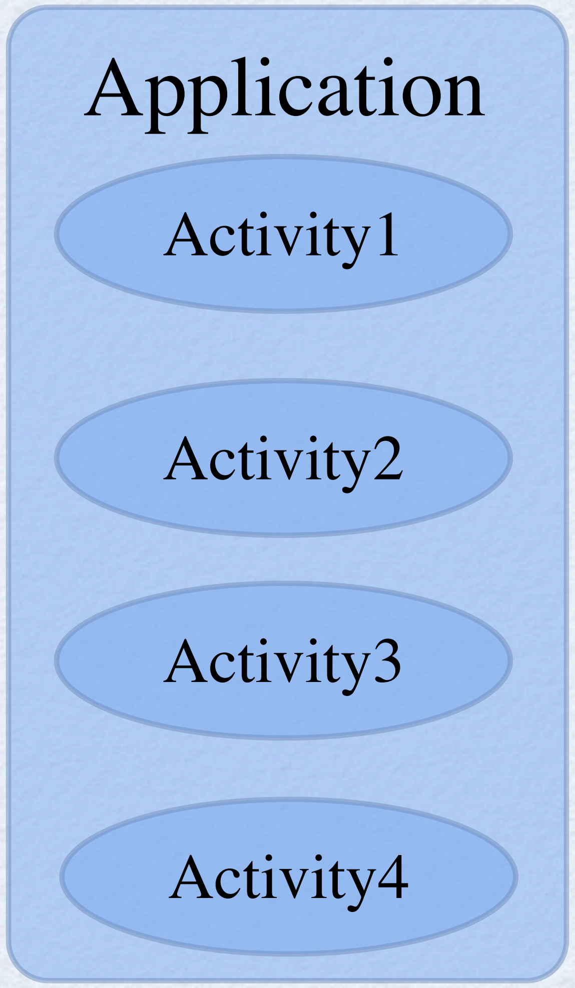

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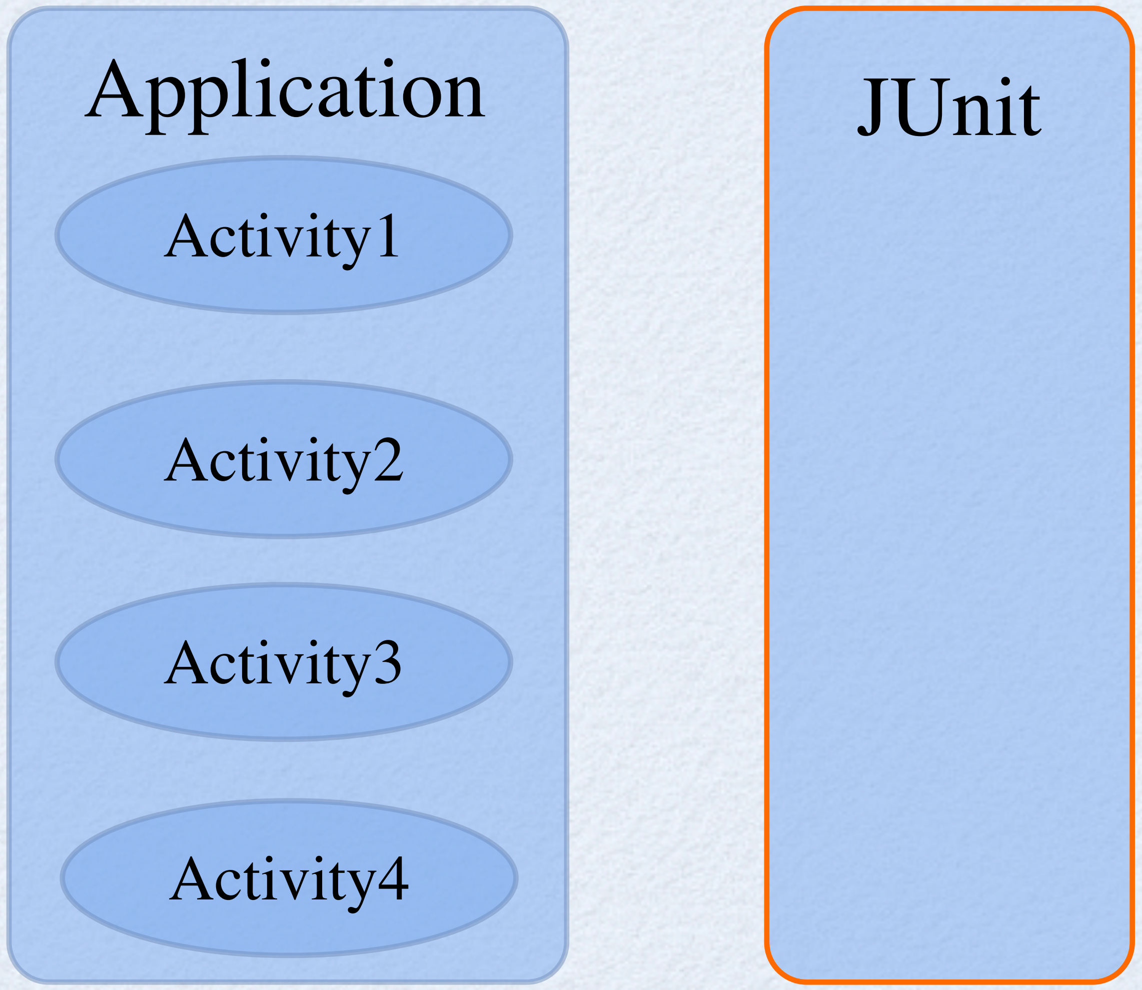

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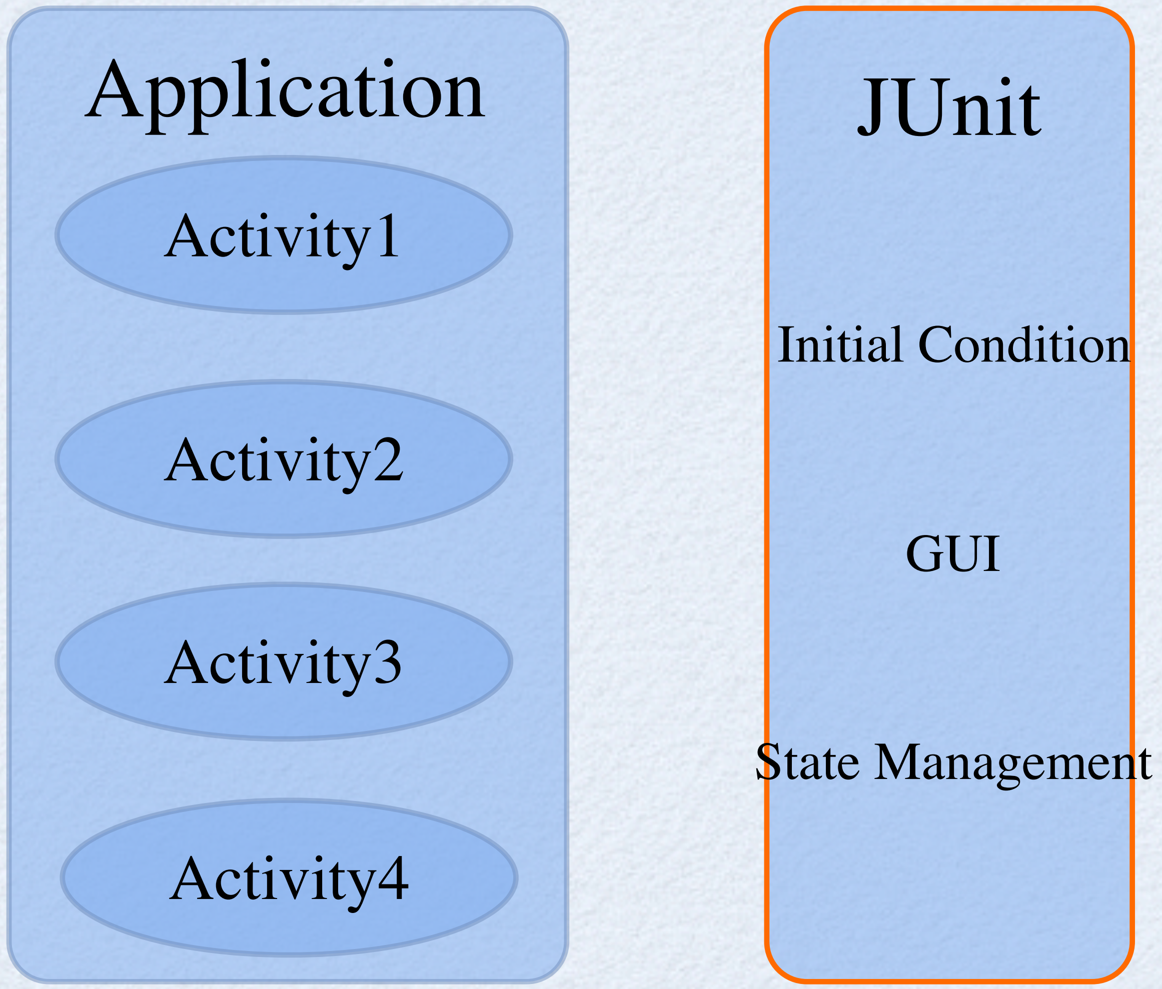

