Securing Embedded User Interfaces: Android and Beyond

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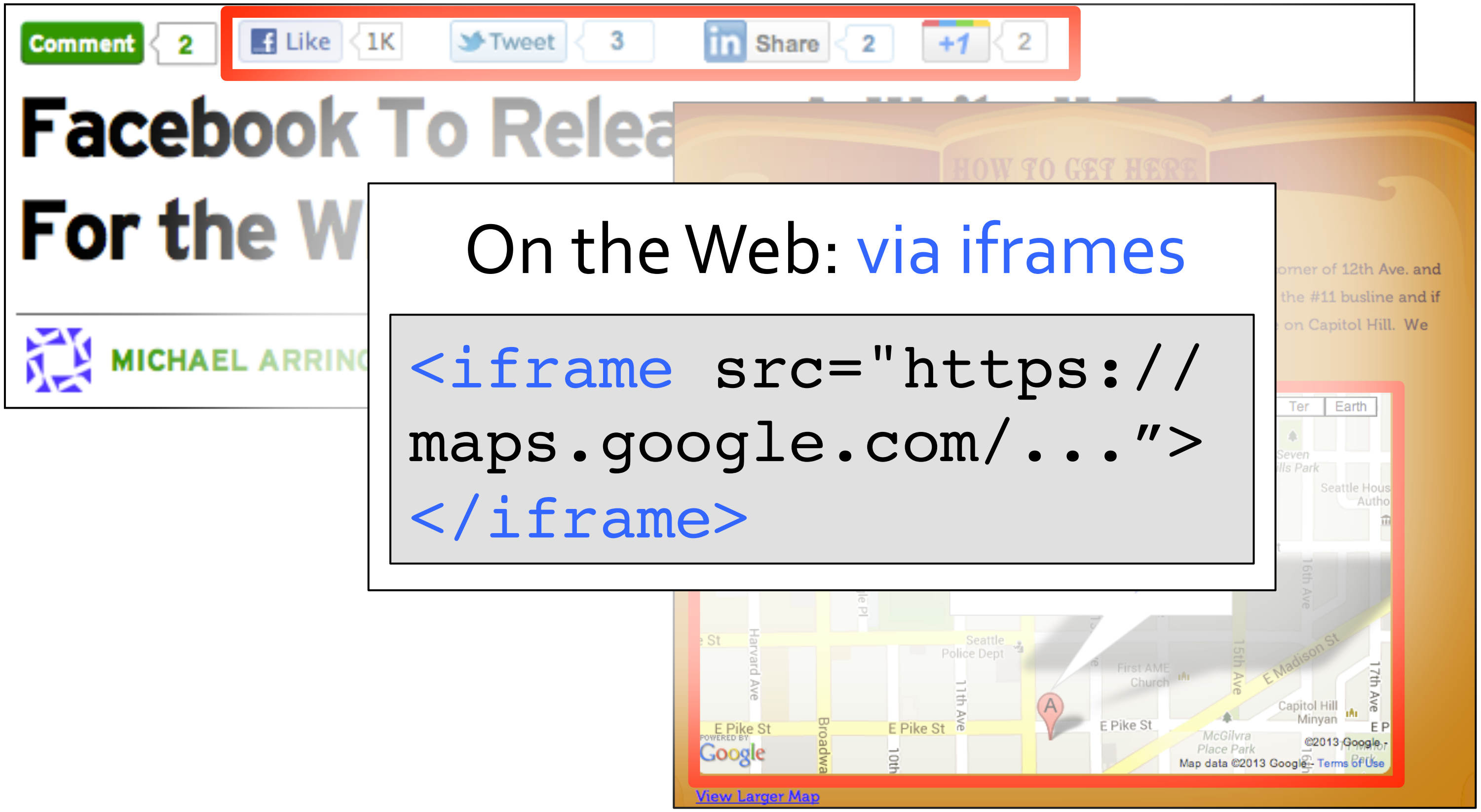
Embedded User Interfaces

Embedded third-party UIs are common on websites and in smartphone apps.



On the Web: via iframes

```
<iframe src="https://
maps.google.com/...”>
</iframe>
```

