SEApp: Bringing Mandatory Access Control to Android Apps

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Speakers

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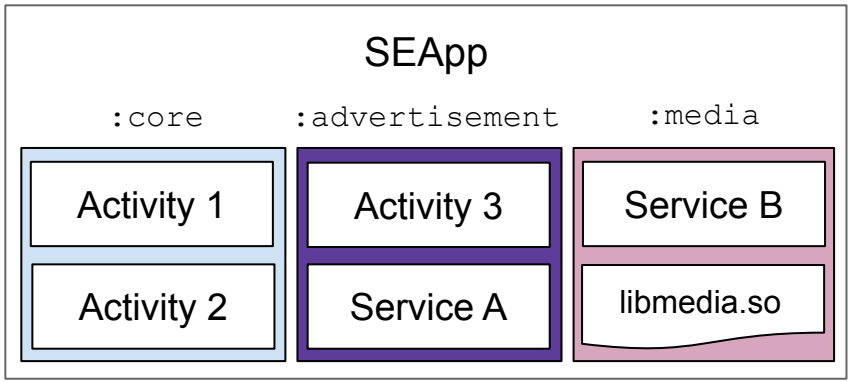
Motivation

Retain control on which components access sensitive data, and limit the impact of internal vulnerabilities

- every component has complete access to the **internal storage**
- 3rd-party libraries may **abuse** app **privileges**
- large and complex components prone to **bug** are not easy to **isolate**

Idea

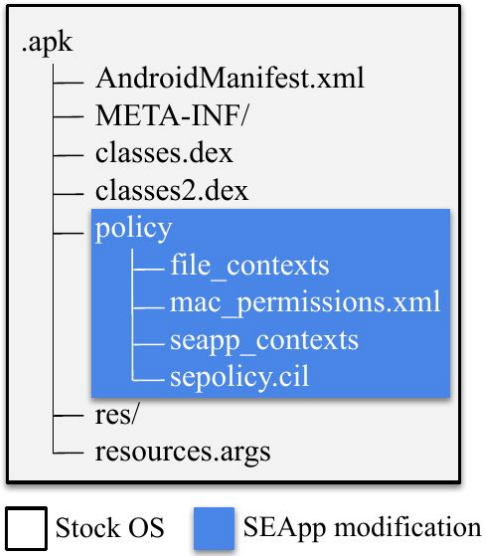
1. Separate components into different app processes
2. Regulate with SELinux the permissions at process level



A component falls into a process based on its `android:process` value in the manifest

Policy module

Each app provides a policy module. The policy module lists the security contexts associated with processes and files.



file_contexts

```
.*                u:object_r:app_data_file:s0
dir/unclassified  u:object_r:pkg_name.unclassified_file:s0
dir/secret        u:object_r:pkg_name.secret_file:s0
```

seapp_contexts

```
user=_app seinfo=cert_id domain=pkg_name.unclassified name=pkg.name:unclassified
user=_app seinfo=cert_id domain=pkg_name.secret name=pkg.name:secret
```

sepolicy.cil

```
(block package_name
      (type secret)
      (call md_appdomain (secret))
      (typebounds untrusted_app secret)
      (allow secret cameraserver_service (service_manager (find)))
...)
```

Policy language syntax

Declare types and assign them permissions

- `type` and `typeattribute` declare types and attributes
- `typeattributeset` populates attributes to improve policy conciseness
- `allow` grants permissions to types and attributes
- `call` adds a set of predefined policy statements and improve usability

Guide and enforce constraints

- `block` wraps the policy in a unique namespace
- `typebounds` bounds the permissions of a type to a parent type

Policy language constraints

To preserve the overall consistency of the SELinux policy, each policy module:

- **must not** change the system policy
- **must** have an impact only on processes and resources associated with the app itself

Policy constraints are enforced at **installation time** and **runtime**

Origin of types and attributes

Using the `block` statement we detect the origin of types and attributes

- **local**: defined within the policy module (ns equal to the package name)
- **global**: defined by the system

