

APIMIGRATOR: An API-Usage Migration Tool for Android Apps

Mattia Fazzini



Qi Xin



Alessandro Orso



Mobile Applications

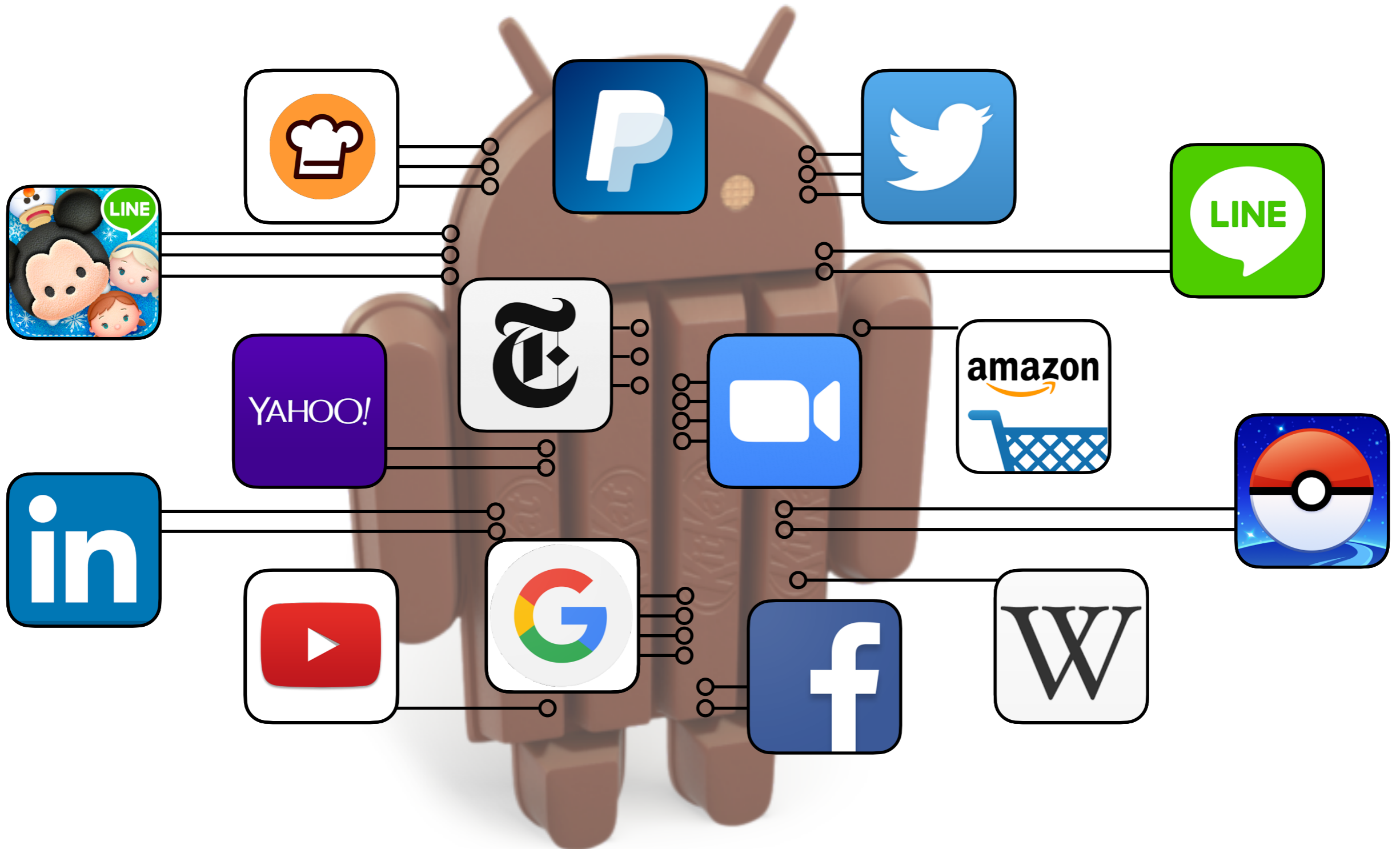


Platform

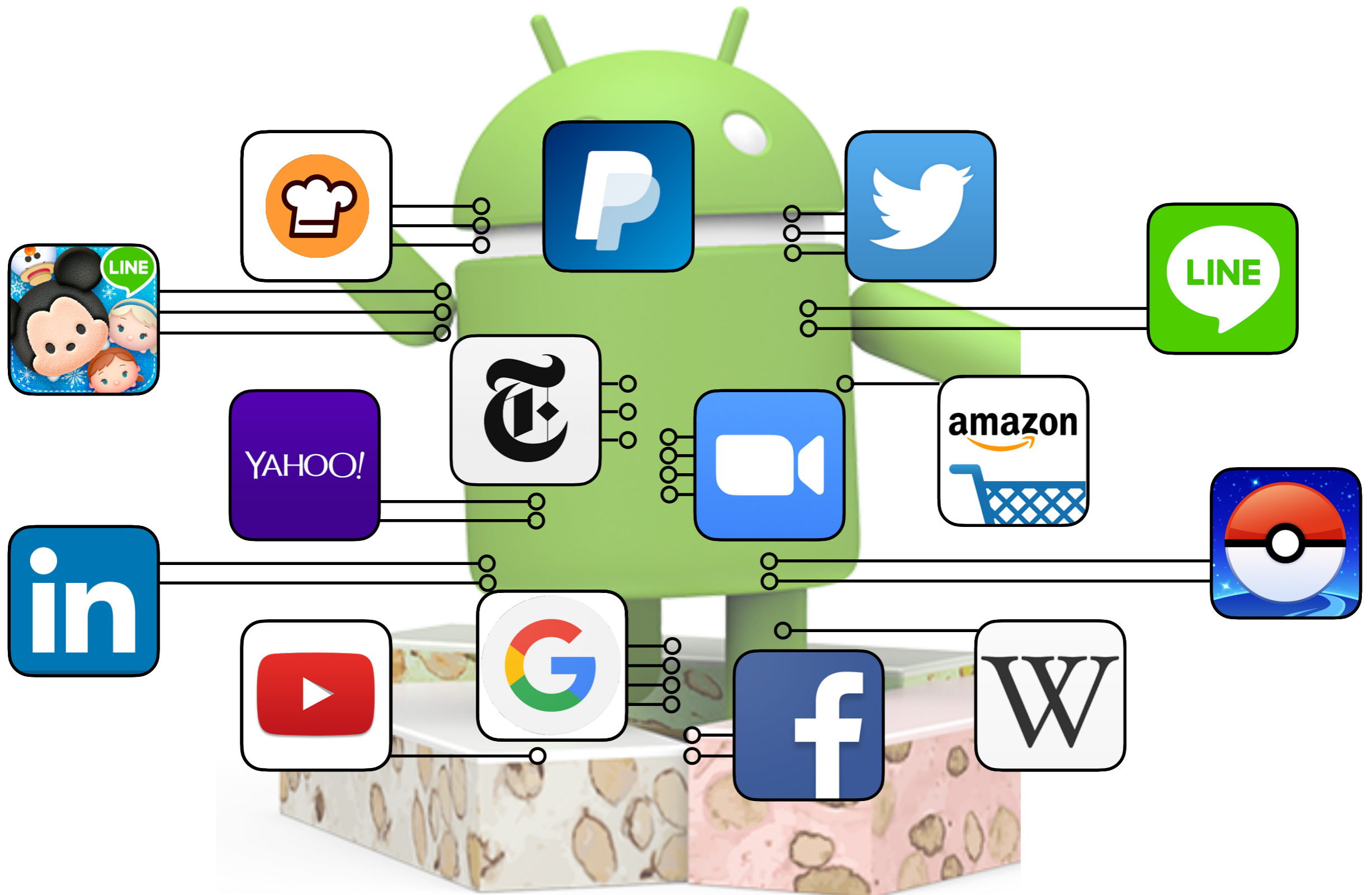


Platform

Tight Coupling



Platforms Change



Platforms Change Frequently

Android



Petit Four



Cupcake



Donut



Eclair



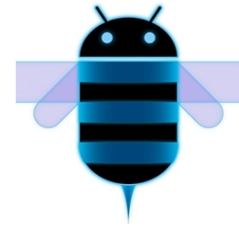
Froyo



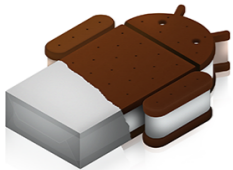
Gingerbread



Honeycomb



Ice Cream



Jelly Bean



KitKat



Lollipop



Marshmallow



Nougat



Oreo



Pie



Android 10



android

Adaptive Maintenance

Platform



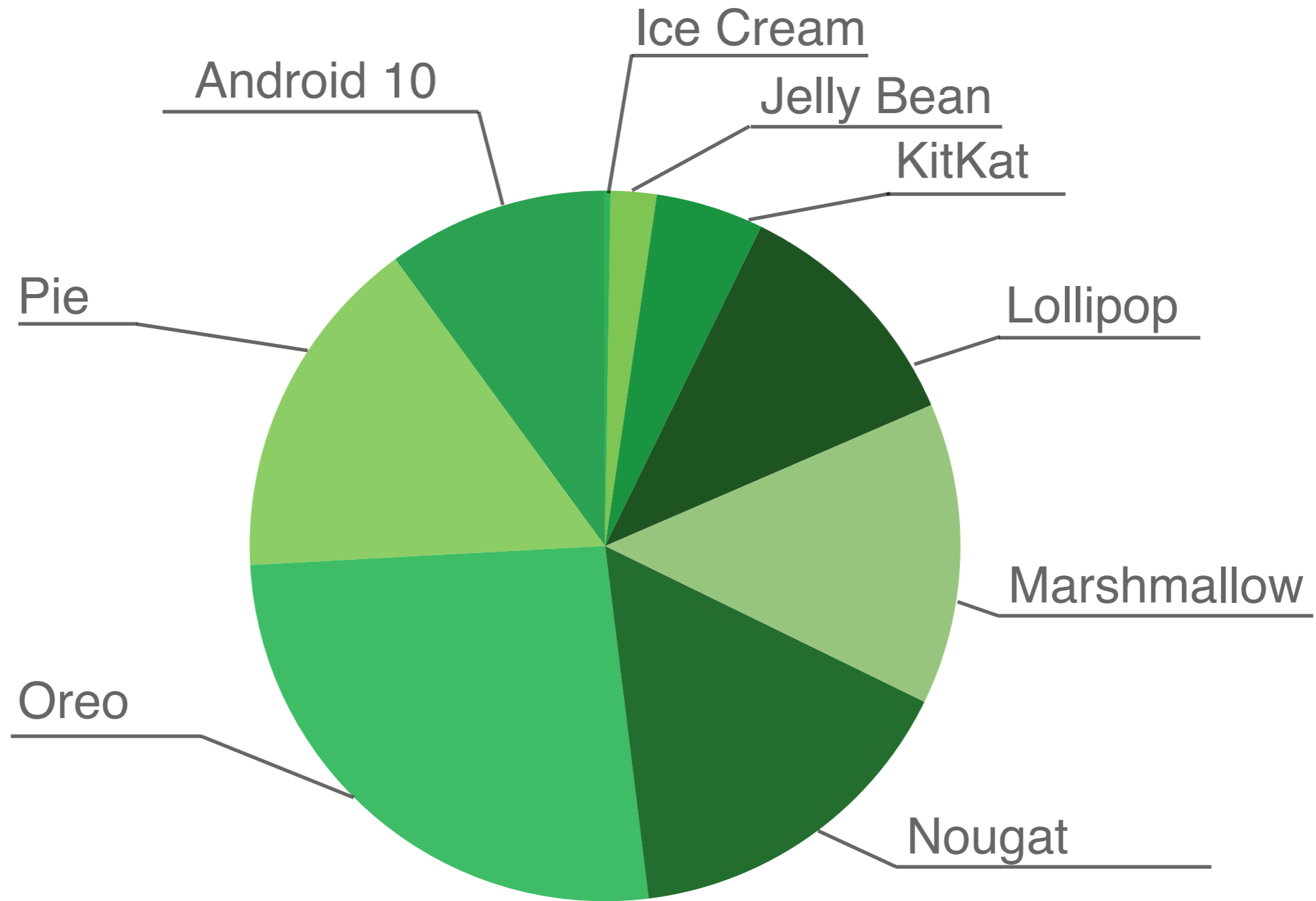
New Platform



Developer



Platform Fragmentation

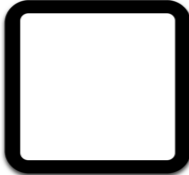


Intuition

Developer A

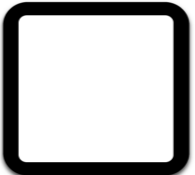


App A



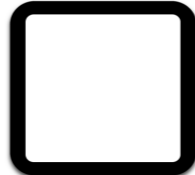