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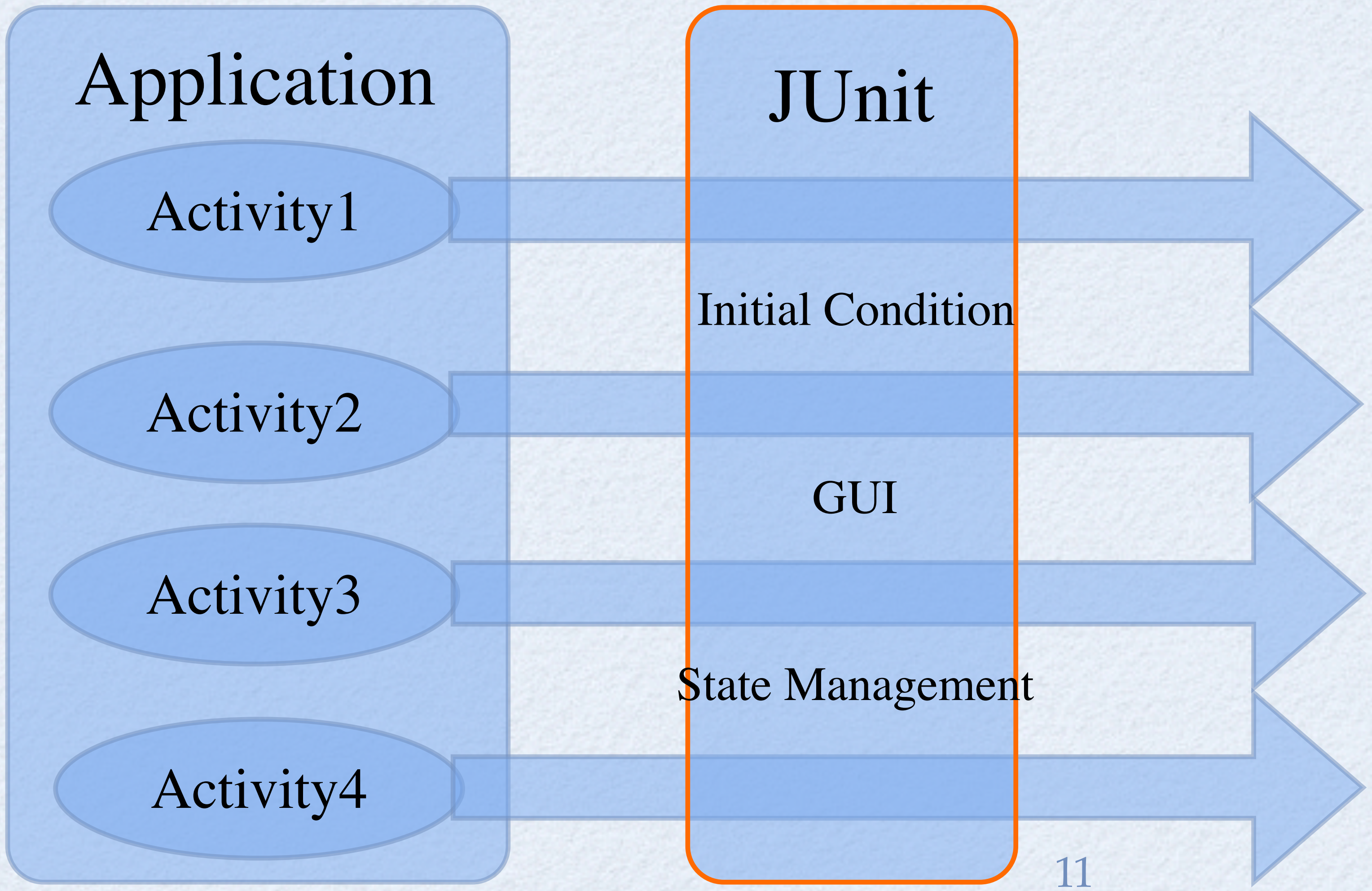

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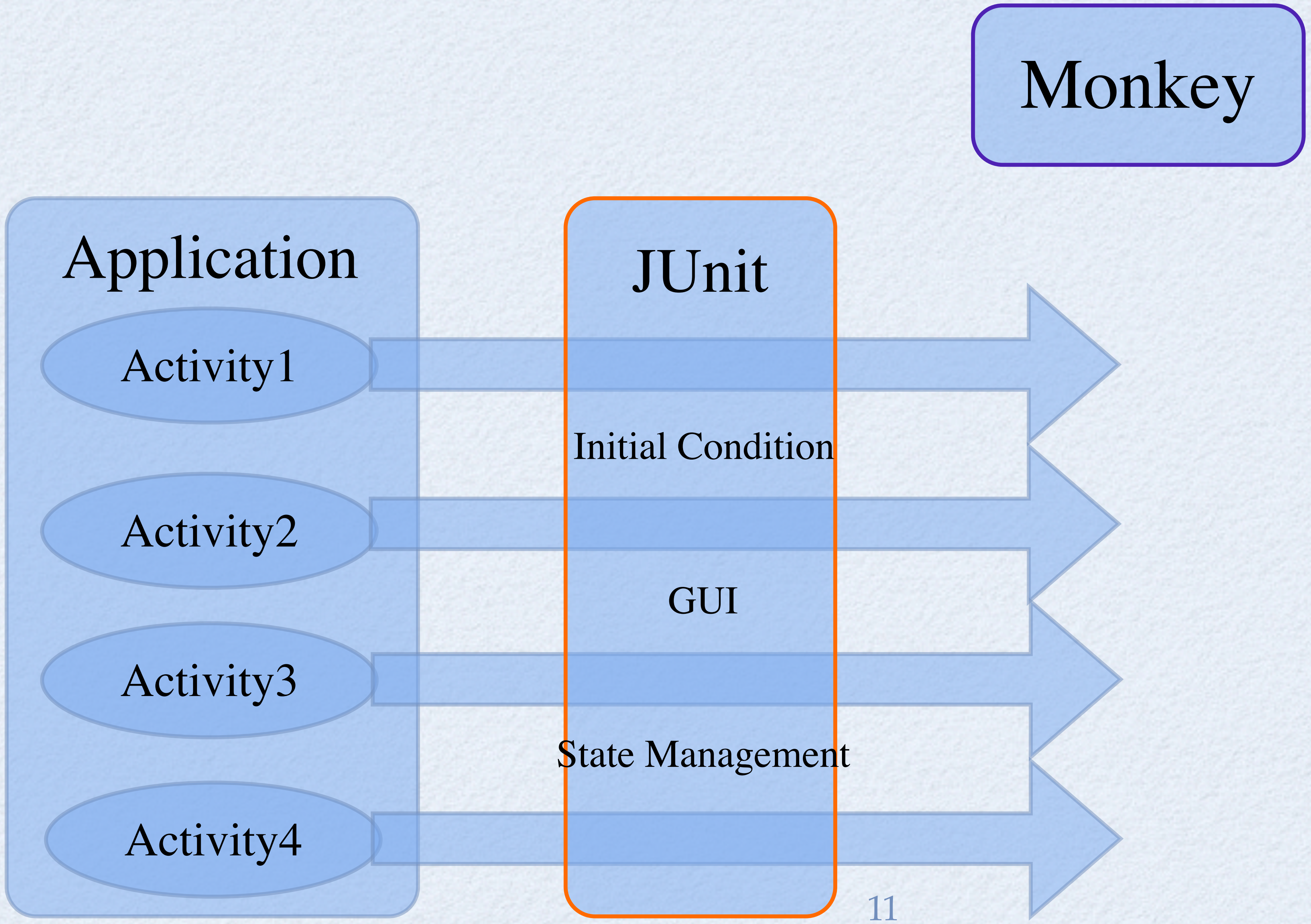

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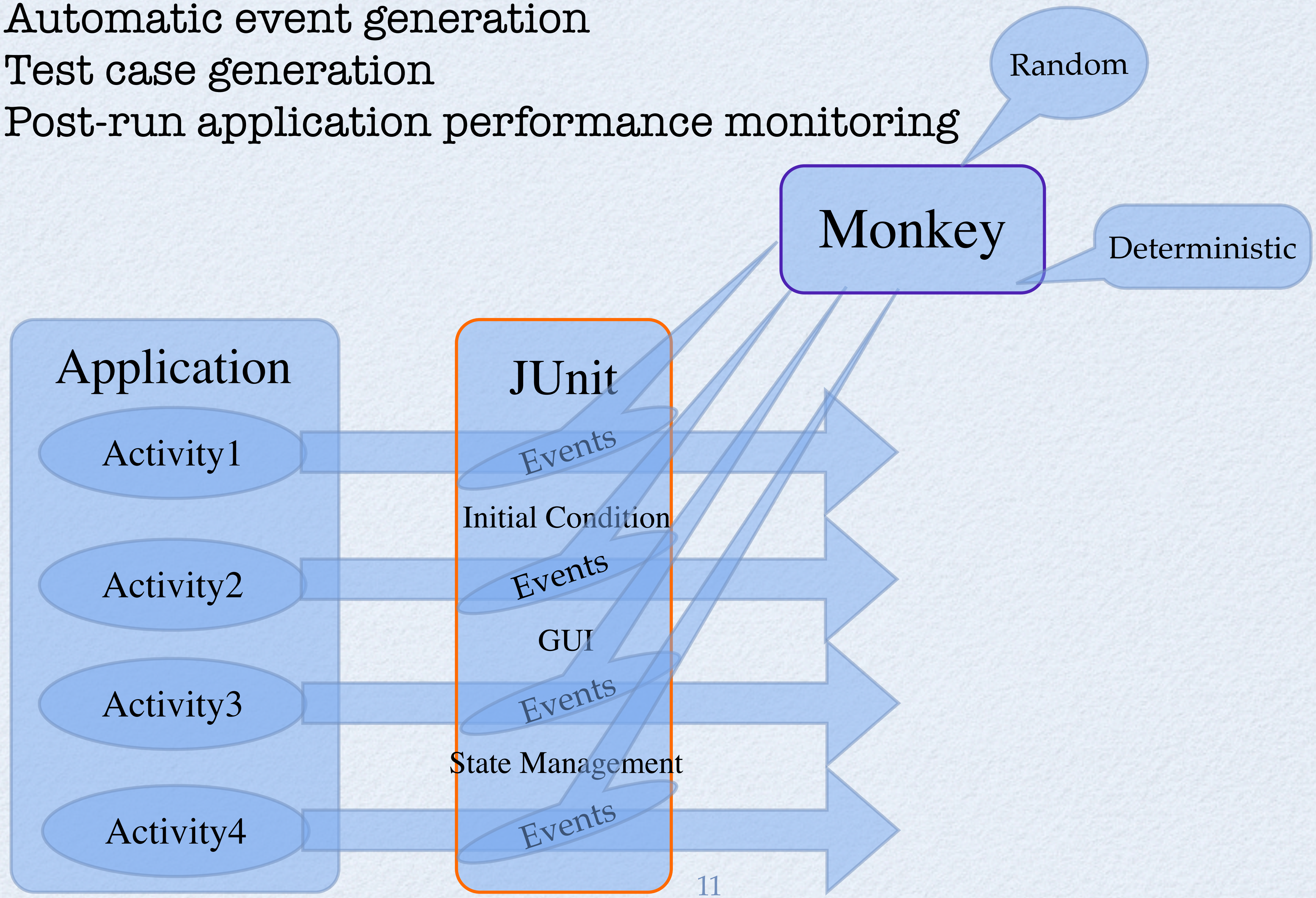

