SACC 2016 第八届中国系统架构师大会

SYSTEM ARCHITECT CONFERENCE CHINA 2016

架构创新之路

安卓应用保护技术发展

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ABOUT ME

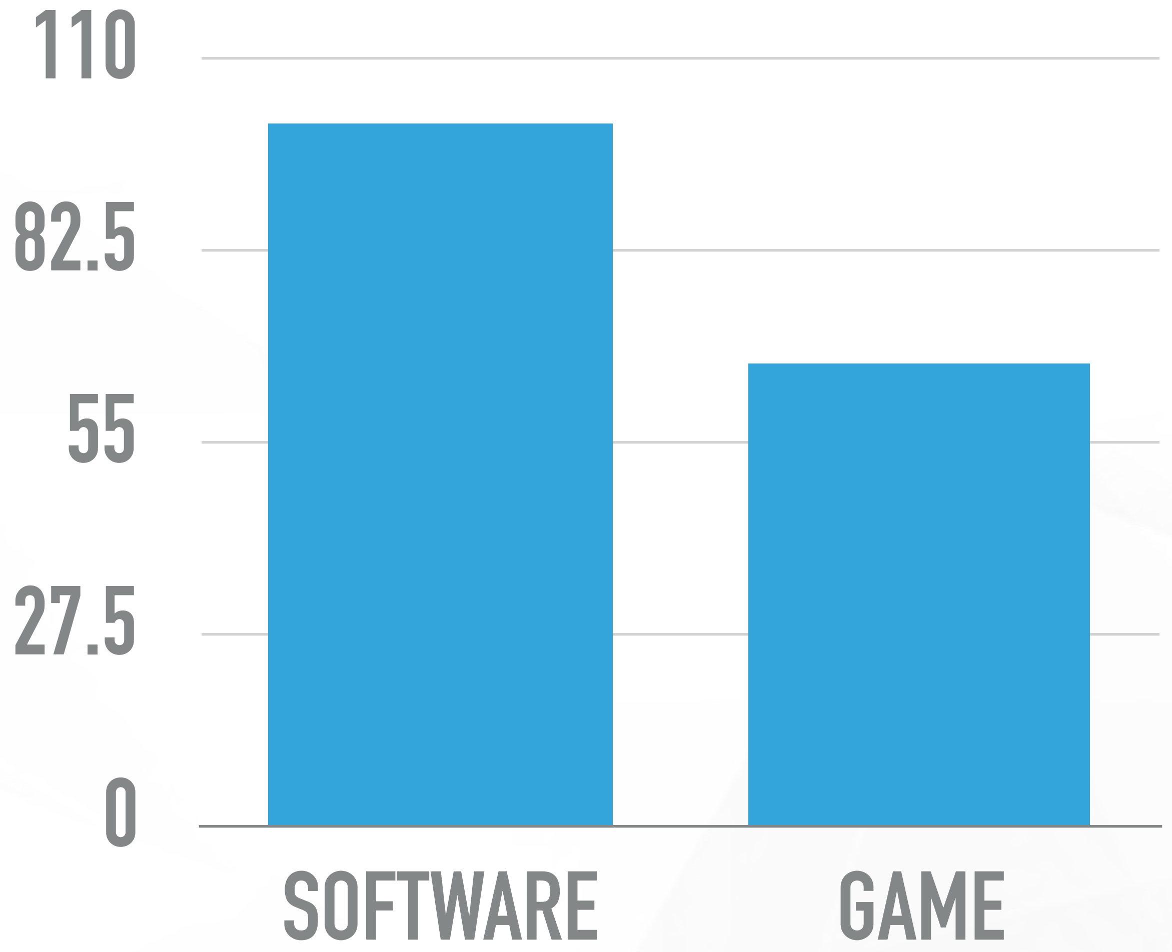
- Earned P.h.D. in Computer Science from NC State University
- Research mainly focuses on smartphone and system security
- More information: http://yajin.org

AGENDA

- Why app packing services are becoming popular
- The main app packing/unpacking techniques
- New trends

APP REPACKAGING

- Given10,305 popular apps, 954,986 repackaged apps are found*



*[Datasource Link]

THE CONSEQUENCES OF APP REPACKAGING

- Developers
- Users

How easily to repackage an app?

Video Demo

APP PACKING SERVICE PROVIDERS

360加固保
jiagu.360.cn

应用加固
反静态分析、反动态调试，
反内存窃取、反恶意篡改...

阿里聚安全
应用更安全，用户更安心!

抗盗版神器
腾讯云应用加固

FREE SERVICE

梆梆安全
BANGCLE

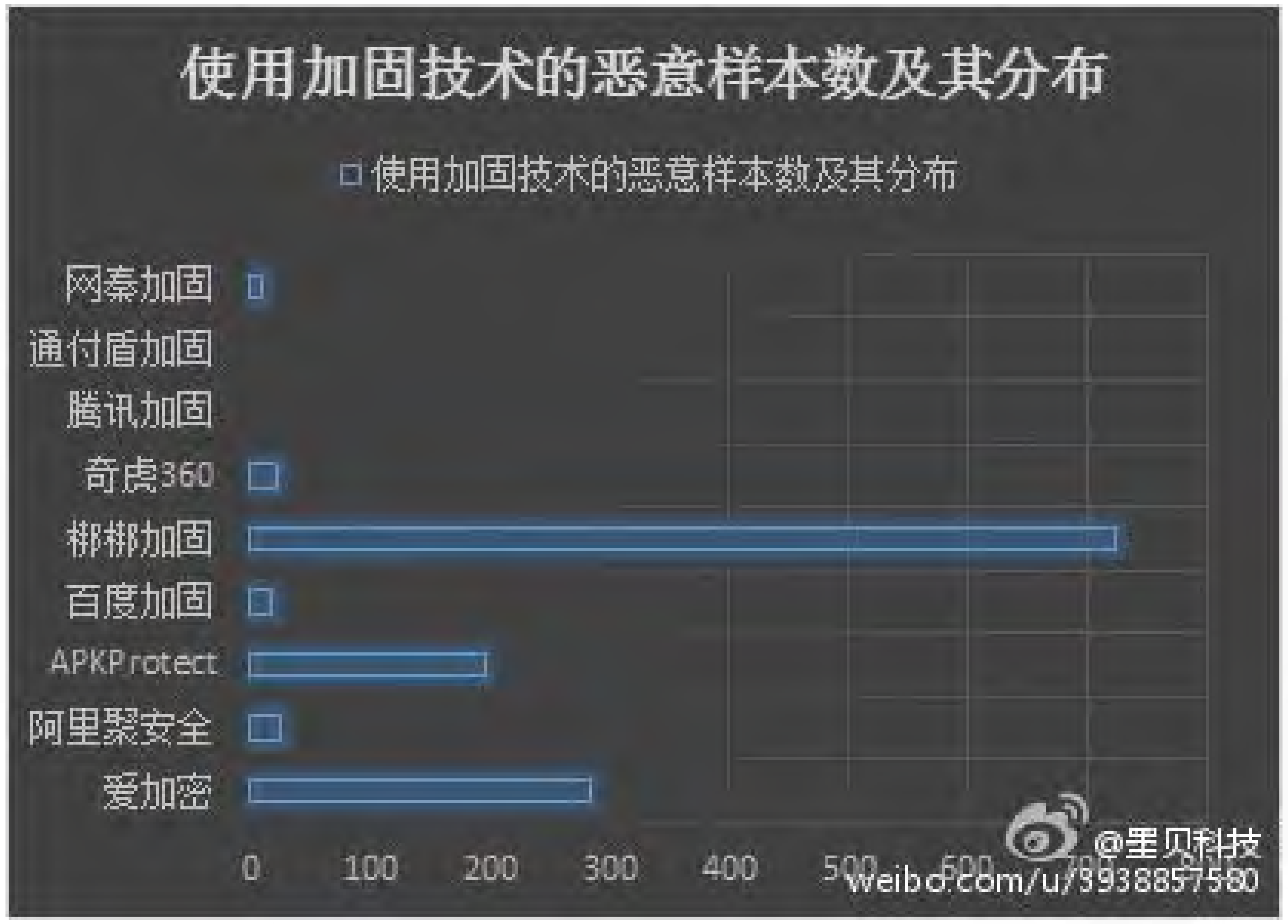
爱加密

DOUBLE-EDGED SWORD

- Packing services create problem for both good and bad guys
    - Bad guys: malware authors, (重)打包党
        - hard to repackage popular apps
    - Good guys: app markets maintainers, security researchers(??) …