Embedded User Interfaces

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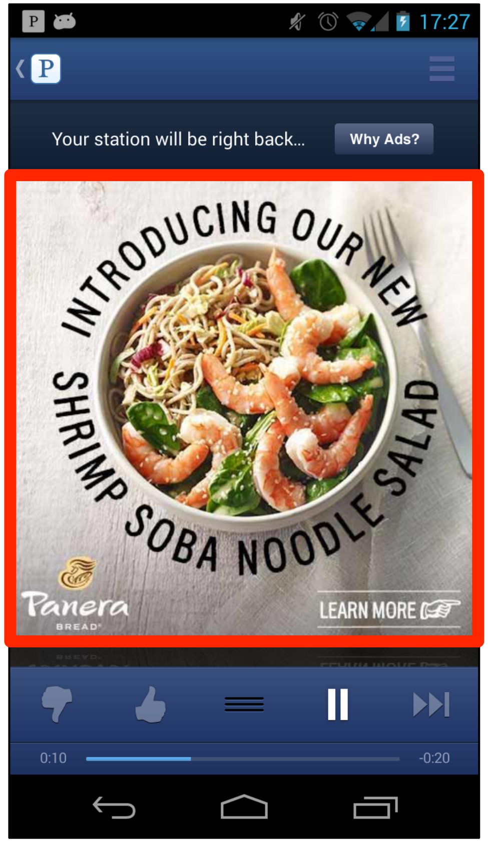
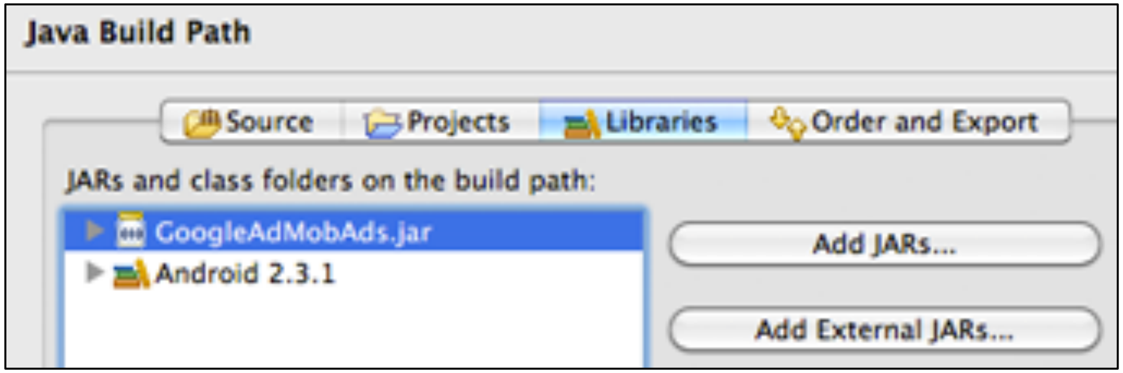


On Android: include library code



Java Build Path

JARs and class folders on the build path:

- GoogleAdMobAds.jar
- Android 2.3.1

Security and Embedding

Browsers provide secure isolation between an embedding page and embedded content.

Android does not.

- Third-party libraries run in app's context.
- No true cross-application UI embedding.

Outline

- The Case for Secure UI in Android
- Design & Implementation: LayerCake
- Evaluation
  - Functionality case studies
  - Performance
- Summary

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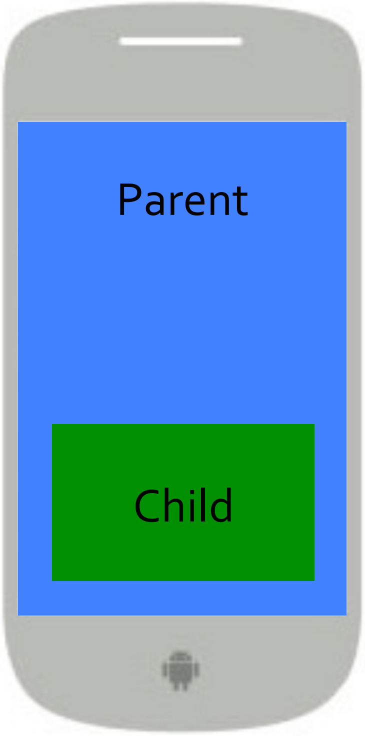
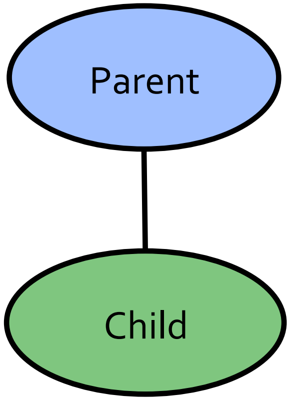
Security Concerns on Android

Both the parent and the child may be malicious.