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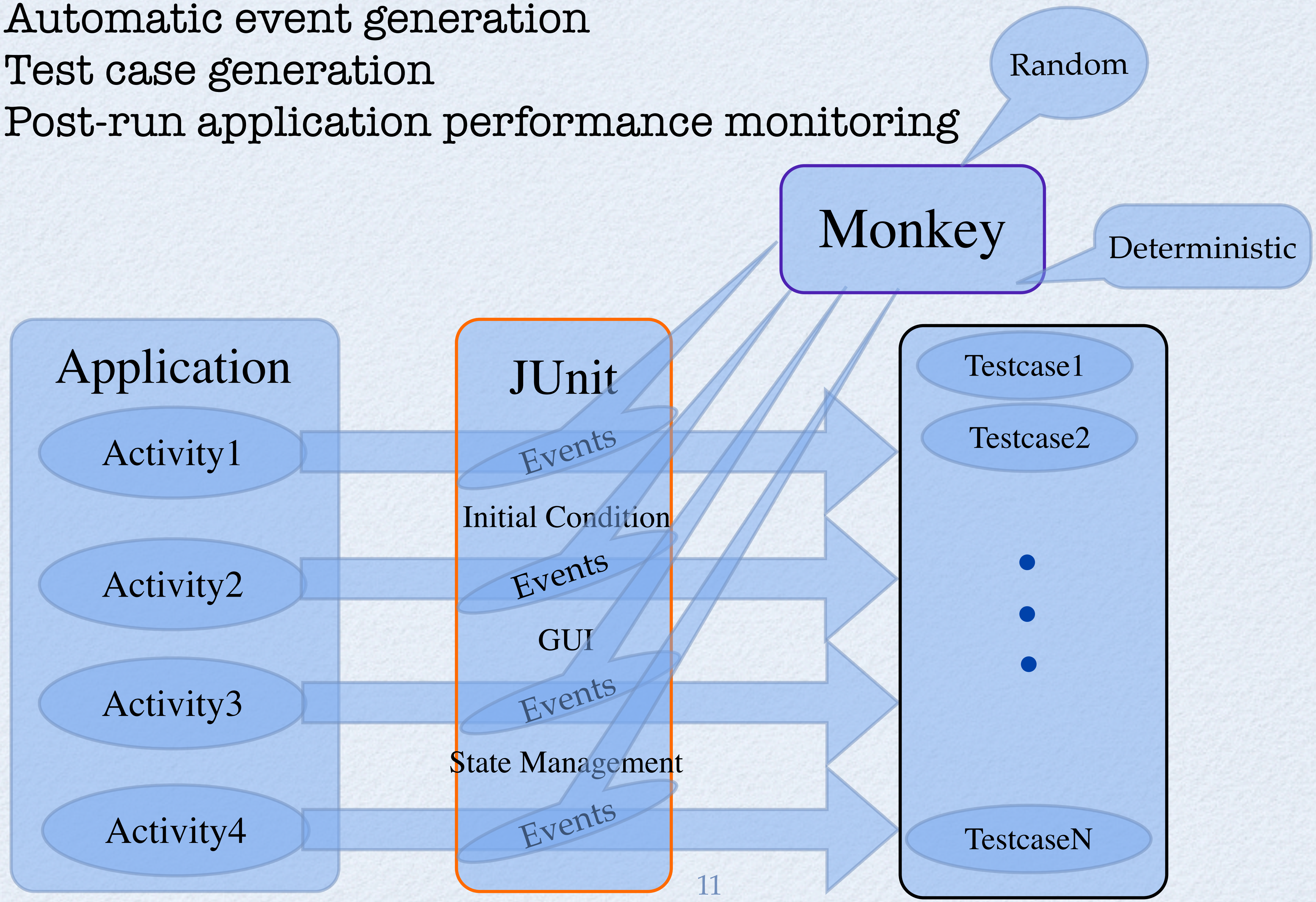

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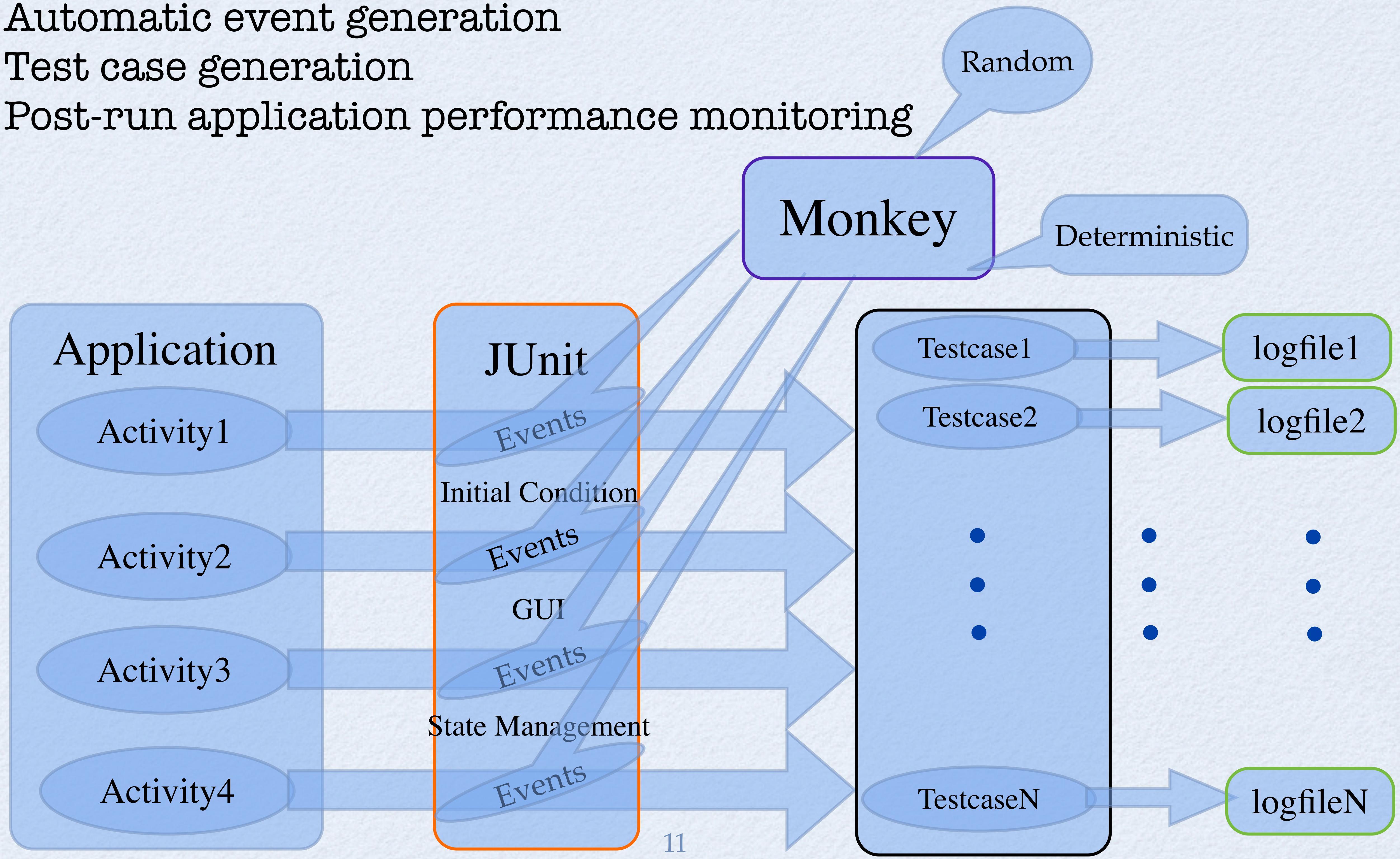