IN REALITY

- App packing services are abused by bad guys



*Datasource Link

MAIN TYPES OF APP PACKING TECHNIQUES

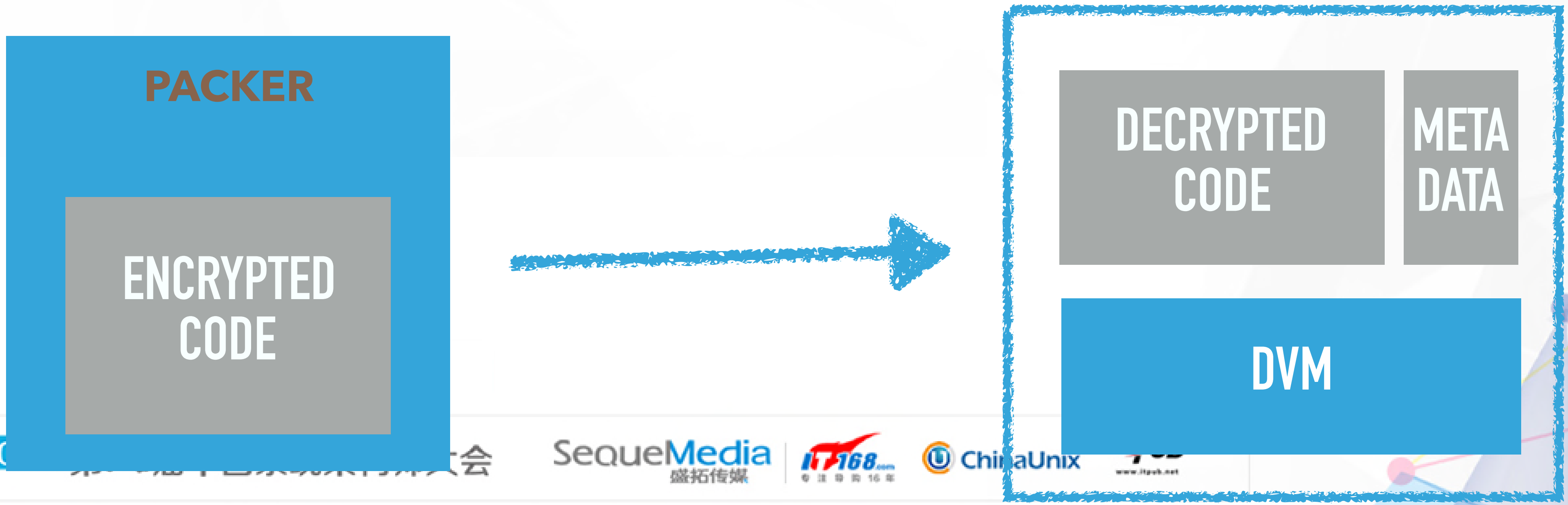
- Static: cheat static analysis tools
- Dynamic
  - Memory dex loading: directly load encrypted dex file into memory and execute
  - Anti-analysis: raise the bar for dynamic analysis

MAIN TYPES OF APP UNPACKING TECHNIQUES

- Static: reverse engineer the encryption algorithm
  - Pros: one method to kill all samples – protected by one packer
  - Cons: hard – usually the encryption algorithm is in the native code, and continuously changing

MAIN TYPES OF APP UNPACKING TECHNIQUES

- Dynamic: memory dump
  - Basic idea: the unencrypted bytecode will be eventually in memory
  - Lack of self-modifying (and JITed bytecode) support



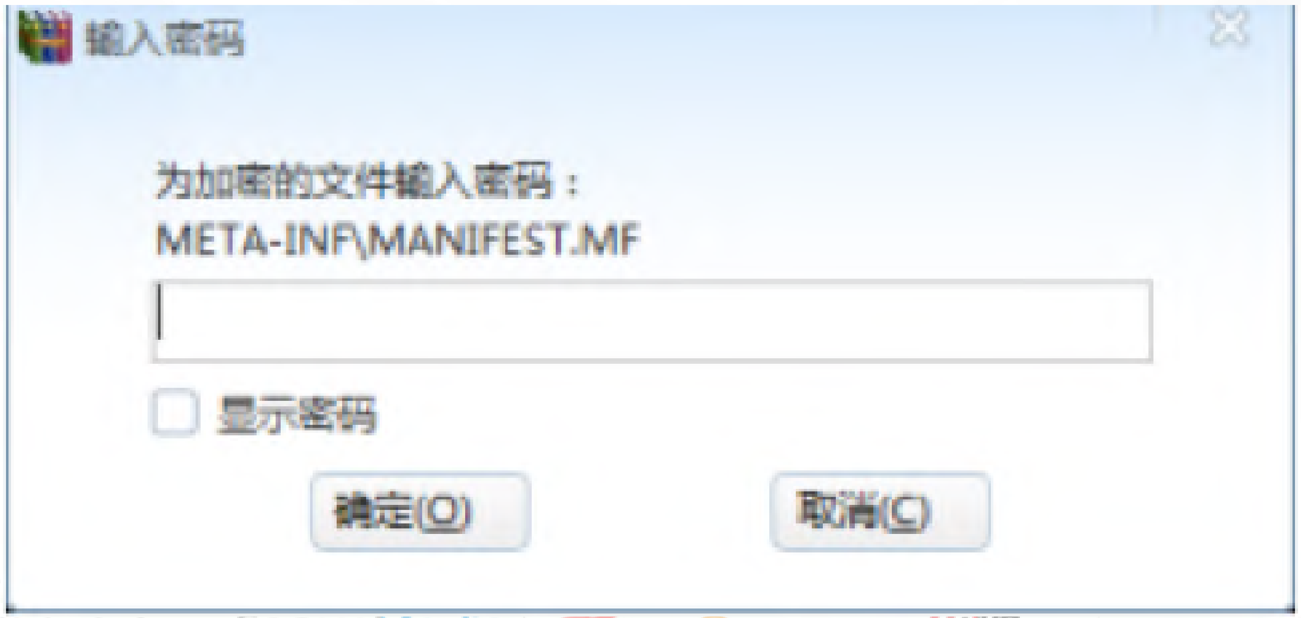
App Packing Techniques: Static

MANIFEST CHEATING

- Manifest file: define package name, permissions, components …
- When parsed, attributes are translated into ids
- If we insert an id to represent an undefined Java class
  - aapt: ignore this
  - apktool: honor this-> app repackaged by apktool will crash due to unimplemented Java classes

FAKE ENCRYPTION

- Apk file is indeed a normal zip file
- Set the encryption flag to true
- Old Android system does ***NOT*** check this flag, but static analyst tool does


