Runtime GUI Adaptation in Dynamic Software Product Lines

Dean Kramer
deankramer@acm.org

University of West London/Middlesex University

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Agenda

1. Introduction & Recap
2. Runtime Adaptation
3. Implementation & Tests
4. Conclusions
Smart phones have been highly prolific.

Large array of applications available

Typically contain GPS, Internet, Compass, Light, Accelerometer sensors.

Sensor data can gain a wide range of contextual information, that can be consumed by context aware applications.
Background II: Software Product Lines (SPL)

- Develop similar software from common assets
- Feature-Oriented Software Development as a method for modularising system features
- Dynamic Software Product Lines (DSPL)
  - Runtime feature binding
  - Unified adaptation
Problem - GUI Variability

- Increasingly popular to develop GUI applications using more than general purpose languages
- GUIs can exhibit variability in SPLs
- Not all GUI variability can be statically realised:
  - Adaptive GUIs
  - Plastic UIs
- Logic adaptation already possible with DSPLs
  - Normally only single language solutions
  - No dedicated GUI support
Scenario - Content Store Application

Feature Model

Screen Variability

Applications

Video

Music
Document-Oriented GUIs

- DSLs for declaring GUI structure, and properties
- Also known as:
  - GUI Description Languages
  - GUI Markup Languages
- Different implementations:
  - Android (XMLBlock)
  - iOS & OSX (XNib/Nib)
  - Microsoft XAML
  - Mozilla XUL
  - QT QML

Android GUI Document Excerpt

```xml
<FrameLayout
    android:id="@+id/mainFrame"
    android:layout_width="match_parent"
    android:fitsSystemWindows="true"
    .....>
    ....
    <Button
        android:id="@+id/applications"
        android:layout_width="160dp"
        android:text="@string/apps"
        android:background="@drawable/apps"/>
    <LinearLayout
        android:id="@+id/adverts"
        .....>
        ....
        <TextView
            android:id="@+id/appAdsTitle"
            android:text="@string/PopularFreeAppss"/>
        ....
    </LinearLayout>
</FrameLayout>
```
Variability implemented in refinements.

Use Dynamic Binding Units

Generate GUI document variants at compile-time using Superimposition:

- Based on document refinement combinations, not just feature combinations.
- All combinations are checked for FM satisfiability.
Previous Work Recap: GPCE 2013 Paper con.

- Code Generation and Transformation
  - Generate variant management code
  - Transform source code to call the variant management when a GUI document is used.

- Adaptation only handled when GUI document is needed (when it is created).

- No full adaptation once the GUI is visible to the user.
Runtime Adaptation Overview

- Full runtime adaptation now handled for:
  - GUI Document related
  - Source code related
- Adaptation can be handled either:
  - On inflation: When the GUI is first created (not program, but a particular screen).
  - When Active: After a GUI is already visible.
- Two class methods used with FOP to assist runtime adaptation:
  - Document Initialisation Methods
  - Other GUI Adaptations
Methods for Runtime Adapt.: Document Initialisation

- Used for all operations related to the GUI initialisation
- Can be also invoked in the GUI controller constructor
- Can be refined like other methods
  - Add initialisation operations when adding an additional widget

Video feature example for homepage

```java
public void onCreate_homescreen(ViewGroup vg){
    original();
    Button btnVideo = (Button)vg.findViewById(R.id.video);
    btnVideo.setOnClickListener(new onClickListener() {
        public void onClick(View v) {
            gotoVideoStoreScreen();
        }
    });
}
```
GUI adaptation can be implemented in sourcecode including visual and nonvisual e.g. gestures
- Contained in `onGUIConfiguration` methods
- Can be refined also
- Is not automatically reversed!

Example operations to implement a List “swipe to remove”

```java
public void onGUIConfiguration() {
    SwipeDismissListViewTouchListener touchListener =
        new SwipeDismissListViewTouchListener(
            listView, new SwipeDismissListViewTouchListener.OnDismissCallback() {
                public void onDismiss(ListView listView, int[] reverseSortedPositions) {
                    for (int position : reverseSortedPositions) {
                        adapter.remove(adapter.getItem(position));
                    }
                    adapter.notifyDataSetChanged();
                }
            });
    listView.setOnTouchListener(touchListener);
    listView.setOnScrollListener(touchListener.makeScrollListener());
}
```
Generation & Transformations

- Three additional types of components generated:
  - Adaptation Manager - Orchestrates the adaptation.
  - State Transfer Component - For ensuring state is transferred between variants.
  - Feature classes (similar to FeatureC++) - Which hold data needed for the GUI adaptation.

- Further code transformations within the GUI controllers to handle the variant reloading, and tree composition.
Adaptation Process

- Runs over all currently active controllers (Android activities and fragments).
- Can handle adaptation of multiple documents in a reconfiguration.
- Adapts each instance of that GUI tree (important for lists!)
Implementation

- Developed to handle applications for the Android platform
- Built on top of FeatureIDE (No extension name yet)
- Static composition handled using FeatureHouse\(^1\)
- FeatureDroid (DSPL Middleware)\(^2\) used for handling context-acquisition and runtime configuration management

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\(^1\) [https://github.com/deankramer/featurehouse]

\(^2\) [http://deansserver.co.uk/gitweb/?p=AndroidDSPLMiddleware.git;a=summary]
Examined how GUI document variability affects:

- Variant and support code generation time.
- Application size.
  - The size of the installation file (Android .apk file)
  - The installation size once installed on device
- Runtime adaptation time.
  - Base GUI document $\rightarrow$ Variant with all active features $\rightarrow$ Base GUI document.
  - Average time of 1000 adaptation cycles.
Scaling & Performance con.

- Tested different generated GUI document sizes including <1KB, 2KB, 4KB, 8KB
- Each refinement adds an additional button to the GUI document
- Refinements contained in optional features.
- Test machines:
  - Intel i5 laptop with 8GB of ram, Windows 8.1, standard HDD.
  - Nexus S phone running Android 4.2.1 - Single core, 3 1/12 years old.
Generation Time (Log)
Generation Time (Lin)

- Generation Time (lin)
- Time (s)
- # of Features
- <1KB
- 2KB
- 4KB
- 8KB

Source: generationtime
Application Installation Size Increase (Lin)
Runtime Adaptation Time

Adaptation Time (lin)

- Blue: <1KB
- Orange: 2KB
- Green: 4KB
- Red: 8KB

Time (ms) vs. # of Features

- Y-axis: Time (ms)
  - 0 to 60
- X-axis: # of Features
  - 2 to 14

The graph demonstrates the time taken for runtime adaptation as the number of features increases for different data sizes.
Conclusions

- GUIs can exhibit both static and dynamic variability, which should be unified
- Our updated work allows for full runtime adaptation of the GUI
- Implementation shows promising feasibility for GUI documents
  - Feasible to 10-12 dynamic binding units
  - Still room for optimisation.
Any questions?