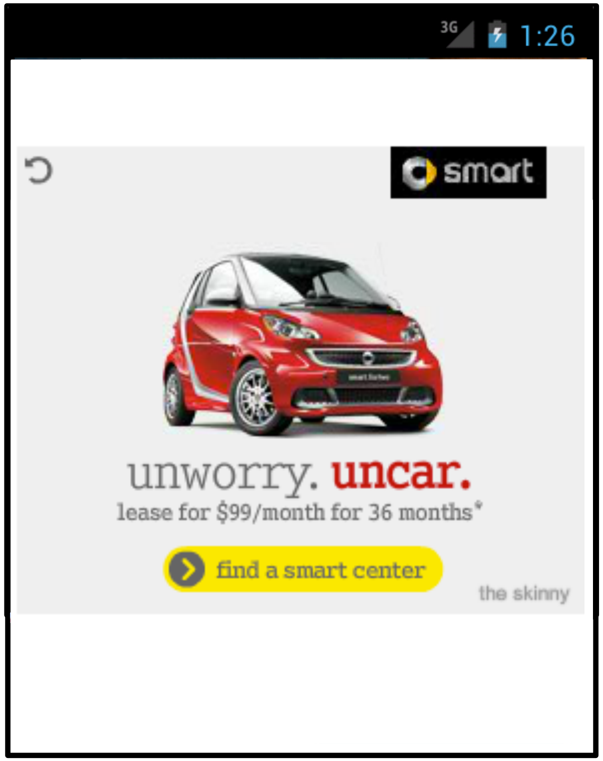


UI Layout Tree



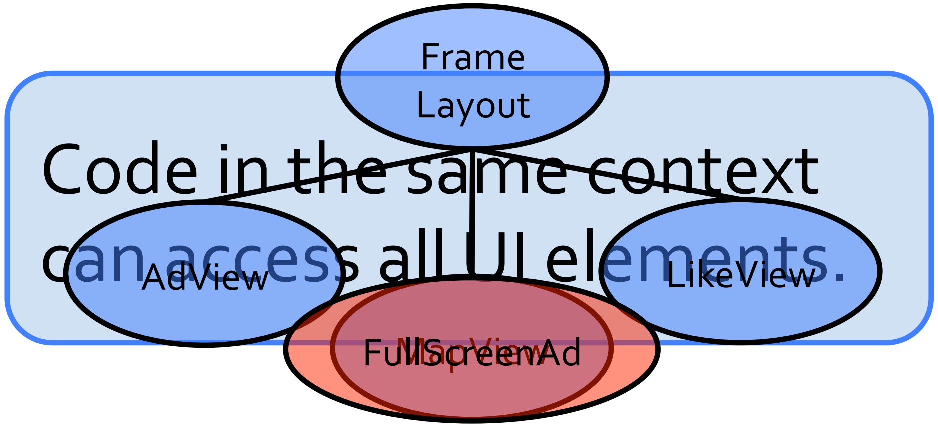
Security Concerns: Malicious Child

Example: Screen takeover (or redirection)



Ad Library Code

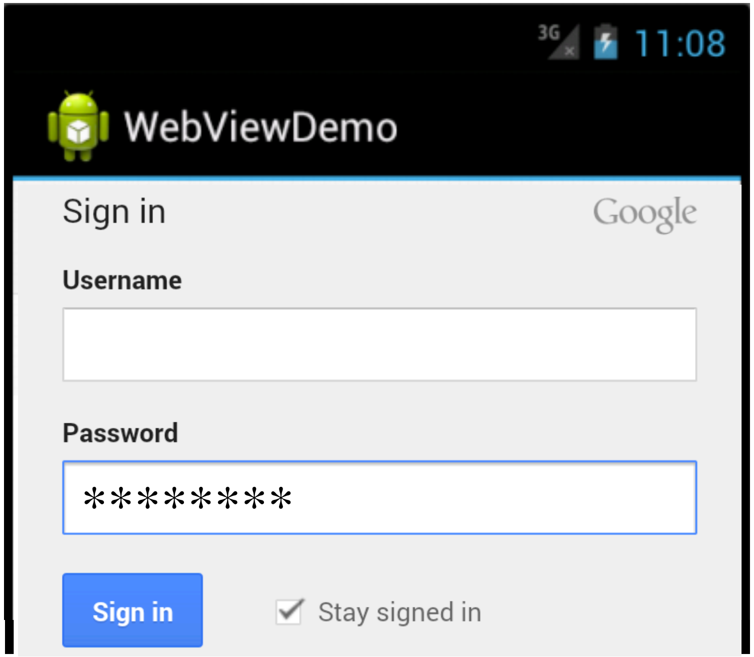
```
View parent = adView.getParent();
parent.removeChildren();
parent.addChild(fullScreenAd);
```

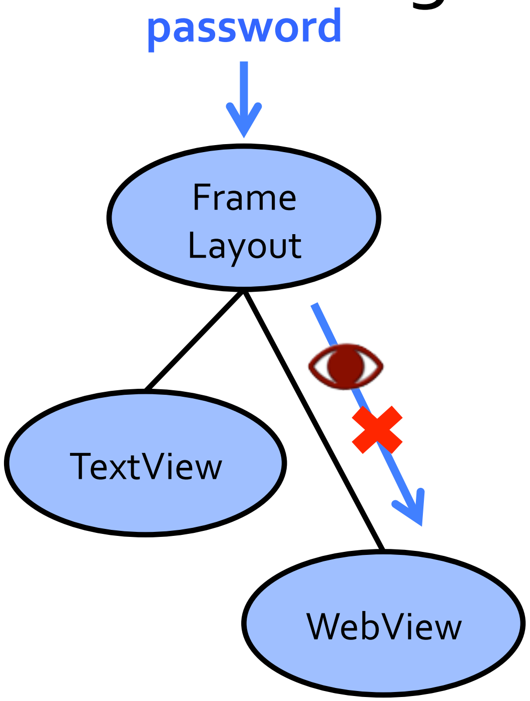


Code in the same context can access all UI elements.

Security Concerns: Malicious Parent

Example: Input Eavesdropping and Blocking





Input events propagate down the UI layout tree, through potentially untrusted nodes.

Many Security Concerns

Malicious parents and children can both perform:

Data theft, Display forgery, Focus stealing, Programmatic input forgery

Additionally, a malicious parent can perform:

Input eavesdropping, Input DoS, Size manipulation, Clickjacking

Additionally, a malicious child can perform:

Ancestor redirection

This Work

Many (though not all) of these attacks are impossible with iframes on the Web.

Most of these attacks are possible on Android.

- Existing approaches *[AdDroid: Pearce et al., AdSplit: Shekhar et al.]* only target ad scenario.
- Our prior work *[UIST '12]* considered secure UI embedding in theory.

What does it take to implement secure third-party embedding on Android?

