# ASLR
# Lecture 14b

## COMPSCI 702
## Security for Smart-Devices

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# iOS SECURITY: MAIN TOPICS

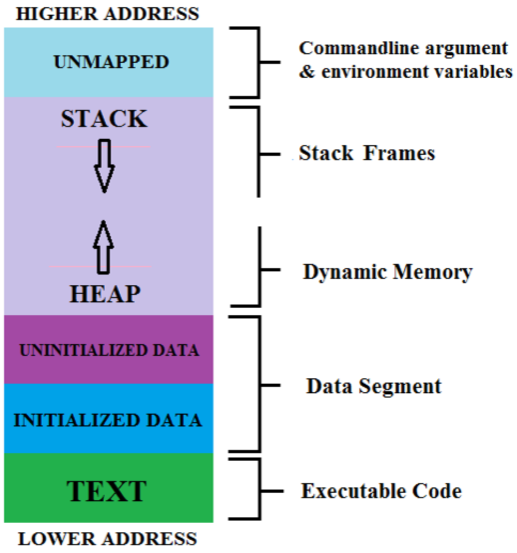
- Introduction to iOS security
- iOS device and app trust evaluation
- **Address Space Layout Randomisation (ASLR)**
- iOS sandboxing
- iOS encryption
- Enterprise security in iOS
- iOS jailbreaking

# WE NEED MORE PROTECTION

Code signing and DEP not sufficient to withstand ROP

# ROP LIMITATIONS

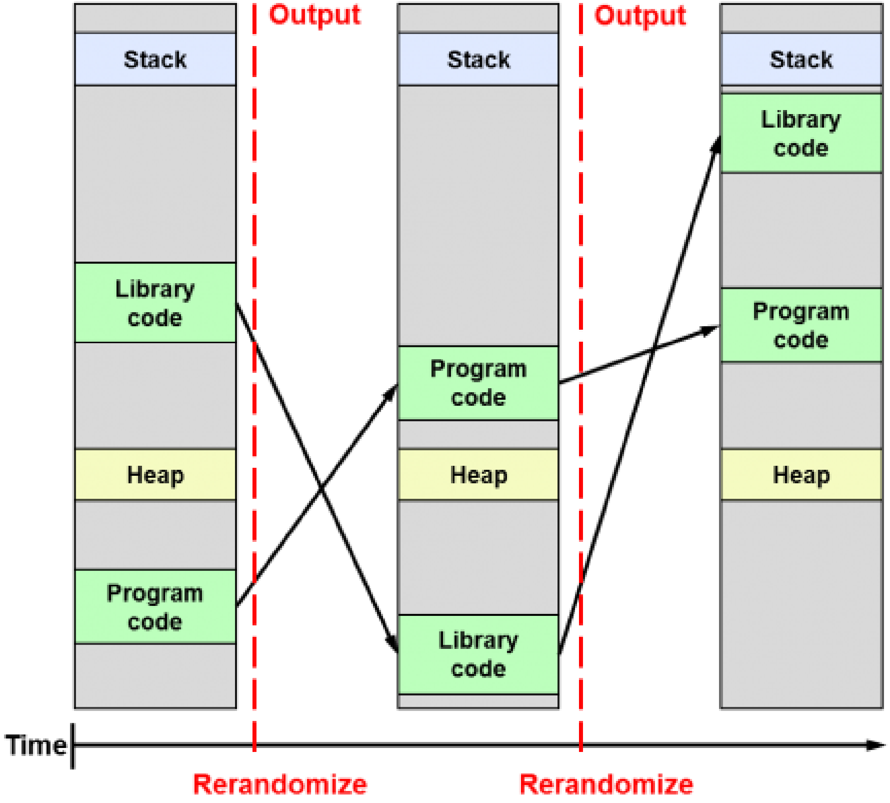
- For ROP to succeed, the memory map (addresses) of an App (in execution) need to be found.
  - Executable code
  - Heap
  - Stack



Picture taken from https://proprogramming.org/memory-layout-of-c-program/

# ASLR

- Randomize the memory location (base address) of key program components



Slide originally from http://www.daniloaz.com/en/differences-between-aslr-kaslr-and-karl/