Developer B

App B



Developer C

App C

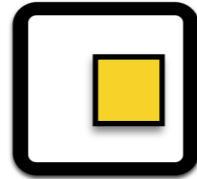


Intuition

Developer A

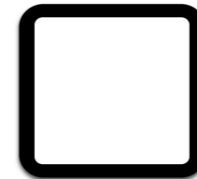


App A



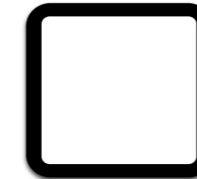
Developer B

App B



Developer C

App C

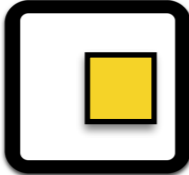


Intuition

Developer A



App A



Developer B

App B



Developer C

App C



API-Usage Migrations

API-Usage Changes

```
public NetworkInfo[] getAllNetworkInfo()
```

! **This method was deprecated in API level 23.**

This method does not support multiple connected networks of the same type.

Use [getAllNetworks\(.\)](#) and [getNetworkInfo\(android.net.Network\)](#) instead.

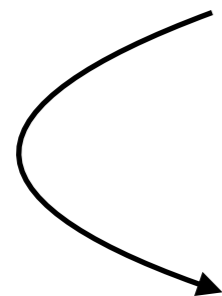
Old API Usage

```
public NetworkInfo[] getAllNetworkInfo()
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New API Usage

```
public Network[] getAllNetworks()
```

```
public NetworkInfo getNetworkInfo(Network network)
```



API Updates

API-Usage Changes

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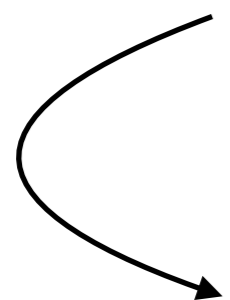
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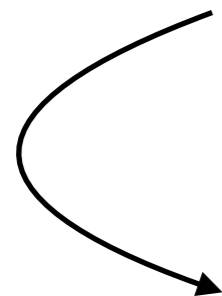
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New API Usage

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```
public NetworkInfo getNetworkInfo(Network network)
```



Migration Example

Migration Example Before

```
public boolean isConnected(Context cont) {
    ConnectivityManager cm = ...;
    NetworkInfo[] info = cm.getAllNetworkInfo();
    for (int i = 0; i < info.length; i++) {
        if(info[i].isConnected()) {
            return true;
        }
    }
    Toast.makeText(R.s.noNet).show();
    return false;
}
```