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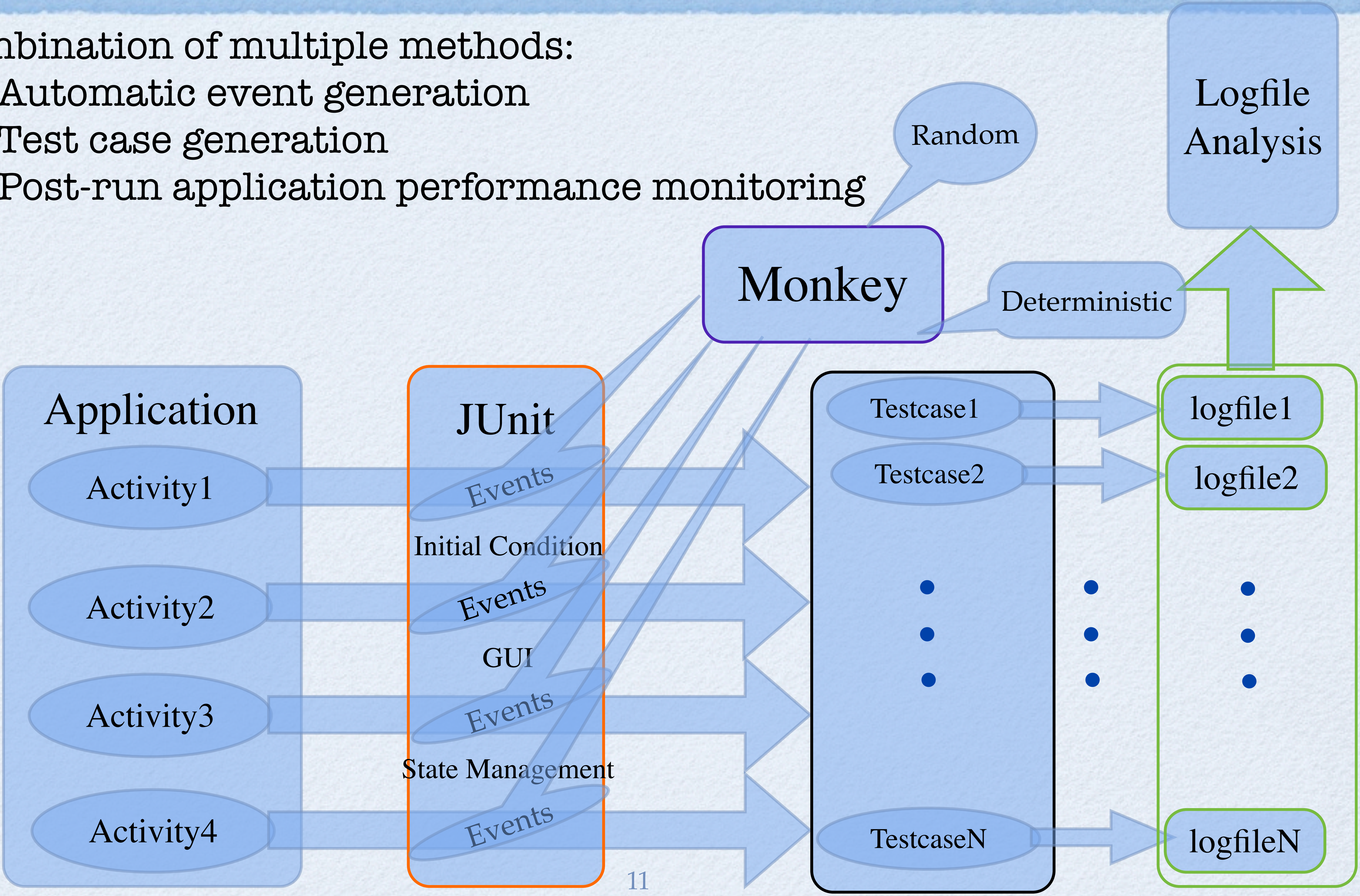
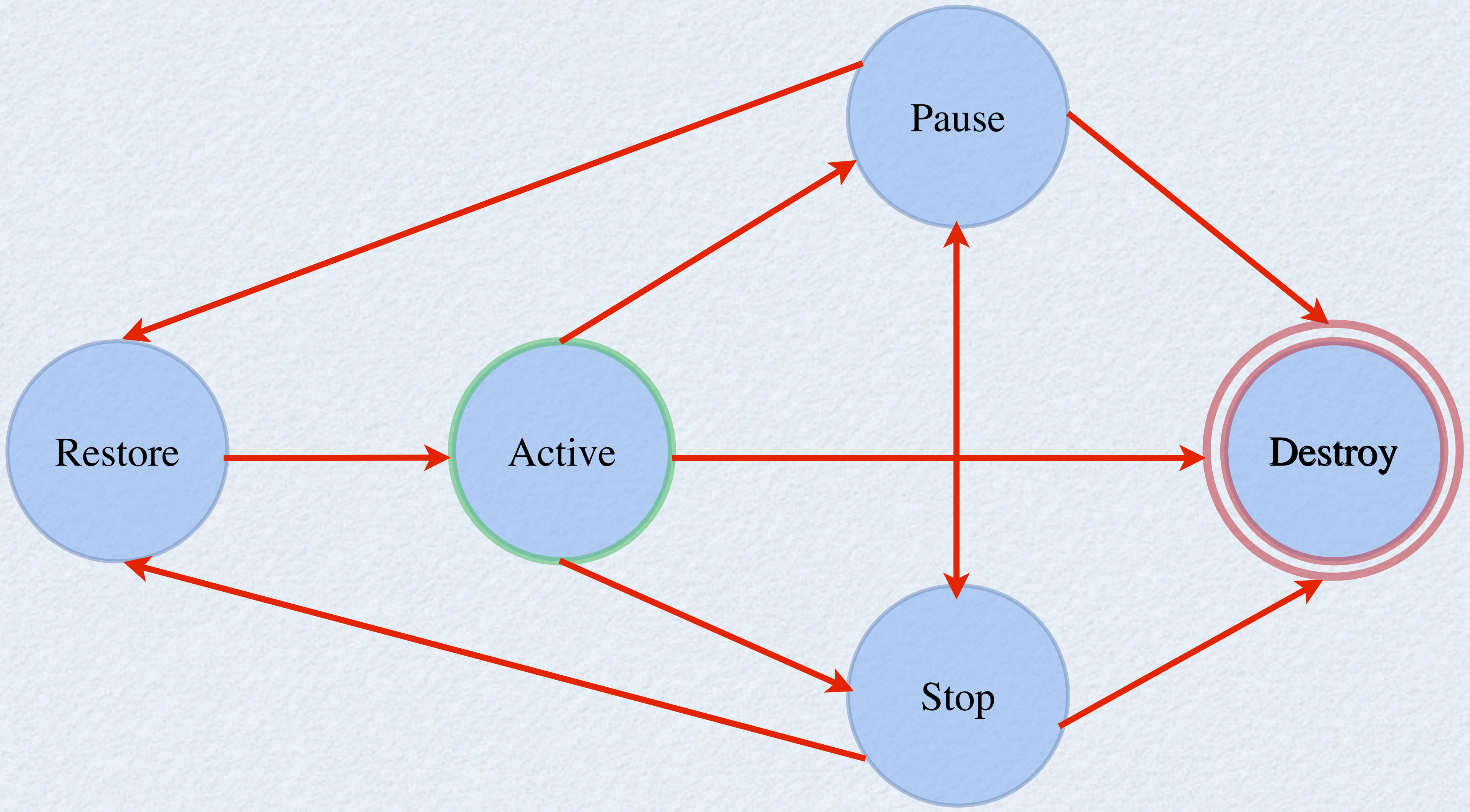


