Security in Action: Demo and Tools

IEEE IoT Seasonal School

Muhammad **Rizwan** Asghar

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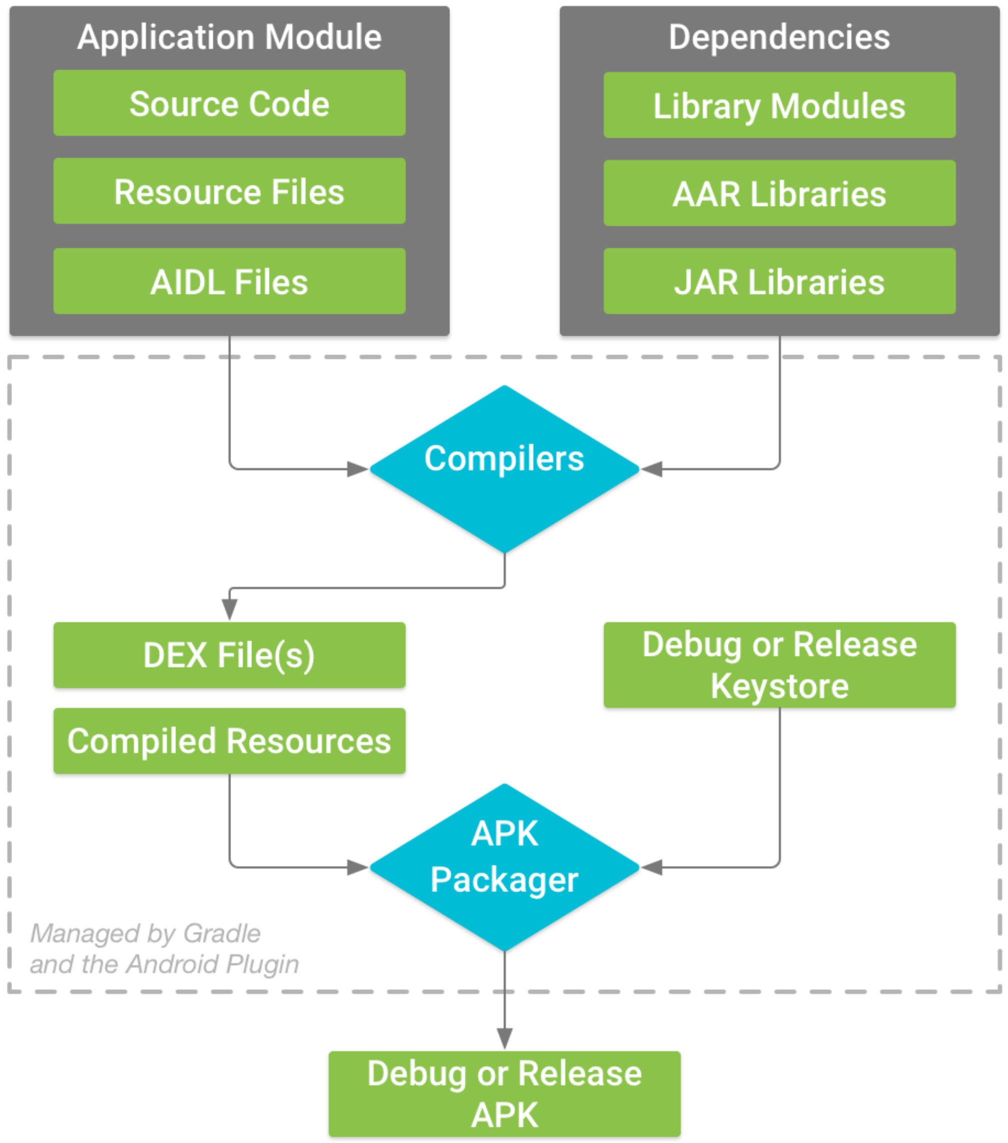
Key Focus

- App building and decoding
- Code obfuscation and reverse engineering
- A case study and results
- Some exercises

Android Build Process

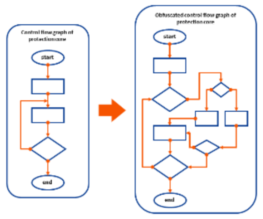


Source: developer.android.com

Decoding APK

- Download Hello World Android app
- Rename apk to zip
- Extract classes.dex
- Download dex2jar
- Download java decompiler