Migration Example After

```
public boolean isConnected(Context cont) {
    ConnectivityManager cm = ... ;
    if (VERSION.SDK_INT >= VERSION_CODES.M) {
        Network[] networks = cm.getAllNetworks();
        for (Network mNetwork : networks) {
            NetworkInfo networkInfo =
            cm.getNetworkInfo(mNetwork);
            if(networkInfo.isConnected()) {
                Log.d(networkInfo.getTypeName());
                return true;
            }
        }
    } else {
        NetworkInfo[] info = cm.getAllNetworkInfo();
        for (NetworkInfo anInfo : info) {
            if(anInfo.isConnected()) {
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Migration Example

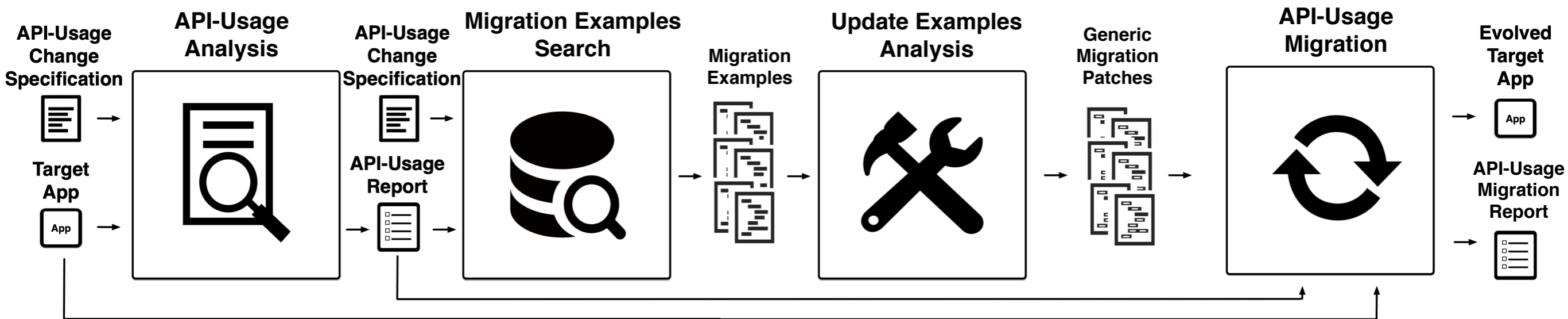
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APIMIGRATOR Overview



1

Identify API usages requiring migration in target app

2

Find migration examples for identified API usages

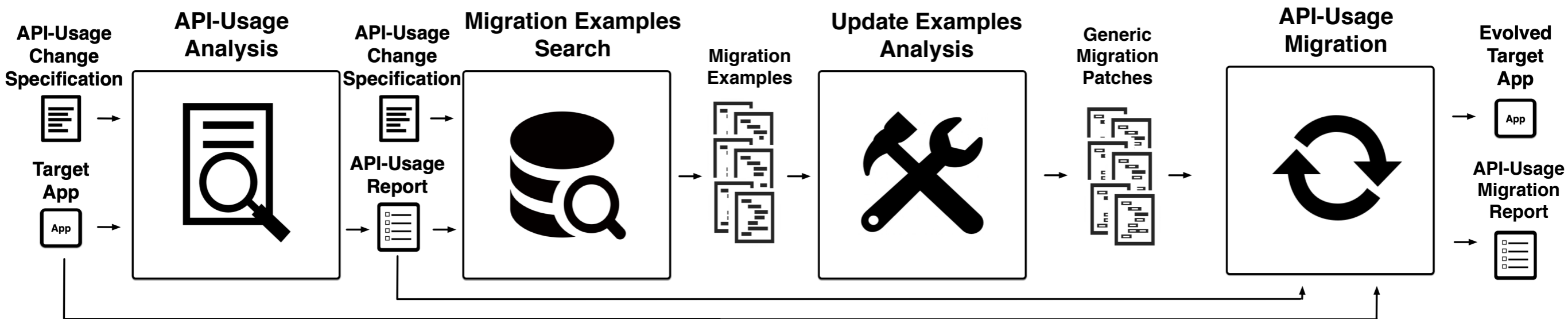
3

Abstract migration examples into generic migration patches and rank them