Automatic Log File Analysis

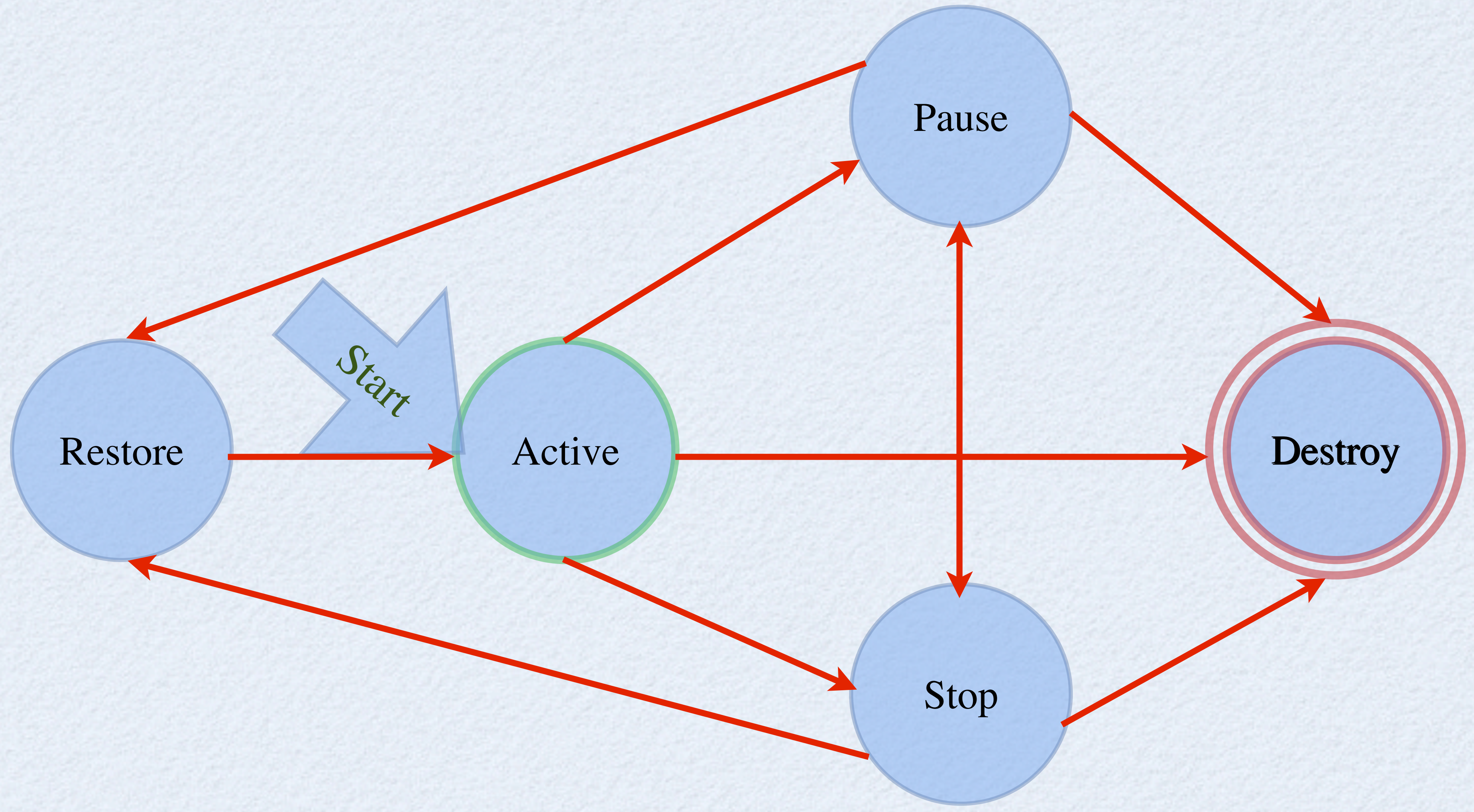
- ✦Activity and event bugs: state machine-based analysis
- ✦Runtime type errors: look for exceptions

State Machine-based Analysis



State machine used to detect activity and event bugs

State Machine-based Analysis



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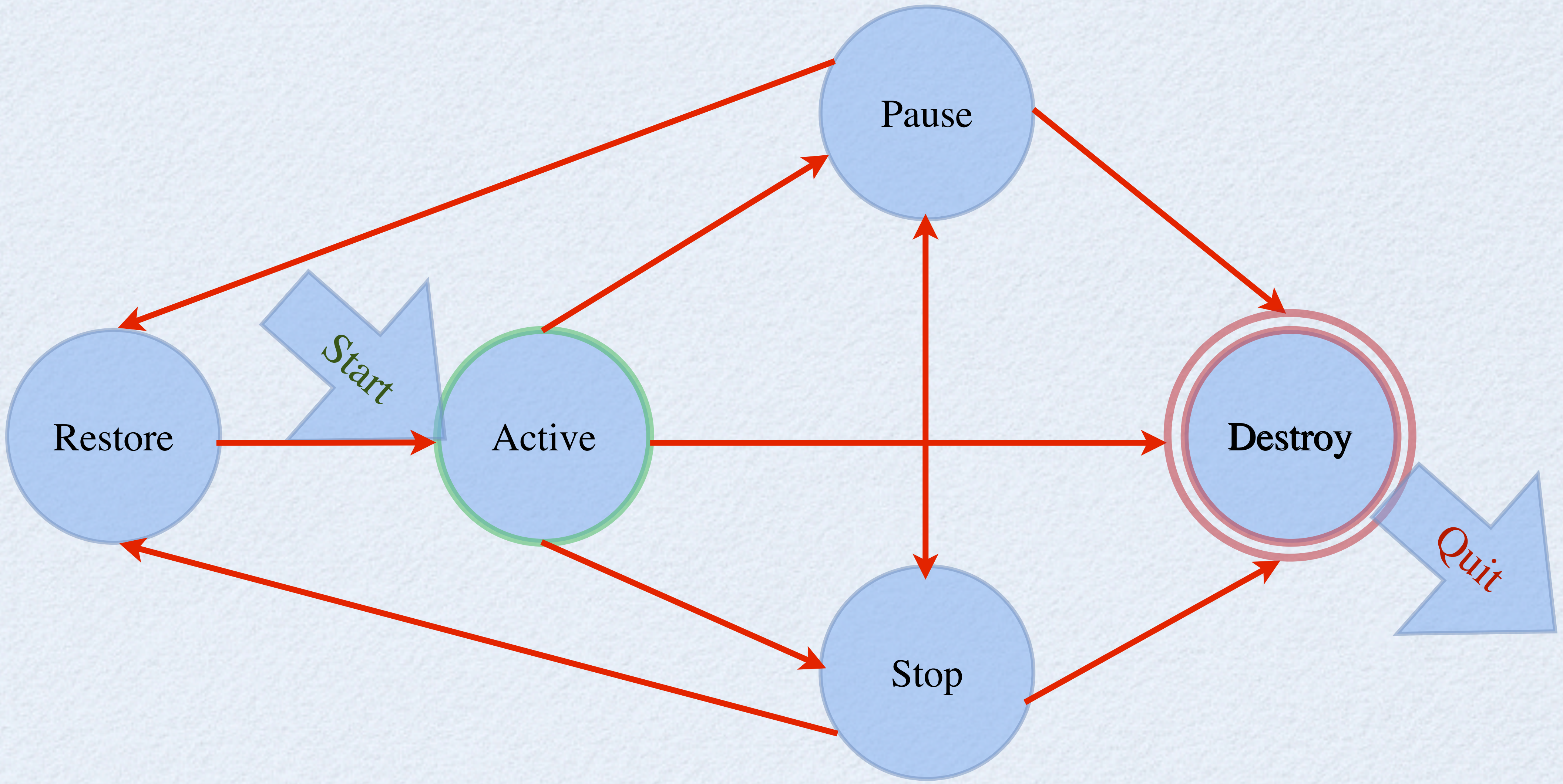

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Correct Pattern:

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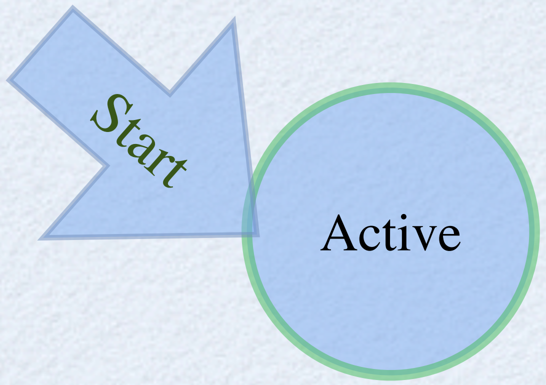

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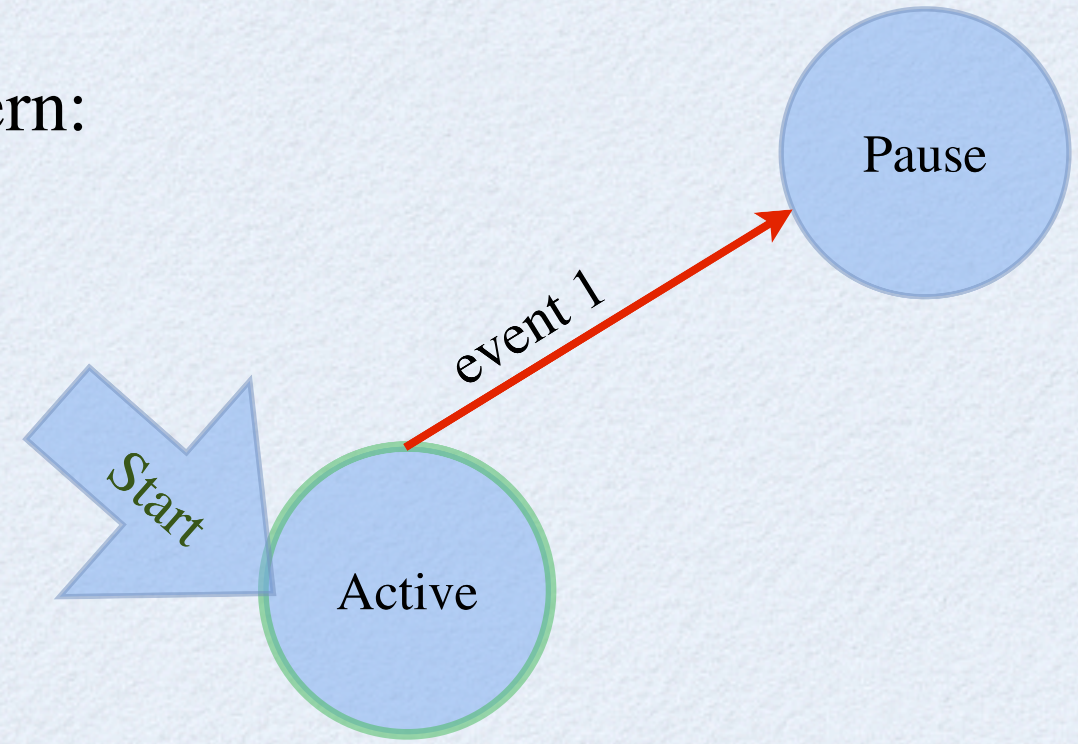

