Android Provenance: Debugging Device Disorders

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Android OS

- Smartphone Operating System by Google
- 49.4% Market share in the US [1]
- 75% Market share worldwide [2]
- Over 700,000 apps at the end of 2012 [3]
- Developers average ~$2,700 per app, per month [4]

Traditional Development and Debugging

- Eclipse – Open Source IDE
  - Android Developer Tools and Debugger
- Android SDK (“Java” Apps and the Framework API)
  - Emulator
  - Automatic UI Interactions (Monkey, MonkeyRunner, uiautomator – Not related)
  - System tracing utilities
  - Static code analysis
- Android NDK (Native libraries)
  - A compiler, a linker, and a non-standard C library.

Challenges to Traditional Debugging on Android

- Lots of Inter-Process Communication (IPC)
  - Both within the app and through the framework
- Lots of Asynchronous Functions and Threading
- Background processes, foreground processes in the same App

Complex Device Disorders

- Performance issues
- Bug’s disappearing with the debugger (Heisenbugs)
- Battery life issues
- How can we solve these issues when all our tools focus on a single application?

How can we debug complex disorders?

Provenance!

Provenance for Troubleshooting

- Chiarini's Provenance for System Troubleshooting [5].
- Focuses on *nix based server environments
- Goals were to improve a system's administrators mental model of the system.

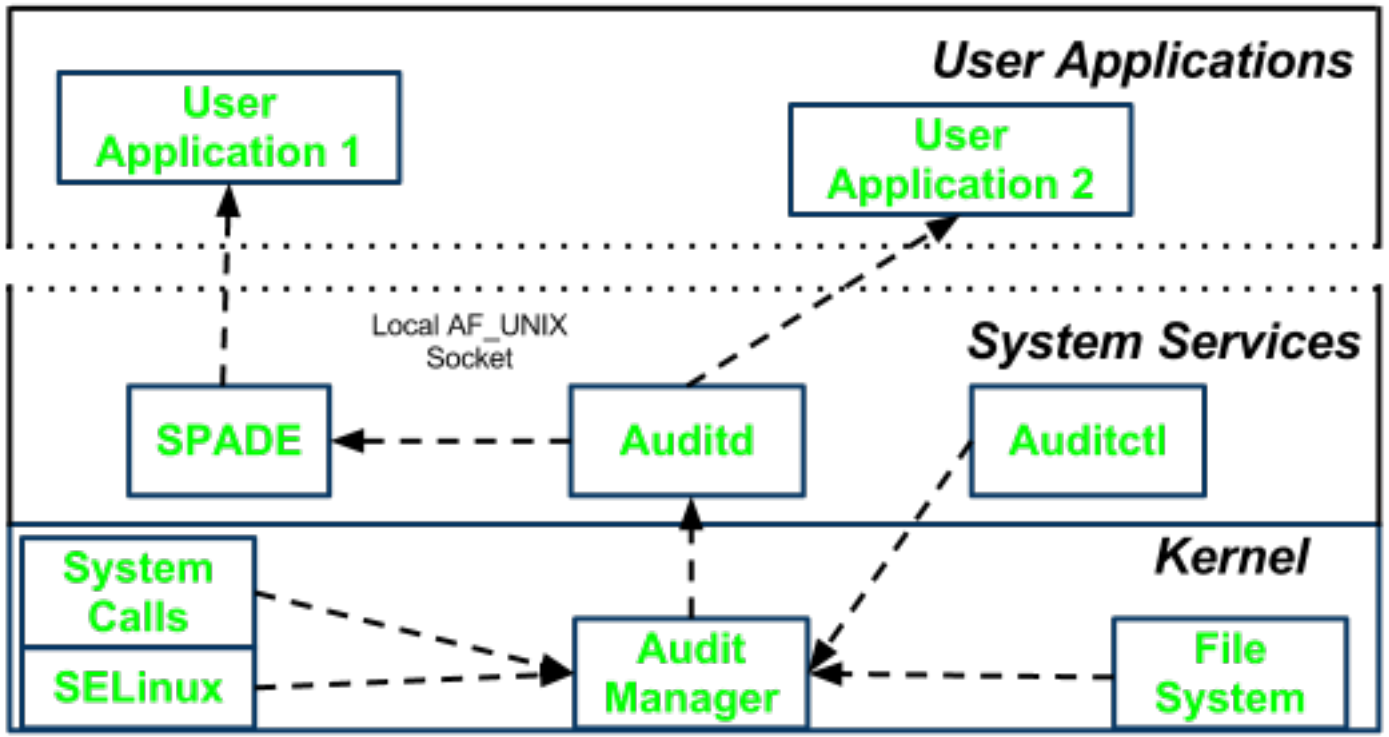
Our Contribution: Provenance for Debugging