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- **Design & Implementation: LayerCake**
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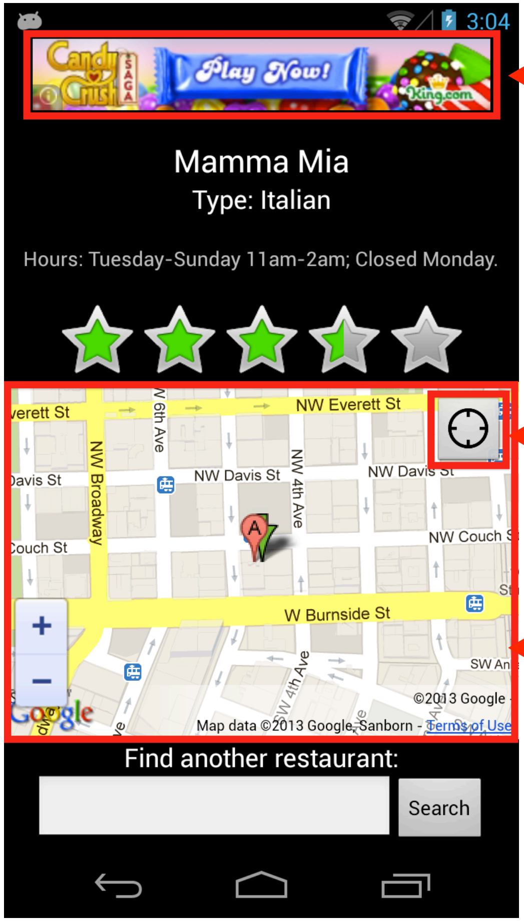
Secure UI Embedding for Android

LayerCake is a modified version of Android 4.2 (Jelly Bean) that securely supports embedded applications.



Mamma Mia

Type: Italian

Hours: Tuesday-Sunday 11am-2am; Closed Monday.

Find another restaurant:

Search

AdView

Location Gadget

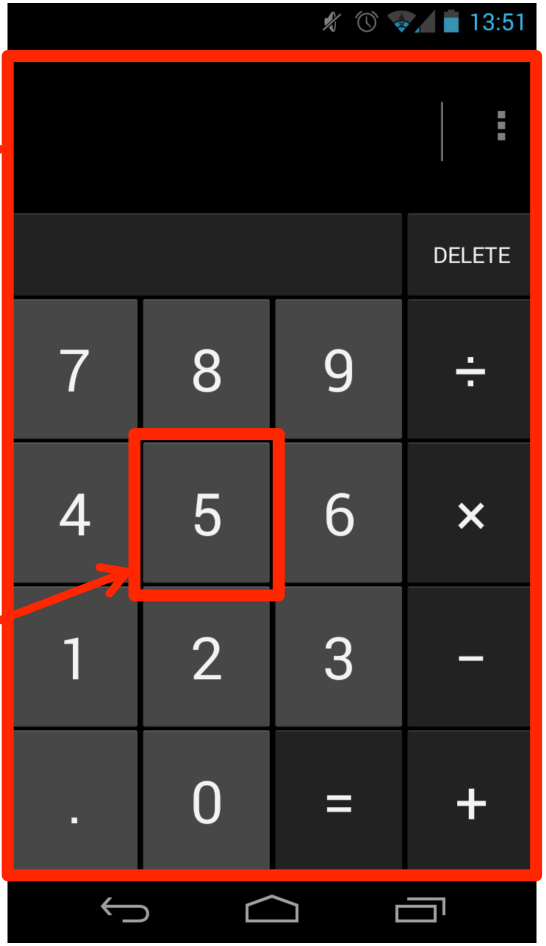
MapView

Android Background

- **Activity:** A page of an application's UI.
  - Only one Activity in the foreground at a time.
  - Activity consists of tree of UI elements (**Views**).

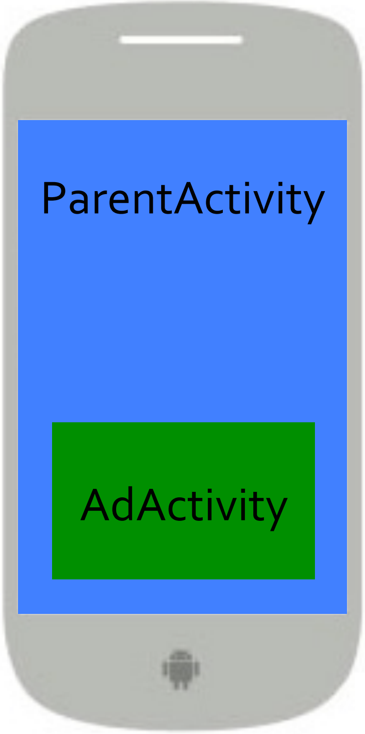
Button (View)

- Activity drawn in a **Window**.
  - Contains one View tree.



Supporting Embedded Activities

Goal: Allow an Activity in one application to securely embed an Activity from another app.