Software Obfuscation

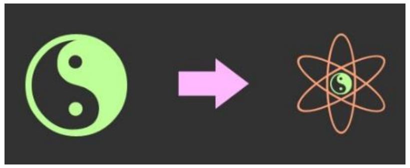


- Software **obfuscation** is a promising technique to protect sensitive information in application code
- The basic idea is to transform code such that it becomes **hard to interpret**
- Software obfuscation makes it difficult for attackers to extract sensitive information from
  - Code consisting of private **data**
    - E.g., **password** matching
  - **Control flow**
    - E.g., business **logic**

Reverse Engineering

- Sophisticated reverse engineering mechanisms and **tools** have been developed for analysing the code
- One can easily understand the code by using **reverse engineering** tools
- For designing obfuscation methods, it is necessary to **test them against** available reverse engineering tools

Obfuscation Types



- Code obfuscation can be broadly classified into four main categories [Balachandran TIFS13]
  - Layout obfuscation
  - Design obfuscation
  - Data obfuscation
  - Control obfuscation

Layout Obfuscation

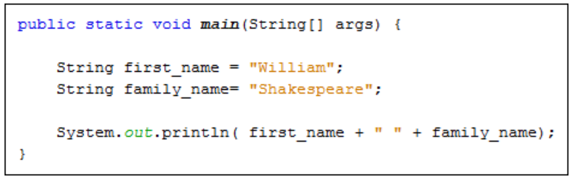
- Layout obfuscation refers to obscuring the layout of the program
- Examples
  - Deleting comments
  - Removing debugging information
  - Renaming variables
  - Changing formatting of source code
  - …

Design Obfuscation

- Design obfuscation refers to obscuring the design of the software system

- Examples
  - Splitting classes
  - Merging classes
  - …

Data Obfuscation

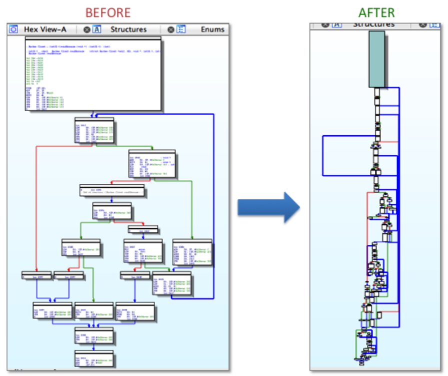


```
public static void main(String[] args) {

    String first_name = "William";
    String family_name= "Shakespeare";

    System.out.println( first_name + " " + family_name);
}
```

- Data obfuscation aims at preventing the adversary from extracting information from the data used in the program

- Examples
  – Data to procedure conversion
    - Encoding (or encryption)
  – Variable splitting
  – Changing lifetime of variables
  – …

Control Obfuscation



- Control obfuscation obscures the control flow information of the program

- Examples
  – Opaque predicates
    - E.g., “if (1 > 0)”
  – Control flow flattening
  – …

Group Project Case Study

- **70** students divided into **13 groups**
  - 5-6 students per group
- Development phase includes (9 weeks)
  - A java app (400-1000 lines of code)
  - Novel obfuscation technique and tool
  - **Obfuscated app**
- A **report** at the end of a challenge phase addressing (2 weeks)
  - Related work
  - Obfuscation technique
  - Performance analysis
  - Limitations
  - **Reverse engineering** of apps developed by other groups
- Post-challenge **group presentation** (1 week)
  - 20 minutes presentation and 10 minutes QA

PIN Authentication Example

- Original code:

```
if(input == “1234")
{
  //authenticate
}
```

Data Obfuscation using Hash Function

- A hash function is a cryptographic checksum
- Let's assume:

```
hash("1234")="9876"
```

- The obfuscated version should be:

```
if(hash(input) == "9876")
{
  //authenticate
}
```

Data Obfuscation using Splitting Variable

- Let's assume

  v=5

- We can split **v** into two:

  a=2 and b=3 and

  replace v with a+b

- Likewise, also consider a string

  name="Ronald Rivest"

- We can split this **name** into two:

  FirstName="Ronald" and LastName="Rivest"

