STAAF

An Efficient Distributed Framework for Performing Large-Scale Android Application Analysis

OWASP AppSec USA

Thursday, September 22, 2011

Allow Me to Introduce Myself

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VP Engineering at Praetorian

- **OWASP DFW Chapter Leader**
  (2011)
- **Active member of The Honeynet Project**
  (2002-)
- **8+ years of work with DoD, Intelligence Community, Federal/State/Local governments, and Fortune 500 companies**

PRAETORIAN®

YOUR WORLD, SECURED

WE ACT AS TRUSTED ADVISORS WHO HELP ORGANIZATIONS BETTER UNDERSTAND AND MINIMIZE OVERALL RISK ACROSS I.T. ASSETS, SO THEY CAN FOCUS ON WHAT'S IMPORTANT - THEIR CORE BUSINESS.

Software Security

Evaluate your application's security over its entire development lifecycle

Security Research

Leverage outside expertise to solve advanced problems

Infrastructure Security

Measure the overall strength of your company's secuirty program

Security Training

Learn online, and in a classroom environment, from the experts

Presentation Roadmap

- **STAAF (Overview)**
- Background
- STAAF (Deep Dive)
- Results
- Future Work
- Conclusions

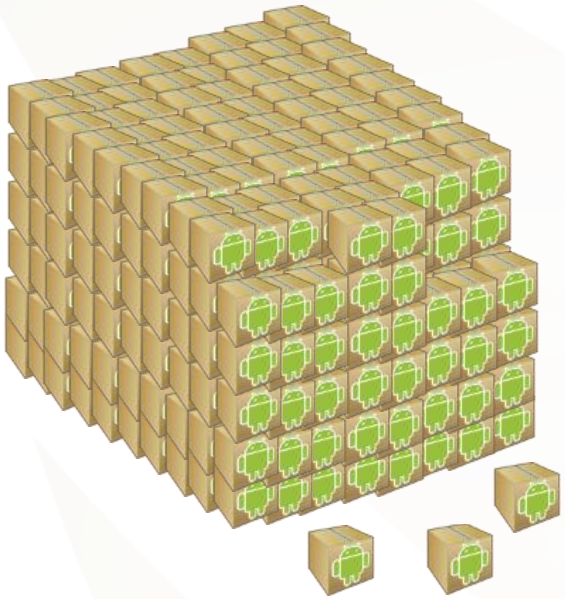
What can STAAF do for you?

Observation #1:
There are a lot of Android app analysis tools freely available

BUT:
They're typically designed for single app analysis

STAAF leverages the power of these tools as modules, And adds efficiency, scalability, data mgmt and sharing

What can STAAF do for you?



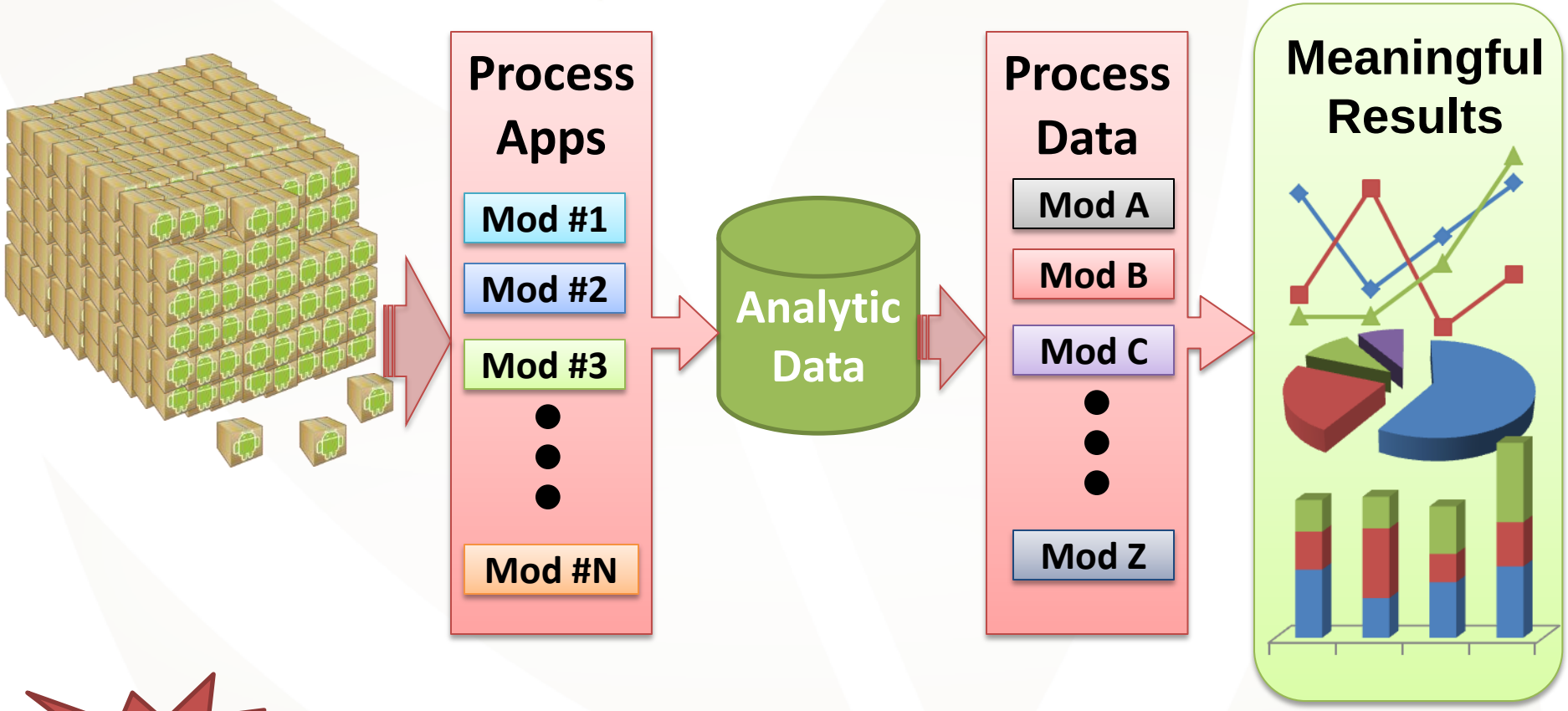
Observation #2:
Higher value analysis can be attained by analyzing large numbers of applications over long periods of time

SOLUTION:
Reduce the time and complexity for an analyst to process large numbers of apps

Goal

Analyze 50k apps in less than 2 days and make the extracted data readily available to analysts

What can STAAF do for you?



Goal

Minimize analysts' effort to extract meaningful results from a large number of applications

What is STAAF

SCALABLE

TAILORED

APP ANALYSIS

FRAMEWORK

What is STAAF

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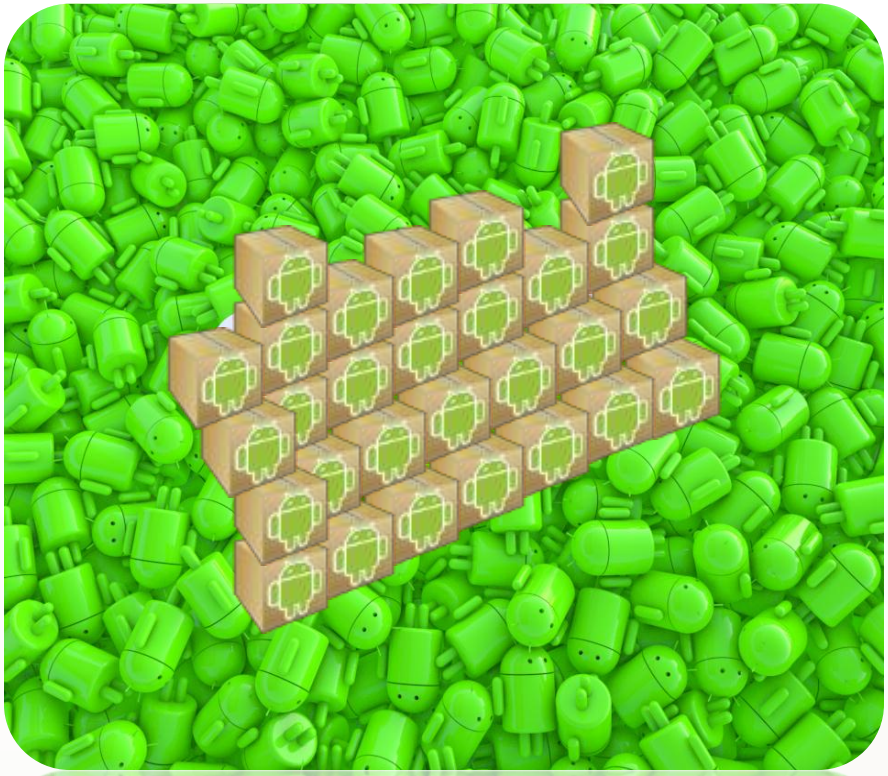
FRAMEWORK



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What STAAF is NOT

- STAAF is not a stand alone application
- STAAF is not *only* a malware detection or anti-virus engine
- STAAF is not an application collection tool