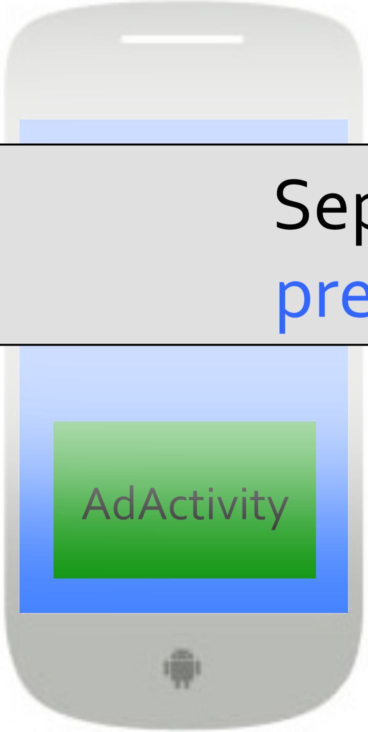


1. Separate processes.
2. Separate windows.
3. Handle additional security concerns.

Requires pervasive changes to ActivityManager and WindowManager.

(1) Separate Processes

Allow developers to embed Activities from other applications ("iframes for Android").



Challenges:

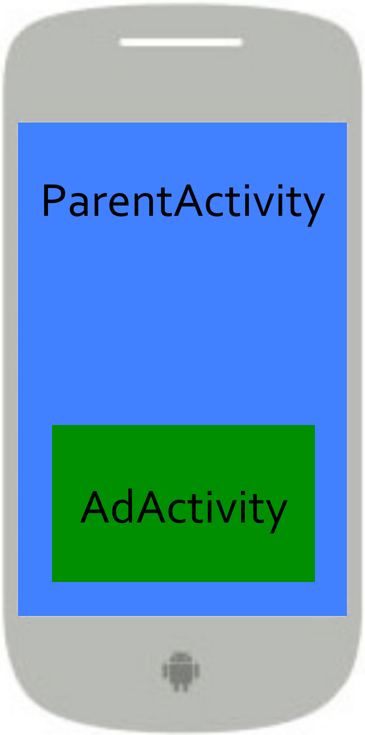
Separating code into processes prevents direct UI manipulation.

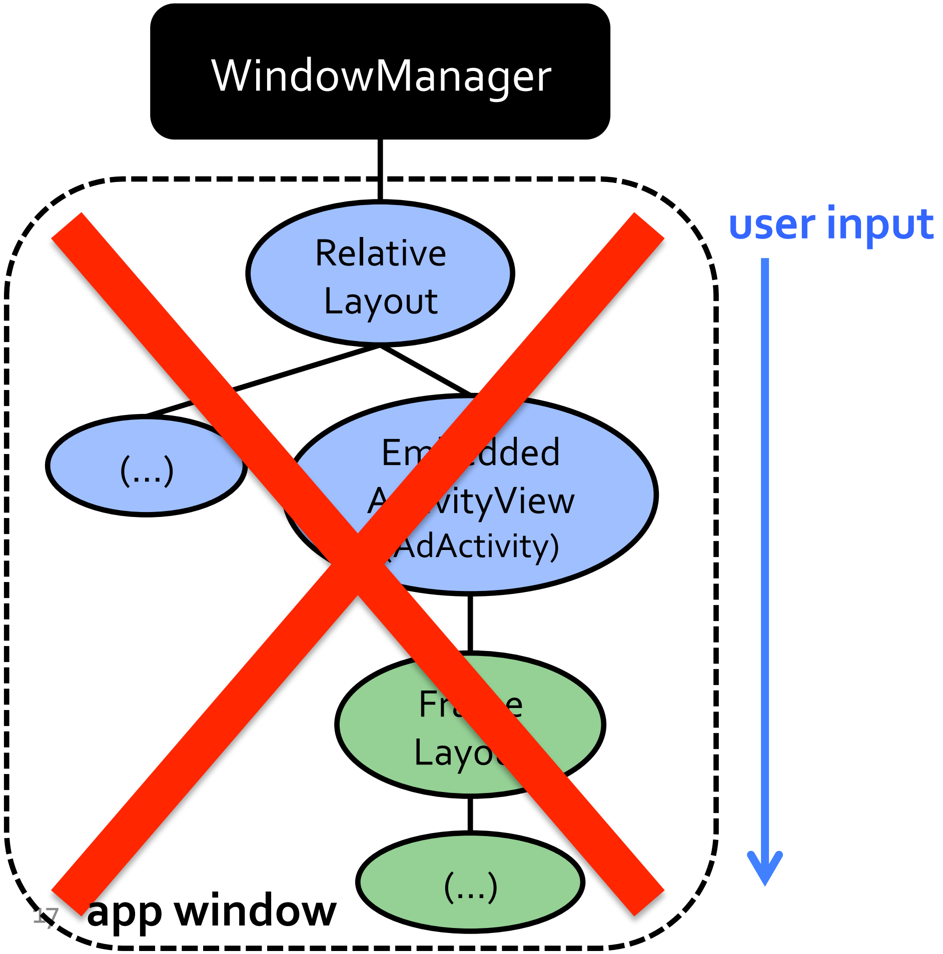
(EmbeddedActivityView)