4

Migrate and validate API usages in target app based on patches

APIMIGRATOR Overview



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Find migration examples for identified API usages

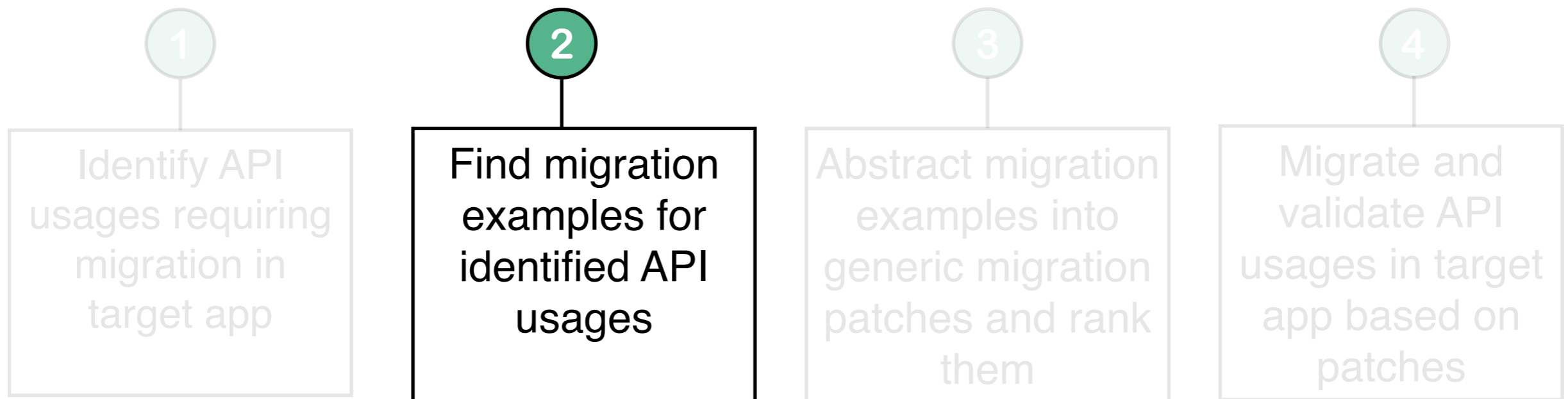
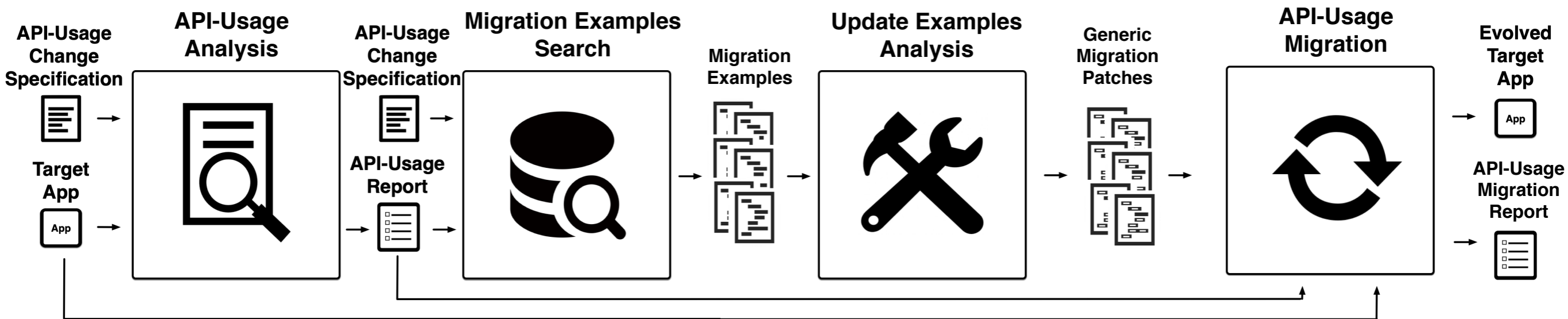
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Abstract migration examples into generic migration patches and rank them

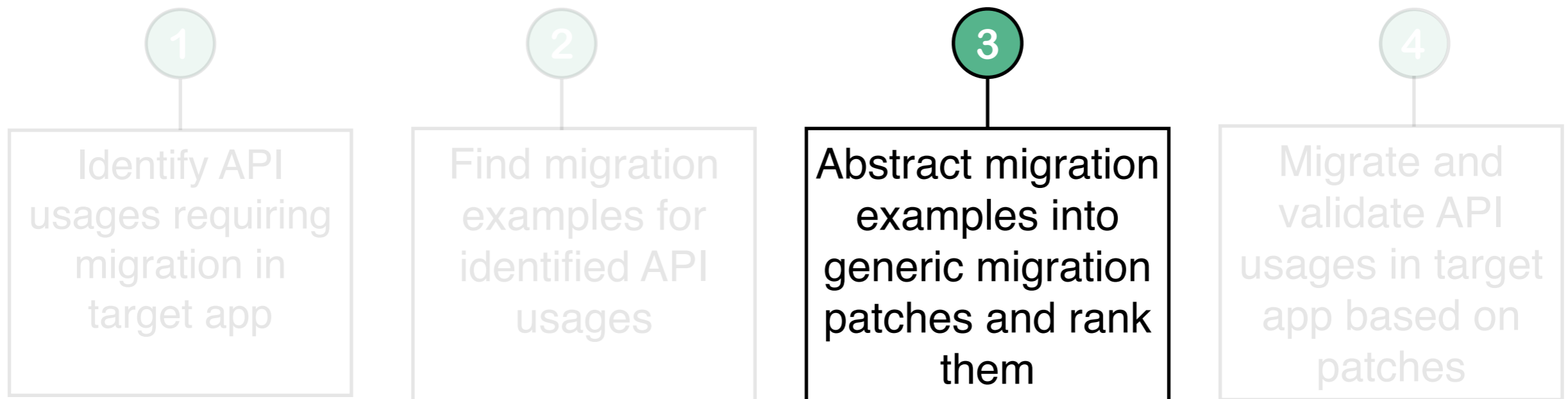
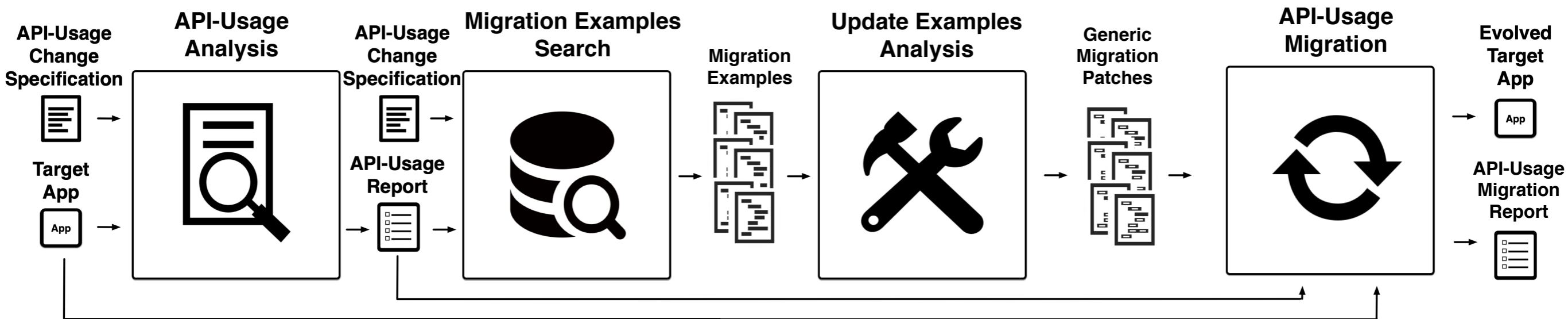
4

Migrate and validate API usages in target app based on patches

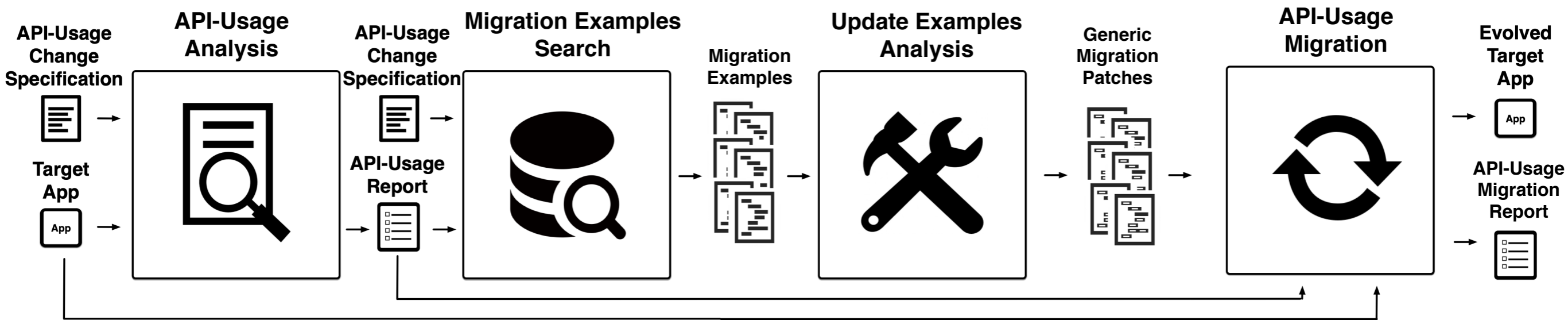
APIMIGRATOR Overview



APIMIGRATOR Overview



APIMIGRATOR Overview



1

Identify API usages requiring migration in target app

2

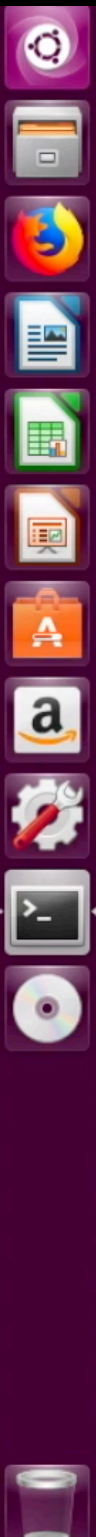
Find migration examples for identified API usages

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Abstract migration examples into generic migration patches and rank them

4

Migrate and validate API usages in target app based on patches