STAAF is a problem agnostic app analysis framework

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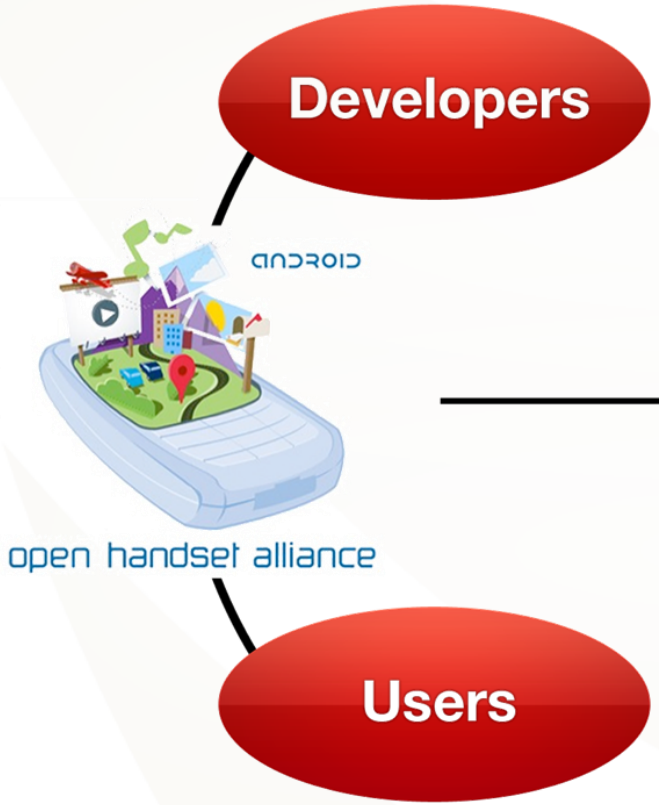
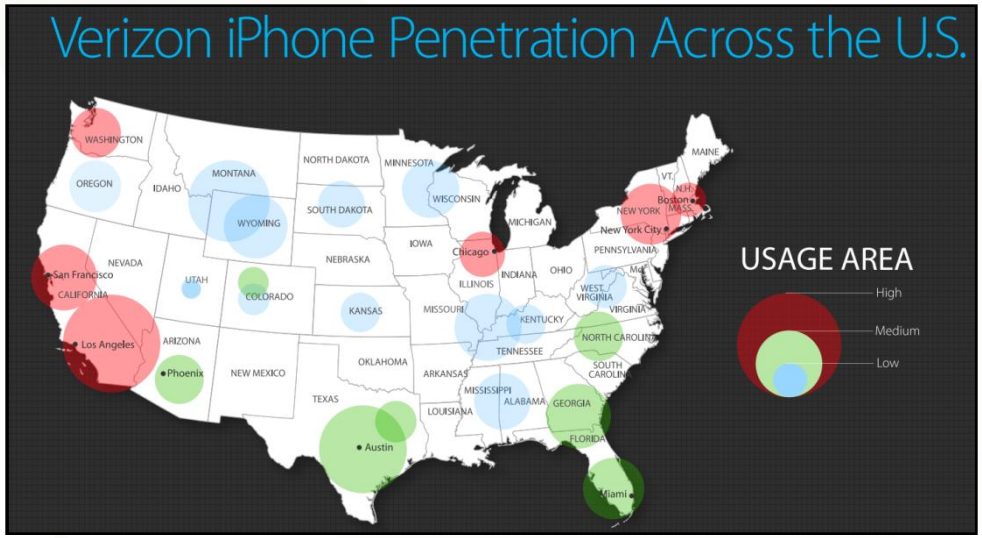
Android's Open App Model



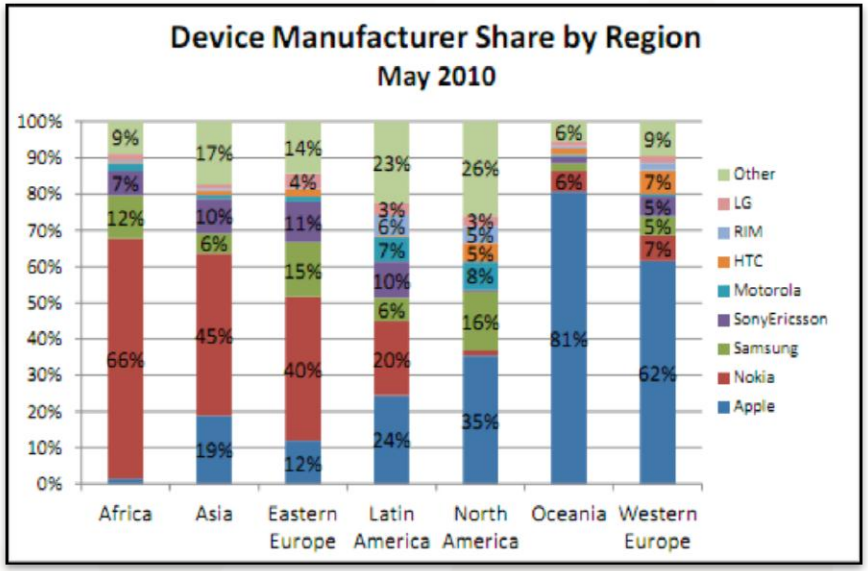
- Low barrier to entry
- Apps hosted and installed from anywhere
- All apps are created equal

- No distinction between core apps and 3rd party apps
- Accept apps based on:
  1. Trust of the source
  2. Permissions requested

“Legitimate” Monitoring Apps



Ad/Marketing Networks



Social Gaming Networks

“Not-So-Legitimate” Permission Use

SMS Trojan

- Link to site hosting rogue app for “free movie player”
- Sends 2 Premium SMS messages to a Kazakhstan number (about $5 per message)

Gemini

- Repackaged apps in Chinese markets
- Sex positions and MonkeyJump2 are known examples
- Central C&C
- Exfiltrates unique device identifiers
- Downloads and Install New Apps (with permission)

DroidDream

- Approx. 50 Malicious apps in **official** market
- Central C&C
- Exfiltrates unique device identifiers
- Downloads additional code modules

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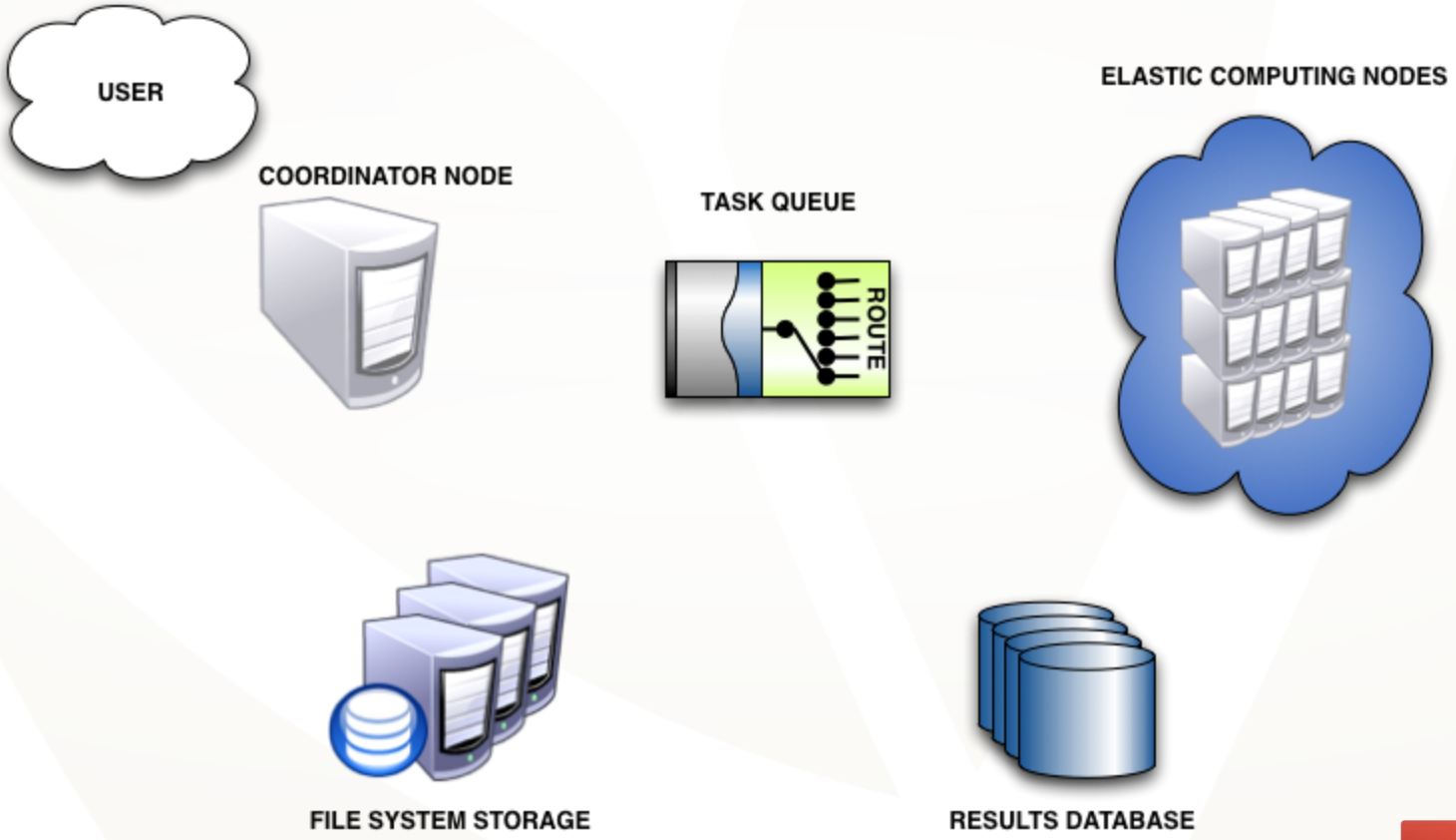
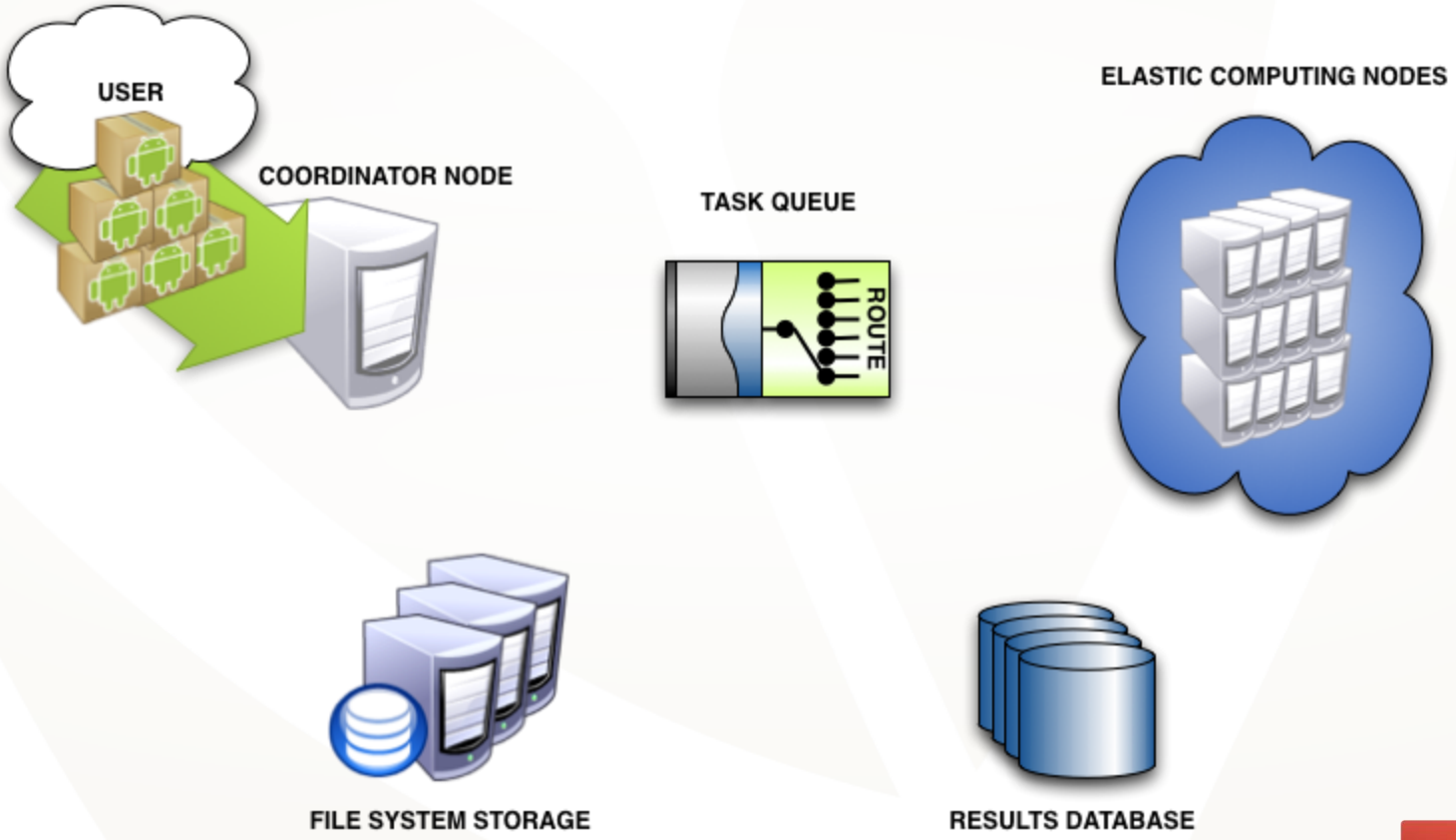
STAAF Workflow