- Multiple running Activities
- Parent-child communication

Separate Processes Not Sufficient

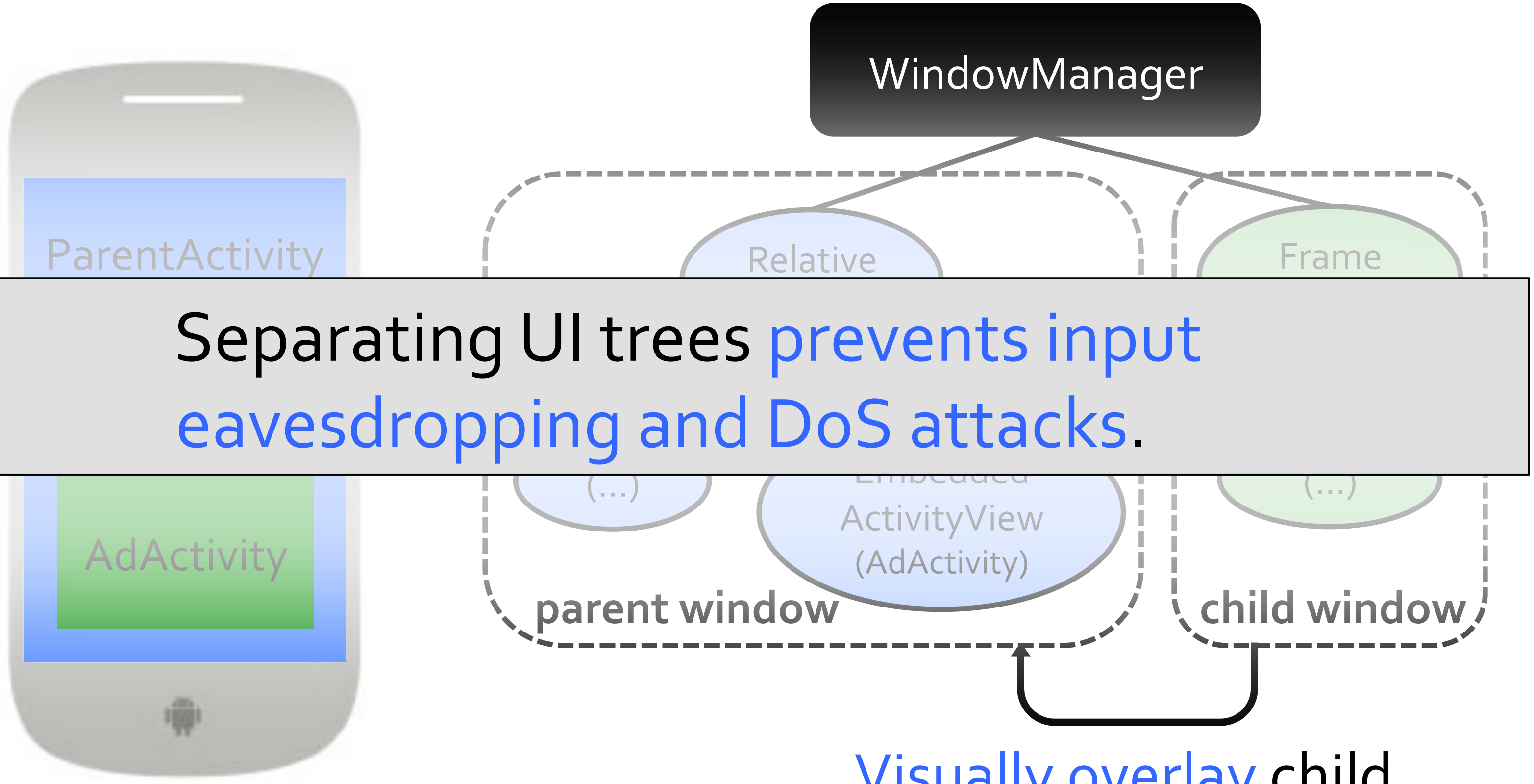
How does LayerCake actually embed cross-application UI?





(2) Separate Windows

Visually overlay separate windows, don't nest UI trees.

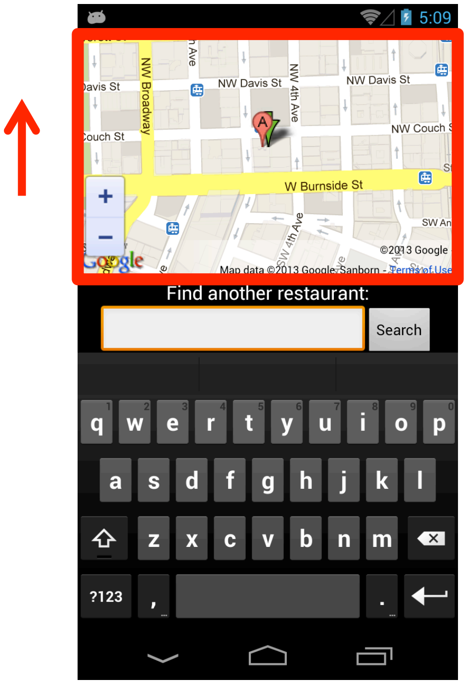


Separating UI trees prevents input eavesdropping and DoS attacks.

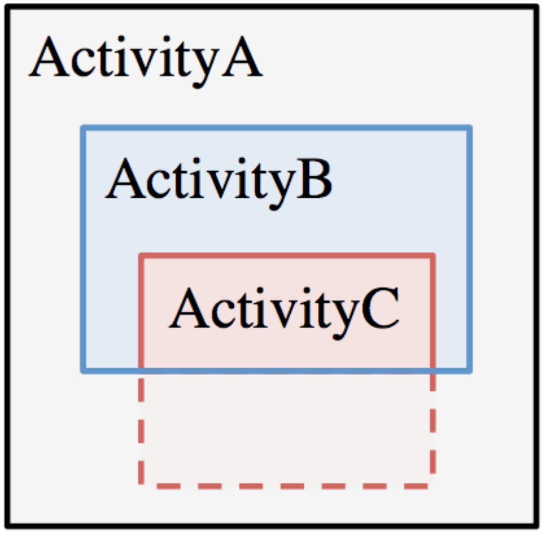
Visually overlay child window on parent window.