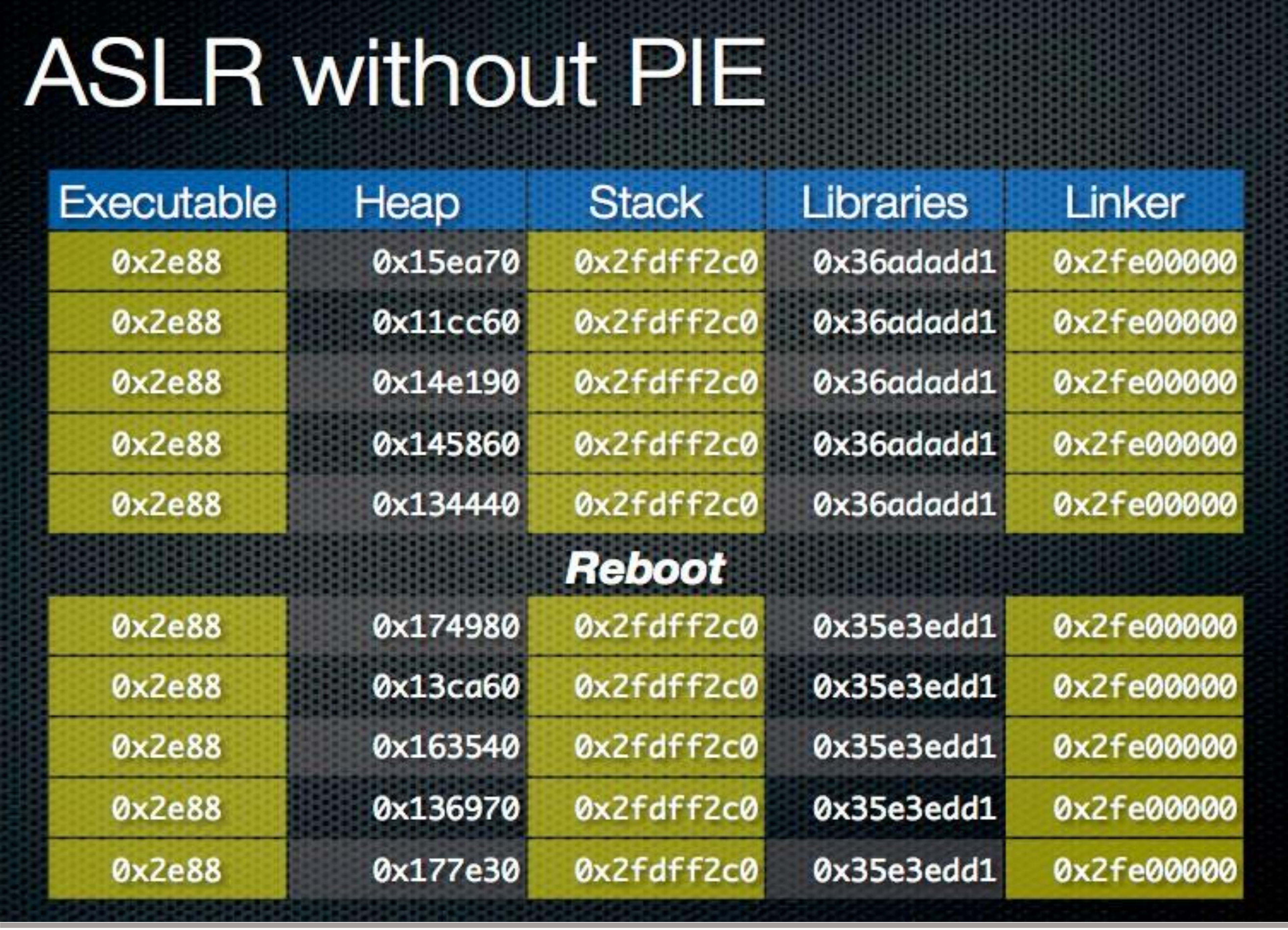
# ASLR

- Was originally designed to overcome “return-to-libc” attack.
  - Randomize libraries
  - Partial ASLR

- Works best if all code is compiled with the Position Independent Execution (PIE) flag
  - Full ASLR
  - Many third party apps are not compiled for PIE

# PARTIAL VS FULL ASLR

| PIE | Main Executable | Heap | Stack | Shared Libraries | Linker |
|---|---|---|---|---|---|
| No | Fixed | Randomised per execution | Fixed | Randomised per device boot | Fixed |
| Yes | Randomised per execution | Randomised per execution (more entropy) | Randomised per execution | Randomised per device boot | Randomised per execution |