Step 0: STAAF components initialized



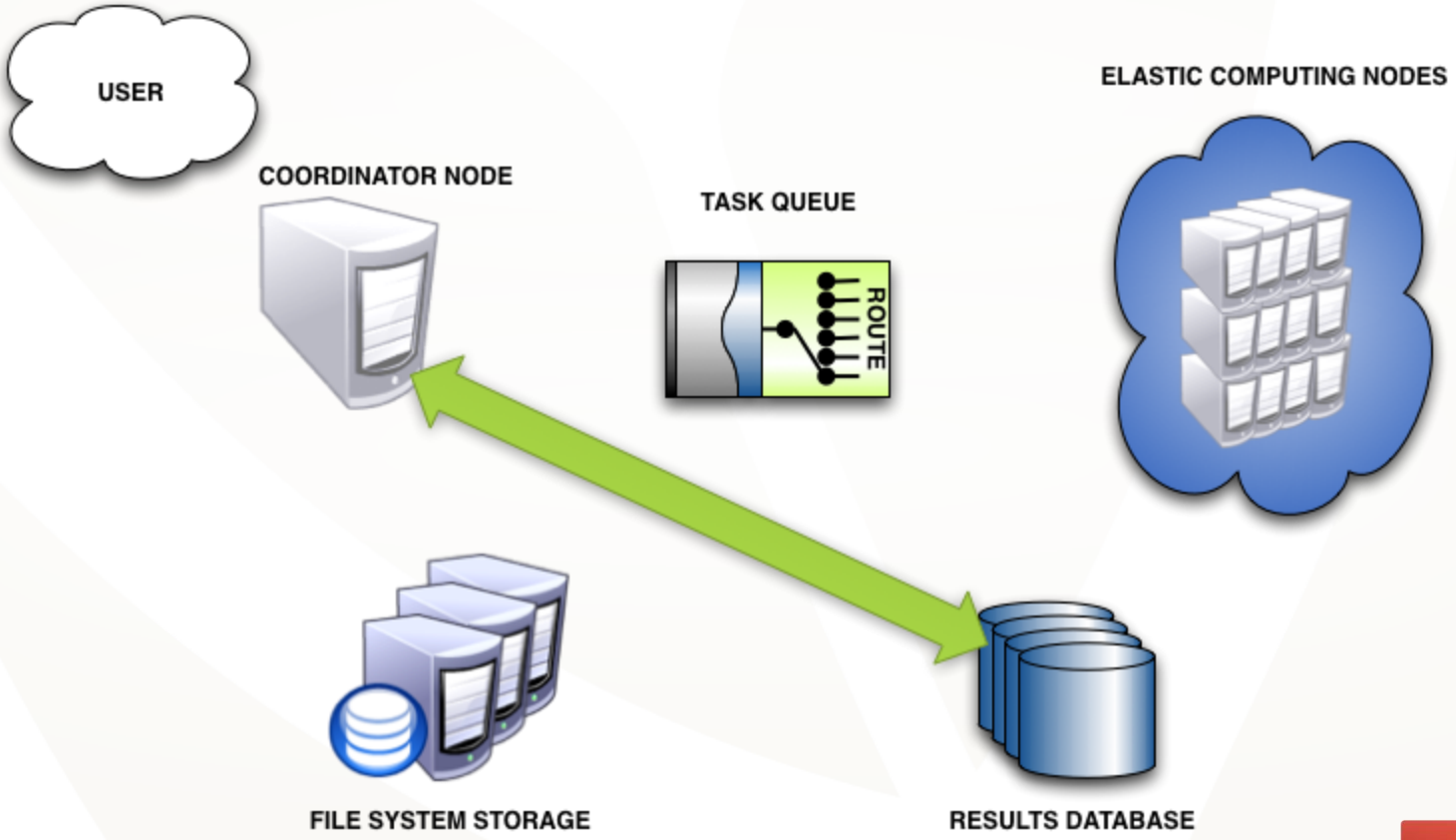
STAAF Workflow

Step 1: Users sends APKs to be processed



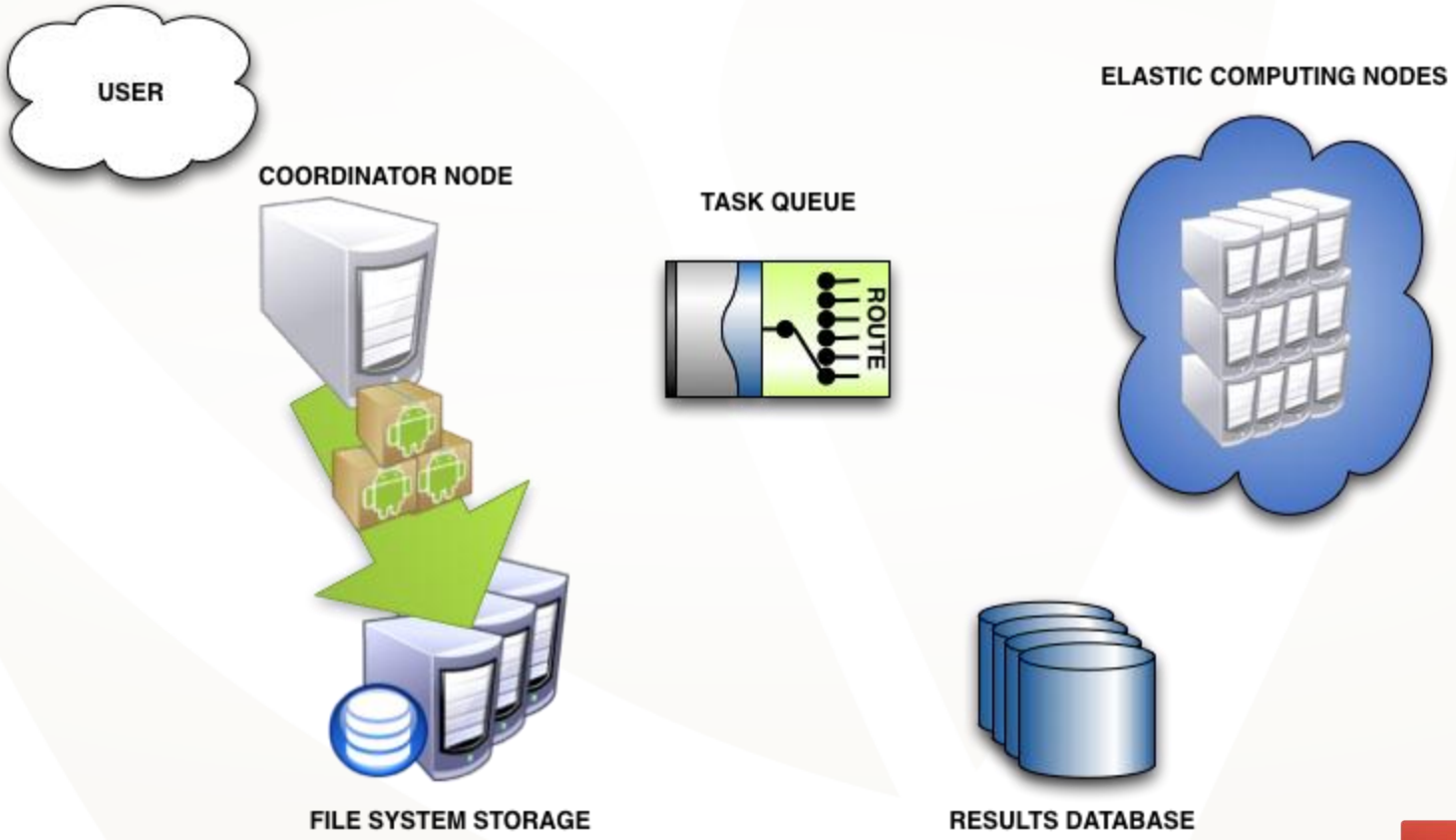
STAAF Workflow

Step 2: Coordinator checks database for previous results and logs new instance data for each APK