输入密码

为加密的文件输入密码：
META-INF\MANIFEST.MF

BYTECODE-OBFUSCATION

- Depends on the disassembly algorithm
  - Linear
  - Recursive

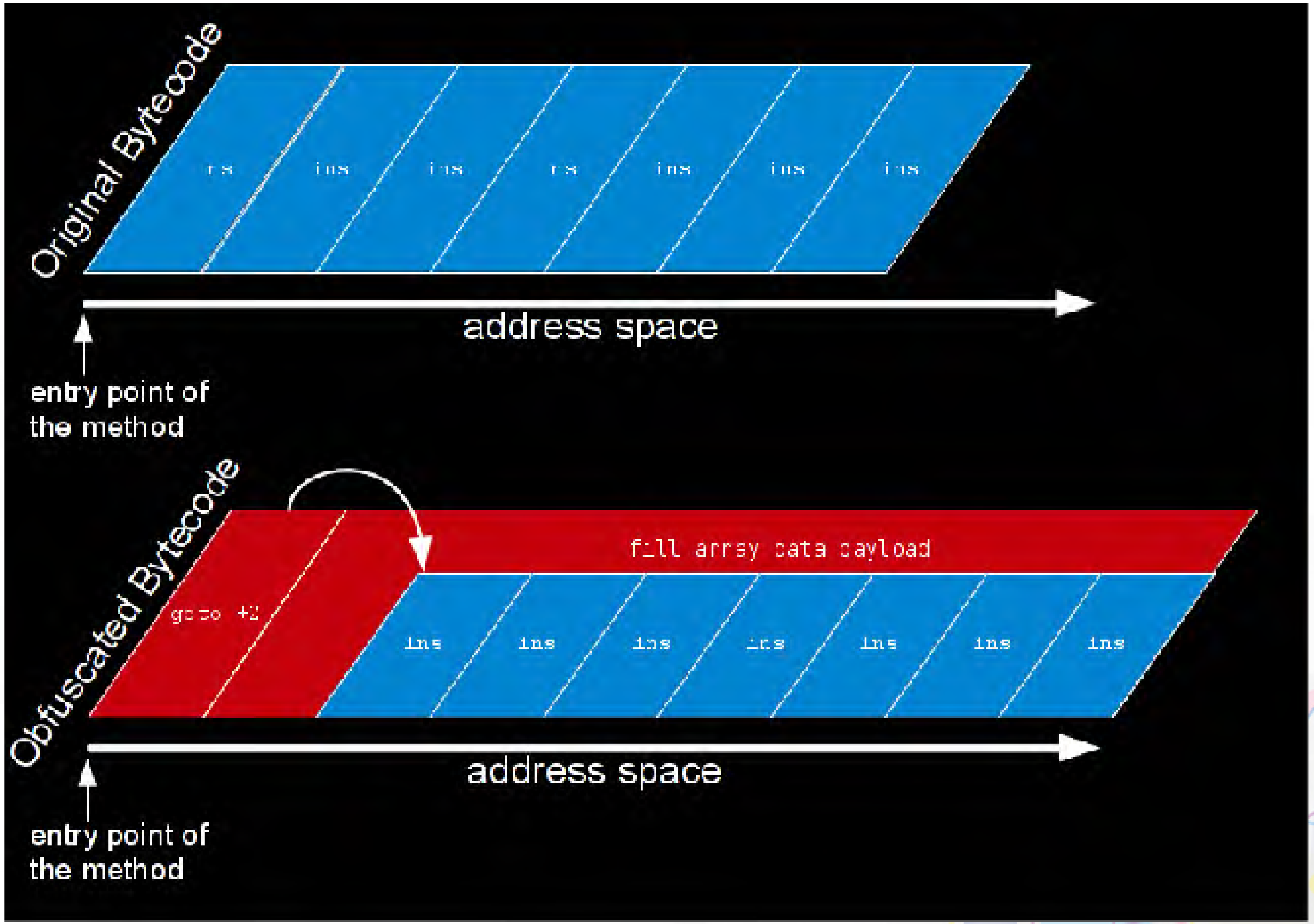
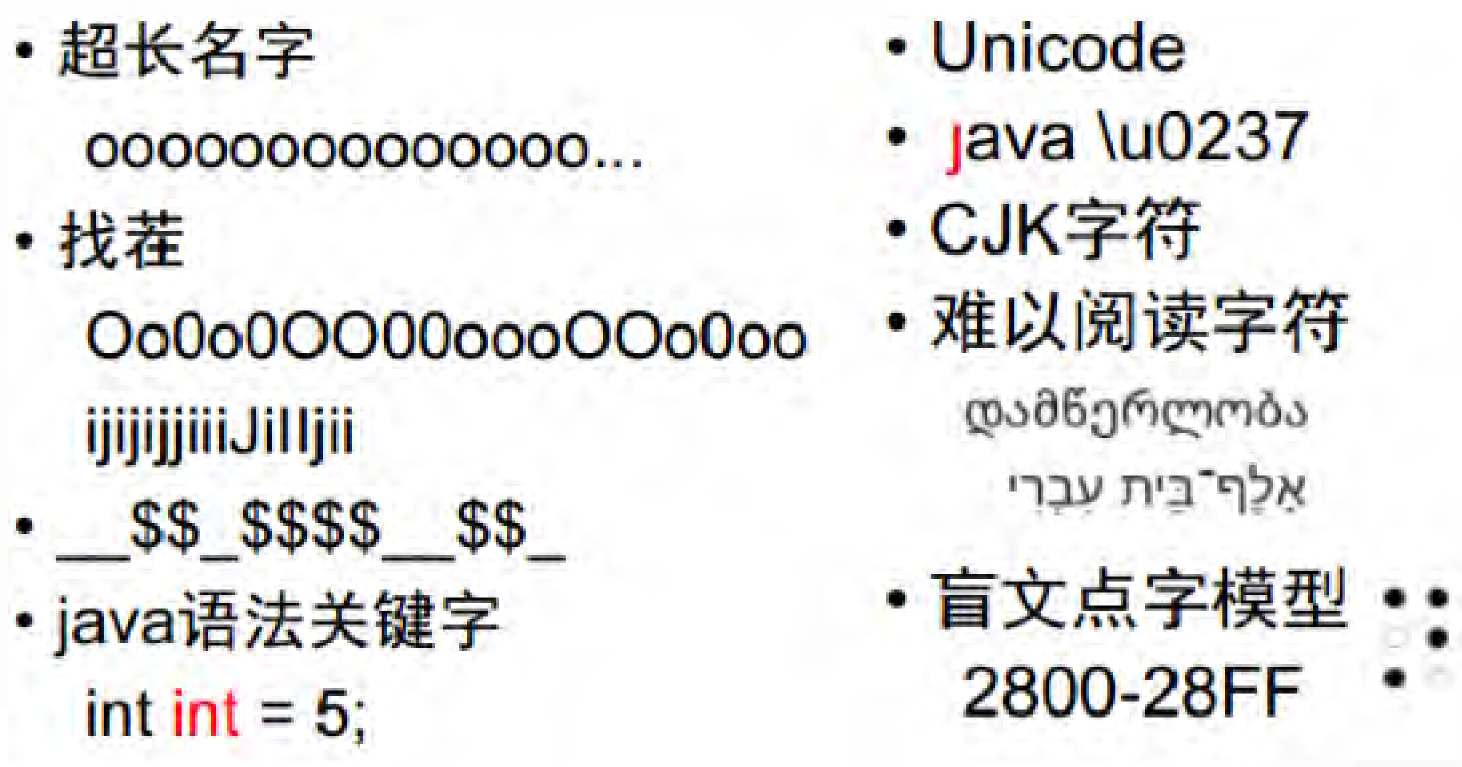


Image source: DexLabs

(LONG)FILE-NAME TRICKS

- Limited length of a file name



- 超长名字
  ooooooooooooooo…
- 找茬
  Oo0o0OO00oooOOo0oo
  ijijijjiiiJiIljii
- __$$\_$$$$\_\_$$_
- java语法关键字
  int int = 5;

- Unicode
- ȷava \u0237
- CJK字符
- 难以阅读字符
  დამწერლობა
  אָלֶף־בֵּית עִבְרִי
- 盲文点字模型 ⠝
  2800-28FF

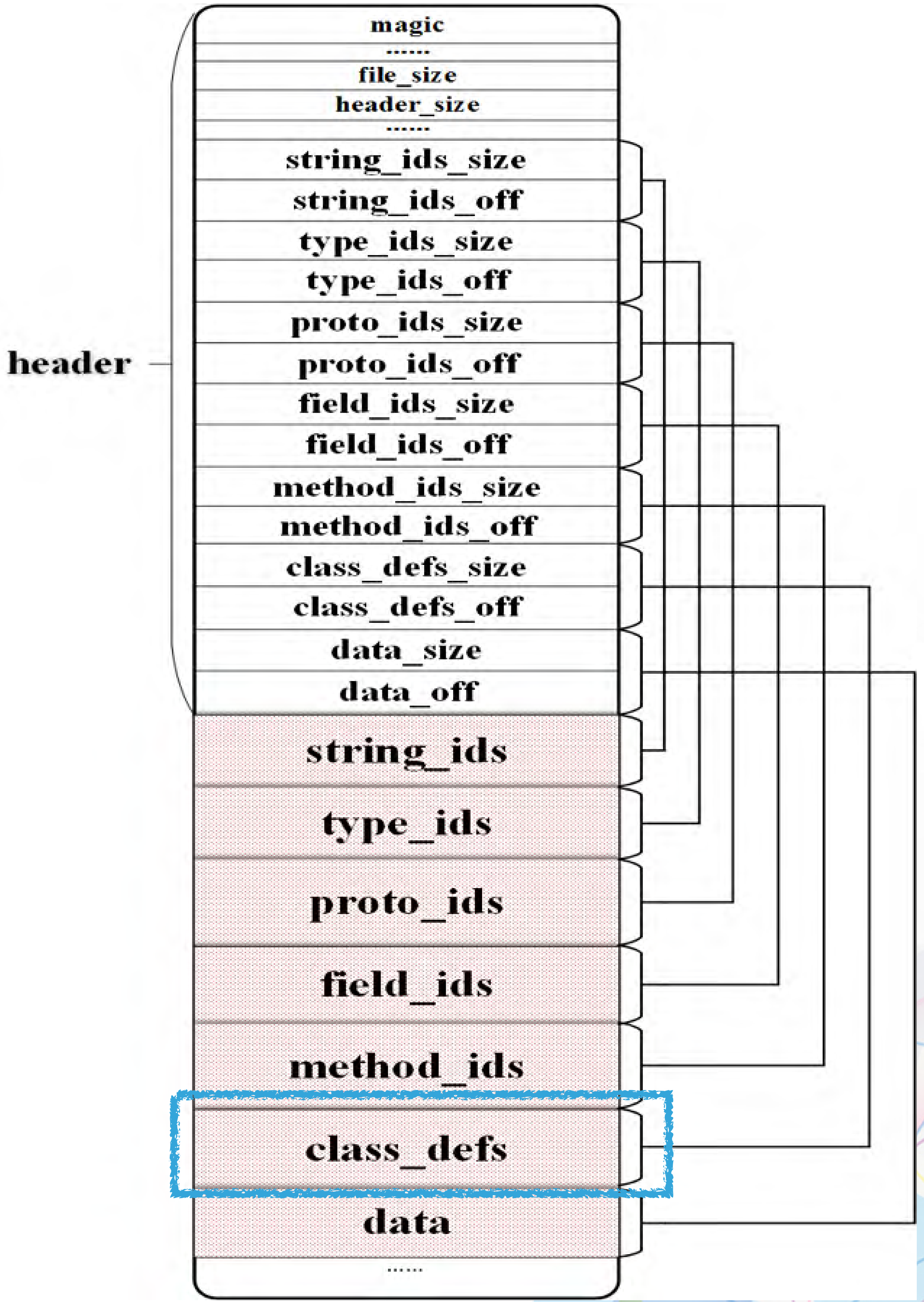
OVERVIEW

- Pros: easy to implement, better compatibility, low performance overhead
- Cons: easy to be bypassed,
    - Small tricks, not a systematic way to protect app