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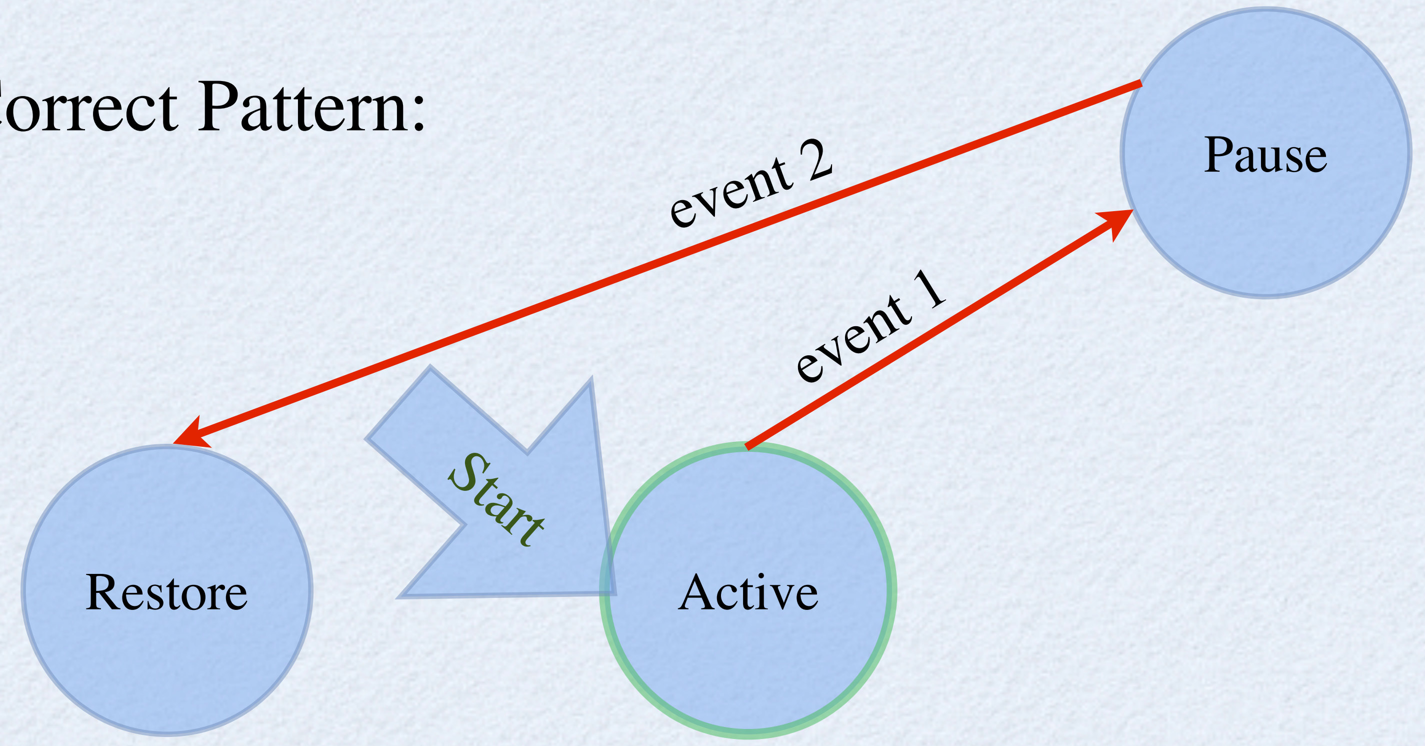

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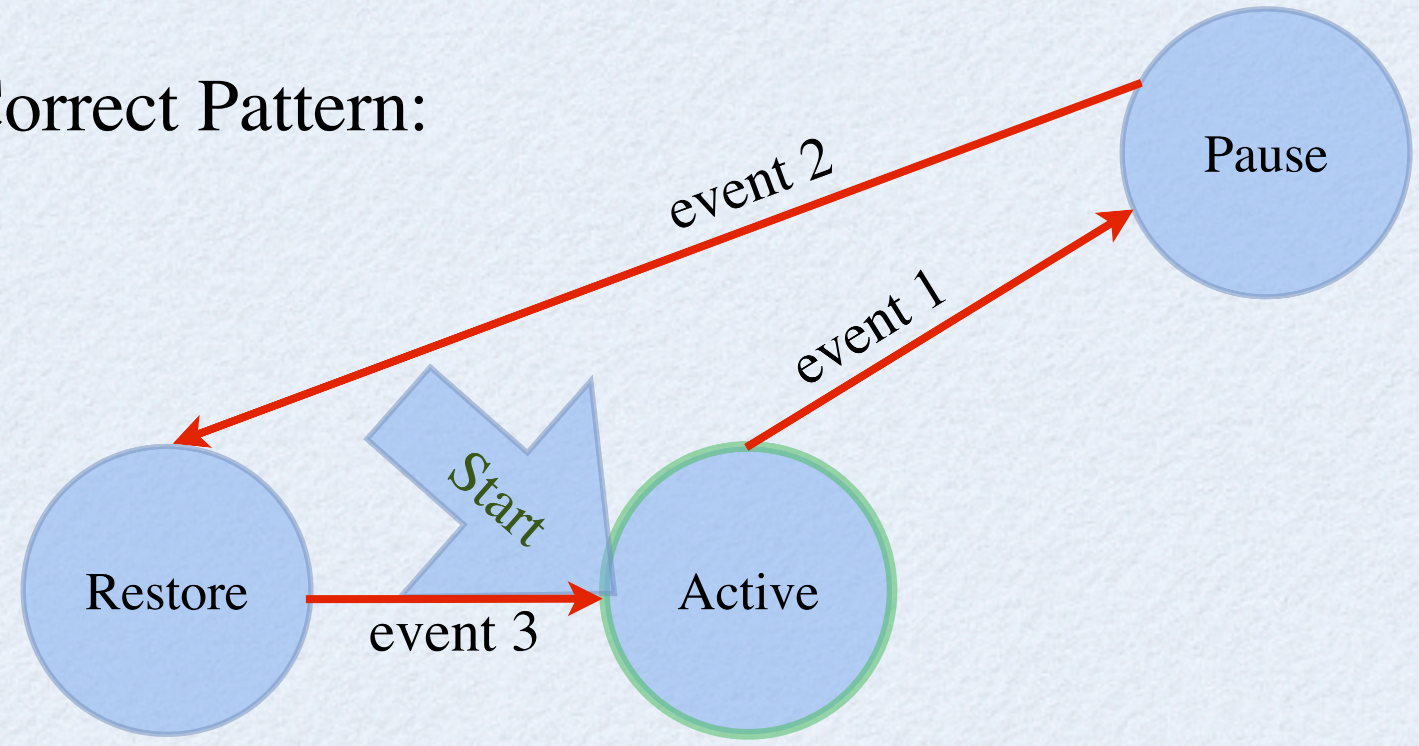

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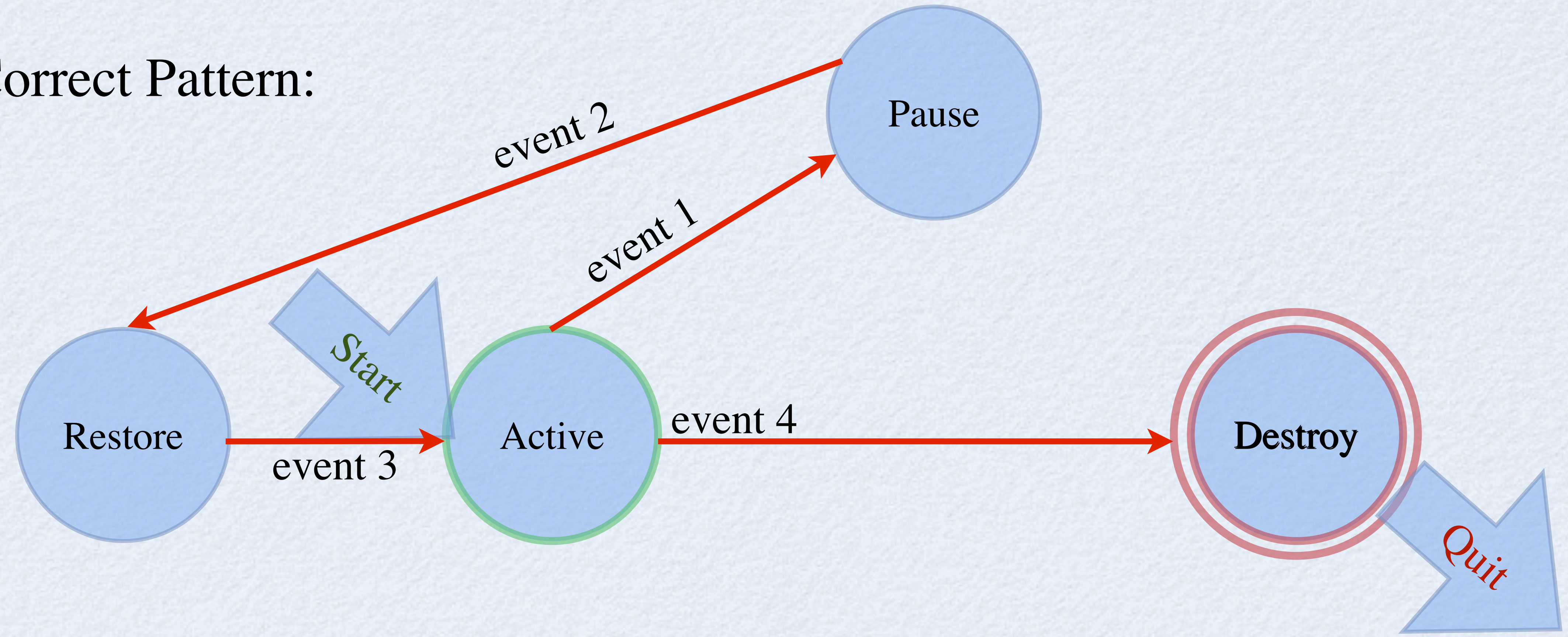

