Automated API-Usage Update for Android Apps

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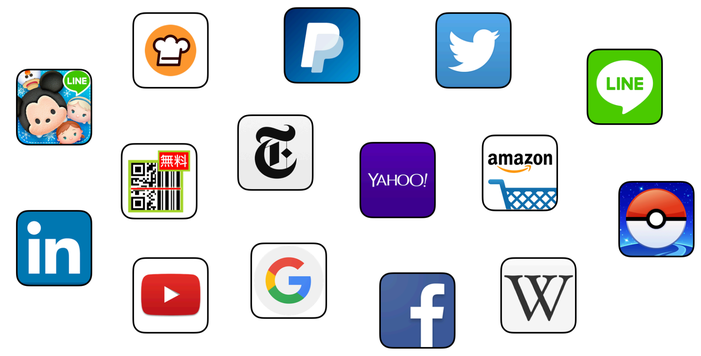
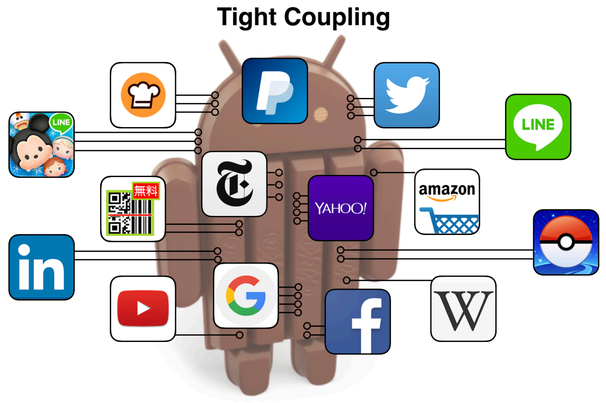
Mobile Applications



Platform Updates

Platform

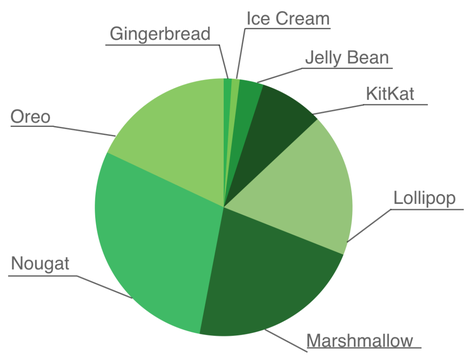
Tight Coupling



Frequent Platform Changes

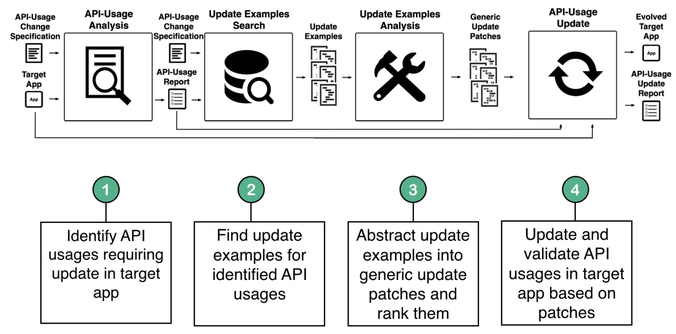
Adaptive Maintenance

Fragmentation



AppEvolve Technique

APPEVOLVE Overview



API-Usage Analysis

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Inter-Procedural Data-flow Analysis

Target App Code

API-Usage Change Specification

```
public void onClick(View view) {
  if (VERSION.SDK_INT >= VERSION_CODE.KITKAT) {
    boolean conn = hasNetwork(context)
    ...
  }
}
public boolean hasNetwork(Context context) {
  ConnectivityManager conn = ...;
  NetworkInfo[] netInfo = conn.getAllNetworkInfo();
  for (int k = 0; k < netInfo; k++) {
    if (netInfo[k].getState() == NetworkInfo.State.CONNECTED) {
      return true;
    } }
  return false;
}
```

VERSION_CODES.<NEW_VERSION>

VERSION_CODES.<NEW_VERSION>

Update Example Search

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Code Hosting Infrastructure

Keyword-Based Search

$\forall$ method signature $\in$ New API Usage

method name, param types, declaring class

Search Result

Code Base App$_1$ | Code Base App$_2$ | Code Base App$_3$ | Code Base App$_4$

Update Example Analysis

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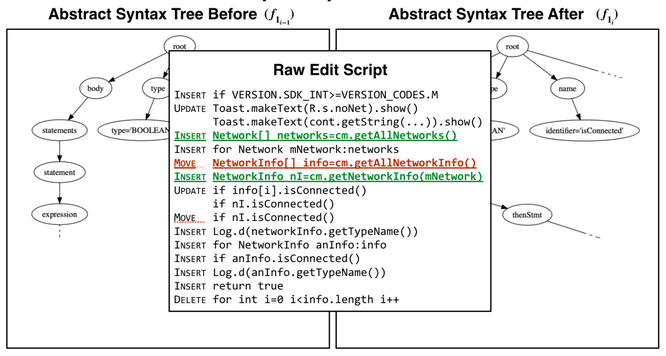
Compute Update Patch