App Packing Techniques: Dynamic

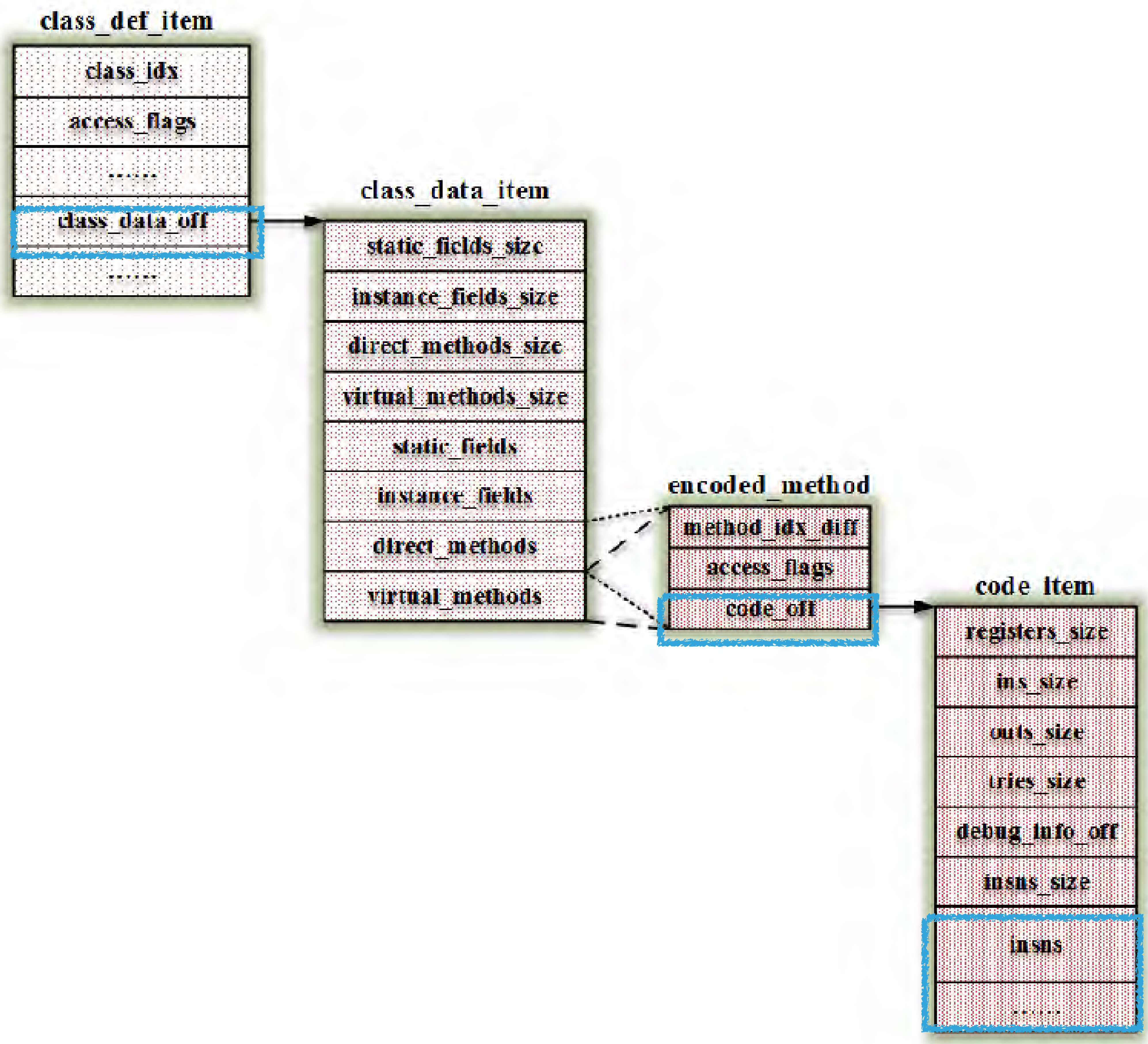
BACKGROUND

- Dex Header



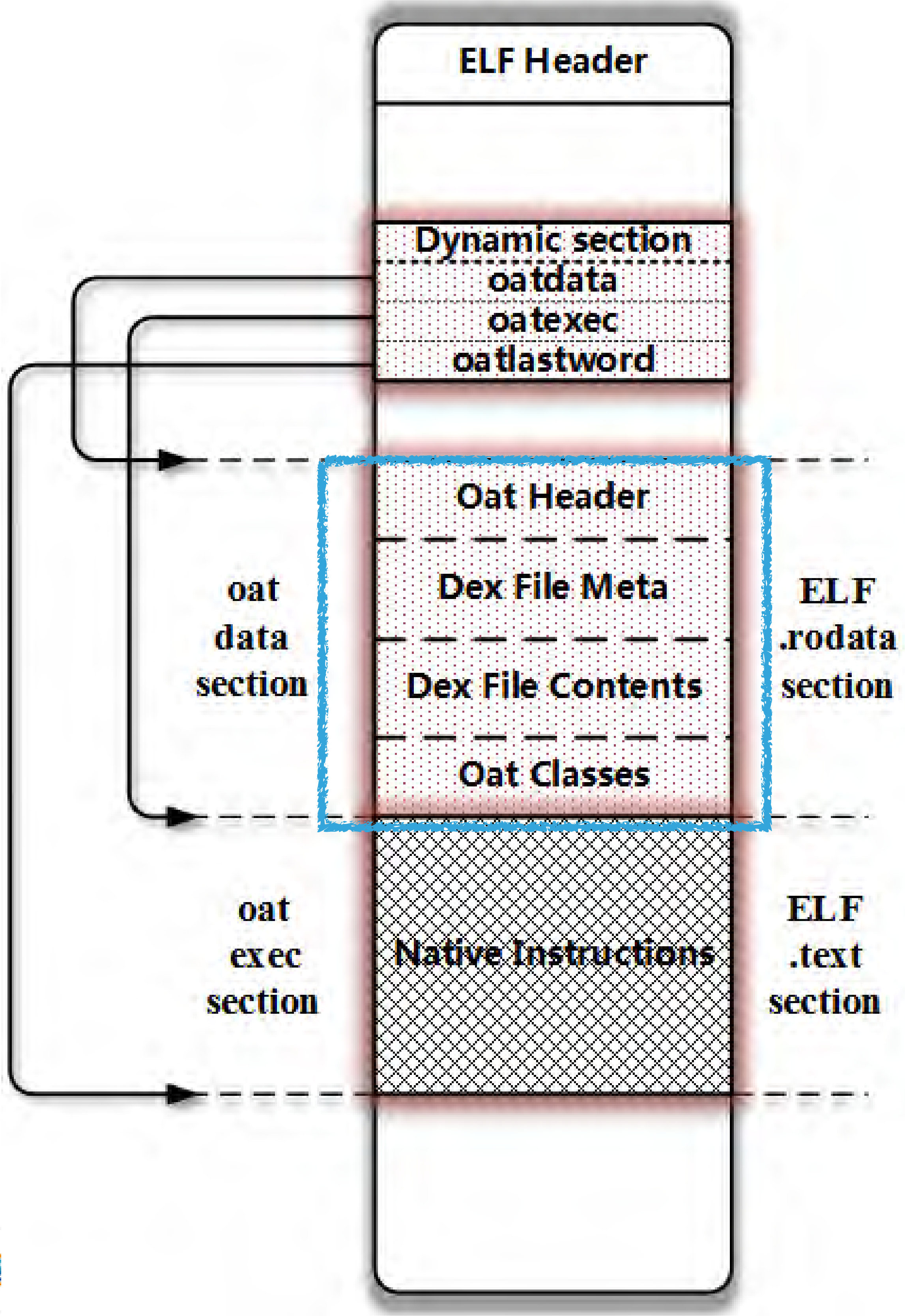
BACKGROUND

- class_def

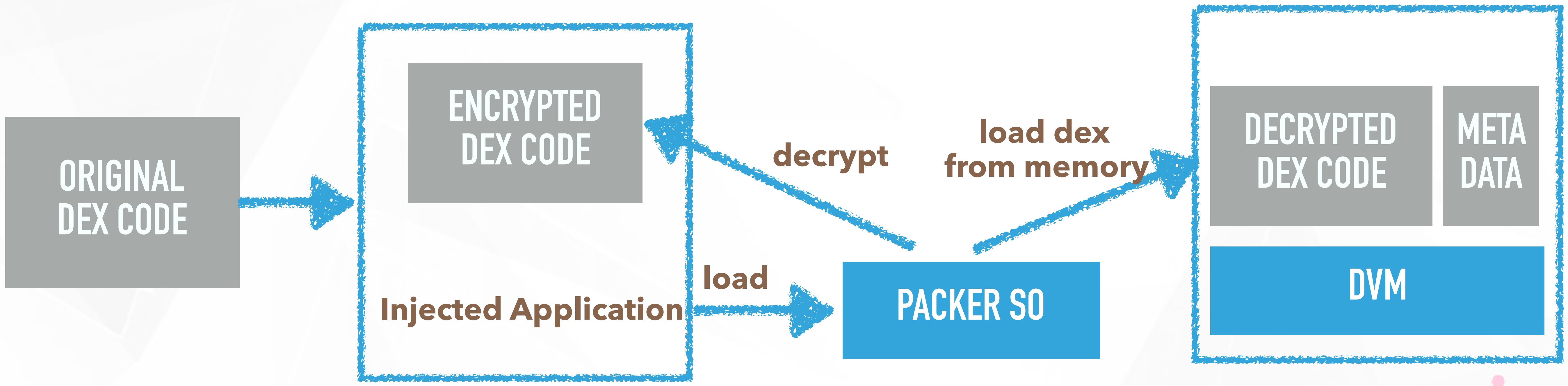


BACKGROUND

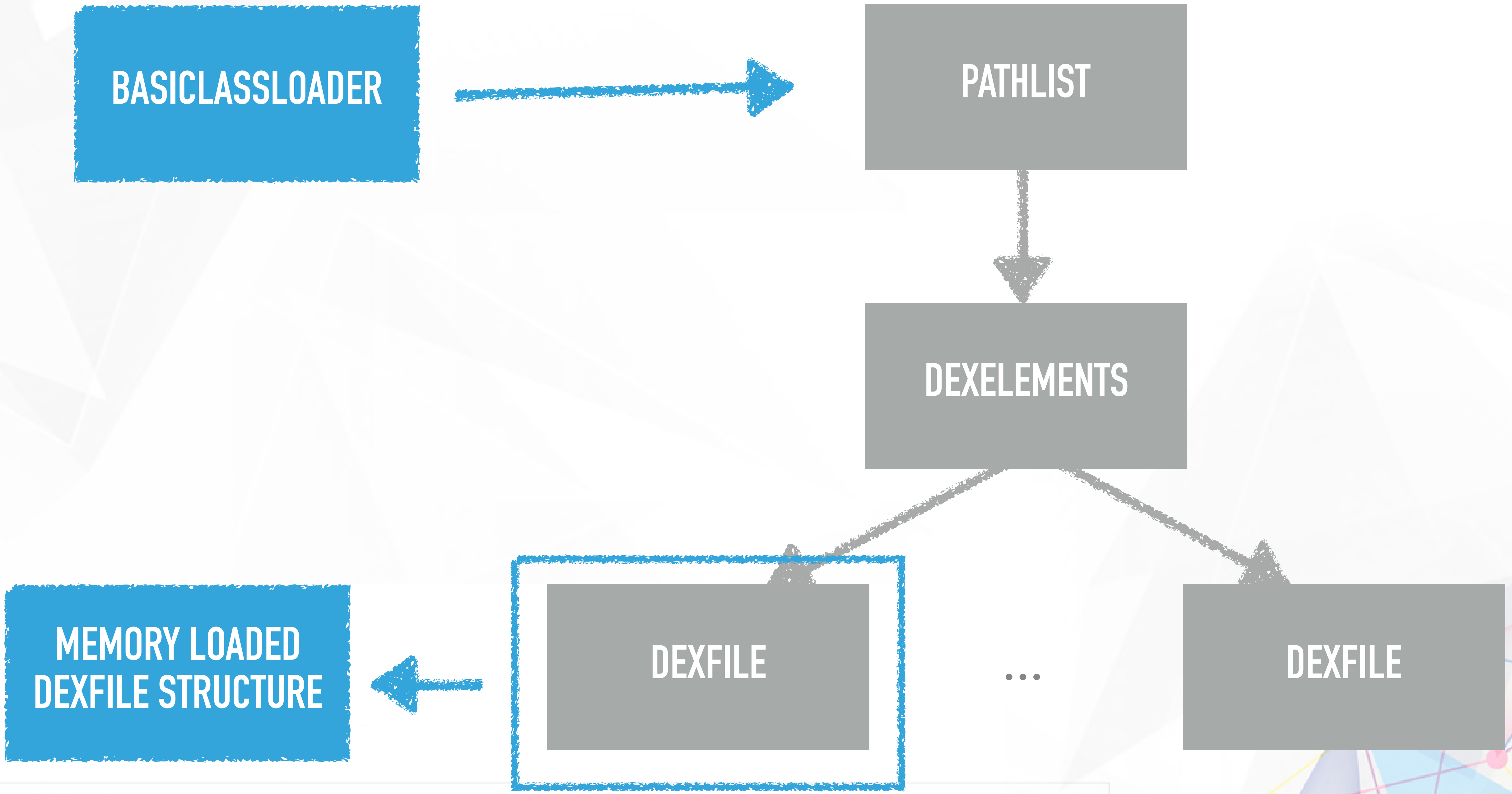
- Original dex file is embedded in the OAT file



THE BASIC IDEA OF APP PACKING



APP PACKING: DALVIK



APP PACKING: ART

- OAT file can still be executed in the interpreter mode – cost: performance loss
    - The embedded dex file
- Dex2oat is responsible for translating dex file into oat file when the app is being **installed**

APP PACKING: ART (CONTINUED)

- Propose I: run the app in the interpreter mode
- How
  - Create an empty dex file (with all classes but empty methods – real methods are encrypted) and the corresponding oat file will be created
  - Decrypt the real methods and make up the empty method structure in memory