Control Flow Example

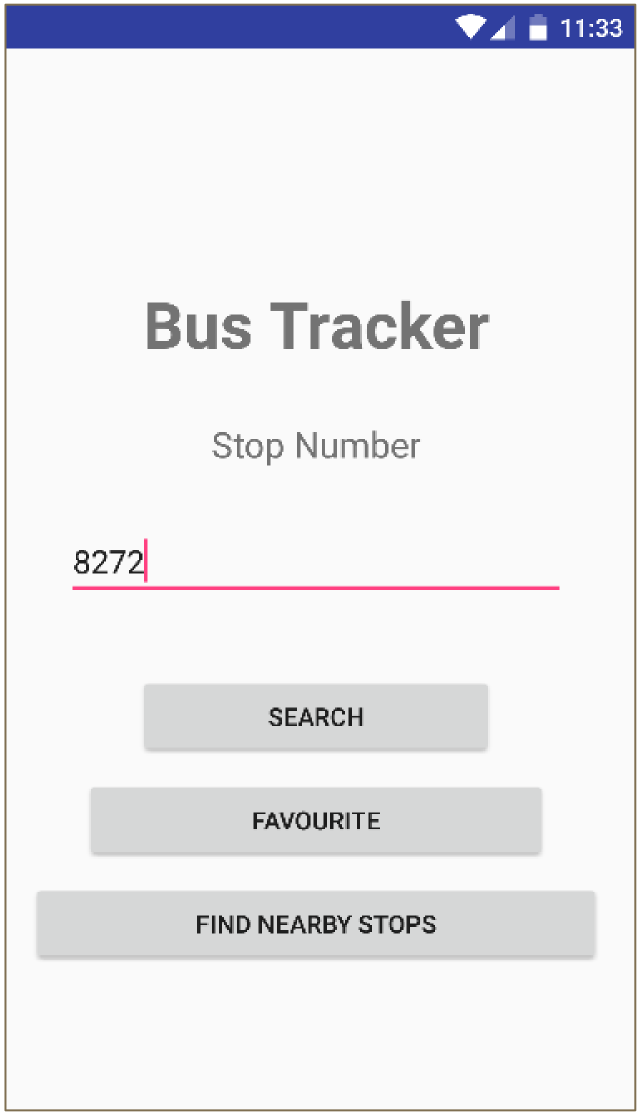
- Consider the following expression:

  (a-b)^2 = a^2 + b^2 - 2ab

- The expression seems to be true always, but it is not the case

- Values of a and b can be chosen to trigger integer overflow on the right side

Bus Tracker App



11:33

Bus Tracker

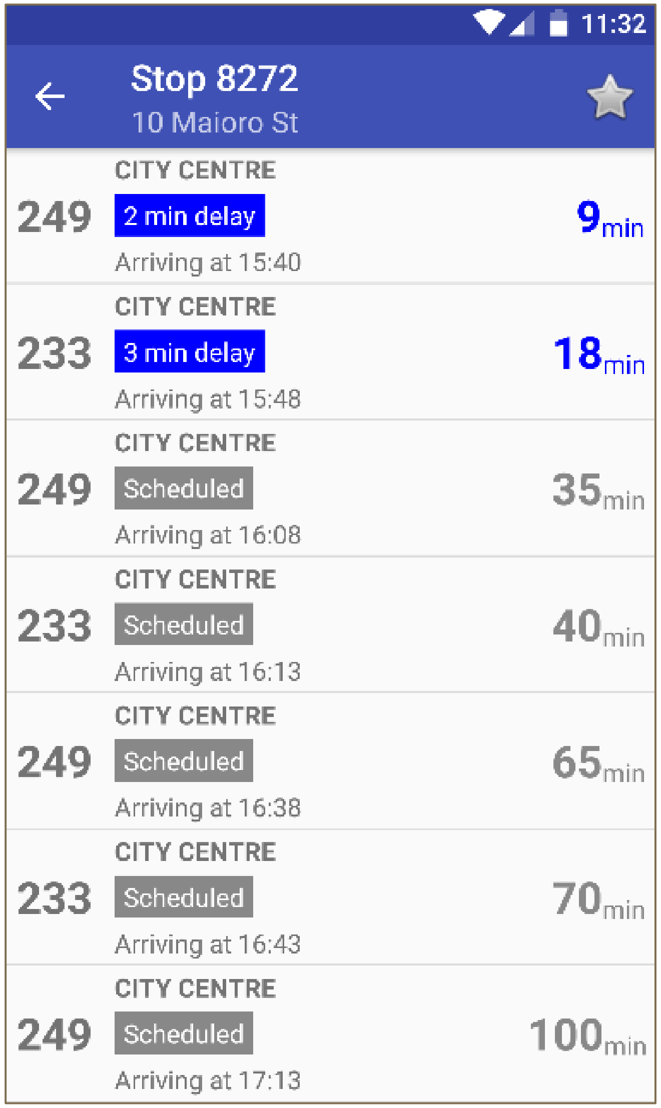
Stop Number

8272

SEARCH

FAVOURITE

FIND NEARBY STOPS

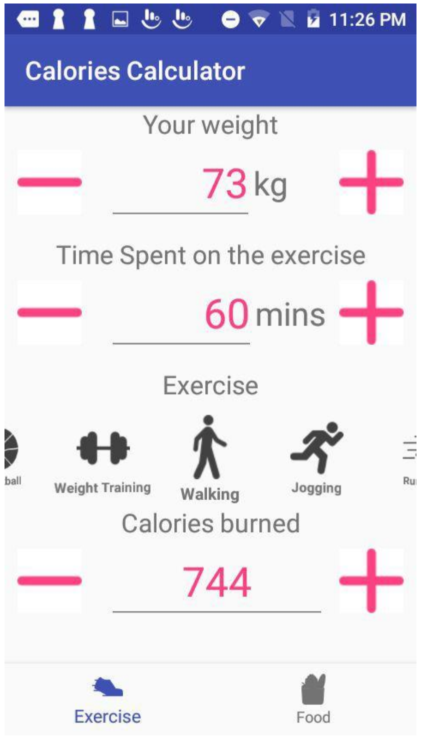


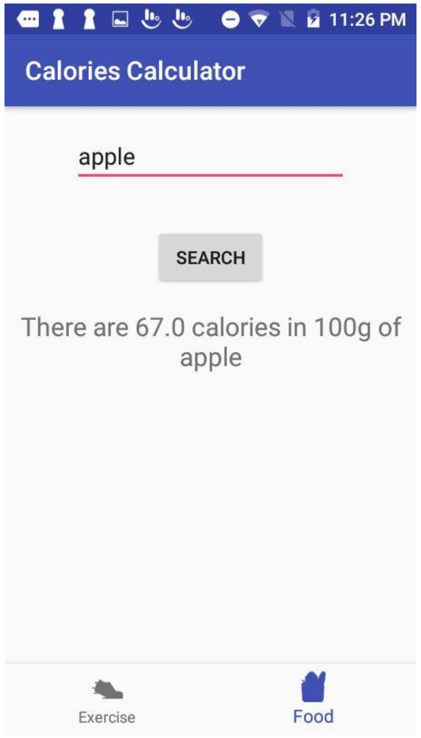
11:32

Stop 8272
10 Maioro St

249	CITY CENTRE 2 min delay Arriving at 15:40	9min
233	CITY CENTRE 3 min delay Arriving at 15:48	18min
249	CITY CENTRE Scheduled Arriving at 16:08	35min
233	CITY CENTRE Scheduled Arriving at 16:13	40min
249	CITY CENTRE Scheduled Arriving at 16:38	65min
233	CITY CENTRE Scheduled Arriving at 16:43	70min
249	CITY CENTRE Scheduled Arriving at 17:13	100min