Origin determines valid `allow` and `typeattributeset` policy statements

For example, the use of types or attributes defined by other modules is prohibited

Constraining `allow` statements

AllowSS represents a direct modification of the system policy **[denied]**

```
(allow isolated_app app_data_file (file (open)))
```

AllowAA defines privileges internal to the app module **[permitted]**

```
(allow mydomain mytype (file (create getattr open read write)))
```

AllowAS when a local type needs to be granted a permission on a system type **[bounded]**

```
(allow mydomain activity_service (service_manager(find)))
  ↳ (typebounds untrusted_app mydomain)
```

AllowSA regulates how system components access internal types **[denied]**

```
(allow gpuservice mytype (file (open)))
```

Macros

But we need to **ensure interoperability** with services crucial to the app lifecycle (e.g., Zygote).

So we introduce macros.

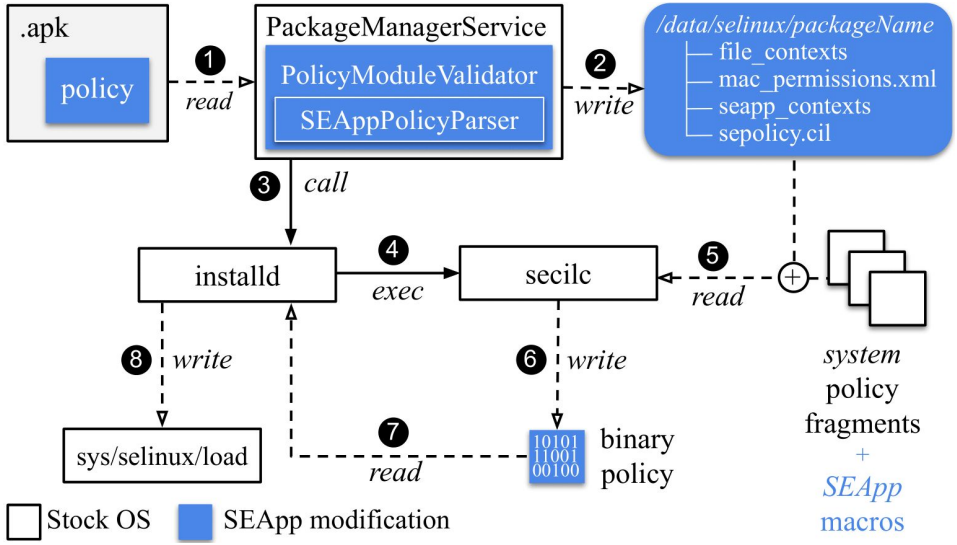
```
(call md_appdomain (mydomain))
```

Benefits:

- safe by design, a predefined set of statements is added to the policy (i.e., by extending system domains that already have permissions on `untrusted_app` and `app_data_file`)
- no need for the app developer to know or understand system policy internals