APP PACKING: ART (CONTINUED)

- Propose II: Encrypt the generated oat file
- How?

APP PACKER: PROTECT THE PACKER ITSELF

- Packer is usually in the format of so library
    - o-LLVM
    - upx
    - init functions
    - Based on custom so loader
    - VMP engine to protect key functions

App UNPacking Techniques: Static

APP UNPACKING: STATIC

- Understand the encryption/decryption logic of the packer
  - Pros: one effort to kill all (apps with one packer)
  - Cons: so packer (VMP engine), encryption method/key is continuously changing …
- But it is efficient if we have an insider

App UNPacking Techniques: Dynamic

THE KEY VULNERABLE POINT OF APP PACKING

- Dalvik VM
  - executes unencrypted dex code
  - requires the integrity of some meta data

点穴

RUNTIME MEMORY STATE

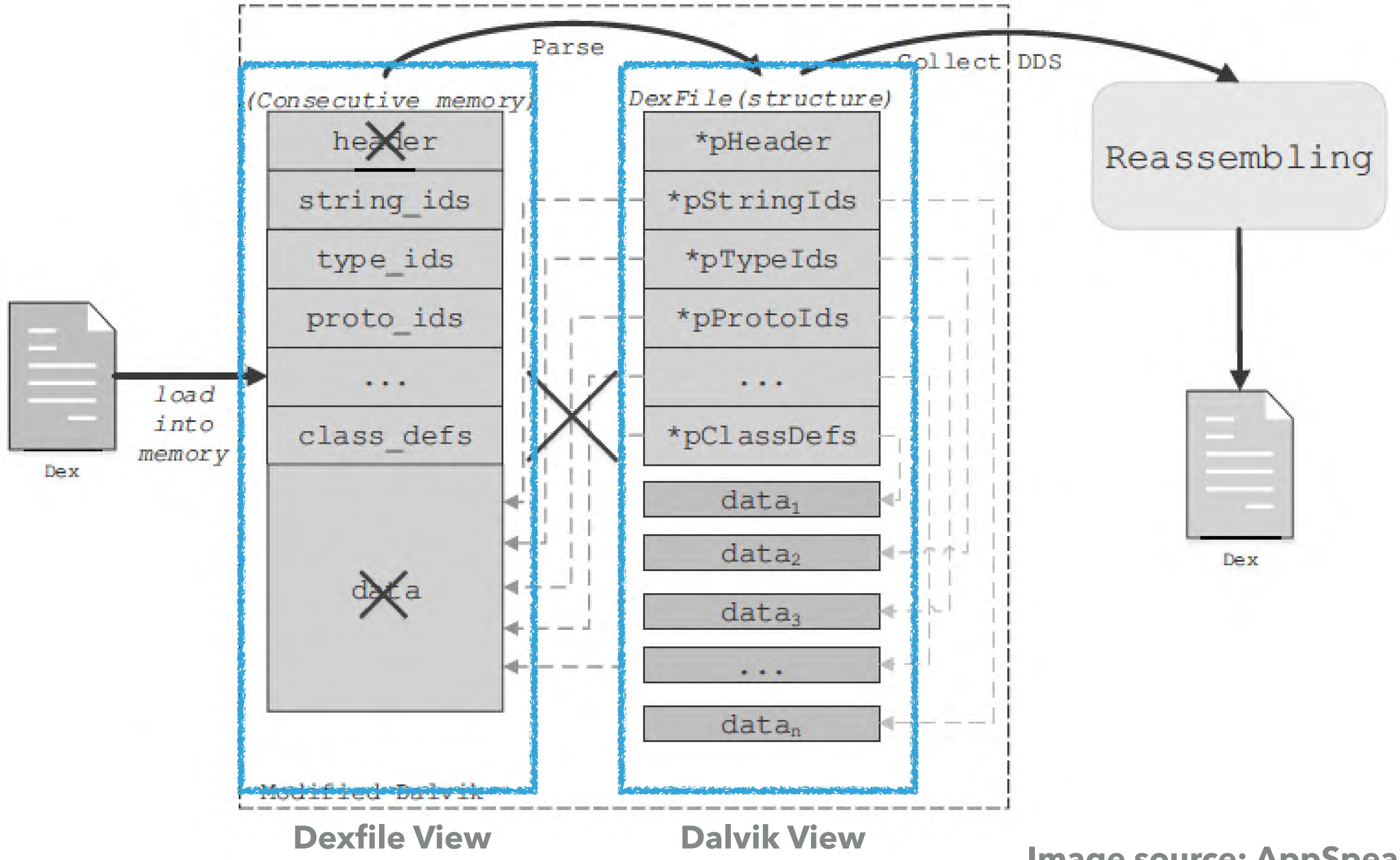
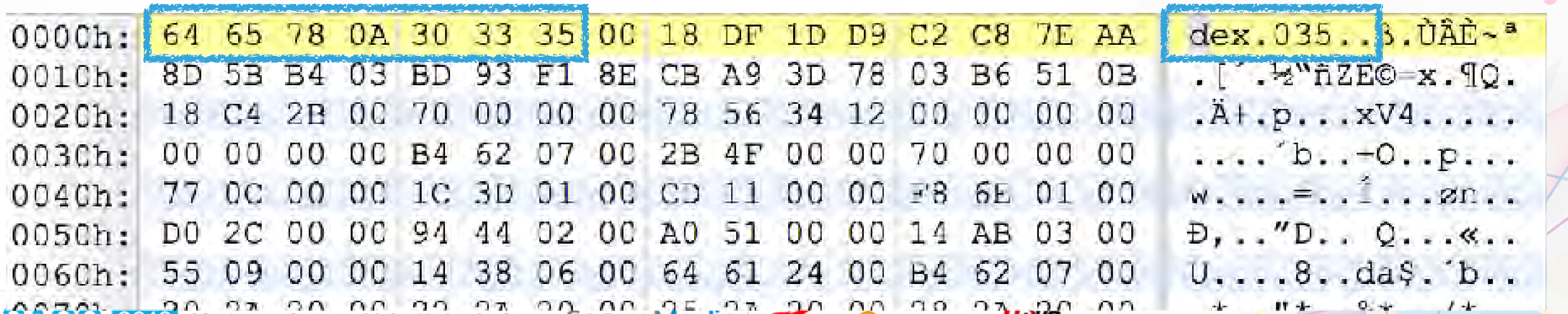