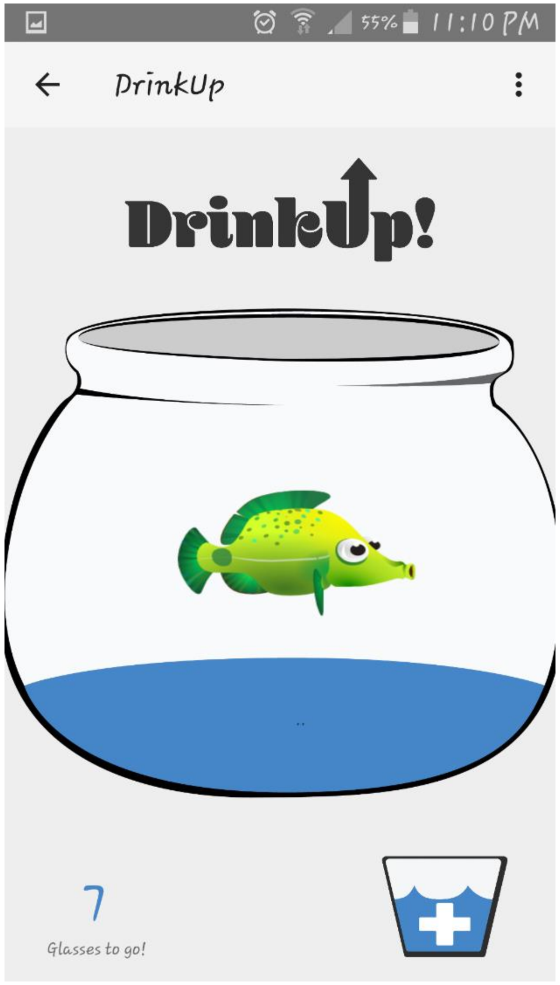
Calories Calculator App

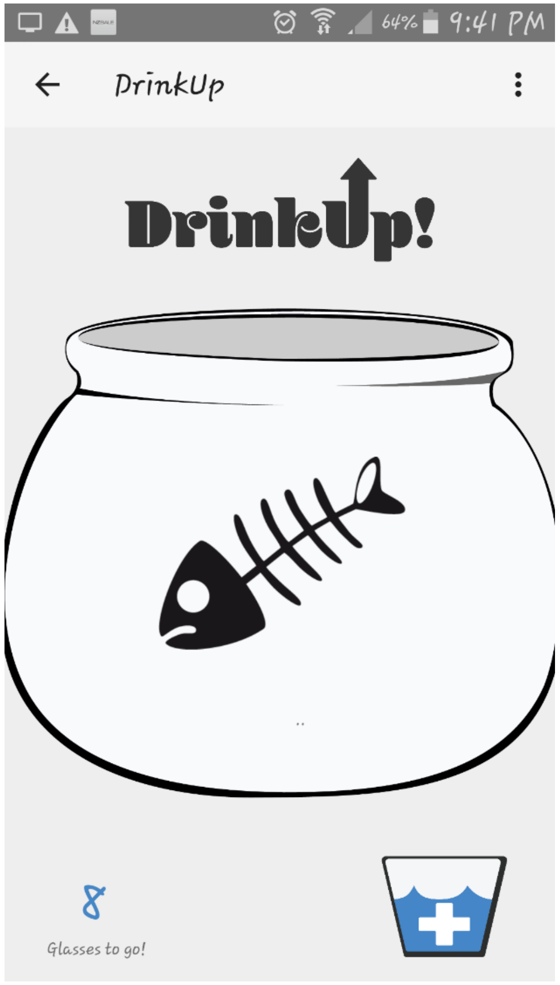




There are 67.0 calories in 100g of apple

Drinkup App


55% 11:10 PM
DrinkUp
DrinkUp!
7
Glasses to go!


64% 9:41 PM
DrinkUp
DrinkUp!
8
Glasses to go!