Overlaying: Practical Challenges

Layout changes must be automatically propagated across processes.



Cropping is needed to make overlaying look like embedding.

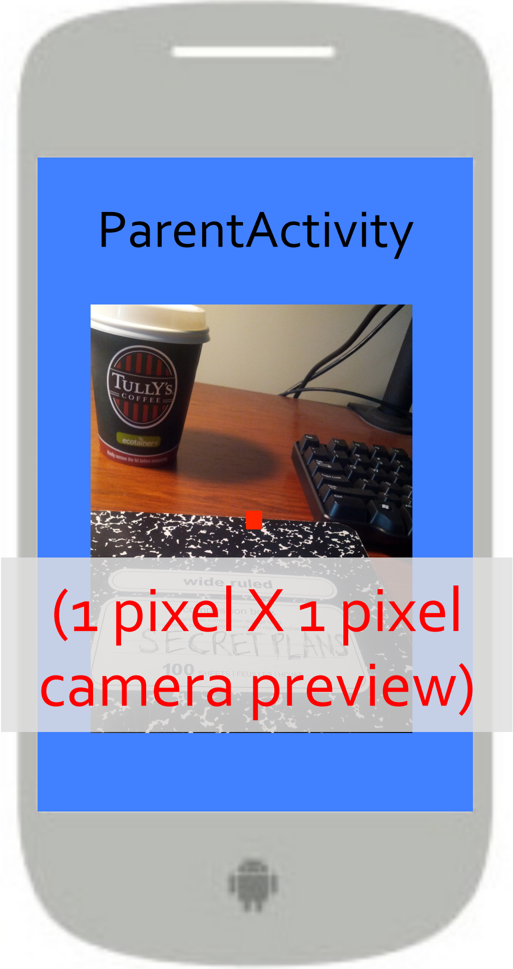


(3) Additional Security: Handling Size Conflicts

Threat: What if the parent makes the child too small?

(e.g., camera preview)

Observation: Enforcing a minimum size provides no additional security on its own: attacker can mimic effect by scrolling or obstructing.



(3) Additional Security: Preventing Clickjacking

Threat: Trick user into clicking on an embedded element that is visually obscured.

Embedded Activities can request to NOT receive user input events if they are:

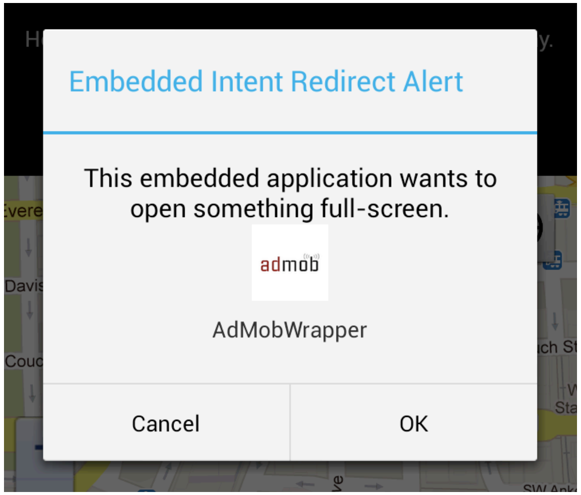
1. Covered (fully or partly) by another window.
2. Not the minimum requested size.
3. Not fully visible due to window placement.

(Additional clickjacking protection: e.g., *InContext: Huang et al.*)

(3) Additional Security: Preventing Ancestor Redirection

Threat: What if a malicious child tries to open a new top-level Activity?

- Note: Opening another **embedded** Activity (in its place) is ok.
- On attempt to open **top-level** Activity:
  - Prompt user, or
  - Allow automatically **if in response to user click** (≈ user intent)



Embedded Intent Redirect Alert

This embedded application wants to open something full-screen.

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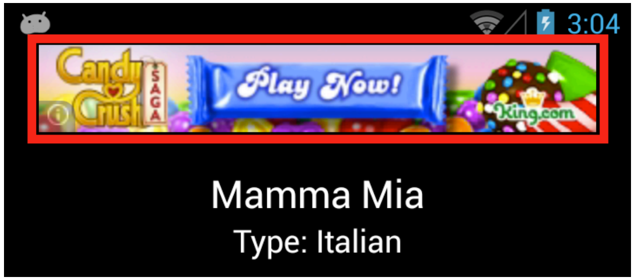
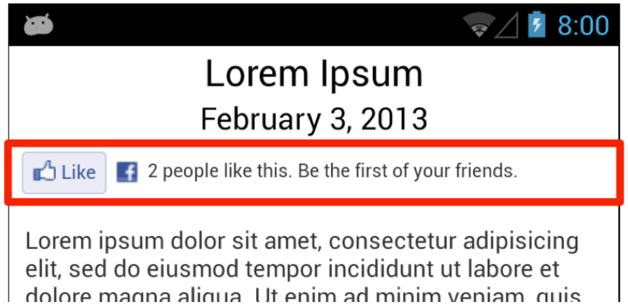
Functionality Case Studies