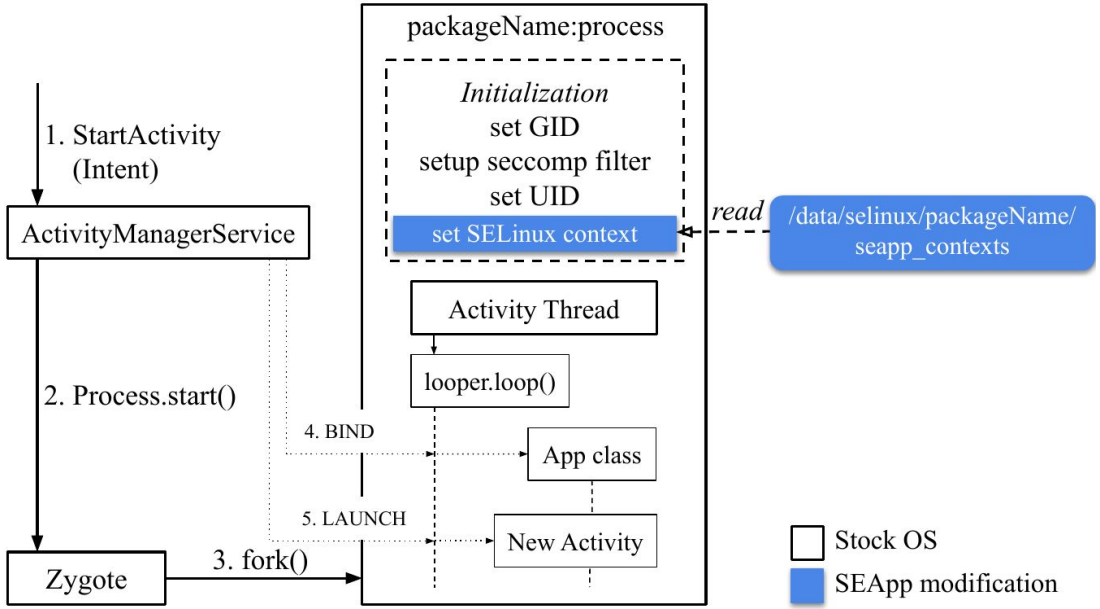
Install time support

Changes to the app installation procedure



Runtime support: processes

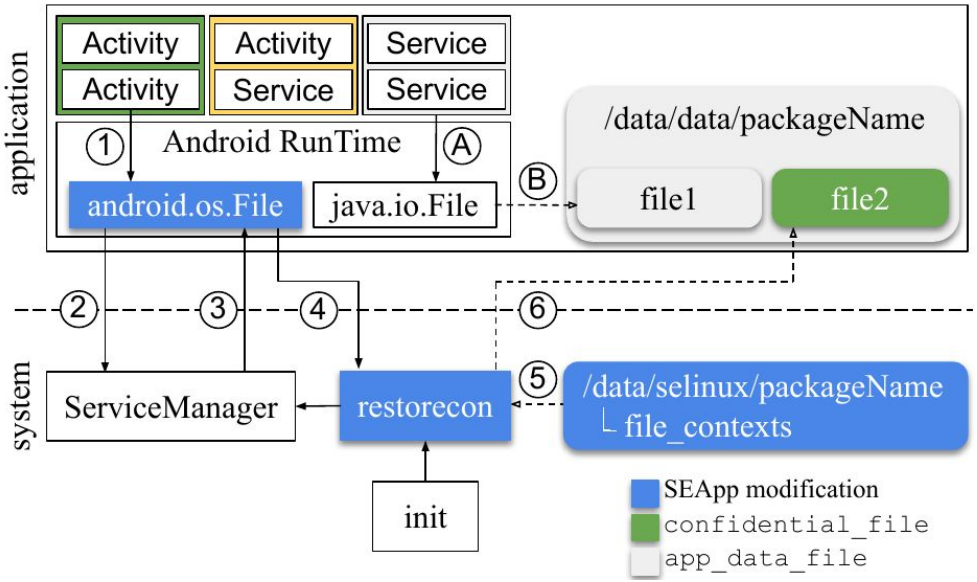
`Zygote` was modified to enable runtime process labeling



Runtime support: files

Introduction of `restorecon` service to enable file labeling

The call to the `restorecon` service is performed transparently by `android.os.File`, a new API with the same interface of `java.io.File`)



Boot procedure

Since **Treble**:

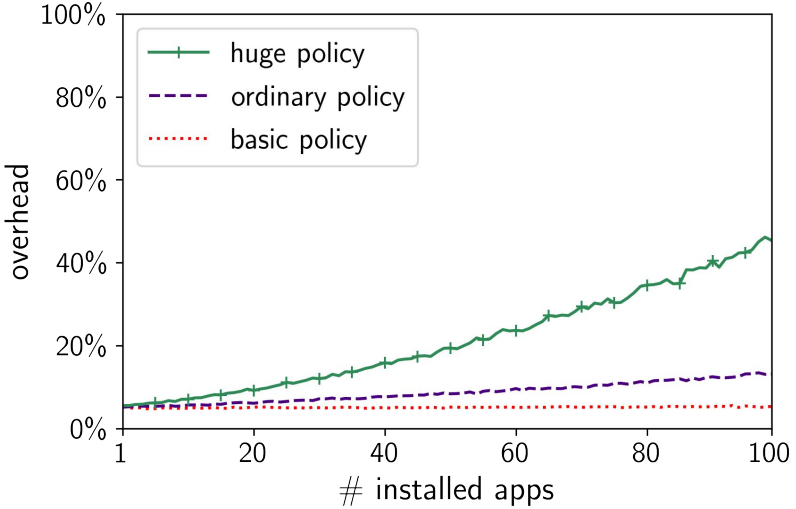
- policy segment changes → **on-device compilation**

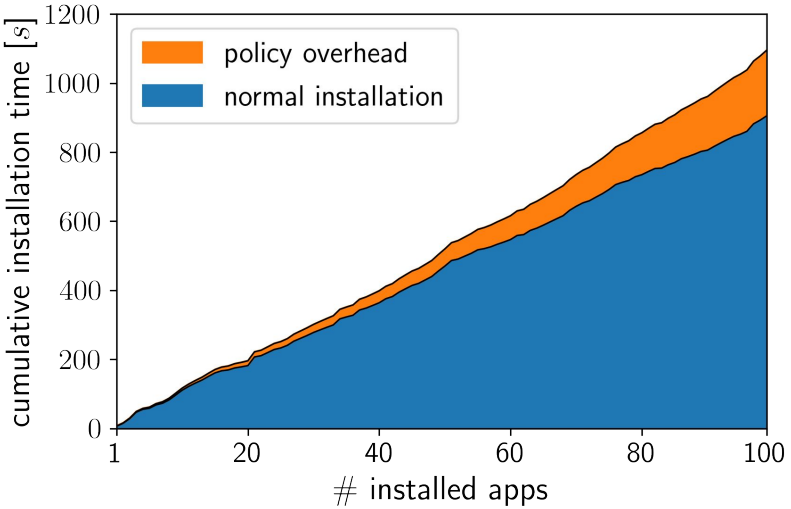
Changed the *second stage* (init.rc):

- to mount `/data` partitions (where policy modules are stored)
- implementing a new built-in function to build and reload the policy

The policy is not bypassable, since the modules are loaded before any application starts

Experiments: install time overhead





Device: Pixel 3, Version: android-10.0.0_r41

Experiments: runtime overhead

Component	Cold start (ms)				Warm start (ms)			
	Stock OS		*SEApp*		*Stock OS*		*SEApp*	
	μ	σ	μ	σ	μ	σ	μ	σ
LocalActivity	39.102	1.094	38.689	0.980	21.052	6.046	18.685	5.001
RemoteActivity	123.468	3.176	124.649	3.526	15.722	2.682	15.933	3.256
SEAppActivity	-	-	127.356	3.542	-	-	15.188	2.394
LocalService	19.164	1.444	18.835	1.392	1.399	0.208	1.328	0.208
RemoteService	105.467	2.800	106.935	2.565	2.617	0.879	2.676	0.593
IsolatedService	103.923	2.425	104.260	3.727	-	-	-	-
SEAppService	-	-	106.925	3.774	-	-	2.528	0.675

File creation		
Test	μ **(µs)**	σ **(µs)**
Stock OS	57.077	5.174
SEApp	60.696	6.782
SEApp + *restorecon*	431.472	109.494

Device: Pixel 3, Version: android-10.0.0_r41

Thank you! Any questions?

SEApp

https://github.com/matthewrossi/seapp
Available for Android 10, 9
Tested on Pixel 3, Pixel 2 XL, Emulator

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