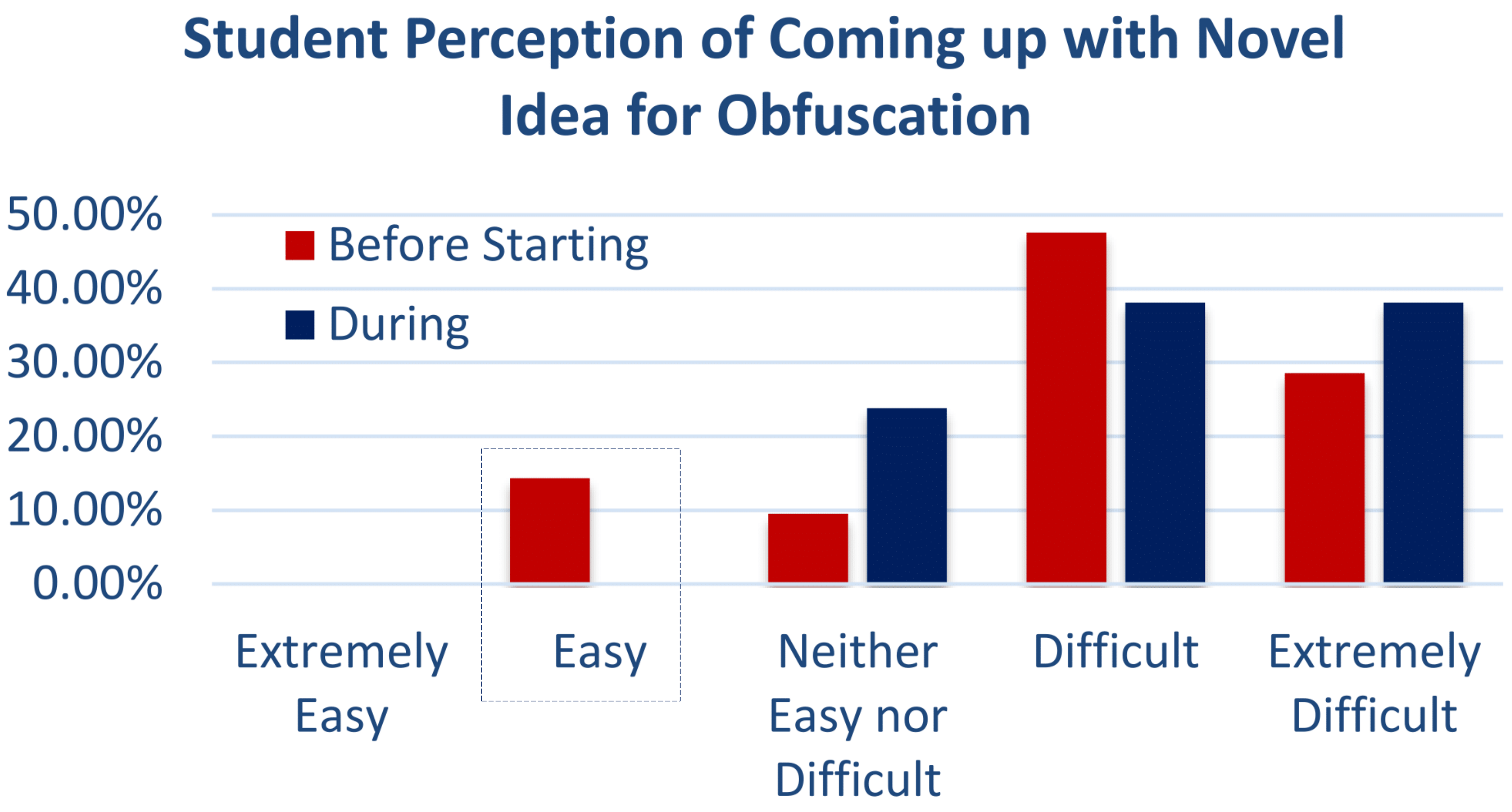
Response Rate

- **Pre**-challenge questionnaire
  - **30%** responded
  - 21 students

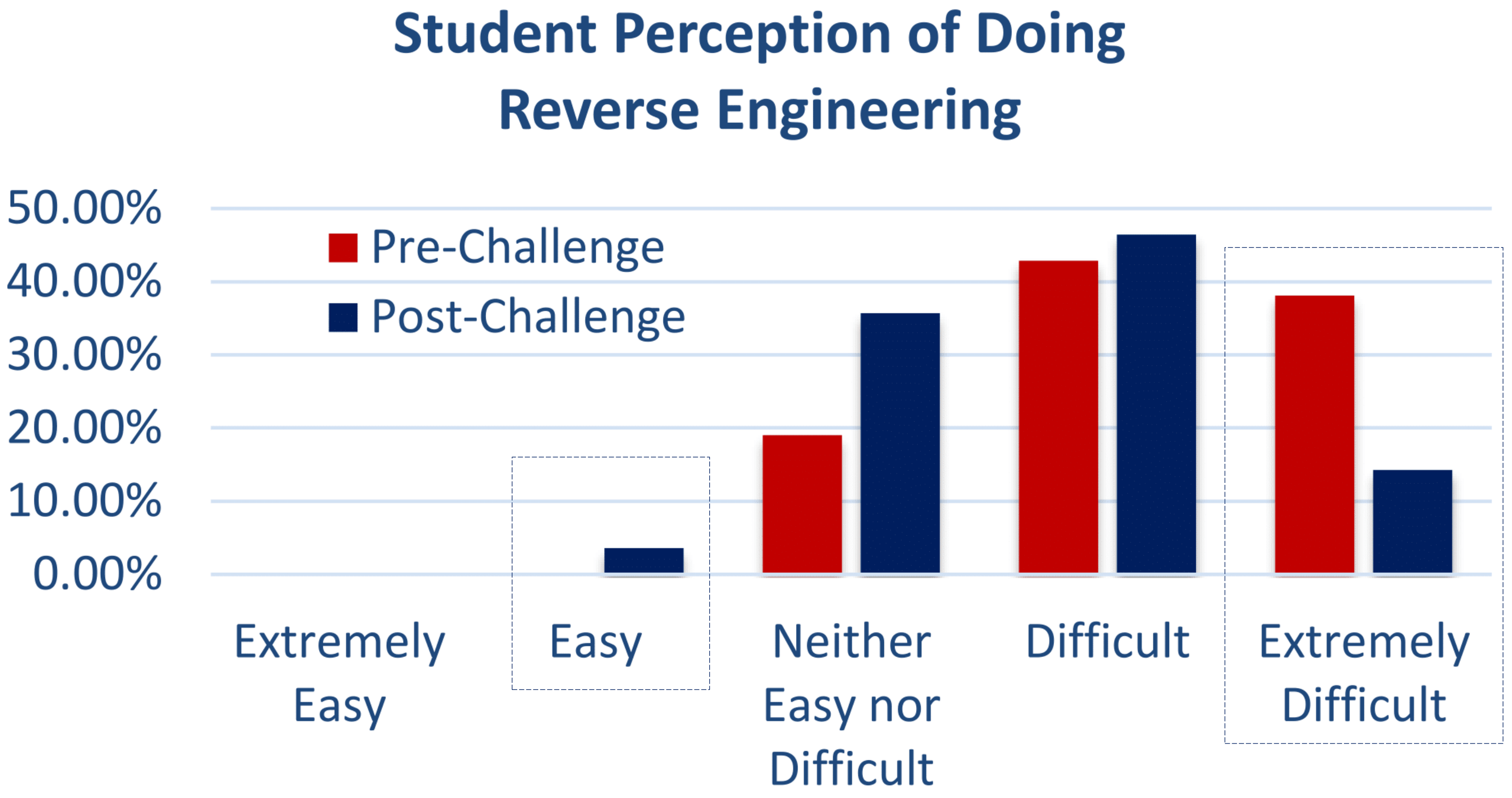
- **Post**-challenge questionnaire
  - **40%** responded
  - 28 students

