# OF AHEAD TIME

## Evaluating Disassembly of Android Apps Compiled to Binary OATs Through the ART

Jakob Bleier, Martina Lindorfer – SecLab TU Wien

EuroSec '23

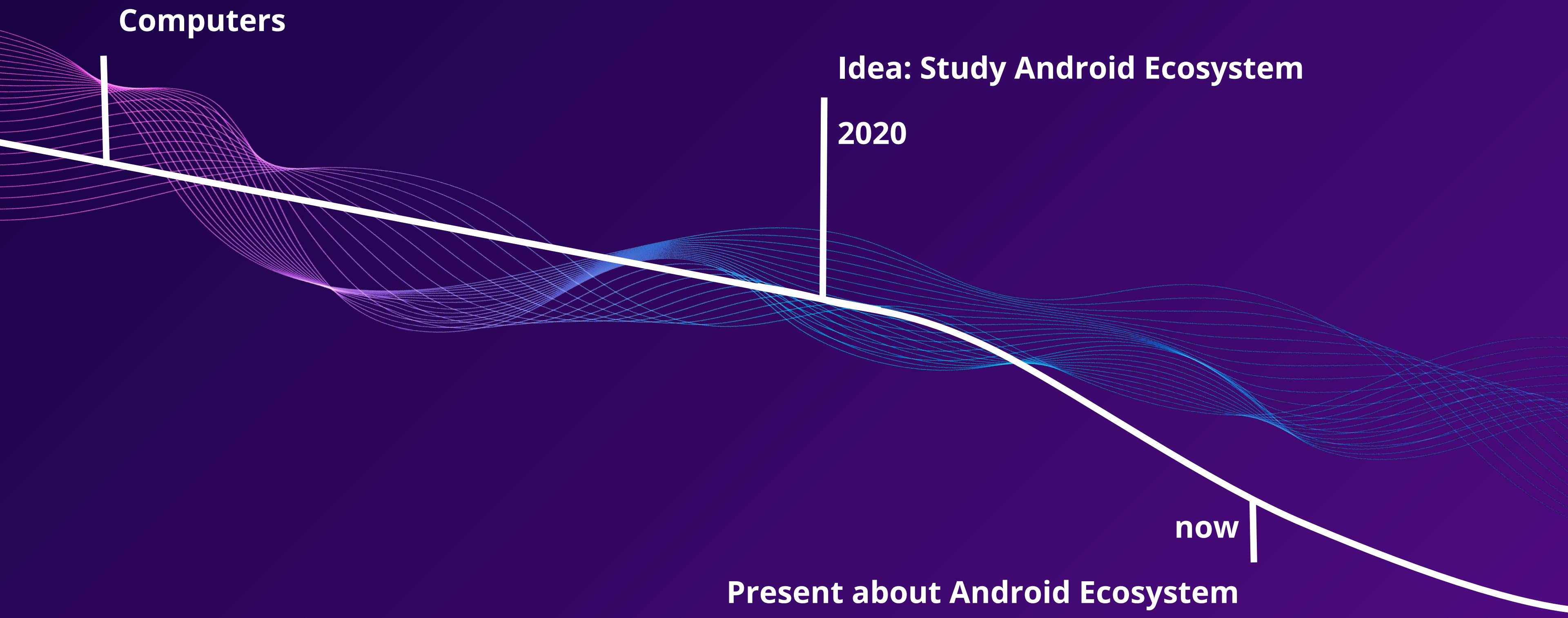
# OF AHEAD TIME

## Evaluating Disassembly of Android Apps Compiled to Binary OATs Through the ART

Jakob Bleier, Martina Lindorfer – SecLab TU Wien

EuroSec ‘23

# How did we get here?



Computers

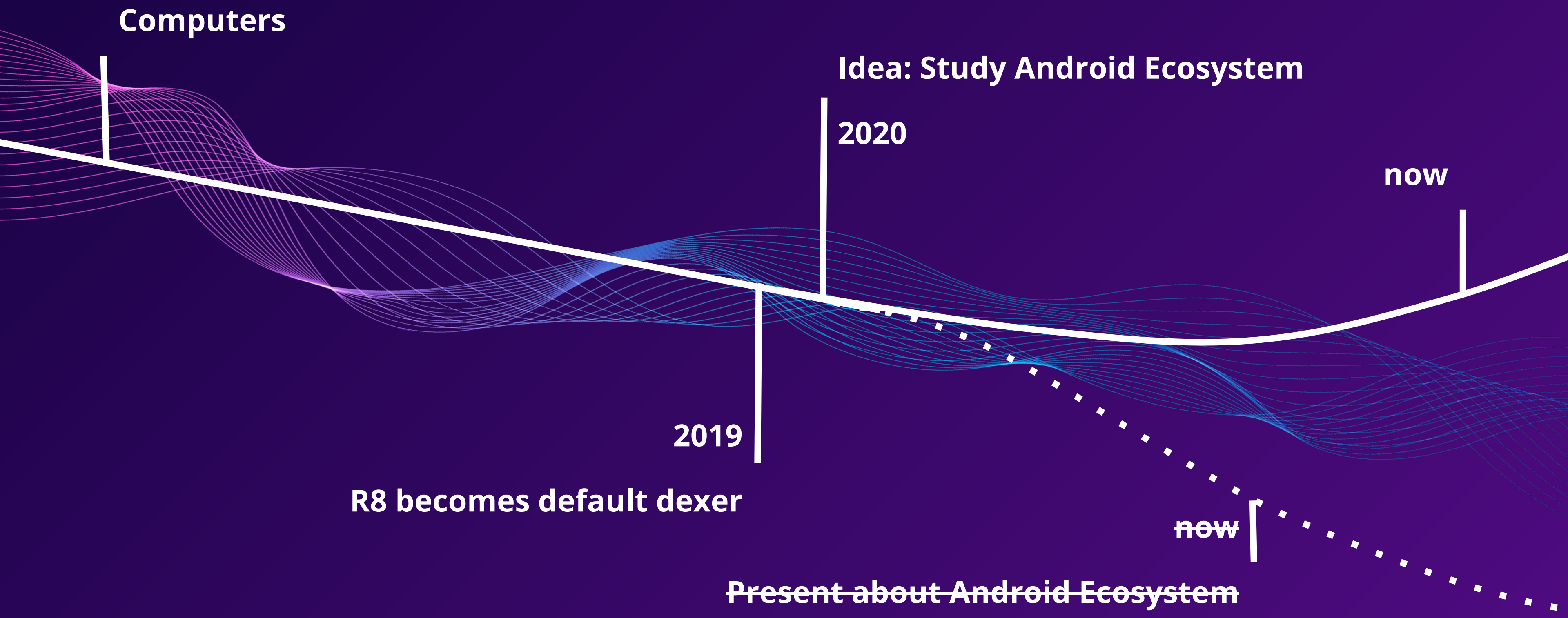
Idea: Study Android Ecosystem

2020

now