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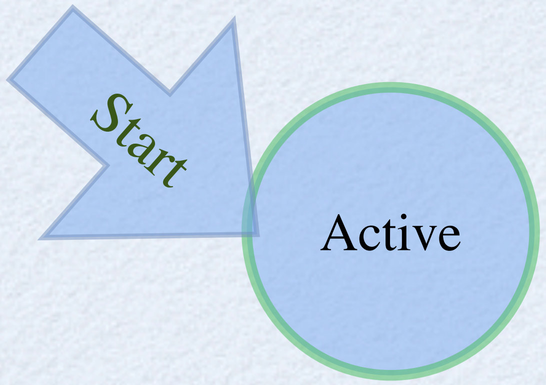

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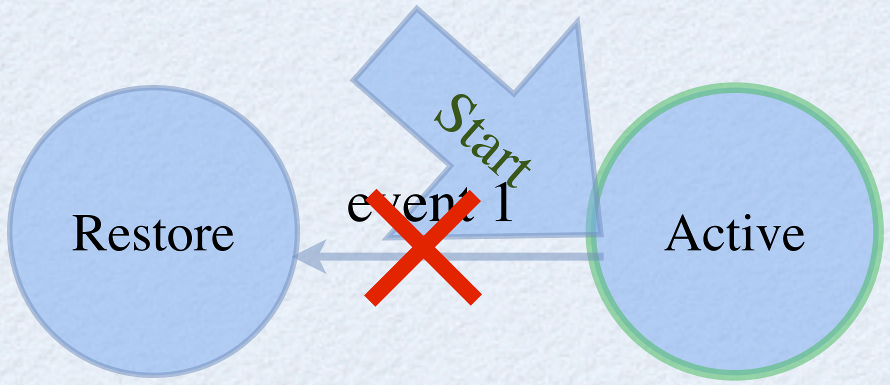

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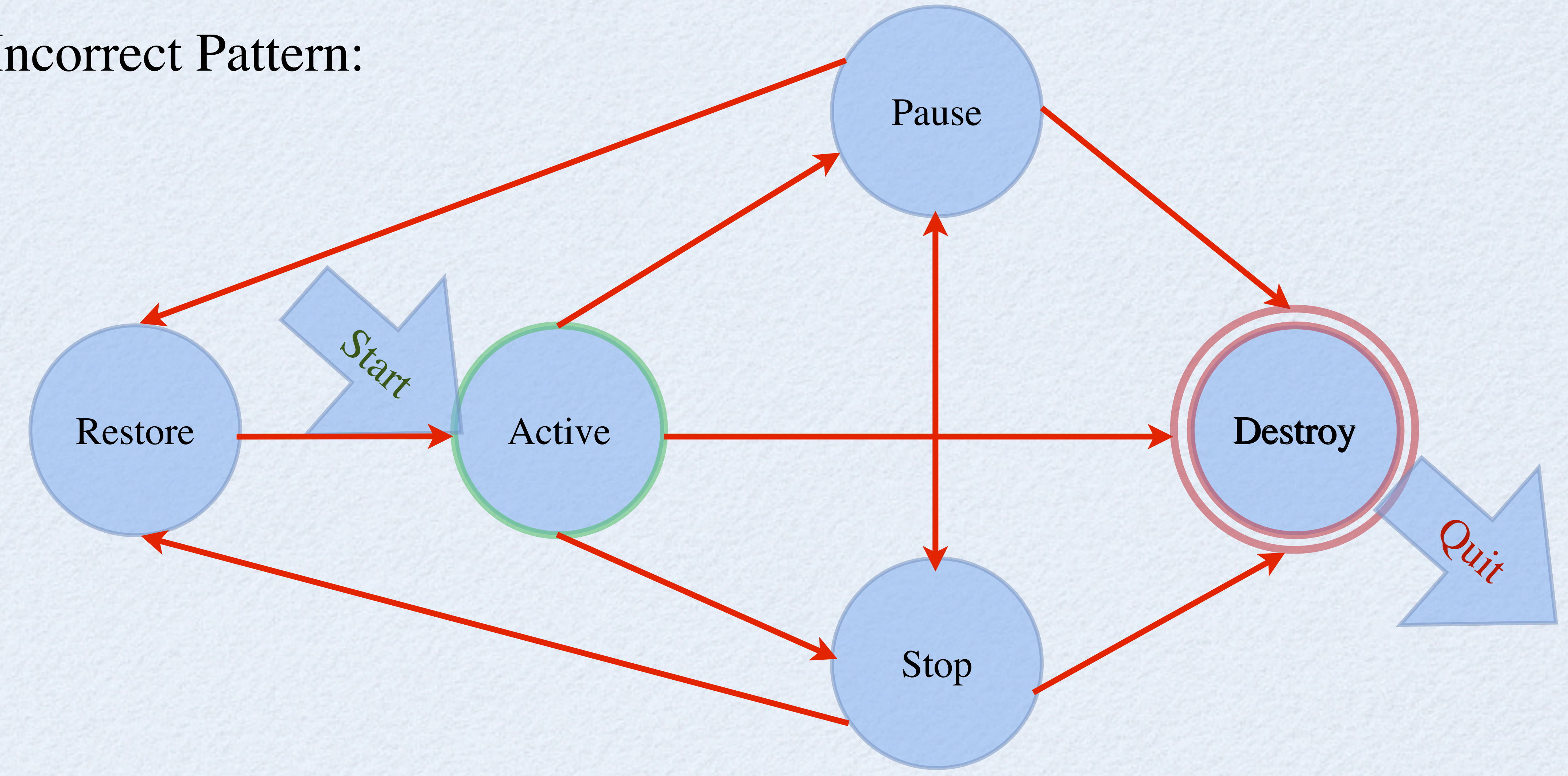
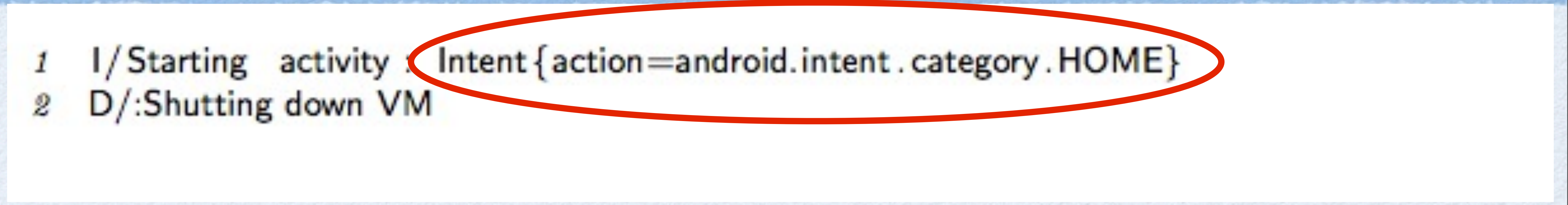


State machine used to detect activity and event bugs

Crash Example



```
I/Starting activity : Intent{action=android.intent.category.HOME}
D/:Shutting down VM
```