- **Approved** by The University of Auckland Human Participants Ethics Committee
  - Reference number 019274

Student Perception of Novel Idea

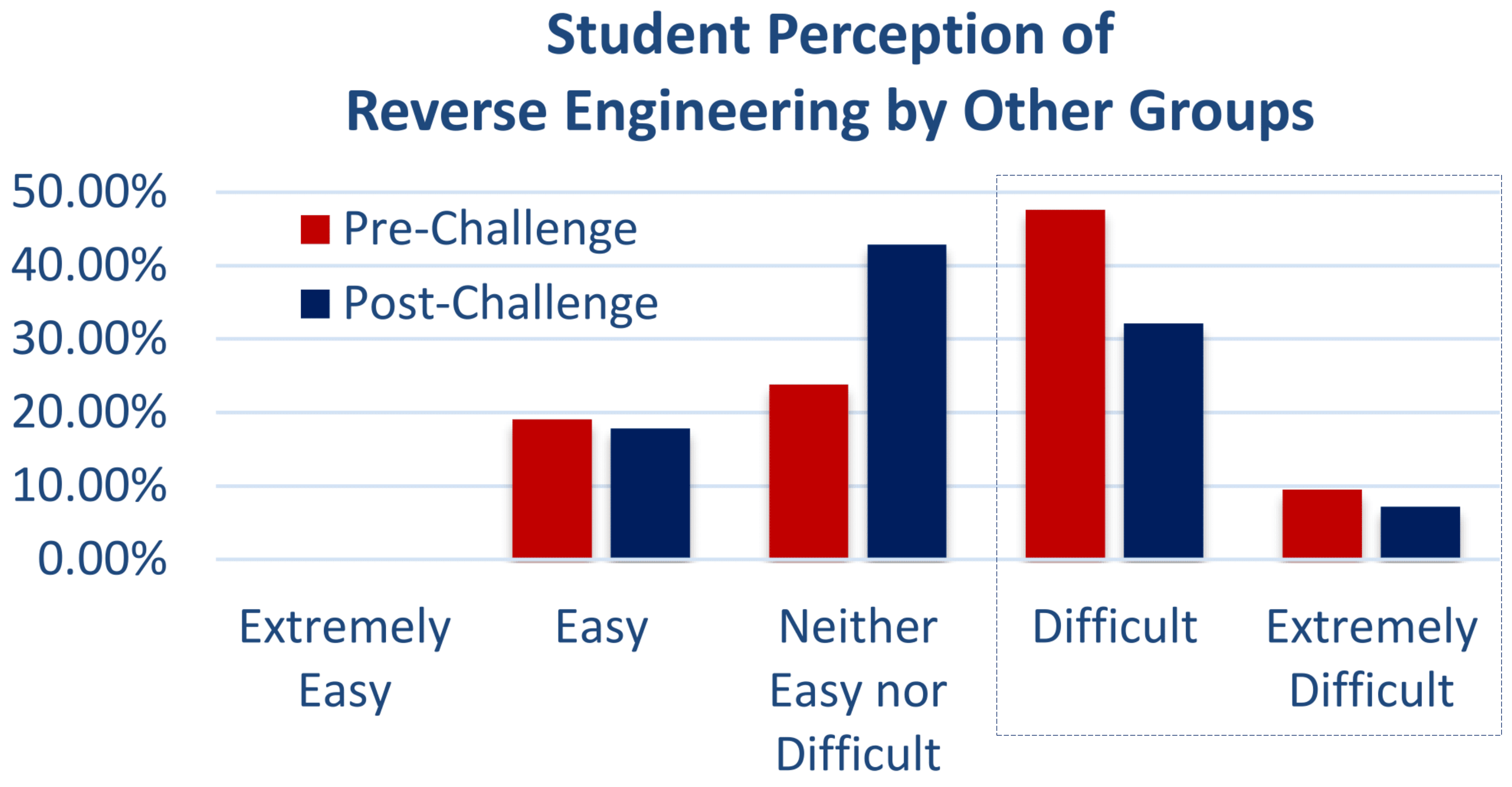