Image source: AppSpear paper

APP UNPACKING 101

- Basic idea: locate the dex file in memory and dump
- How: locate "dex. 035"
- When: hook key functions (mmap, strcmp and etc…)
- Countermeasure: corrupt the header, inline key functions



```
0000h: 64 65 78 0A 30 33 35 00 18 DF 1D D9 C2 C8 7E AA  dex.035...ß.ÙÂÈ~ª
0010h: 8D 5B B4 03 BD 93 F1 8E CB A9 3D 78 03 B6 51 0B  .[´.½"ñŽË©=x.¶Q.
0020h: 18 C4 2B 00 70 00 00 00 78 56 34 12 00 00 00 00  .Ä+.p...xV4.....
0030h: 00 00 00 00 B4 62 07 00 2B 4F 00 00 70 00 00 00  ....´b..+O..p...
0040h: 77 0C 00 00 1C 3D 01 00 CD 11 00 00 F8 6E 01 00  w....=..Í...øn..
0050h: D0 2C 00 00 94 44 02 00 A0 51 00 00 14 AB 03 00  Ð,.."D.. Q...«..
0060h: 55 09 00 00 14 38 06 00 64 61 24 00 B4 62 07 00  U....8..da$.´b..
```

APP UNPACKING 102

- Basic idea: dump the memory and reconstruct the dex file ***without*** relying on the dex header – DexHunter, and AppSpear
- How: modify libdvm, dump memory, reconstruct dex