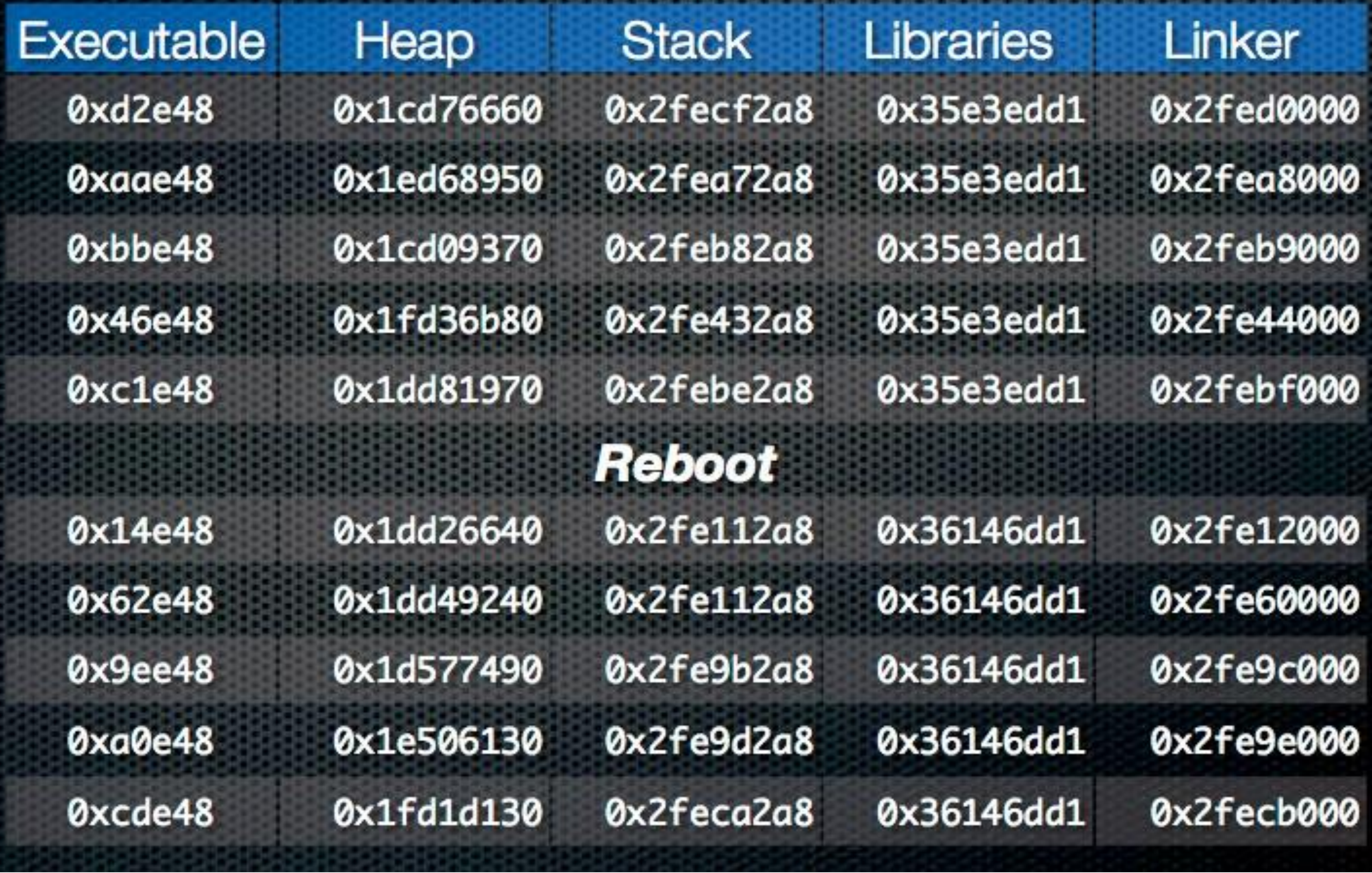


# ASLR without PIE

| Executable | Heap | Stack | Libraries | Linker |
|---|---|---|---|---|
| 0x2e88 | 0x15ea70 | 0x2fdff2c0 | 0x36adadd1 | 0x2fe00000 |
| 0x2e88 | 0x11cc60 | 0x2fdff2c0 | 0x36adadd1 | 0x2fe00000 |
| 0x2e88 | 0x14e190 | 0x2fdff2c0 | 0x36adadd1 | 0x2fe00000 |
| 0x2e88 | 0x145860 | 0x2fdff2c0 | 0x36adadd1 | 0x2fe00000 |
| 0x2e88 | 0x134440 | 0x2fdff2c0 | 0x36adadd1 | 0x2fe00000 |
| | | ***Reboot*** | | |
| 0x2e88 | 0x174980 | 0x2fdff2c0 | 0x35e3edd1 | 0x2fe00000 |
| 0x2e88 | 0x13ca60 | 0x2fdff2c0 | 0x35e3edd1 | 0x2fe00000 |
| 0x2e88 | 0x163540 | 0x2fdff2c0 | 0x35e3edd1 | 0x2fe00000 |
| 0x2e88 | 0x136970 | 0x2fdff2c0 | 0x35e3edd1 | 0x2fe00000 |
| 0x2e88 | 0x177e30 | 0x2fdff2c0 | 0x35e3edd1 | 0x2fe00000 |