Abstract Syntax Tree Before $(f_{i,i-1})$ **Abstract Syntax Tree After** $(f_{i,i})$



Raw Edit Script

```
INSERT if VERSION.SDK_INT>=VERSION_CODES.M
UPDATE Toast.makeText(R.s.noNet).show()
       Toast.makeText(cont.getString(...)).show()
INSERT Network[] networks=cm.getAllNetworks()
INSERT for Network mNetwork:networks
MOVE   NetworkInfo[] info=cm.getAllNetworkInfo()
INSERT NetworkInfo nI=cm.getNetworkInfo(mNetwork)
UPDATE if info[i].isConnected()
       if nI.isConnected()
MOVE   if nI.isConnected()
INSERT Log.d(networkInfo.getTypeName())
INSERT for NetworkInfo anInfo:info
INSERT if anInfo.isConnected()
INSERT Log.d(anInfo.getTypeName())
INSERT return true
DELETE for int i=0 i<info.length i++
```

API-Usage Update

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Target App Code

```
public boolean hasNetwork(Context context) {
  ConnectivityManager conn = ...;
  NetworkInfo[] netInfo =
    conn.getAllNetworkInfo();
  for (int k = 0; k < netInfo; k++) {
    if (netInfo[k].getState() ==
      NetworkInfo.State.CONNECTED) {
      return true;
    } }
  return false;
}
```

Generic Update Patch

Edit Script

```
INSERT if VERSION.SDK_INT>=VERSION_CODES.M
INSERT Network[] networks=$V.getAllNetworks()
INSERT for Network mNetwork:networks
MOVE   NetworkInfo[] info=$V.getAllNetworkInfo()
INSERT NetworkInfo nI=$V.getNetworkInfo(mNetwork)
UPDATE if info[i].getState()==CONNECTED
       if nI.getState()==CONNECTED
MOVE   if nI.getState()==CONNECTED
INSERT for NetworkInfo anInfo:info
INSERT if anInfo.getState()==CONNECTED
INSERT return true
DELETE for int j=0 j<info.length j++
```

Core Proximity Value = 0.72

Context Variables [($V,ConnectivityManager:cMan)]

Evaluation

Research Questions

RQ1 (EFFECTIVENESS): Can APPEVOLVE update API usages in real-world apps?

RQ2 (EFFICIENCY): What is the cost of running APPEVOLVE?

Benchmarks and Setup

15 Apps

BIPOLALARM	WIGLE WIFI	SYMPHONY
CONVERSATIONS	FOOTGUY	SYSLOG
PARKENDD	CALENDAR IE	MUZEI
CLEAN SB	DIOLINUX	NOTES
OPENSUDOKU	SOLAR COMPASS	ONETWO
Lollipop	**Marshmallow**	**Nougat**

20 API Usages

(41 occurrences)

addAction	addGpsStatusListener	abandonAudioFocus
getAllNetworkInfo	fromHtml	getDeviceId
getCurrentHour	release	requestAudioFocus
getCurrentMinute	removeGpsStatusListener	saveLayer
setCurrentHour	shouldOverrideUrlLoading	setAudioStreamType
setCurrentMinute	startDrag	vibrate(long)
setTextAppearance		vibrate(long[],int)

Setup

- Run technique on benchmarks
- Measure successful update and validation rate
- Measure execution time

Evaluation: Effectiveness

RQ1 (EFFECTIVENESS): Can APPEVOLVE update API usages in real-world apps?

Overall Effectivness

- **17/20 (85%)** successful update rate (for API usages)
- **37/41 (90%)** successful update rate (for API-usage occurrences)
- **25/37 (68%)** automatic validation rate (for API-usage occurrences)

Details

- In **19/20** cases, APPEVOLVE could find update examples
- In **14/19** cases, the number of relevant edits is lower than the number of AST edits
- In **11/19** cases, the core proximity value is different from its minimum and maximum

APPEVOLVE is effective in automatically updating API usages.

Evaluation: Efficiency

RQ2 (EFFICIENCY): What is the cost of running APPEVOLVE?

Average Execution Time			
API-Usage Analysis	Update Examples Search	Update Examples Analysis	API-Usage Update
28s	**10h27m**	2s204ms	20s

The cost of the **update examples search** phase dominates the cost of the other phases.

Future Work

- Handle updates that span across multiple methods
- Automatically compute API change specifications
- Improve validation through differential testing
- Investigate use of APPEVOLVE in other contexts (e.g., web apps)