APP UNPACKING 102: DEXHUNTER

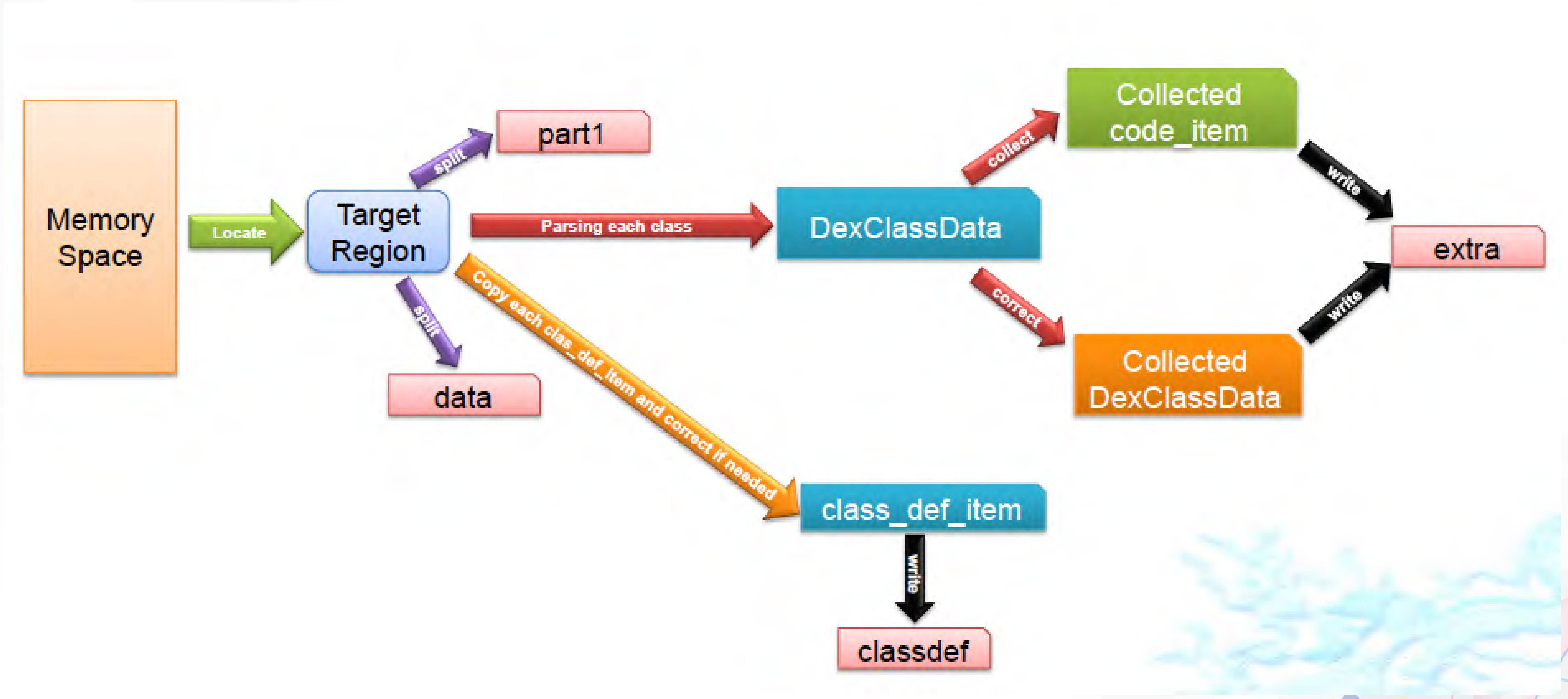


Image source: DexHunter HitCon2015 slides

APP UNPACKING 102: APPSPEAR

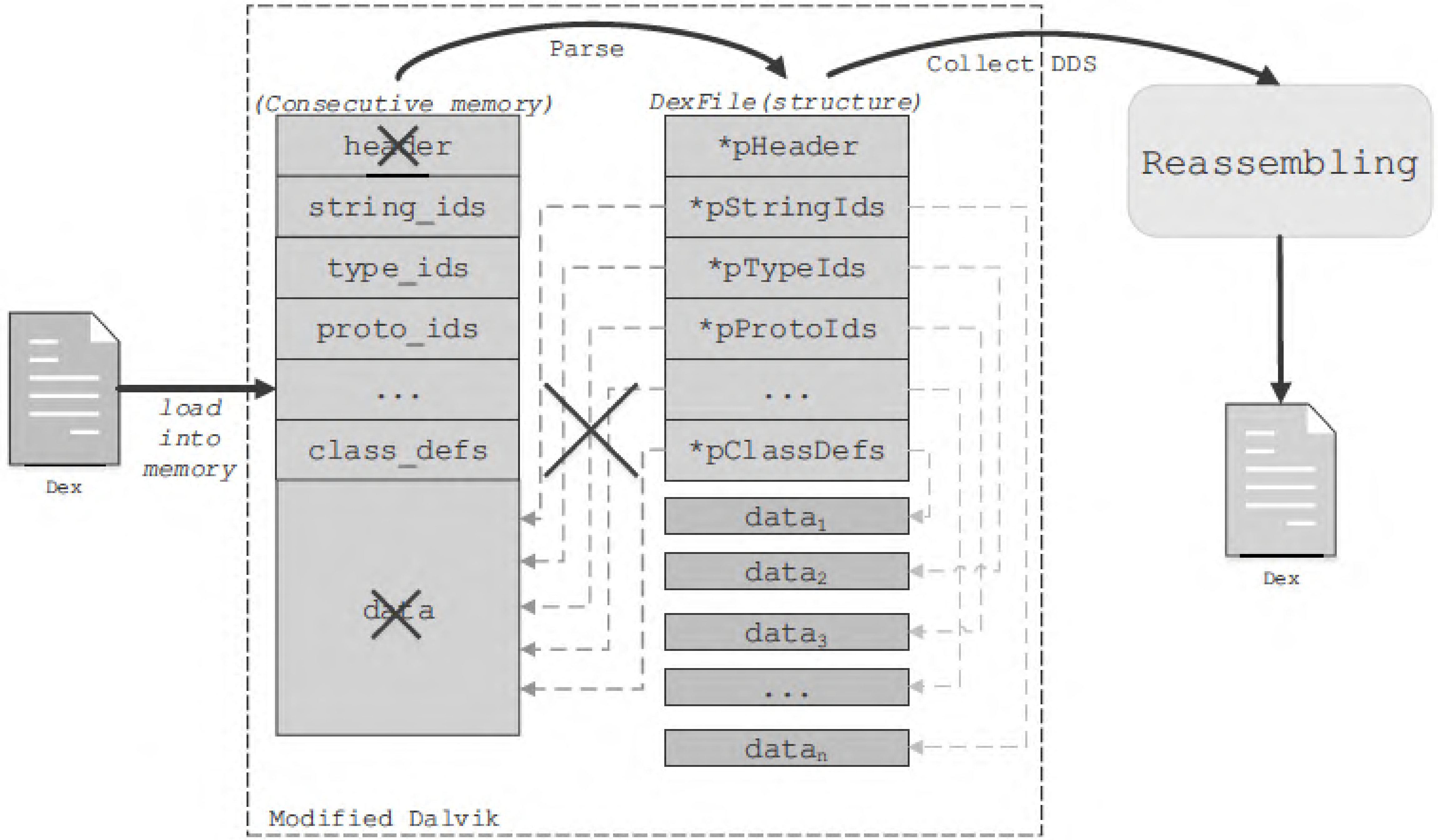
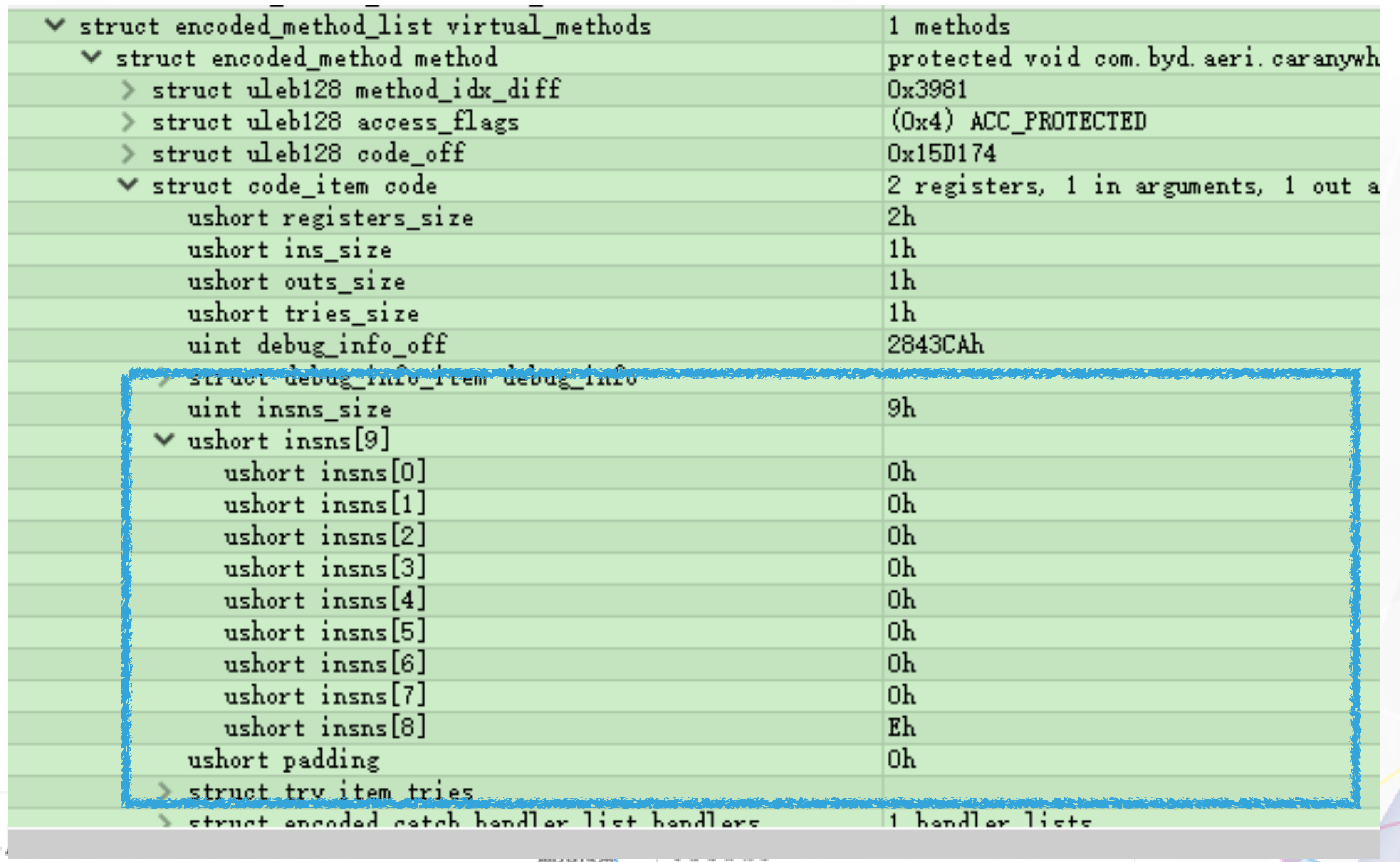


Image source: AppSpear pape

Countermeasures

INCREMENTAL UNPACKING

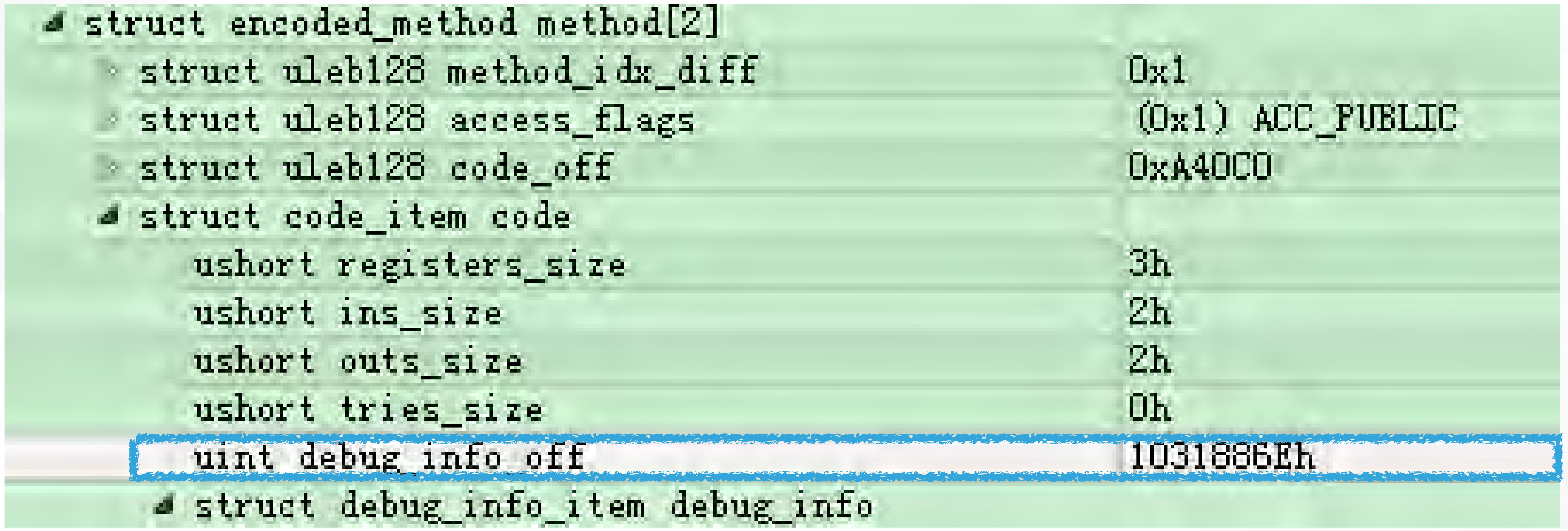
- When to refill these instructions?



```
v struct encoded_method_list virtual_methods        1 methods
  v struct encoded_method method                    protected void com.byd.aeri.caranywh
    > struct uleb128 method_idx_diff                0x3981
    > struct uleb128 access_flags                   (0x4) ACC_PROTECTED
    > struct uleb128 code_off                       0x15D174
    v struct code_item code                         2 registers, 1 in arguments, 1 out a
        ushort registers_size                       2h
        ushort ins_size                             1h
        ushort outs_size                            1h
        ushort tries_size                           1h
        uint debug_info_off                         2843CAh
      > struct debug_info_item debug_info
        uint insns_size                             9h
      v ushort insns[9]
          ushort insns[0]                           0h
          ushort insns[1]                           0h
          ushort insns[2]                           0h
          ushort insns[3]                           0h
          ushort insns[4]                           0h
          ushort insns[5]                           0h
          ushort insns[6]                           0h
          ushort insns[7]                           0h
          ushort insns[8]                           Eh
        ushort padding                              0h
      > struct try_item tries
      > struct encoded_catch_handler_list handlers   1 handler lists
```