Present about Android Ecosystem

# How did we get here?



Computers

2019

R8 becomes default dexer

2020

Idea: Study Android Ecosystem

~~now~~

~~Present about Android Ecosystem~~

now

# App code

## Java(/Kotlin)

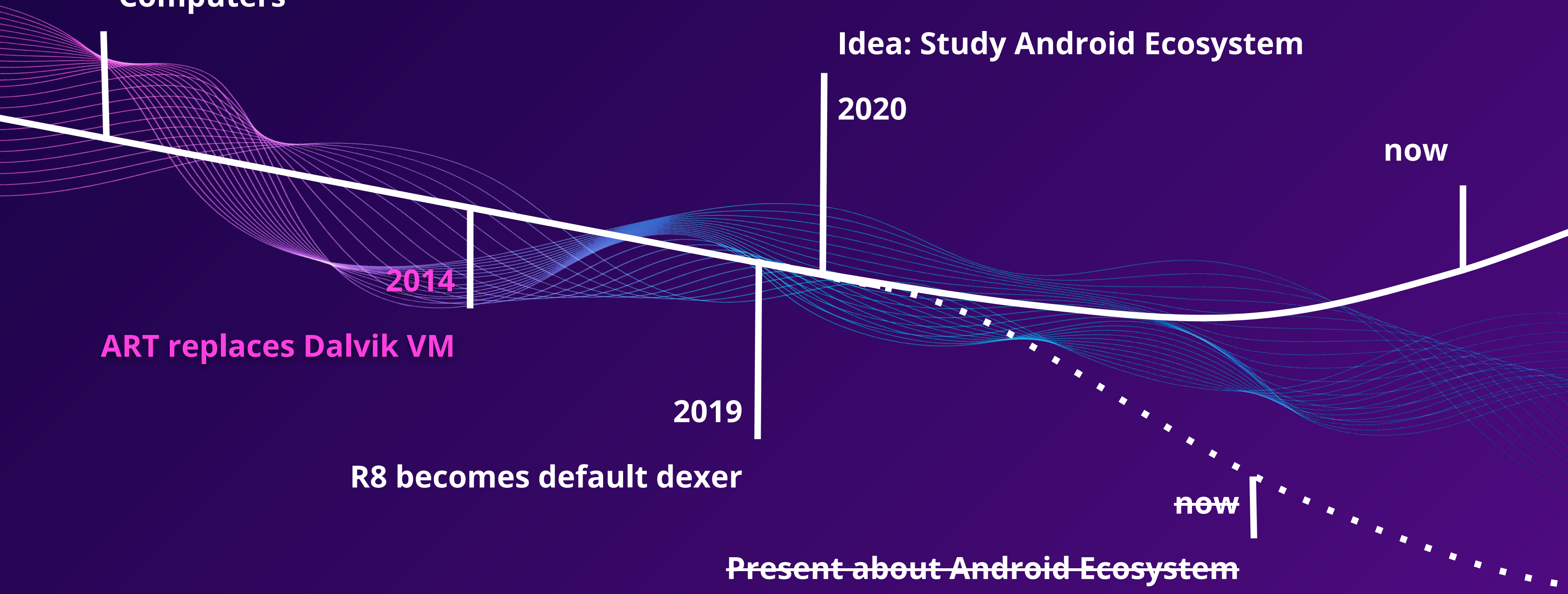
```
int fooBar(int a) {
     int x = halve(a);
     int y = a*3;
     int z = 0;
     if (a > 111) {
          z = fooBar(x);
     } else {
          z = a-2;
     }
     return x+y+z;
}

int halve(int a) {
    return a/2;
}
```