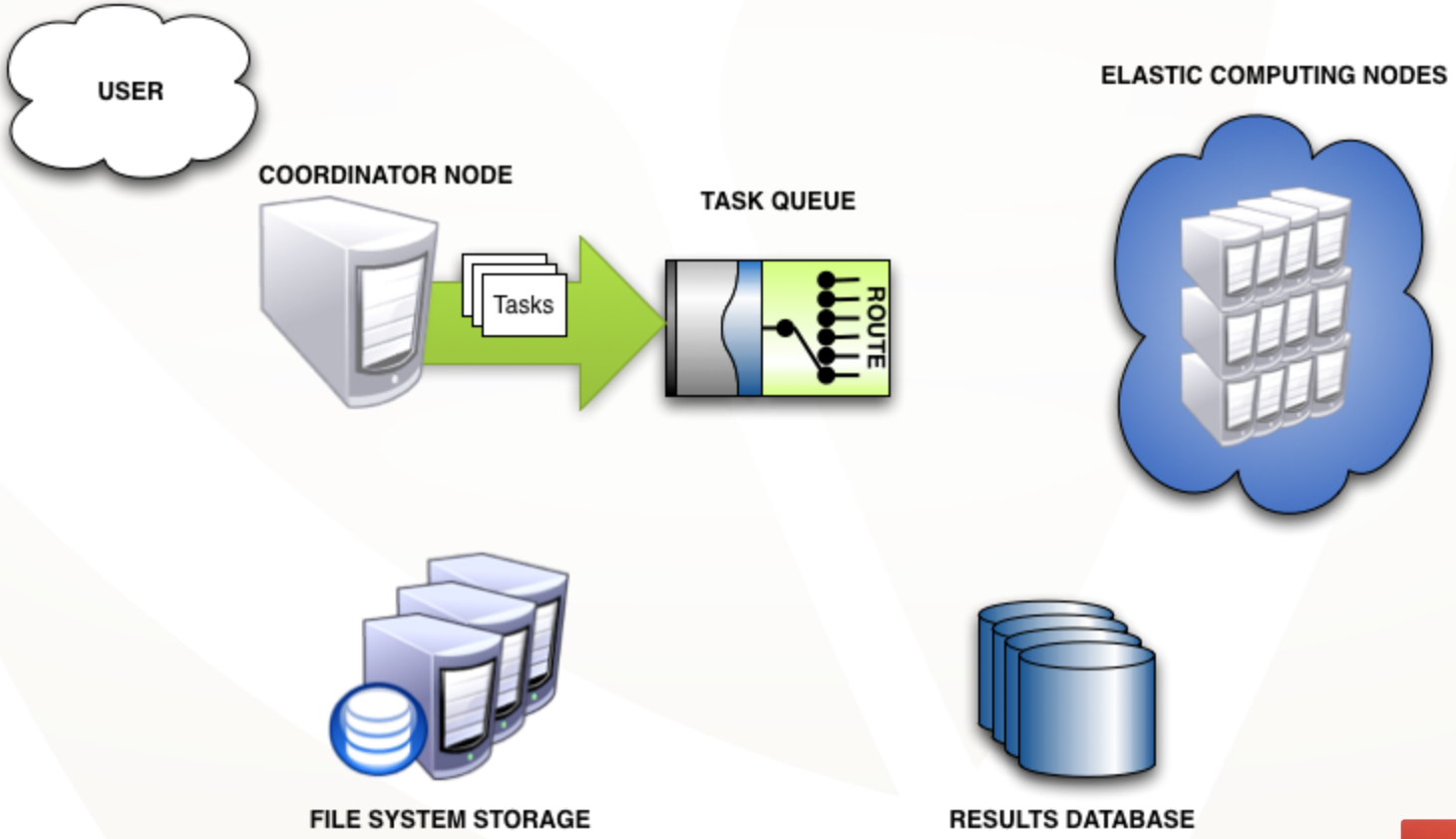
STAAF Workflow

Step 3: Coordinator sends new APKs to the file repository service



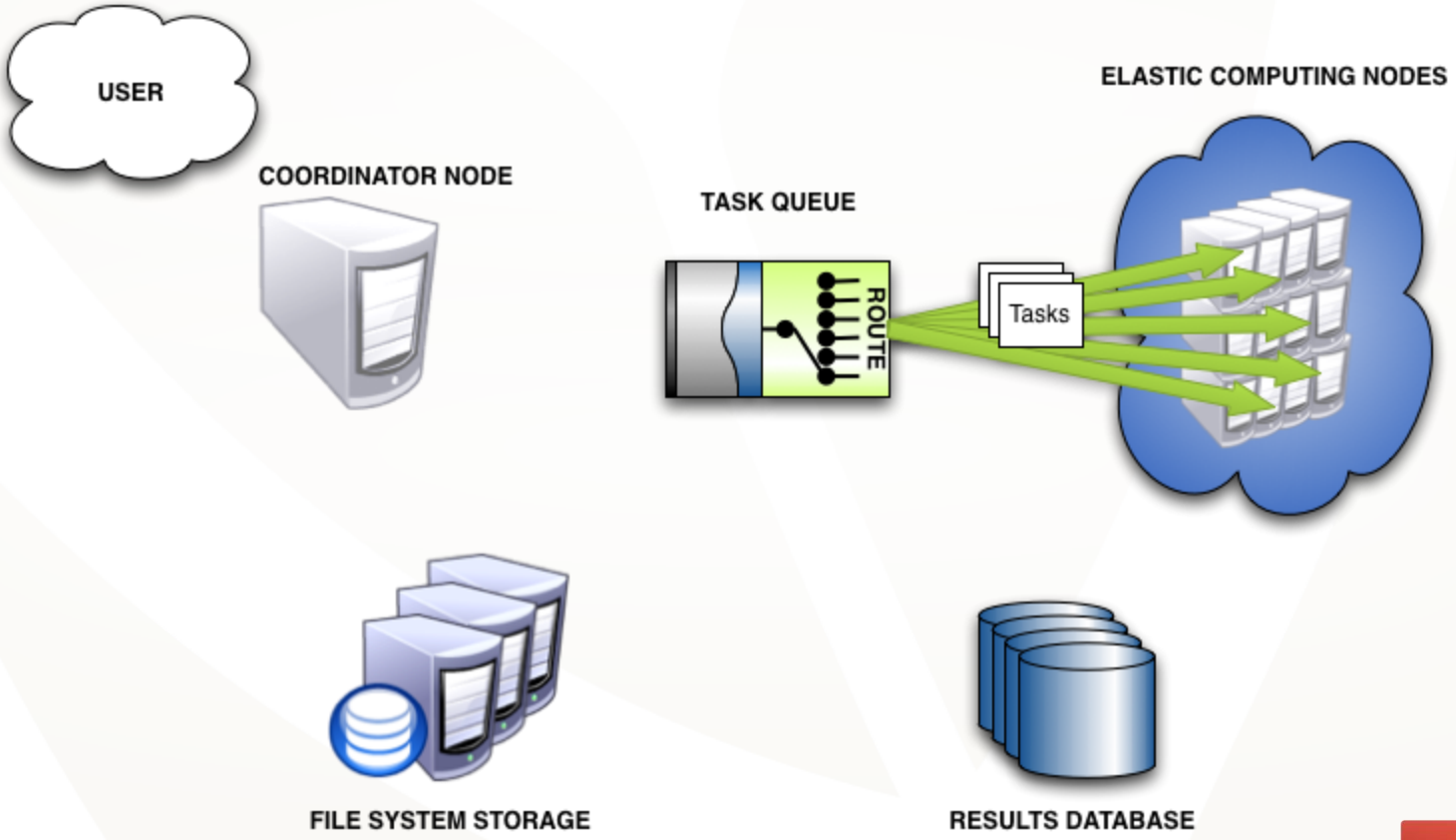
STAAF Workflow

Step 4: Coordinator sends tasking orders to the task queue



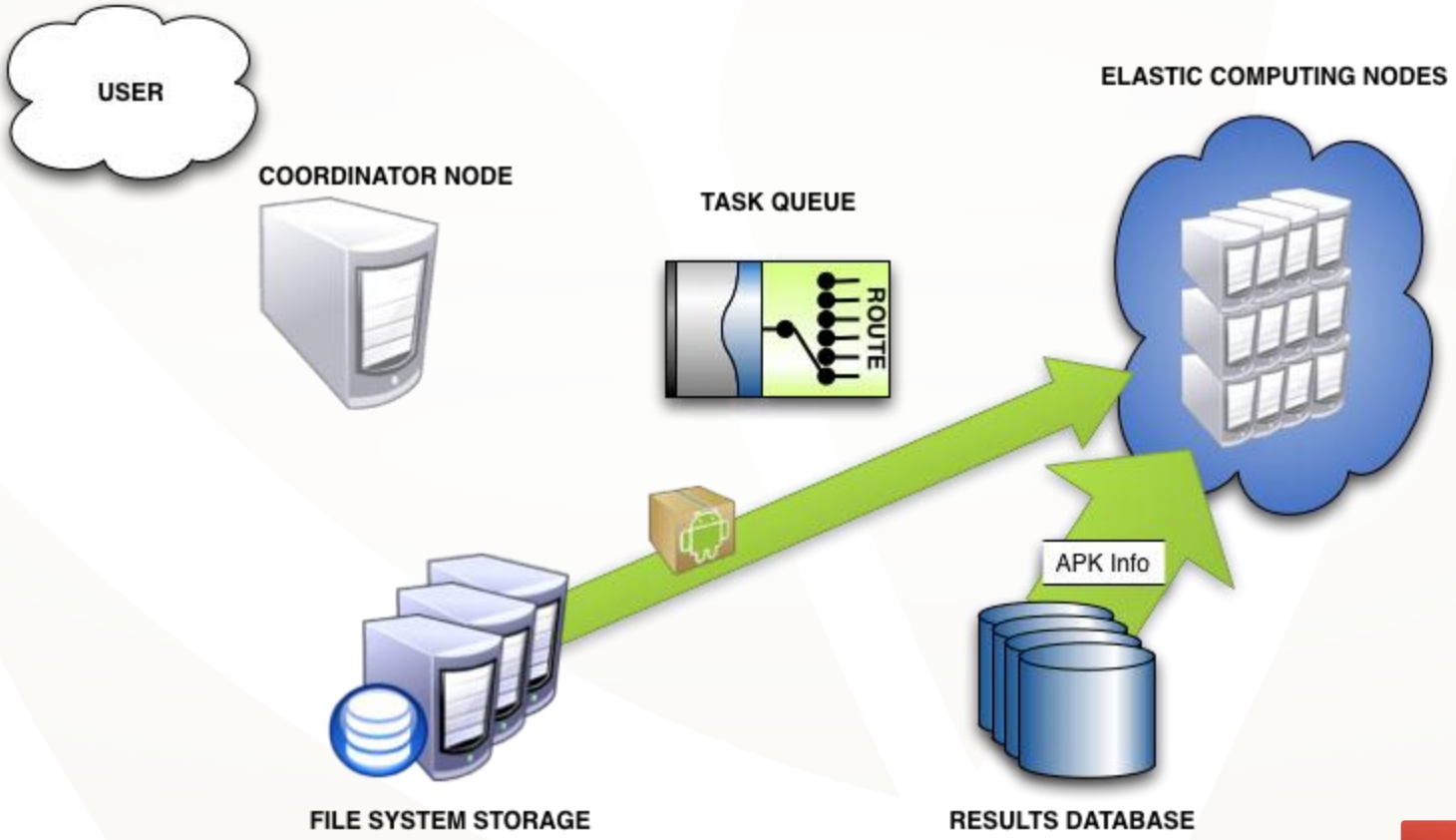
STAAF Workflow

Step 5: Elastic computing nodes pull tasks from their designated task queue



