Automated Cellphone Application Certification in Android (or) Mitigating Phone Software Misuse Before It Happens

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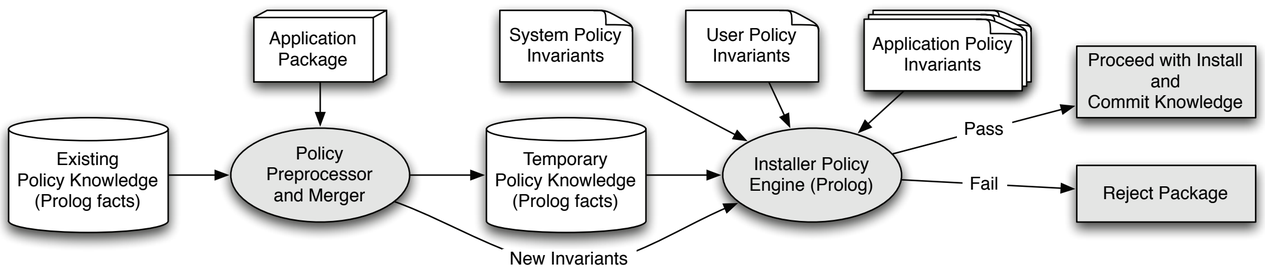
Third Party Phone Applications

- Recent smartphones platforms (e.g., Google Android, Apple iPhone, OpenMoko, etc) indicate a new trend for historically tightly controlled cellular handsets.
- New concerns are raised by the transition from close to open phones.
- A single poorly vetted program can:
  * compromise user data
  * disrupt fragile cellular networks
  * render a cell phone inoperable

Current Solution

- *Trusted Third Party Verification* (e.g., Apple AppStore, Symbian certification, etc). Emerging "AppStores" are expected to use similar tactics.
- This technique is not ideal:
  * Manual inspection is hard
  * Mixed incentives (commercial interestes frequently differ from genuine security and quality concerns)
  * No single definition of acceptible risk
  * Analysis is performed without knowledge of present applications, data, and services

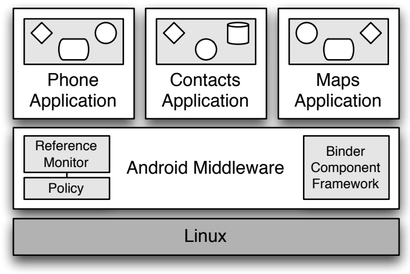
Self-Certification at Installation

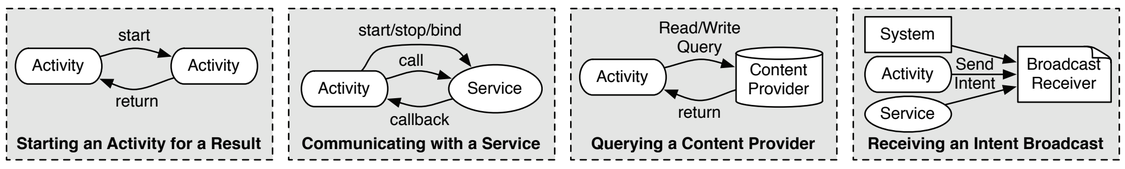


- *Idea*: Enhance the package installer with a policy engine
  * The Google Android smartphone operating system defines a framework where applications request permissions at install time
  * Applications also define access control polices for internal components
- *Challenges*:
  * Formalize Android's policy framework
  * Define appropriate "policy invariants"
  * Develop an install time policy tool

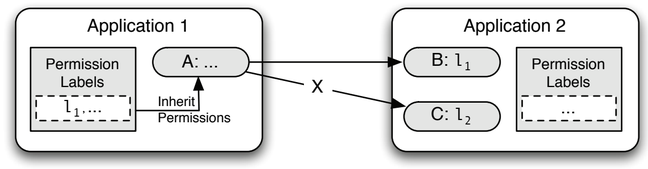
The Google Android OS

- The Android OS provides a middleware application abstraction based on components
- A reference monitor mediates the establishment of Inter-Component Communication (ICC)