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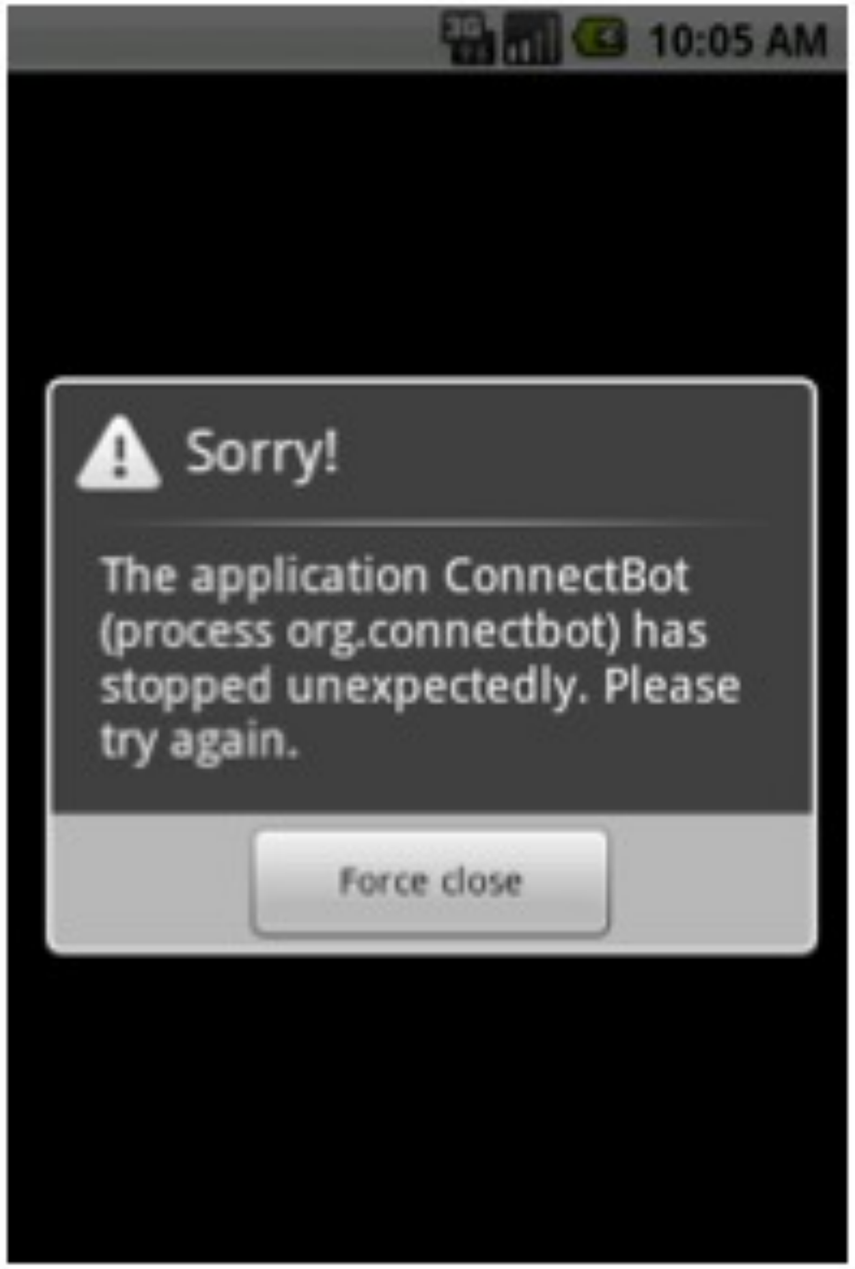
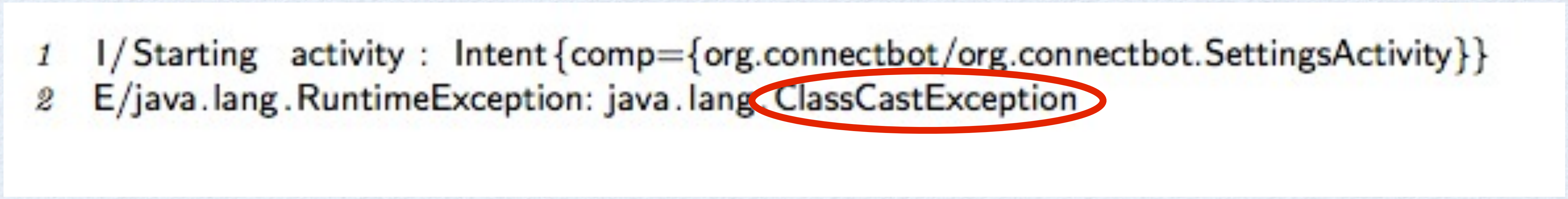


Sorry!

The application ConnectBot (process org.connectbot) has stopped unexpectedly. Please try again.

Exception Analysis

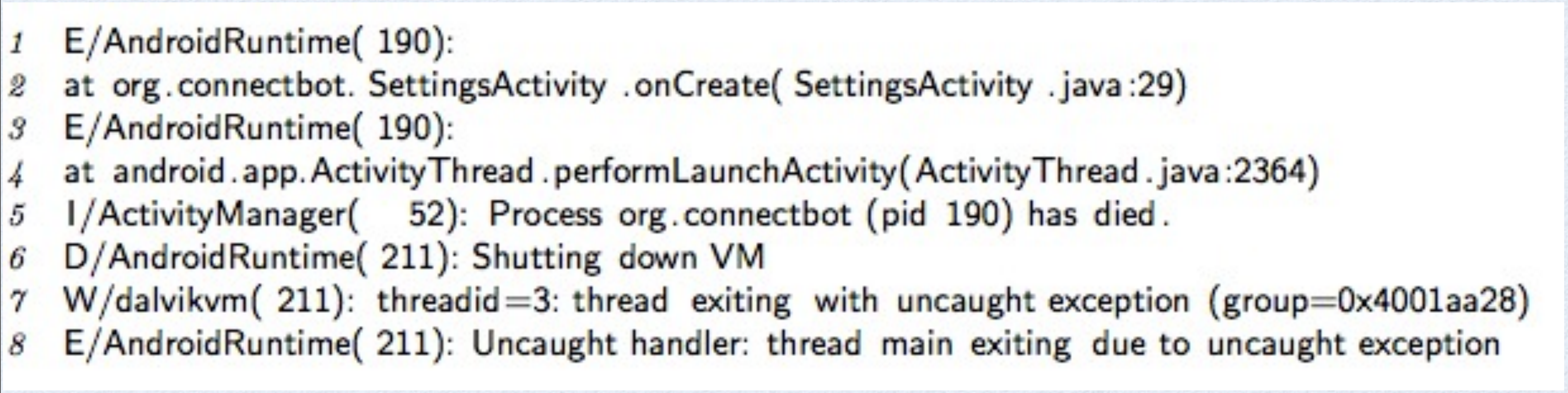
ClassCatchException in the log file



```
I/Starting activity : Intent{comp={org.connectbot/org.connectbot.SettingsActivity}}
E/java.lang.RuntimeException: java.lang.ClassCastException
```

Using Our Tool as Debugging Aid

Unrolled stack helps developers reproduce bugs and pinpoint errors



```
E/AndroidRuntime( 190):
at org.connectbot. SettingsActivity .onCreate( SettingsActivity .java:29)
E/AndroidRuntime( 190):
at android.app.ActivityThread.performLaunchActivity(ActivityThread.java:2364)
I/ActivityManager(    52): Process org.connectbot (pid 190) has died.
D/AndroidRuntime( 211): Shutting down VM
W/dalvikvm( 211): threadid=3: thread exiting with uncaught exception (group=0x4001aa28)
E/AndroidRuntime( 211): Uncaught handler: thread main exiting due to uncaught exception
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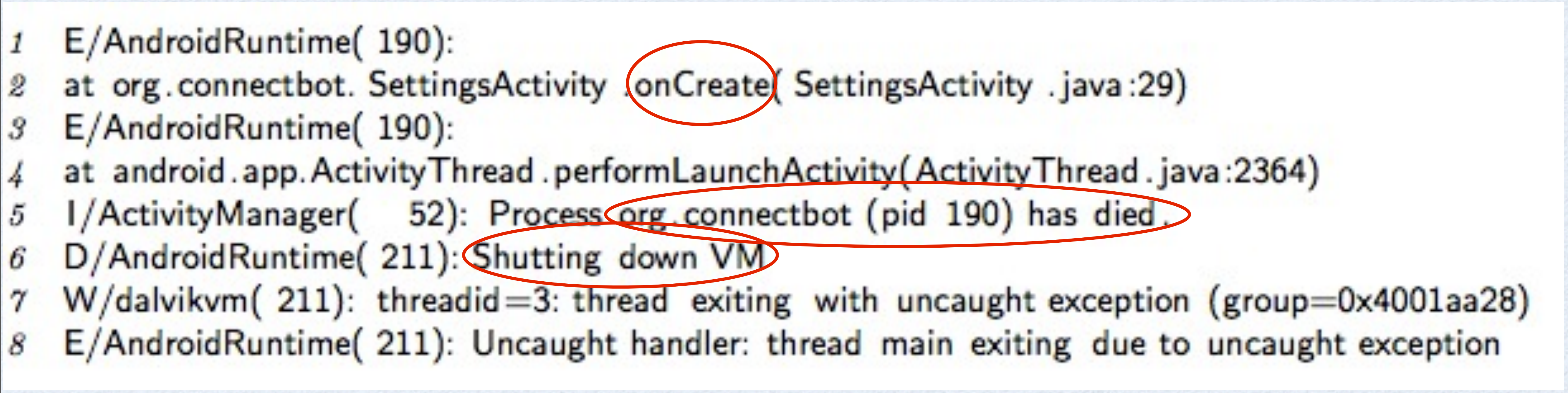

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```

Results

Program	**Bugs reported (bugs we found)**		
	Activity	*Event*	*Type*
Skylight1	3 (3)	2 (5)	0 (0)
CMIS	0 (0)	0 (0)	0 (0)
Delicious	0 (0)	0 (0)	0 (0)
ConnectBot	2 (4)	8 (8)	2 (2)
DealDroid	1 (1)	1 (0)	0 (0)
Rokon	0 (0)	6 (6)	2 (2)
Andoku	0 (1)	0 (0)	0 (0)
Opensudoku	1 (1)	1 (2)	0 (0)
GuessTheNumber	1 (1)	1 (1)	0 (0)
MonolithAndroid	0 (0)	2 (2)	0 (0)
Total	**8 (11)**	**21 (24)**	**4 (4)**

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Opensudoku	1 (1)	1 (2)	0 (0)
GuessTheNumber	1 (1)	1 (1)	0 (0)
MonolithAndroid	0 (0)	2 (2)	0 (0)
Total	**8 (11)**	**21 (24)**	**4 (4)**

Conclusions

- ✦ Android applications prone to specific errors (activity, event)
  - ✦ We perform a bug study and categorization on 10 Android applications
- ✦ New Android-specific verification techniques needed
  - ✦ We implement a tool to detect activity/event/type bugs (Available on http://www.cs.ucr.edu/~huc)
  - ✦ Our work proved effective for detecting Android bugs
- ✦ Our approach can be extended to capture other types of bugs like API, I/O, or concurrency errors