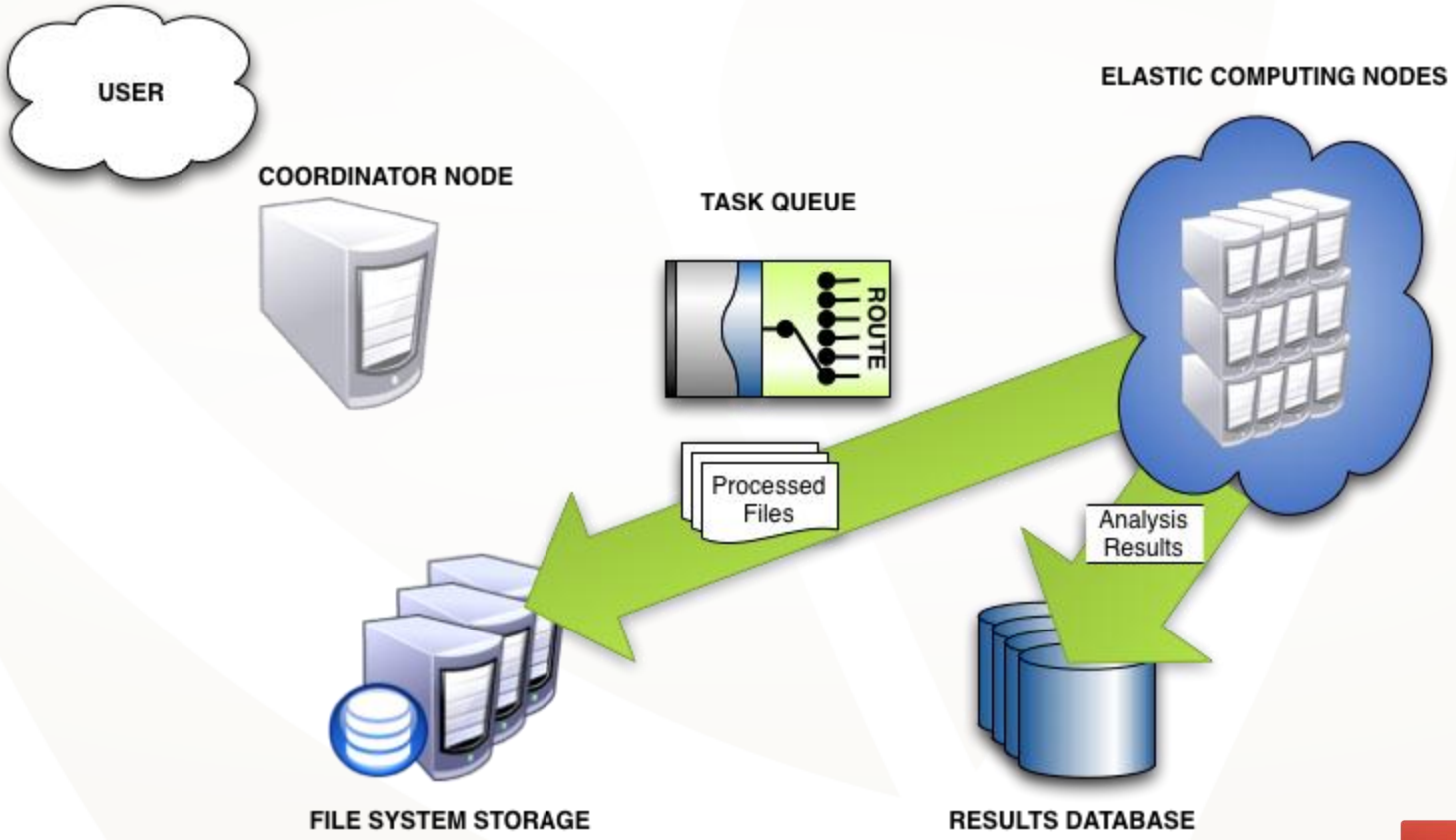
STAAF Workflow

Step 6: Elastic computing nodes pull in the APK and related information



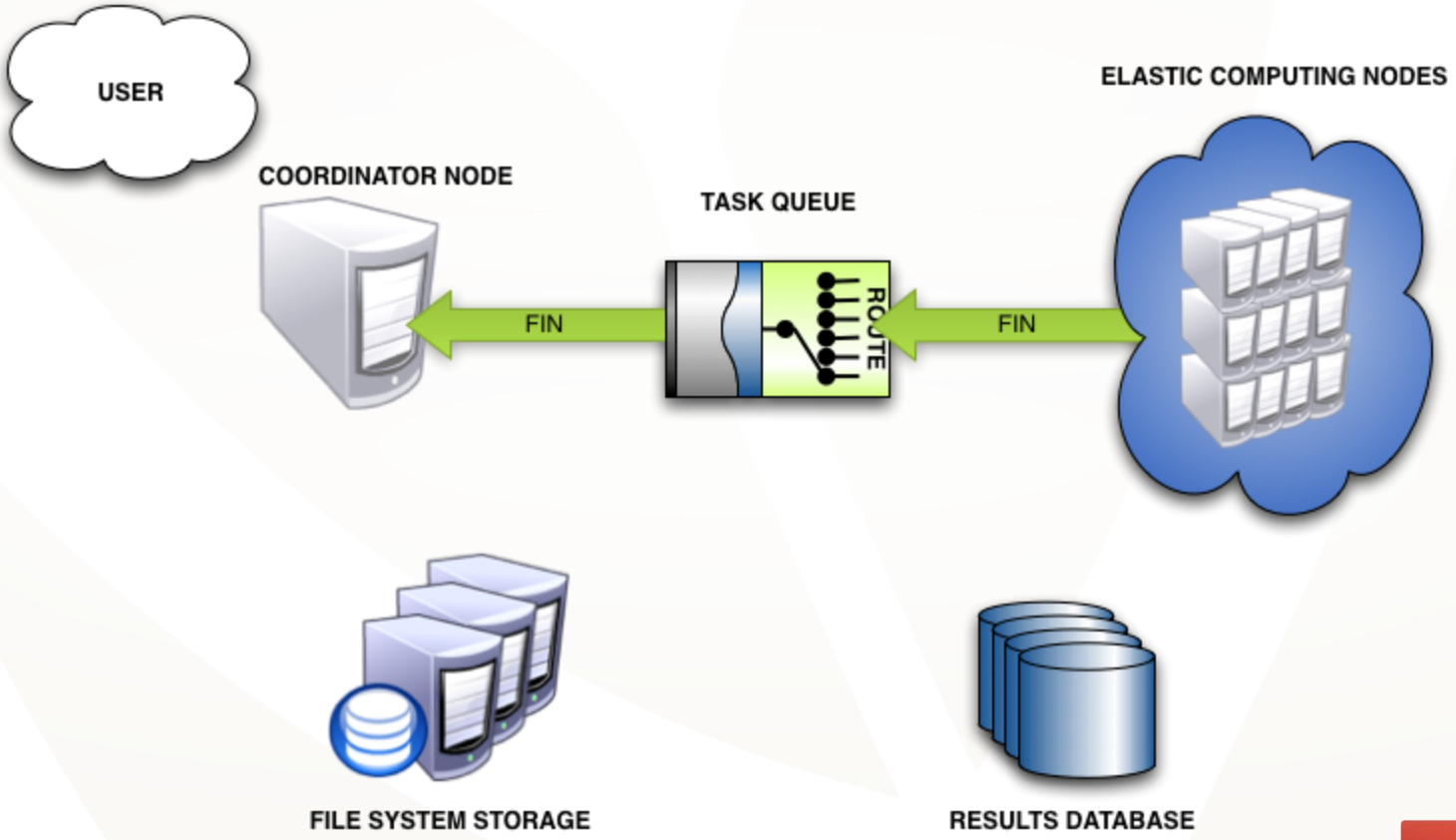
STAAF Workflow

Step 6: After processing the elastic computing nodes push out processed files and analysis results



STAAF Workflow

Step 7: When all tasking is complete elastic computing nodes notify the coordinator