- A manner to gather low level system provenance on Android with minimal performance impact
- A way of quickly querying our provenance output

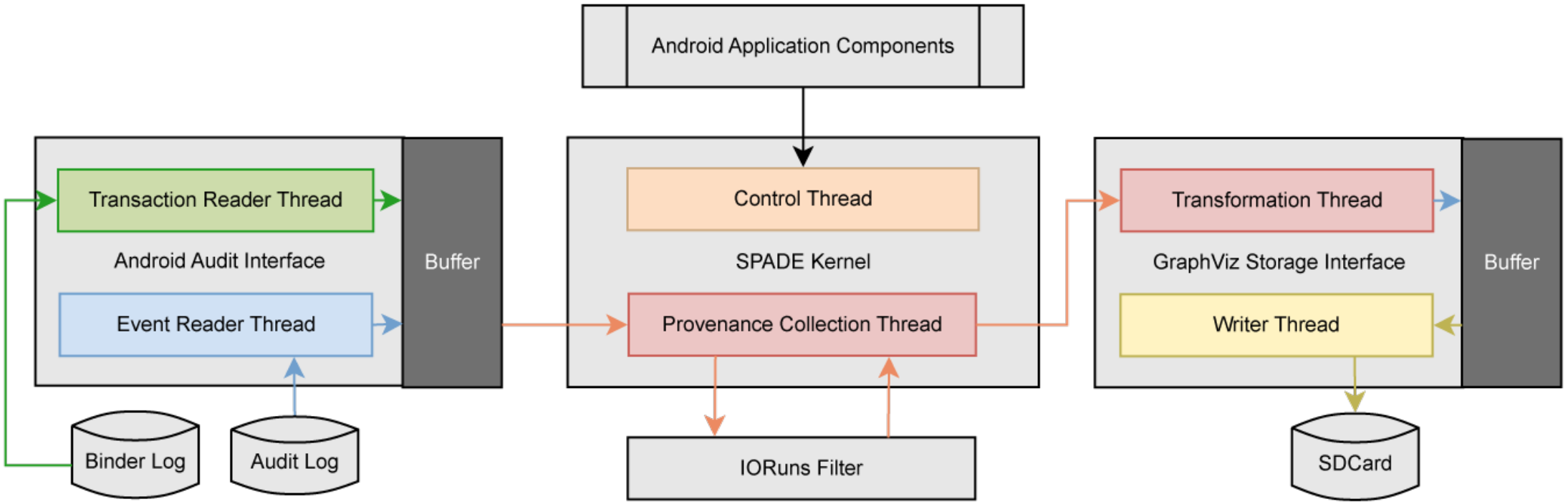
Provenance for Debugging Requirements

- Low level Information Source: Linux Audit [4]
- A Data Provenance System: SPADE [5]
- A Provenance Querying Method
  - Built in to SPADE