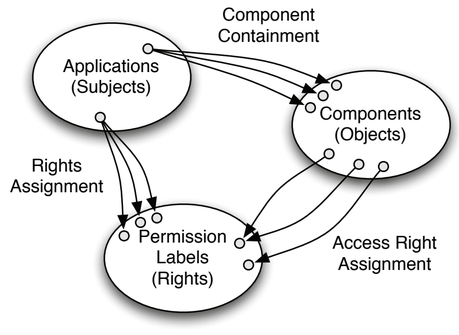
- Android uses a relatively straightforward security model where application assigned "permission labels" are inherited by components for use when performing ICC



- However, there are many practical exceptions ...

A Formal Logic

- We express Android's security policy as a traditional Subject-Objects-Rights (SOR) Access Matrix
- The policy allows a component in application *s* to access a component *o* that requires right *r* if the following evaluates to true:



$$P(s,o,r) = \texttt{requires}(o,r) \wedge \texttt{has\_perm}(s,r)$$

- We model additional policy semantics (caveats) through preprocessing that increases the number of objects/rights
- **Default Allow Policy**: Components with unspecified access rights can be accessed by anyone. We model this by creating a reserved "open" right assigned to all applications and components with unspecified access conditions.
- **Protected APIs**: Framework interfaces requiring special rights are modeled as objects.
- **Content Providers**: The read and write semantics of Content Providers are modeled by creating two objects
- **Broadcast Permissions**: Intent broadcasts allow "reverse permission checks," therefore Intents are modeled as objects.
- **Permission Protection Levels**: Not all requested permissions are granted, therefore preprocessing creates "virtual rights."

Example Policy Invariants

"An application must request permission to make an outgoing call"

$$\begin{aligned}\texttt{invariant}_{1i}(s) \;=\; & \forall r_1 \in R, \exists r_2 \in R.\, \neg P(s, \texttt{IF}_i, r_1) \\ & \vee (P(s, \texttt{IF}_i, r_2) \wedge (\texttt{has\_perm}(s, \texttt{CALL\_PHONE}) \vee \texttt{has\_perm}(s, \texttt{CALL\_PRIVILEGED}))\end{aligned}$$

"Applications that can perform audio record must not have network access or pass data to an application that has network access"

$$\begin{aligned}\texttt{invariant}_5(s) \;=\; & \forall r_1 \in R, \exists r_2 \in R, \forall r_3 \in R, \forall s_1 \in S, \forall o \in O, \forall \{r_4, r_5\} \in R.\, \neg P(s, \texttt{record\_audio}, r_1) \\ & \vee (P(s, \texttt{record\_audio}, r_2) \wedge \neg P(s, \texttt{network}, r_3) \\ & \wedge \neg (P(s, o, r_4) \wedge \texttt{contains}(s_1, o) \wedge P(s_1, \texttt{network}, r_5)))\end{aligned}$$

"An application can only receive SMS from trusted components"

$$\texttt{invariant}_{7i}(s) \;=\; \forall r_1 \in R, \exists r_2 \in R.\, \neg P(s, \texttt{BR}_i, r_1) \vee (P(s, \texttt{BR}_i, r_2) \wedge (s \equiv \texttt{PhoneApp}))$$

Kirin: An Enhanced Installer

- We developed Kirin, an enhanced installer that tests invariants.
- An evaluation of applications bundled with the SDK identifed multiple flaws that lead to vulnerabilities in the smartphone.
  * Unprivileged phone calls
  * Forged SMS messages within the system
  * Forged location updates to applications not following "best practices"
- Install time "self-certification" of applications provides flexibility and expressibility not achievable with "AppStore"-like application distribution models. This technique will be valuable for protecting next generation technology from malicous applications, before they are installed.

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