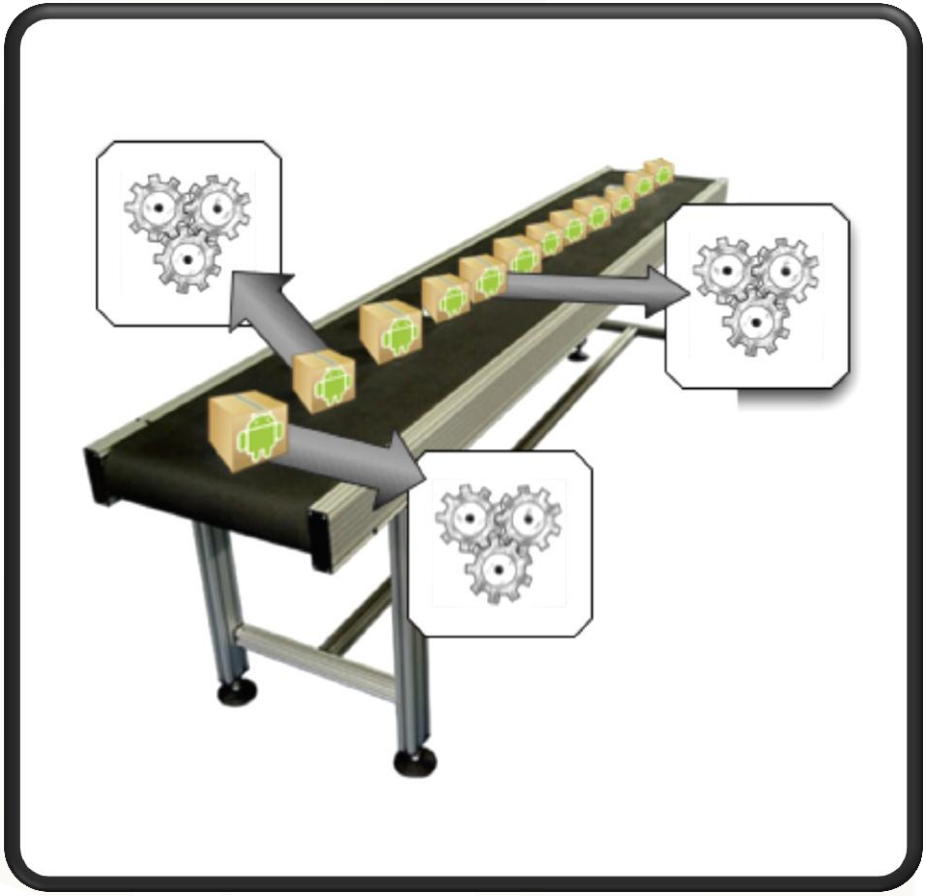


Task Modules

- Can be registered dynamically
- Task-Oriented
  - High level
    - What % of apps use permission X
    - What is the most common libraries used
  - Mid level
    - Extract Permissions
    - Extract static URLs
    - Extract Methods Called
  - Low level
    - Extract manifest
    - Extract Dex bytecode

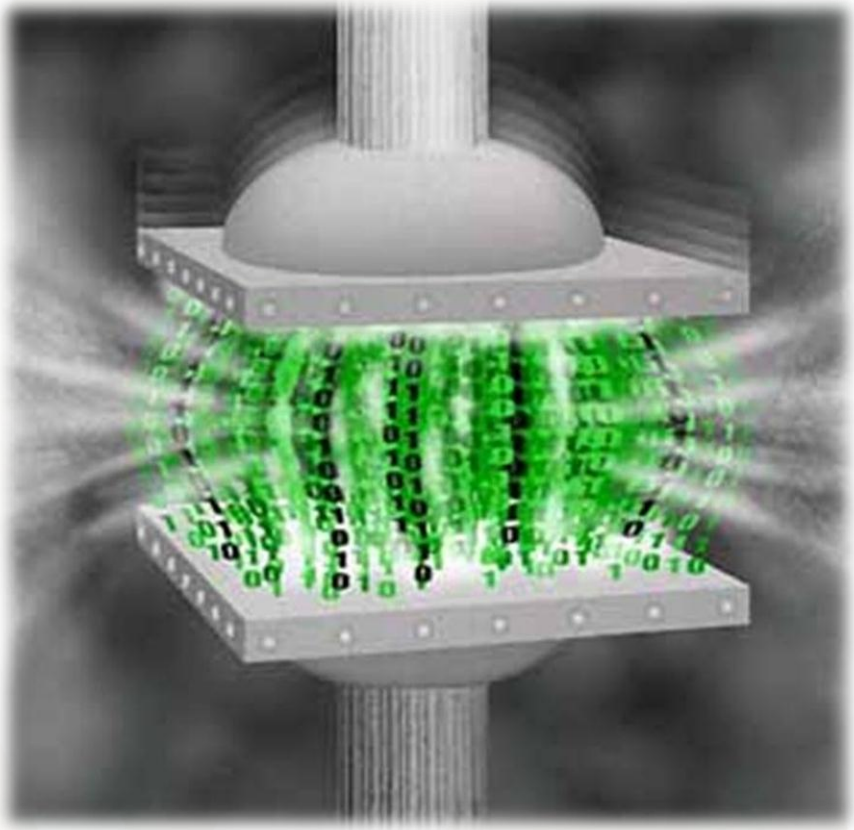
PRIORITY

COMPLEXITY



Deduplication of Effort

- All Intermediate data are cached for later use
  - Extract and convert manifest to ASCII
  - Extract Dex and convert to Smali and Java
  - Compute the control flow graph from the Dex
- Libraries and shared resources must only be processed once
- Apps must only be processed once by each module, ever



Small savings matter at large scales

Distributed Data Sharing

- Sharing app samples is just the beginning
- Share the entire process:
  - Raw Application
  - Extracted Resources
  - Raw Data
  - Processed Data
- Or set specific limits on what data is shared

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Time Trials

	STAAF Performance Tests				
#	Time	Apps	ECUs	Nodes	Database
1	2h25m	500	1	1	Central
2	2h00m	500	1	2	Central
3	1h56m	500	1	4	Central
4	0h36m	500	1	4	Local
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6	0h28m	500	5	4	Central
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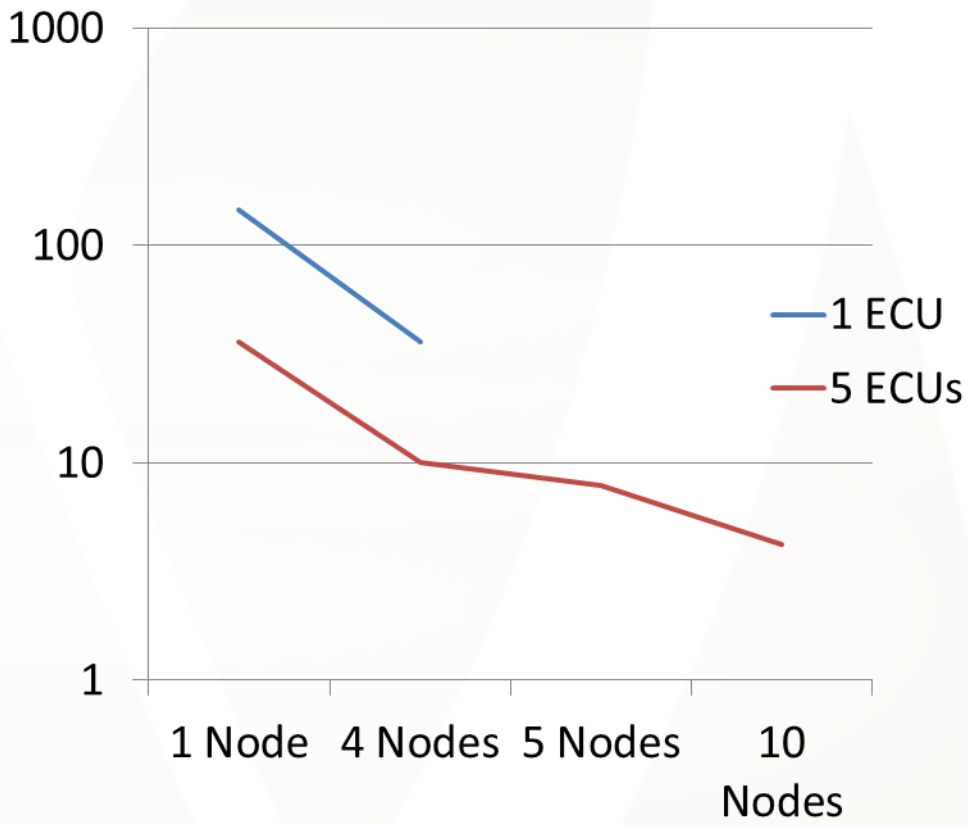

Achieved 50k apps in ~7 hours*

***Extrapolated from shorter tests**

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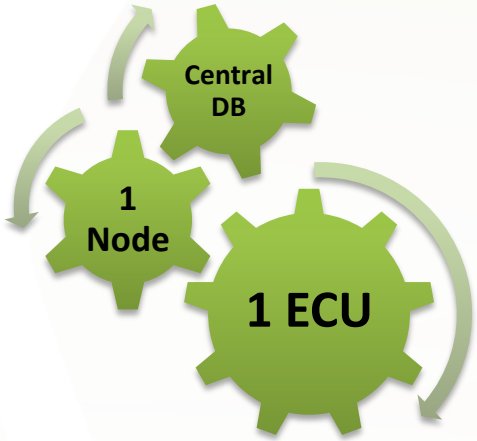

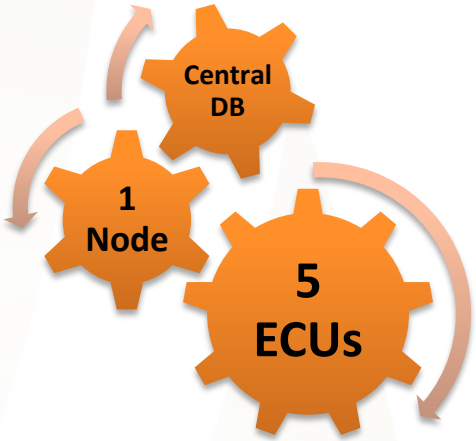

Compute Time 2h25m

Compute Time 0h36m

"One EC2 Compute Unit (ECU) provides the equivalent CPU capacity of a 1.0-1.2 GHz 2007 Opteron or 2007 Xeon processor." -Amazon