```
root@apimigrator-VirtualBox:/home/apimigrator/Desktop/apimigrator/run/API-Usage_Analysis#  
./run.sh A02
```





```
root@apimigrator-VirtualBox:/home/apimigrator/Desktop/apimigrator/run/API-Usage_Analysis#  
./run.sh A02
```



Empirical Evaluation

Research Questions

RQ1 (EFFECTIVENESS): Can APIMIGRATOR migrate API usages in real-world apps?

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

Evaluation

RQ1 (EFFECTIVENESS): Can APIMIGRATOR migrate API usages in real-world apps?

- **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)

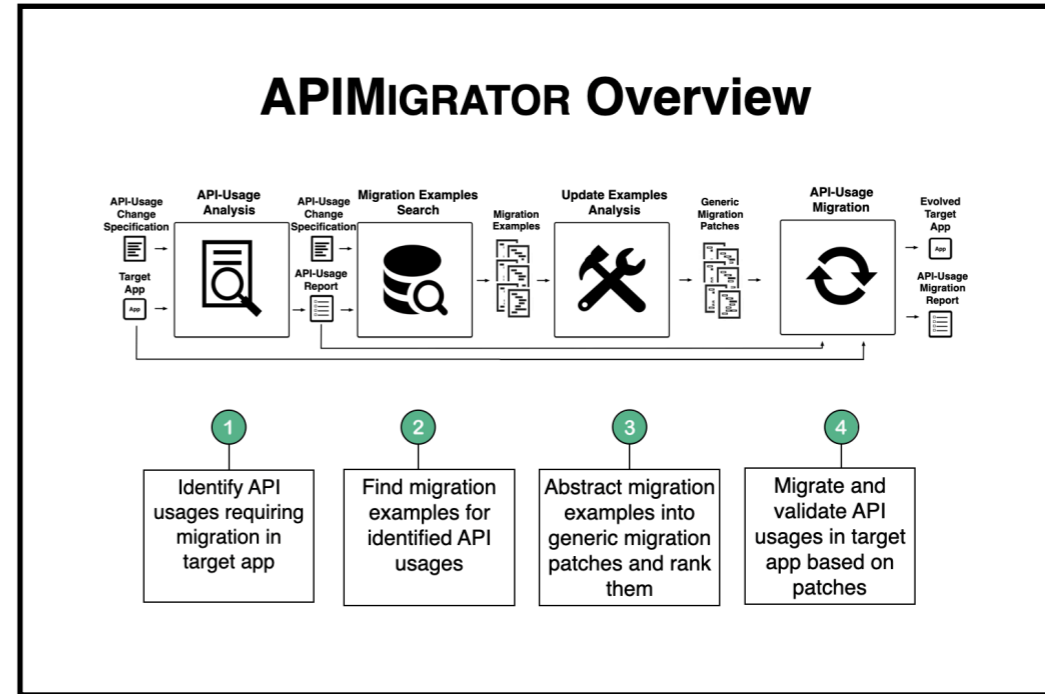
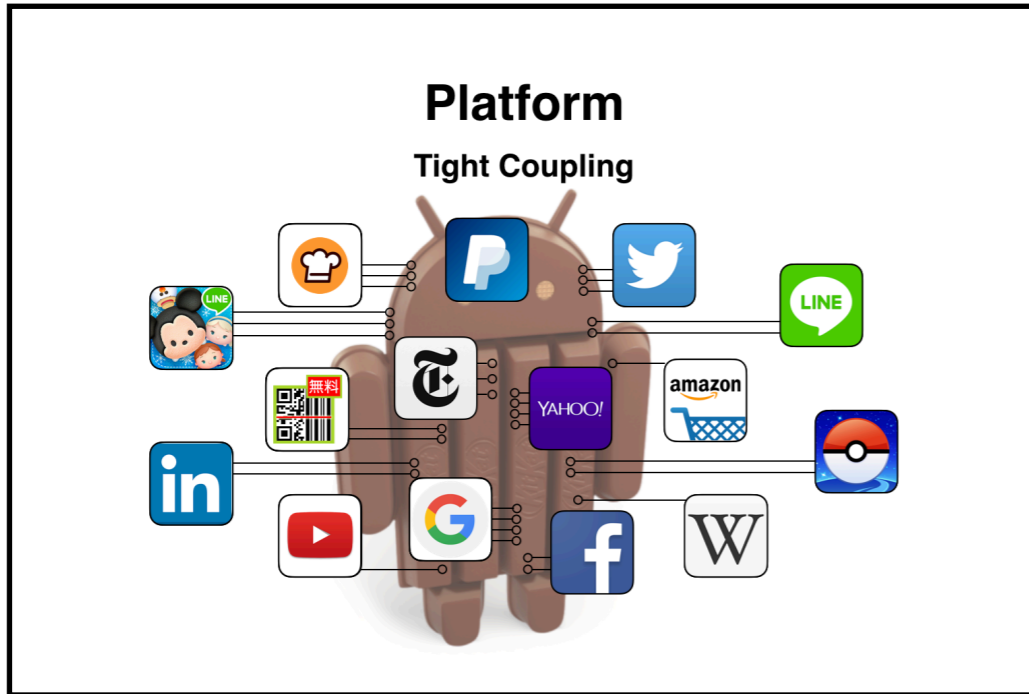
APPEVOLVE is effective in automatically updating API usages.

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

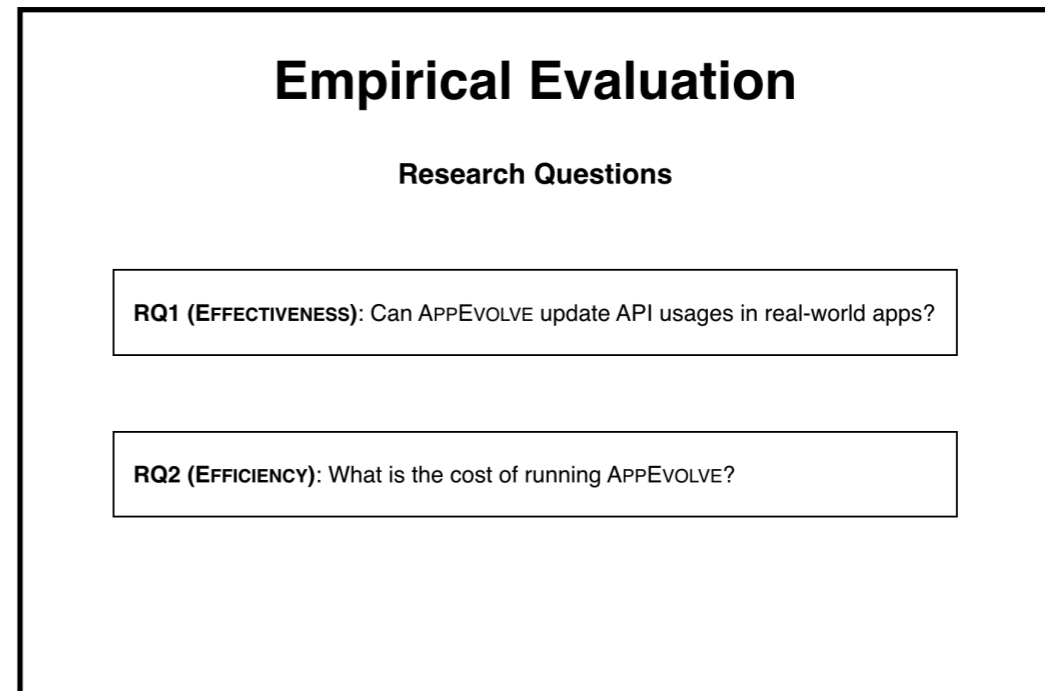
Average Execution Time			
API-Usage Analysis	Update Examples Search	Update Examples Analysis	API-Usage Update
28s	<u>10h27m</u>	2s204ms	20s

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

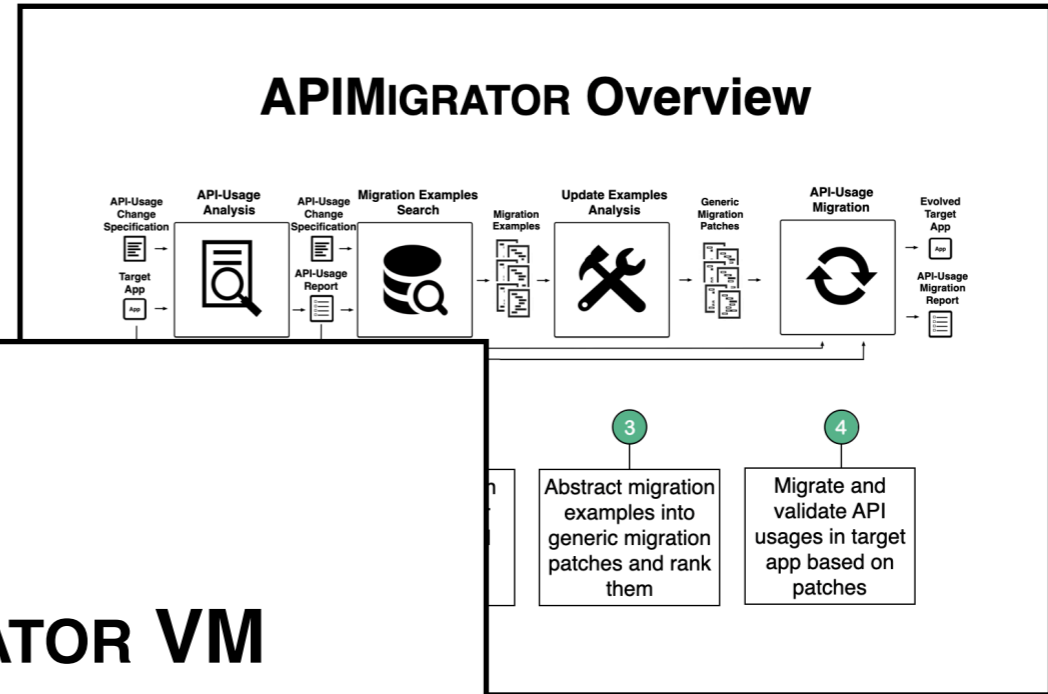
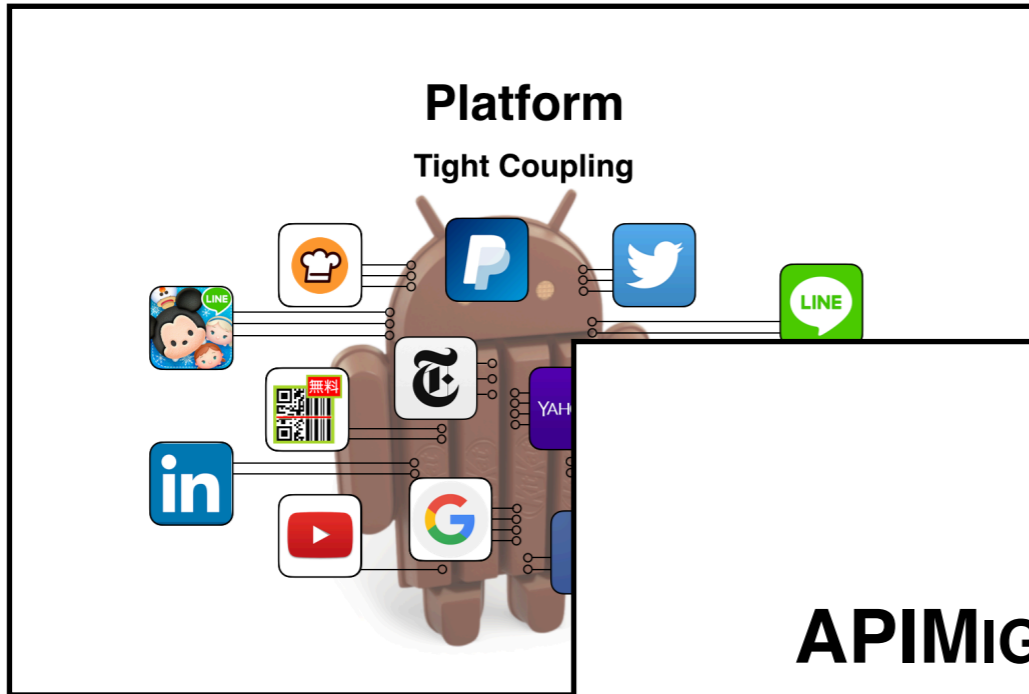
Summary