Slide originally from: http://www.rsaconference.com/writable/presentations/file_upload/mbs-402.pdf

# ASLR with PIE



| Executable | Heap | Stack | Libraries | Linker |
|---|---|---|---|---|
| 0xd2e48 | 0x1cd76660 | 0x2fecf2a8 | 0x35e3edd1 | 0x2fed0000 |
| 0xaae48 | 0x1ed68950 | 0x2fea72a8 | 0x35e3edd1 | 0x2fea8000 |
| 0xbbe48 | 0x1cd09370 | 0x2feb82a8 | 0x35e3edd1 | 0x2feb9000 |
| 0x46e48 | 0x1fd36b80 | 0x2fe432a8 | 0x35e3edd1 | 0x2fe44000 |
| 0xc1e48 | 0x1dd81970 | 0x2febe2a8 | 0x35e3edd1 | 0x2febf000 |
| | | ***Reboot*** | | |
| 0x14e48 | 0x1dd26640 | 0x2fe112a8 | 0x36146dd1 | 0x2fe12000 |
| 0x62e48 | 0x1dd49240 | 0x2fe112a8 | 0x36146dd1 | 0x2fe60000 |
| 0x9ee48 | 0x1d577490 | 0x2fe9b2a8 | 0x36146dd1 | 0x2fe9c000 |
| 0xa0e48 | 0x1e506130 | 0x2fe9d2a8 | 0x36146dd1 | 0x2fe9e000 |
| 0xcde48 | 0x1fd1d130 | 0x2feca2a8 | 0x36146dd1 | 0x2fecb000 |

Slide originally from: http://www.rsaconference.com/writable/presentations/file_upload/mbs-402.pdf

# ASLR SECURITY BASED ON ENORPY

- Single non-randomized area can be enough for attacker

- The larger the range of entropy, the better
  - 32 bit vs 64 bit

- Relocation frequency
  - randomization during boot time vs execution time

# ADDRESS LEAKAGE

- Getting address information from an app
- Brute force can be effective
- Lots of exploits have been designed to leak addresses
- Even PIE is not enough, we really need every function (or method) scattered randomly through the address space
  - Otherwise, if we find one address, we can easily determine others

# ASLR IN iOS

- Apple introduced ASLR in iOS 4.3
  - Released in March 2011
- Full ASLR support in iOS 5 and later

# ASLR IN ANDROID

- Android 4.0 provides ASLR
- Full ASLR was supported in Android 4.1
- Android 5.0 dropped non-PIE support and requires all dynamically linked binaries to be position independent

# SUMMARY

- Both DEP and ASLR make it difficult to mount attacks

- Although ASLR hardens the attack, it is still vulnerable to ROP
  - With address leakage

# PREVENTING MALICIOUS APPS

- Prevent malicious apps at submission time
  - Static and dynamic analysis
- Prevent malicious apps at install (or load) time
  - Code Signing Enforcement (CSE)
- Operating System (OS) also prevents malicious apps
  - Data Execution Prevention (DEP)
  - Address Space Layout Randomisation (ASLR)

# ACKNOWLEDGEMENT

- Some of the slides are based on the presentation shared by Muhammad Rizwan Asghar, thanks to him!

## Questions?

## Thanks for your attention!

# RESOURCES

- **iOS Hacker’s Handbook**
  Charlie Miller, Dionysus Blazarkis, Dino Dai Zovi, Stefan Esser,Vincenzo Iozzo, Ralf-Philipp Weinmann
  John Wiley & Sons, Inc., 2012

- **Apple iOS 4 Security Evaluation**
  Dai Zovi, Dino A
  Black Hat USA 2011
  http://media.blackhat.com/bh-us-11/DaiZovi/BH_US_11_DaiZovi_iOS_Security_WP.pdf

- **Too Much PIE is Bad for Performance**
  Payer, Mathias
  2012
  http://e-collection.library.ethz.ch/eserv/eth:5699/eth-5699-01.pdf?pid=eth:5699&dsID=eth-5699-01.pdf