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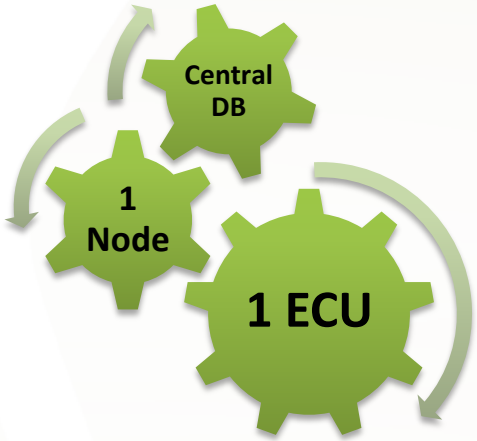

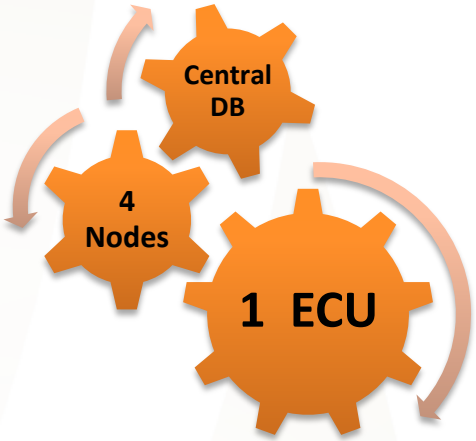

Compute Time 2h25m

Compute Time 1h56m

STAAF is bound by both CPU and database throughput

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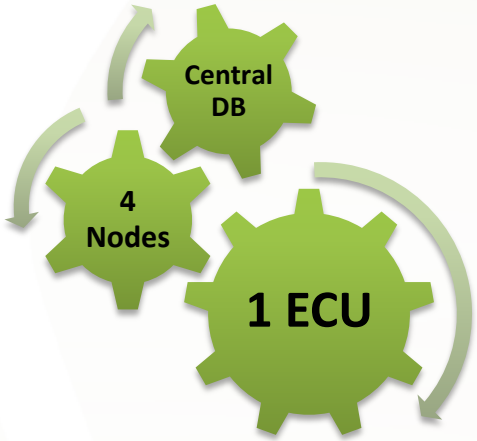

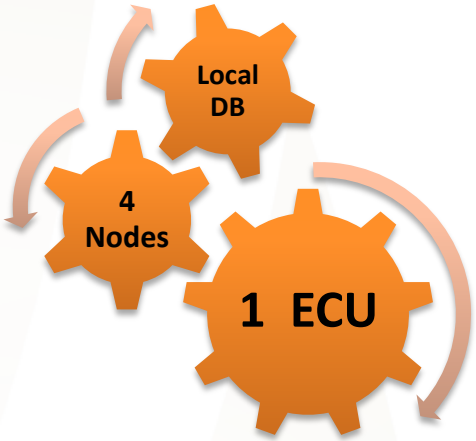

Compute Time 1h56m

Compute Time 0h36m

By using distributed, local databases STAAF achieves a significant time performance increase

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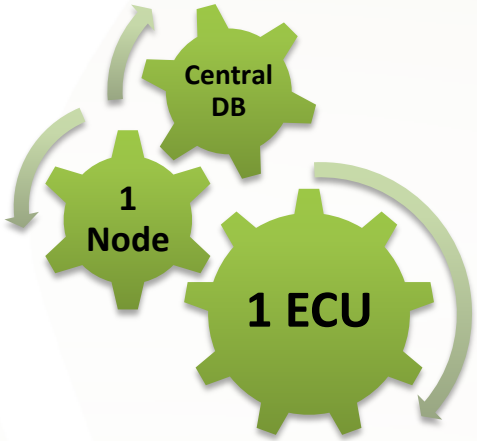

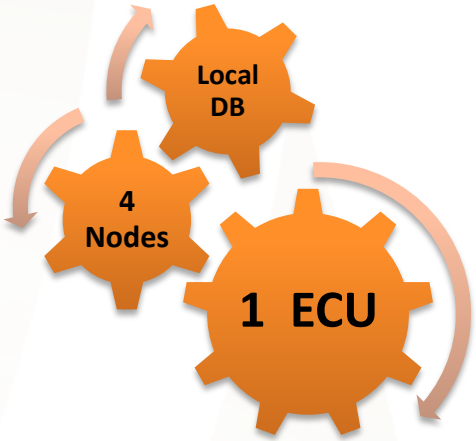

Compute Time 2h25m

Compute Time 0h36m

Using by adding multiple processors with local databases, we achieve near linear scalability

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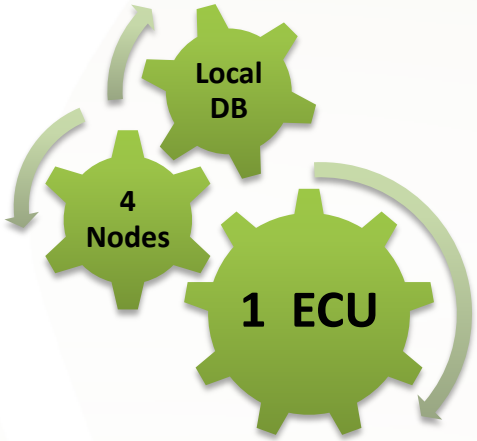

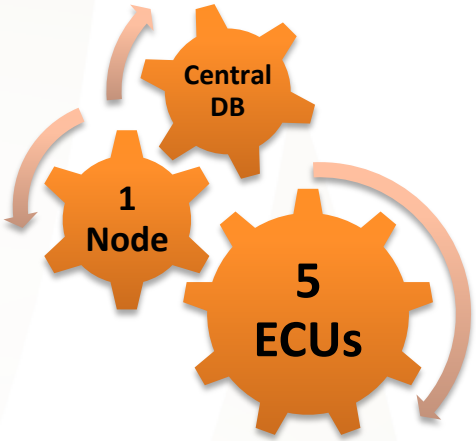

Compute Time 0h36m

Compute Time 0h36m

By simply increasing the CPU capacity to 5 ECUs, we achieve the same performance as four 1 ECU nodes

Time Trials

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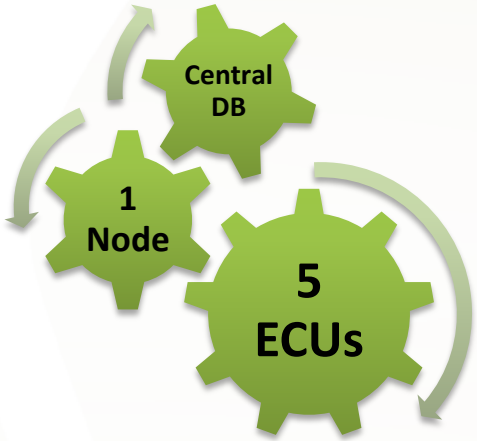

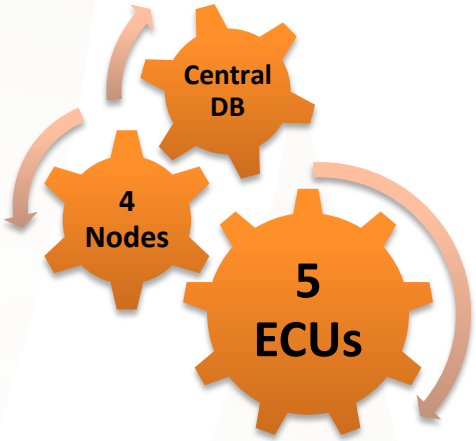

Compute Time 0h36m

Compute Time 0h28m

Once again, using a central database fails to achieve linear performance gains

Time Trials

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1	2h25m	500	1	1	Central
2	2h00m	500	1	2	Central
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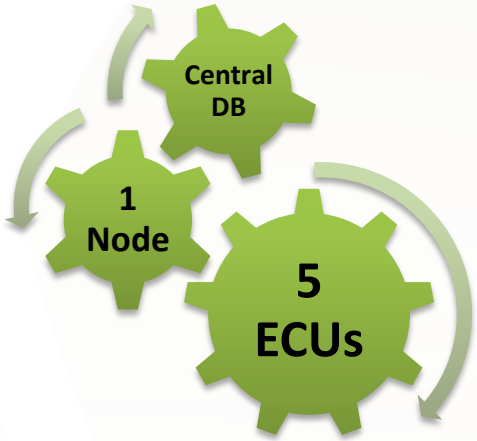

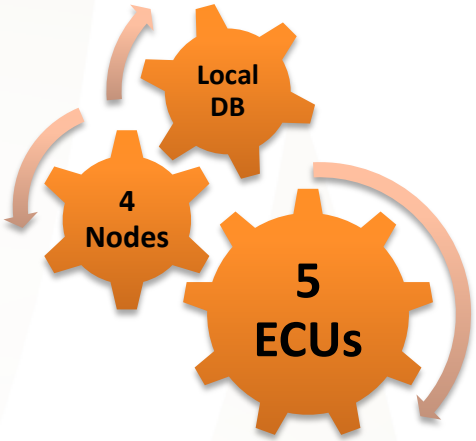

Compute Time 0h36m

Compute Time 0h10m

By using distributed, local databases we once again achieve near linear performance gains

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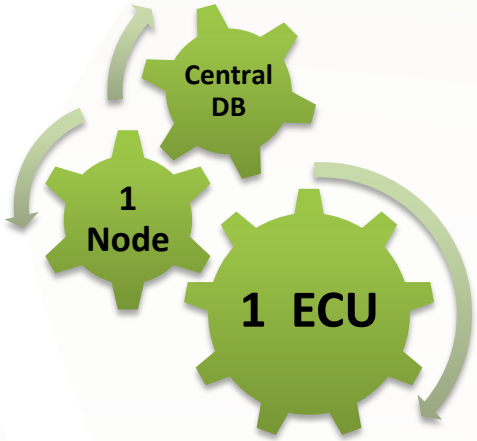