```
nalysis+API-Usage_Migration# ./run.sh A02 U02 04
private boolean isNetworkAvailable(Context context){
    ConnectivityManager connectivity=(ConnectivityManager)context.getSystemService(Context
CONNECTIVITY_SERVICE);
    if (android.os.Build.VERSION.SDK_INT >= android.os.Build.VERSION_CODES.LOLLIPOP) {
        Network[] networks=connectivity.getAllNetworks();
        NetworkInfo networkInfo;
        for ( Network mNetwork : networks) {
            networkInfo=connectivity.getNetworkInfo(mNetwork);
            if (networkInfo.getState().equals(NetworkInfo.State.CONNECTED)) {
                return true;
            }
        }
    }
    else {
        NetworkInfo[] info=connectivity.getAllNetworkInfo();
        if (info != null) {
            for ( NetworkInfo anInfo : info) {
                if (anInfo.getState() == NetworkInfo.State.CONNECTED) {
                    return true;
                }
            }
        }
    }
}
return false;
```



Summary



APIMIGRATOR VM
<https://zenodo.org/record/3668385>

```
analysis+API-Usage_Migration# ./run.sh A02 U02 0
private boolean isNetworkAvailable(Context cont
    ConnectivityManager connectivity=(Connectivit
CONNECTIVITY_SERVICE);
    if (android.os.Build.VERSION.SDK_INT >= andro
        Network[] networks=connectivity.getAllNetw
        NetworkInfo networkInfo;
        for ( Network mNetwork : networks) {
            networkInfo=connectivity.getNetworkInfo(m
            if (networkInfo.getState().equals(NetworkInfo.State.CONNECTED)) {
                return true;
            }
        }
    }
    else {
        NetworkInfo[] info=connectivity.getAllNetworkInfo();
        if (info != null) {
            for ( NetworkInfo anInfo : info) {
                if (anInfo.getState() == NetworkInfo.State.CONNECTED) {
                    return true;
                }
            }
        }
    }
    return false;
}
Microsoft Word
```

Evaluation

Research Questions

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

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