## Dalvik

```
invoke-virtual {v3, v4},
     int [..].halve(int)
move-result v0
mul-int/lit8 v1, v4, #+3
const/16 v2, #+111
if-le v4, v2, +7
invoke-virtual {v3, v0},
     int [..].fooBar(int)
move-result v3
goto +3
add-int/lit8 v3, v4, #-2
add-int/2addr v0, v1
add-int/2addr v0, v3
return v0
```

# How did we get here?



Computers

2014

ART replaces Dalvik VM

2019

R8 becomes default dexer

Idea: Study Android Ecosystem

2020

~~now~~

~~Present about Android Ecosystem~~

now

# App code

## Java(/Kotlin)

```
int fooBar(int a) {
     int x = halve(a);
     int y = a*3;
     int z = 0;
     if (a > 111) {
          z = fooBar(x);
     } else {
          z = a-2;
     }
     return x+y+z;
}

int halve(int a) {
    return a/2;
}
```

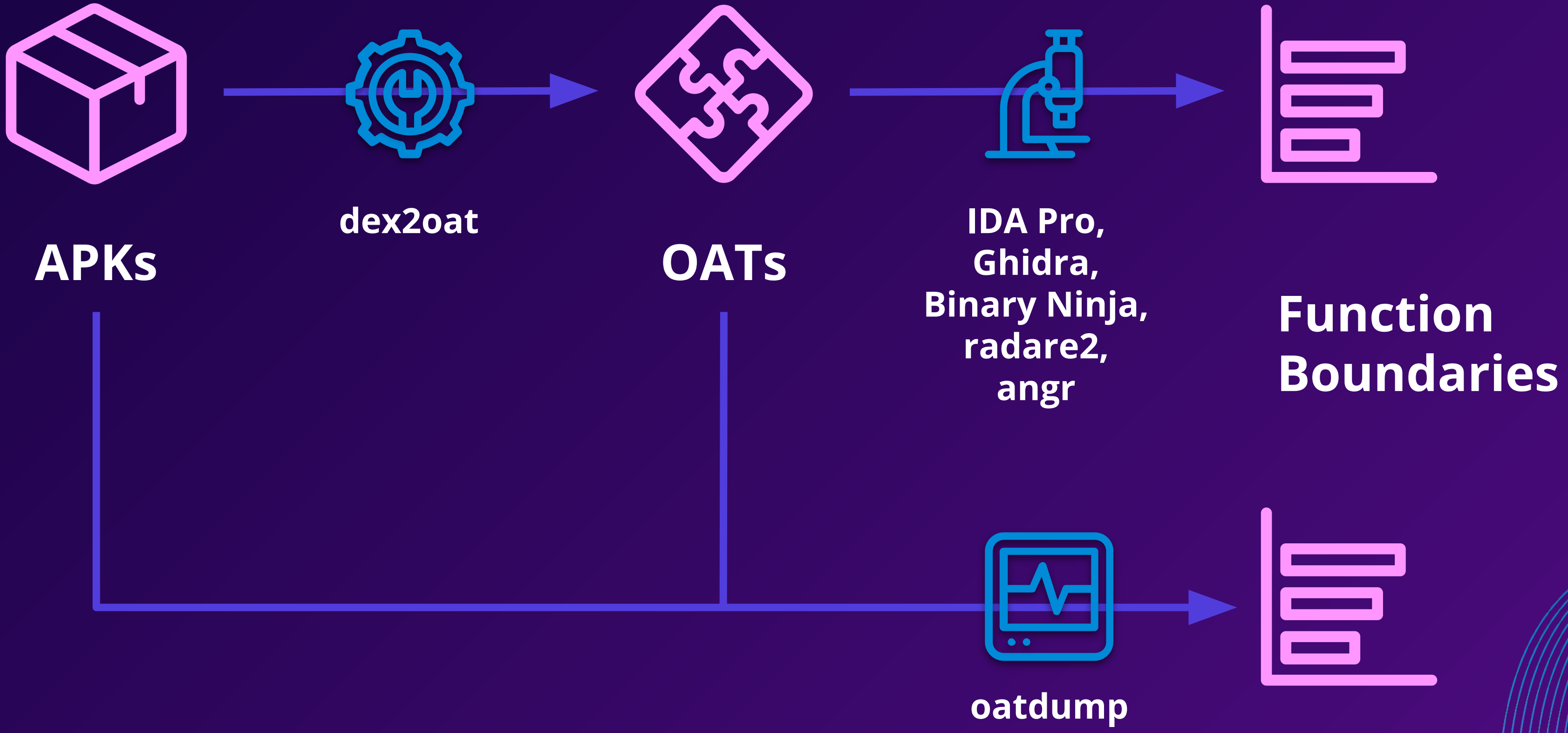
## Dalvik

```
invoke-virtual {v3, v4},
     int [..].halve(int)
move-result v0
mul-int/lit8 v1, v4, #+3
const/16 v2, #+111
if-le v4, v2, +7
invoke-virtual {v3, v0},
     int [..].fooBar(int)
move-result v3
goto +3
add-int/lit8 v3, v4, #-2
add-int/2addr v0, v1
add-int/2addr v0, v3
return v0
```

## Binary

```
[..]
mov x22, x1
mov x23, x2
[..]
cmp w23, #0x6f (111)
b.le #+0x20 (addr 0x7f0730)
mov x2, x0
mov x1, x22
mov x25, x2
[..]
mov x25, x0
sub w0, w23, #0x2 (2)
add w1, w25, w24
add w0, w0, w1
[..]
ret
```