Not (securely) possible on stock Android; enabled by LayerCake:



Mamma Mia
Type: Italian

Advertising

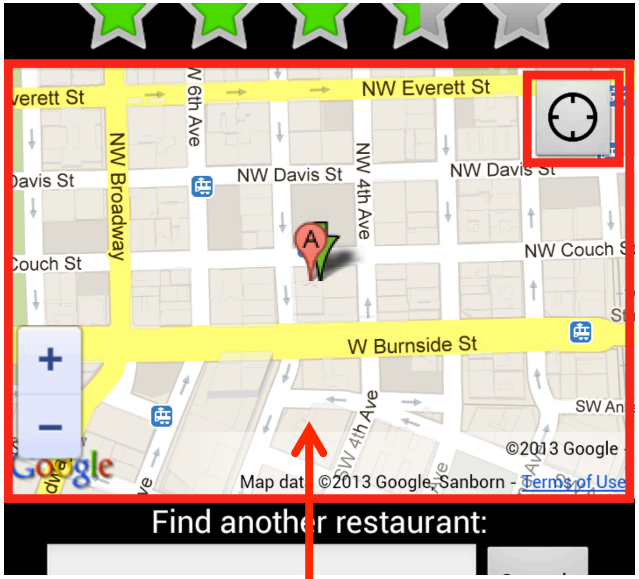


Lorem Ipsum
February 3, 2013

2 people like this. Be the first of your friends.

Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis

Facebook Widgets



Find another restaurant:

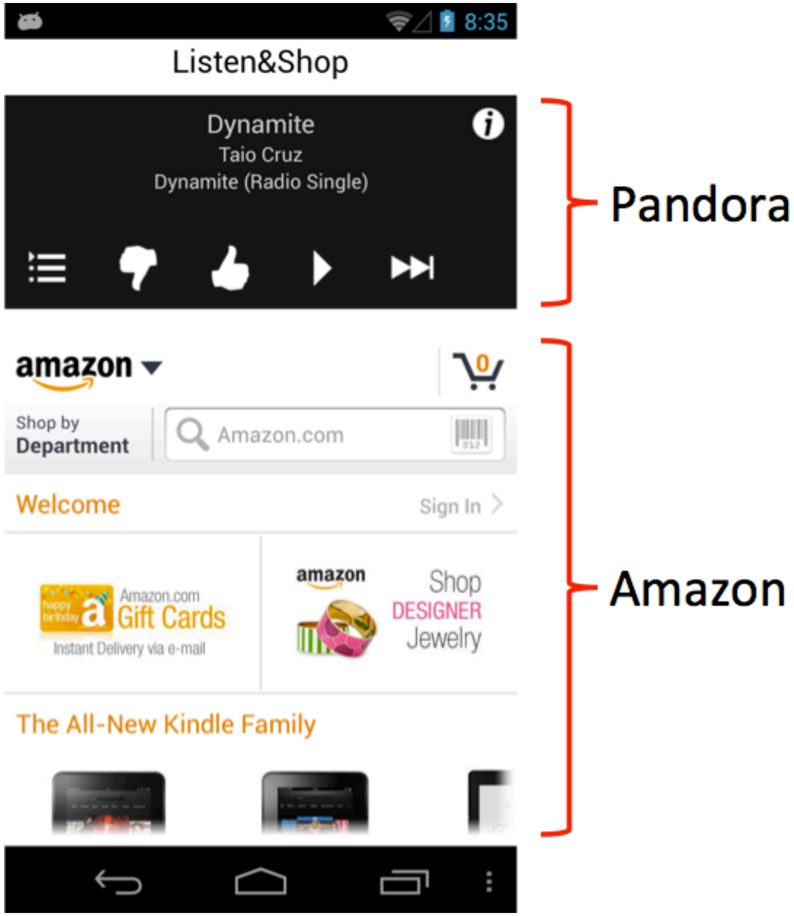
User-Driven Access Control *[Oakland '12]*

Apply to top-level redirection.

Secure WebView

Legacy Applications

Applications don’t require modification to be embedded.



Performance Evaluation: Activity Load Time

Application	*Load time (10 trial average)*	
	No Embedding	**Embedding***
RestaurantReviewer	163 ms	533 ms
FacebookDemo	158 ms	305 ms
Listen&Shop	160 ms	303 ms

* Note that load time for parent Activity is unaffected.

Performance Evaluation: Event Dispatch

Scenario	**Event Dispatch Time** *(10 trial average)*
Stock Android	1.9 ms
No focus change	2.1 ms
Focus change	3.6 ms

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Contributions

LayerCake: Artifact resulting from systematic application of secure embedded UI concepts.

Code: **http://layercake.cs.washington.edu**

Lessons Learned:

- Visually overlay windows, don’t nest UI trees.
- Size manipulation, scroll placement, and obstruction must be considered together.
- Ancestor redirection can follow user intent.

Summary

- Embedded third-party UIs pose security concerns, unaddressed on Android.
- **LayerCake**: modified version of Android that securely supports application embedding.
- See me for demo!

http://layercake.cs.washington.edu