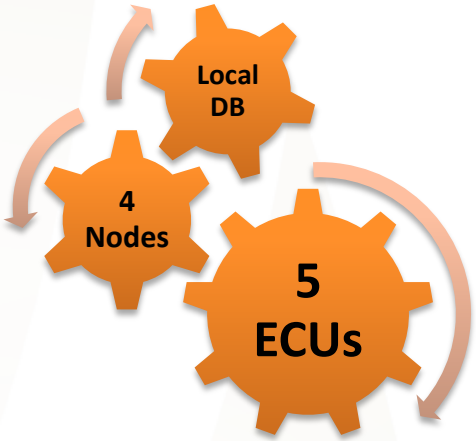

Compute Time 2h25m

Compute Time 0h10m

By increasing CPU capacity, number of processing nodes, and number of databases, we decreased processing time by 14.5x

Time Trials

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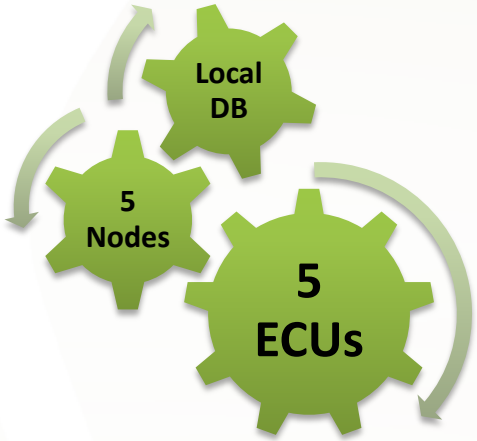
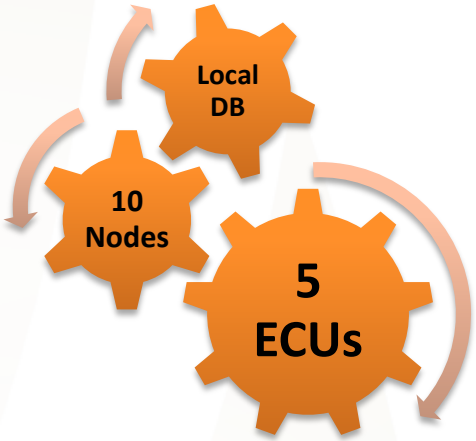
9	1h19m	9349	5	10	Local





1722 Apps
Compute Time 0h27m

9349 Apps
Compute Time 1h19m

Larger tests confirm that STAAF continues to scale linearly

Initial Results :: Permissions Requests

53,000 Applications Analyzed

- **Android Market:** ~48,000
- **3rd Party Markets:** ~5,000

Permissions Requested

- **Average:** 3
- **Most Requested:** 117

Location Data	11,929 (24%)
Read Contacts	3,636 (8%)
Send SMS	1,693 (4%)
Receive SMS	1,262 (4%)
Record Audio	1,100 (2%)
Read SMS	832 (2%)
Process Outgoing Calls	323 (1%)

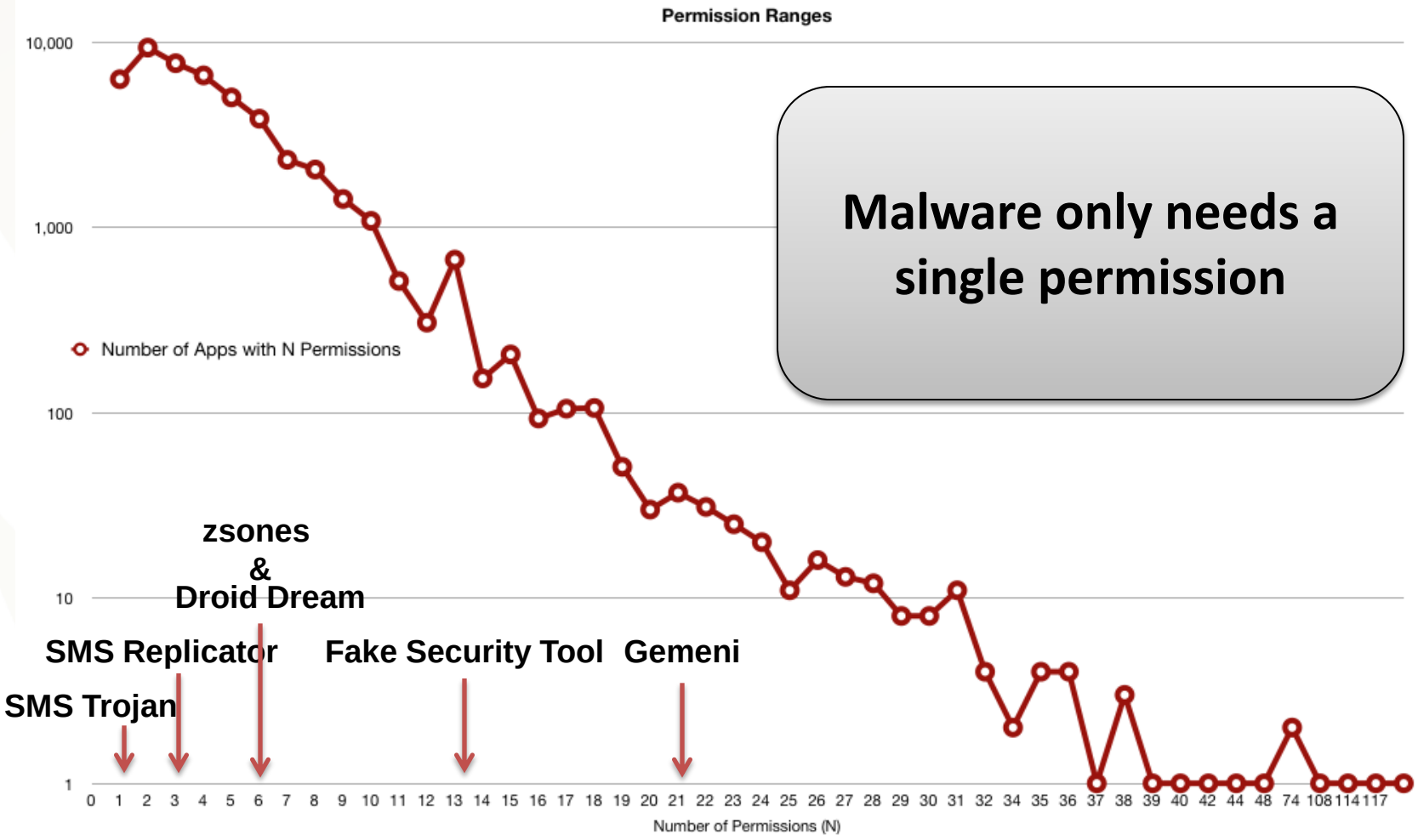
Additional Results :: Shared Libraries

53,000 Applications Analyzed

- **Android Market:** ~48,000
- **3rd Party Markets:** ~5,000

com.admob	38% (18,426 apps)
org.apache	8% (3,684 apps)
com.google.android	6% (2,838 apps)
com.google.ads	6% (2,779 apps)
com.flurry	6% (2,762 apps)
com.mobclix	4% (2,055 apps)
com.millennialmedia	4% (1,758 apps)

Permissions Are Not a Good Indicator



Malware only needs a single permission

Presentation Roadmap

- STAAF (Overview)
- Background
- STAAF (Deep Dive)
- Results
- **Future Work**
- Conclusions

STAAF's Future

- Build a publically available user interface
- Provide a dashboard with global stats
- Further Tune database performance issues
- Build more complex analysis modules
  - Static data flow analysis
  - Dynamic sandbox analysis
- Expose a public module interface through UI

Presentation Roadmap

- STAAF (Overview)
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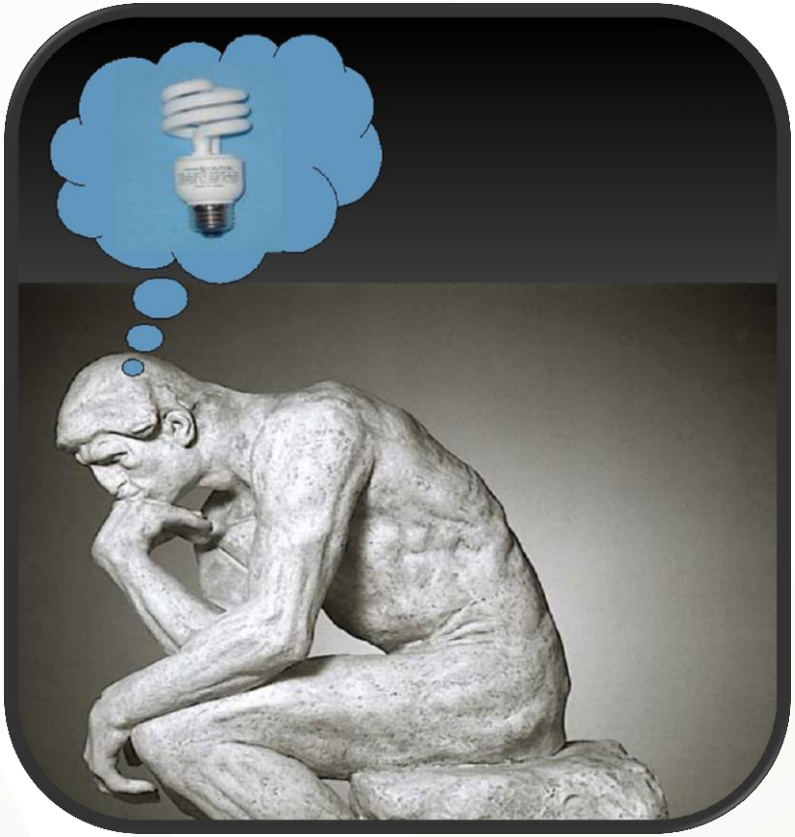
- **Conclusions**

Final Thoughts

- STAAF is a system of systems and services, not an application
- STAAF enables large scale Android application analysis
- STAAF is problem agnostic and can be tailored to answer many analytic questions
- STAAF augments the capabilities of the analyst, it does not replace them
- STAAF achieves scalable performance increases by increasing computer nodes/power



Q&A