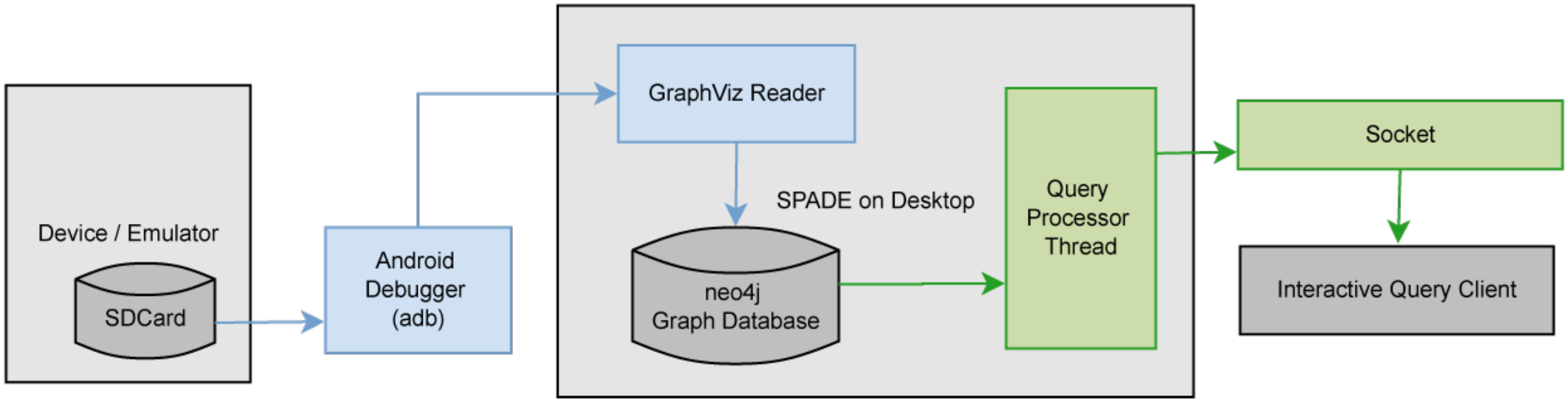
Information Source: Linux Audit



Provenance System: SPADE for Android



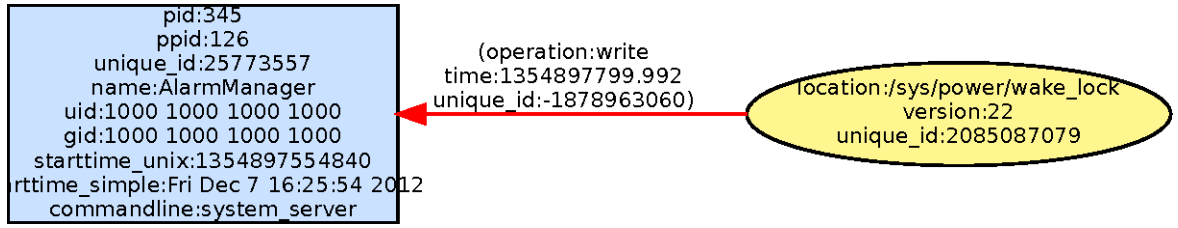
Querying the Android SPADE database



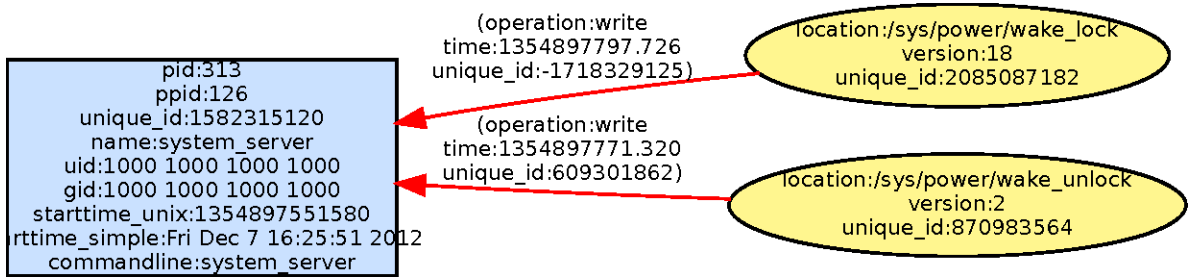
Provenance Debugging Methodology

- Installed Android ports of SPADE and Audit on a Samsung Galaxy Nexus phone running a custom Android (AOSP) OS.
  - https://github.com/nwhusted/AuditdAndroid
  - http://spade.csl.sri.com/SPADE/Downloads.html
- Configured Audit to ignore information regarding SPADE and itself
- We ran our example applications and manually interfaced with them
- Final output was analyzed on a desktop machine
  - Output graphs were ~900 vertices and ~5000 edges
- Output was filtered with SPADE's Interactive Query Client

Provenance for Solving Wakelocks



BUGGY!



Correct!

result = getEdges(location:*wake *lock, null, operation:write)

Provenance for Solving UI Latency

- Enthusiast replaces blocking calls to /dev/random
- Potential solution: Call /dev/urandom instead.
- It's easy to identify if a call is being made to /dev/random instead of /dev/urandom:
  - result = getEdges(null, location:/dev/*random, operation:read)

Provenance Has Little Performance Impact

Performance Benchmarks	
Configuration	**AnTuTu Score**
Factory Default	7890
Audit Only	7770
Audit with SPADE	7760

- Score Context
  - 8634 (according to website)
  - 16301 (Galaxy S III)

Conclusion

- Our system captures complicated system bugs
- Our system impacts performance negligibly
- Querying system bugs is “straight forward”
- Querying still requires expert knowledge of the system
  - This could be eased by increased developer tools
  - Google could integrate our method in to their tool chain

Acknowledgements

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References

1. http://www.theinquirer.net/inquirer/news/2250787/android-takes-the-us-smartphone-market-share-lead-for-january
2. http://readwrite.com/2013/01/29/why-do-americans-hate-android-and-love-apple
3. http://mashable.com/2012/11/01/google-apps-tie-apple/
4. http://www.neobytesolutions.com/which-mobile-oss-apps-make-most-money/
5. http://www.usenix.org/event/lisa11/tech/full_papers/Chiarini.pdf