# Evaluate Disassembly



APKs

dex2oat

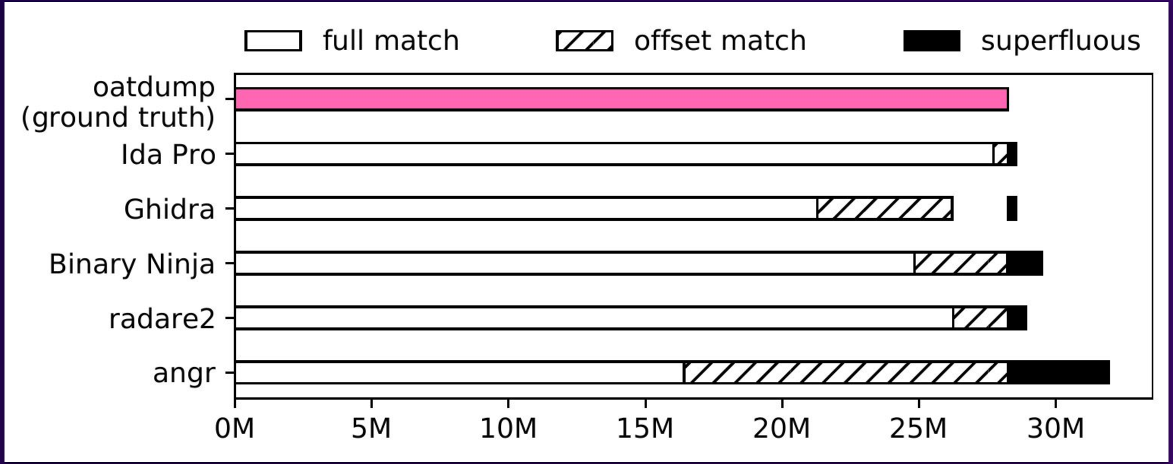
OATs

IDA Pro,
Ghidra,
Binary Ninja,
radare2,
angr

Function
Boundaries

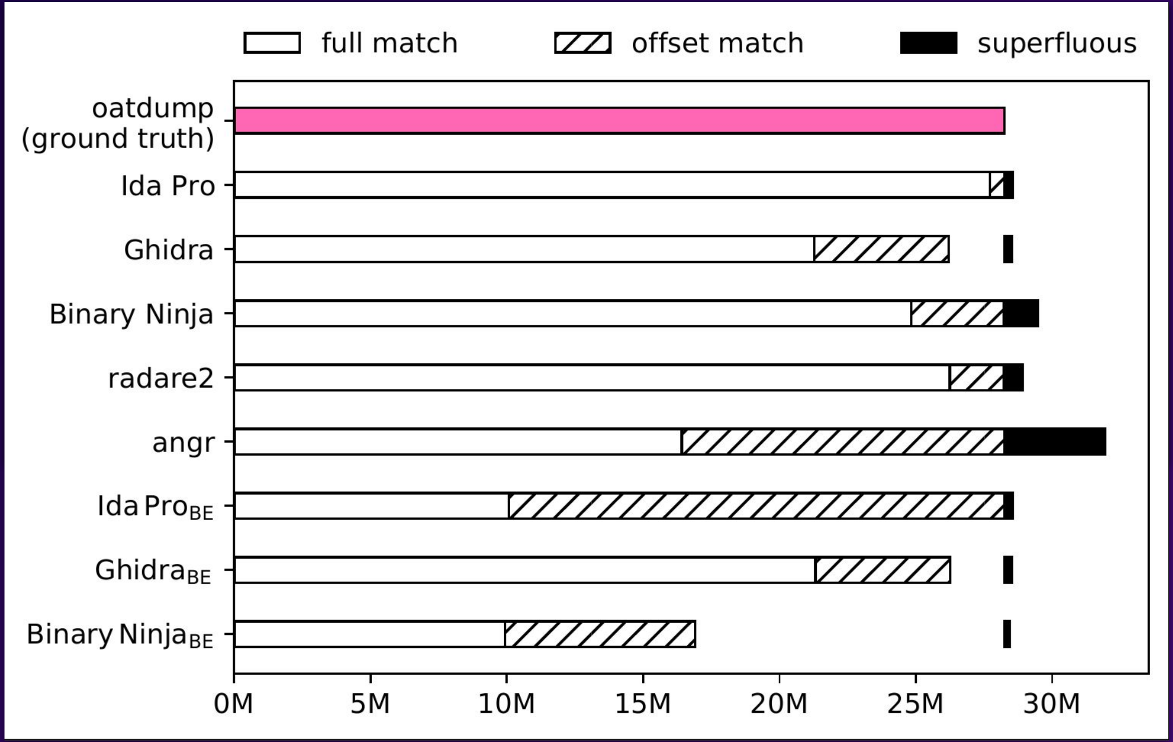
oatdump

# Function Boundaries

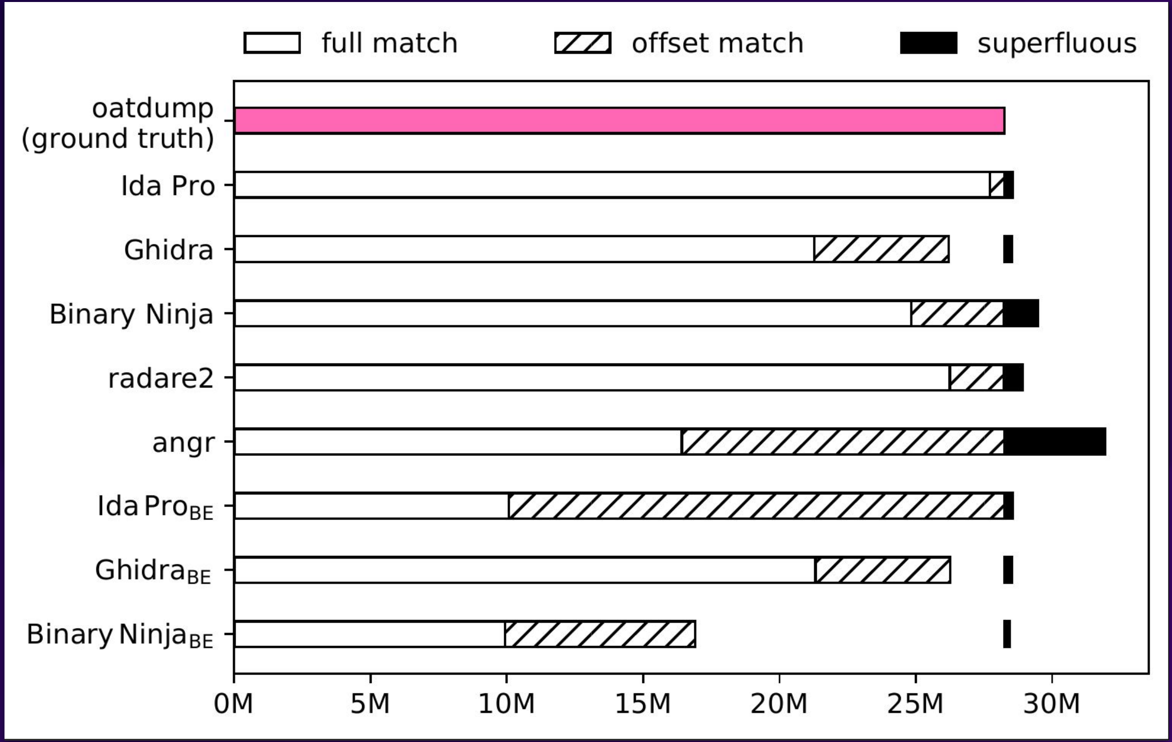


- full match: offset + size match
- (only) offset matches
- superfluous functions at unexpected offsets

# Function Boundaries



# Function Boundaries



**Soot:**
**1,261 (94.17%)**

**SootUP:**
**1339 (100%)**
**Failed on 7 functions in 5 apps**

# Of Ahead Time: Evaluating Disassembly of Android Apps Compiled to Binary OATs Through the ART

Jakob Bleier, Martina Lindorfer – SecLab TU Wien

- APK to OAT compilation and Disassembly possible at scale
- Differences in decompilers re: Function boundaries, but promising results

Ongoing work:

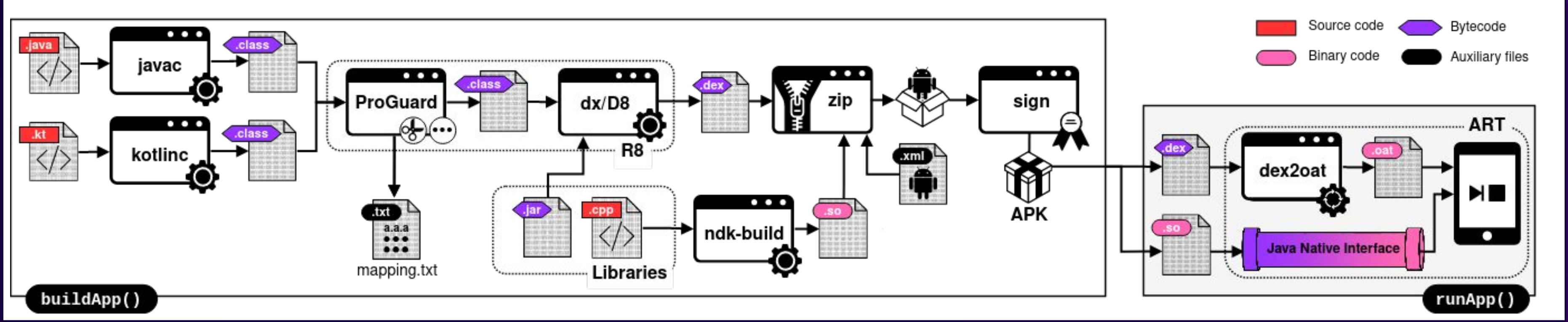
- Downstream tools for full app analysis
- Open source pipeline for extendable benchmark with robust ground truth

TECHNISCHE
UNIVERSITÄT
WIEN

This presentation template was created by Slidesgo, including icons by Flaticon, infographics & images by Freepik

# Extra slides

# Lifetime of an Android App


.java
javac
.class
.kt
kotlinc
.class
ProGuard
.class
dx/D8
R8
.dex
zip
sign
APK
.txt
a.a.a
mapping.txt
.jar
.cpp
Libraries
ndk-build
.so
.xml
Source code
Bytecode
Binary code
Auxiliary files
ART
.dex
dex2oat
.oat
.so
Java Native Interface
buildApp()
runApp()