ANTI-DISASSEMBLY

- Change the value of debug_info_off



```
struct encoded_method method[2]
    struct uleb128 method_idx_diff           0x1
    struct uleb128 access_flags              (0x1) ACC_PUBLIC
    struct uleb128 code_off                  0xA40C0
    struct code_item code
        ushort registers_size                3h
        ushort ins_size                      2h
        ushort outs_size                     2h
        ushort tries_size                    0h
        uint debug_info_off                  1031886Eh
        struct debug_info_item debug_info
```

ANTI-PTRACE/DEBUG

- Check files: /proc/$pid/status, etc …
- Check process name
- SIGTRAP
- Multi-process
- Inotify
- Hook read/write APIs

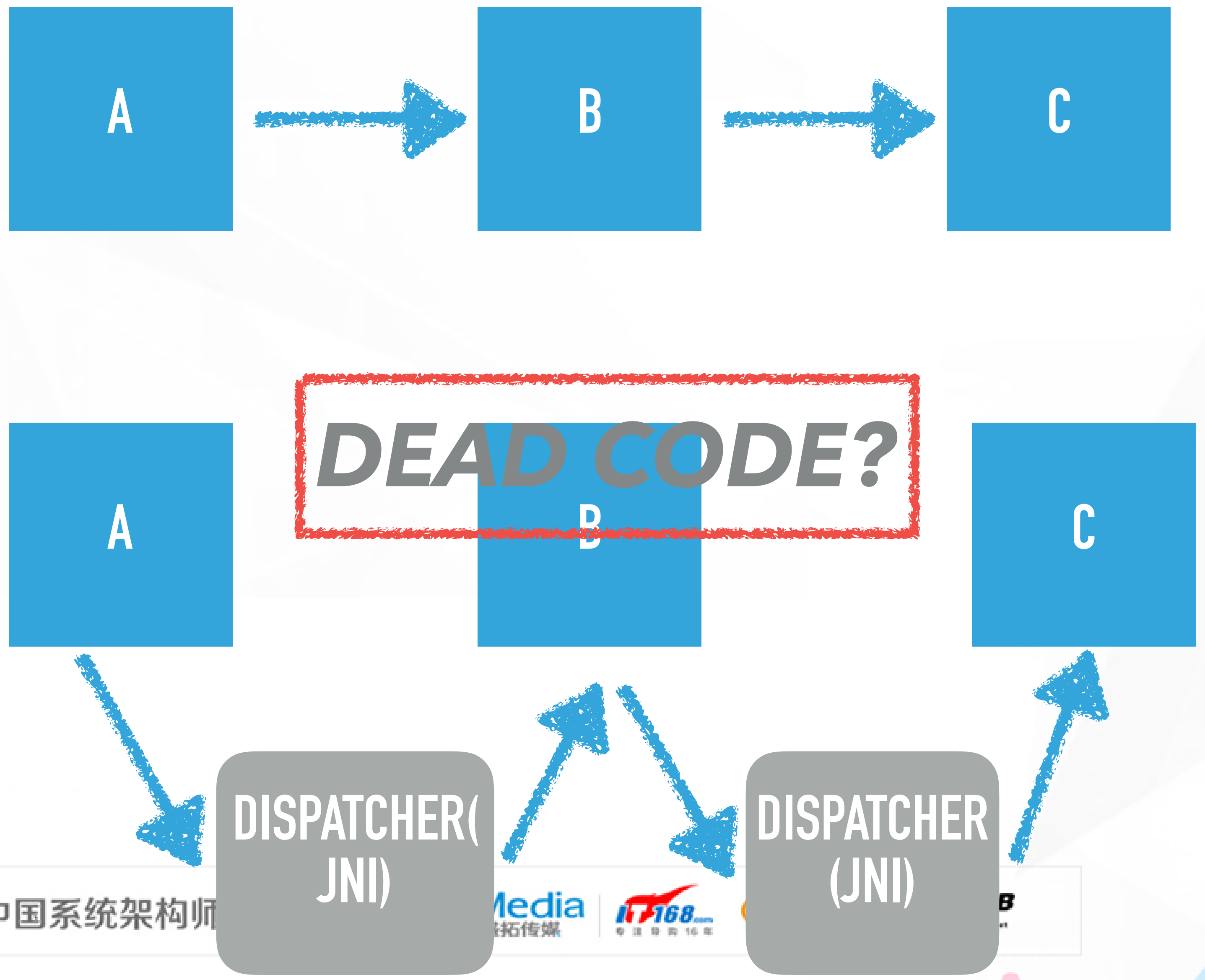
New Trends

DEX2NATIVE

- The dex code could be dumped from memory (as long as Dalvik is still used)
- Dex code could be recovered
- Native code is much harder to understand

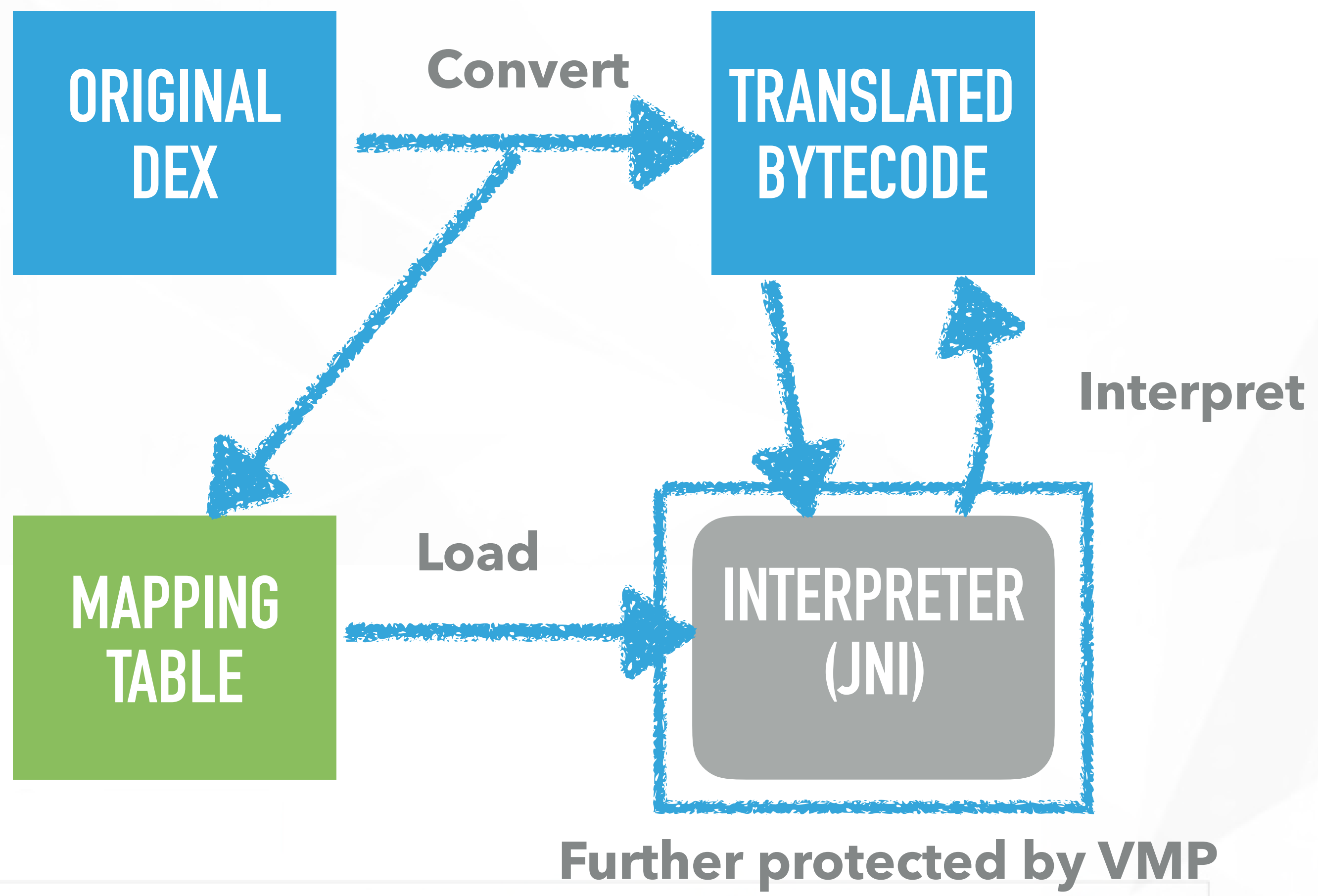
DEX2NATIVE: 101

- Hide the control flow



DEX2NATIVE 102

- Completely convert the bytecode to another format of bytecode: how to maintain the semantics of the bytecode?



DEX2NATIVE 102

```
.class public Lcom/example/ApiTest/MyActivity;

.method protected native onCreate(Landroid/os/Bundle;)V

.end method
```

THANKS

THANKS