Student Perception of Reverse Engineering



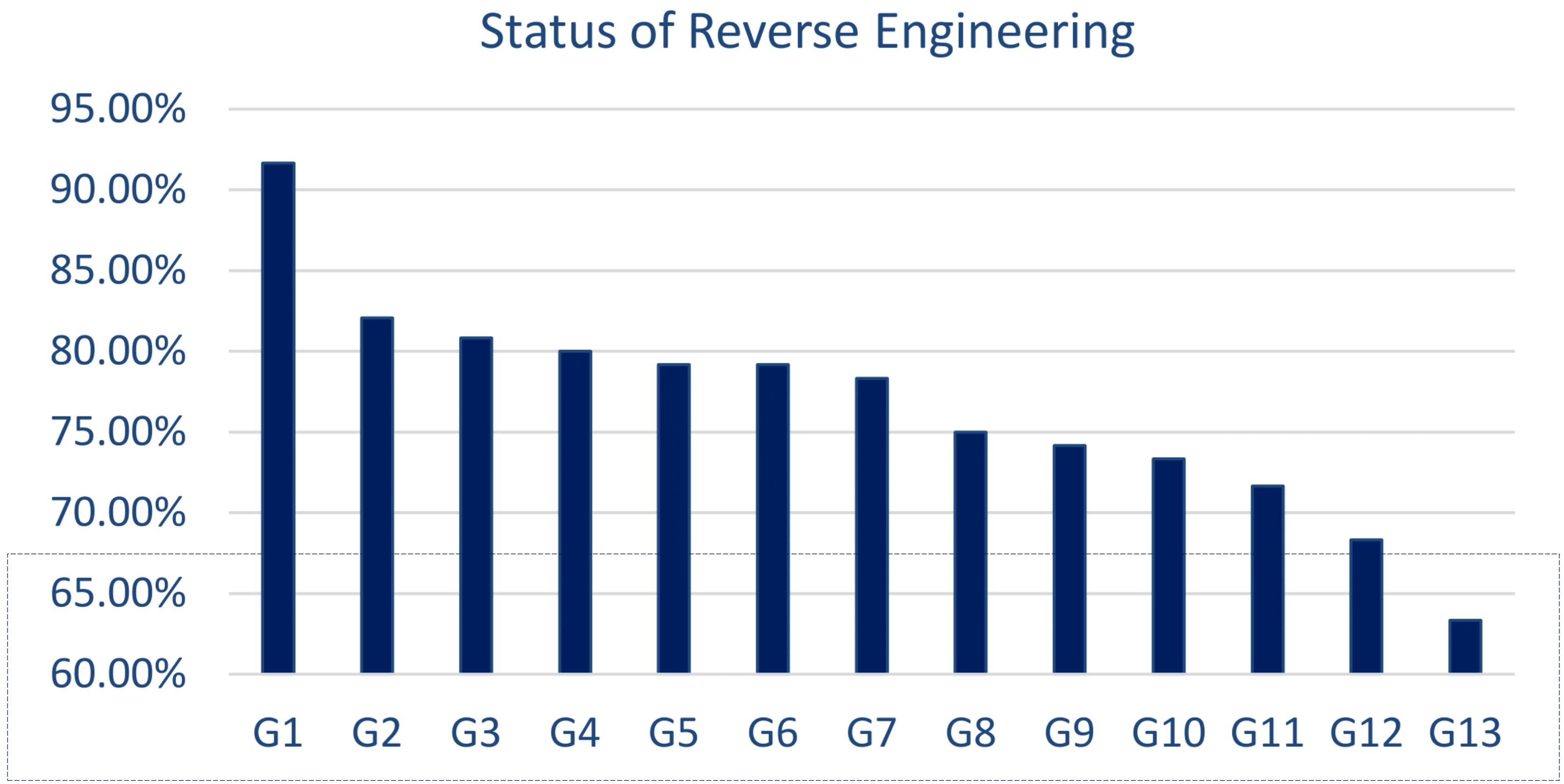
2-tailed Mann-Whitney U test: **alpha=.05 < p-value=.05486**

Student Perception of Reverse Engineering by Others

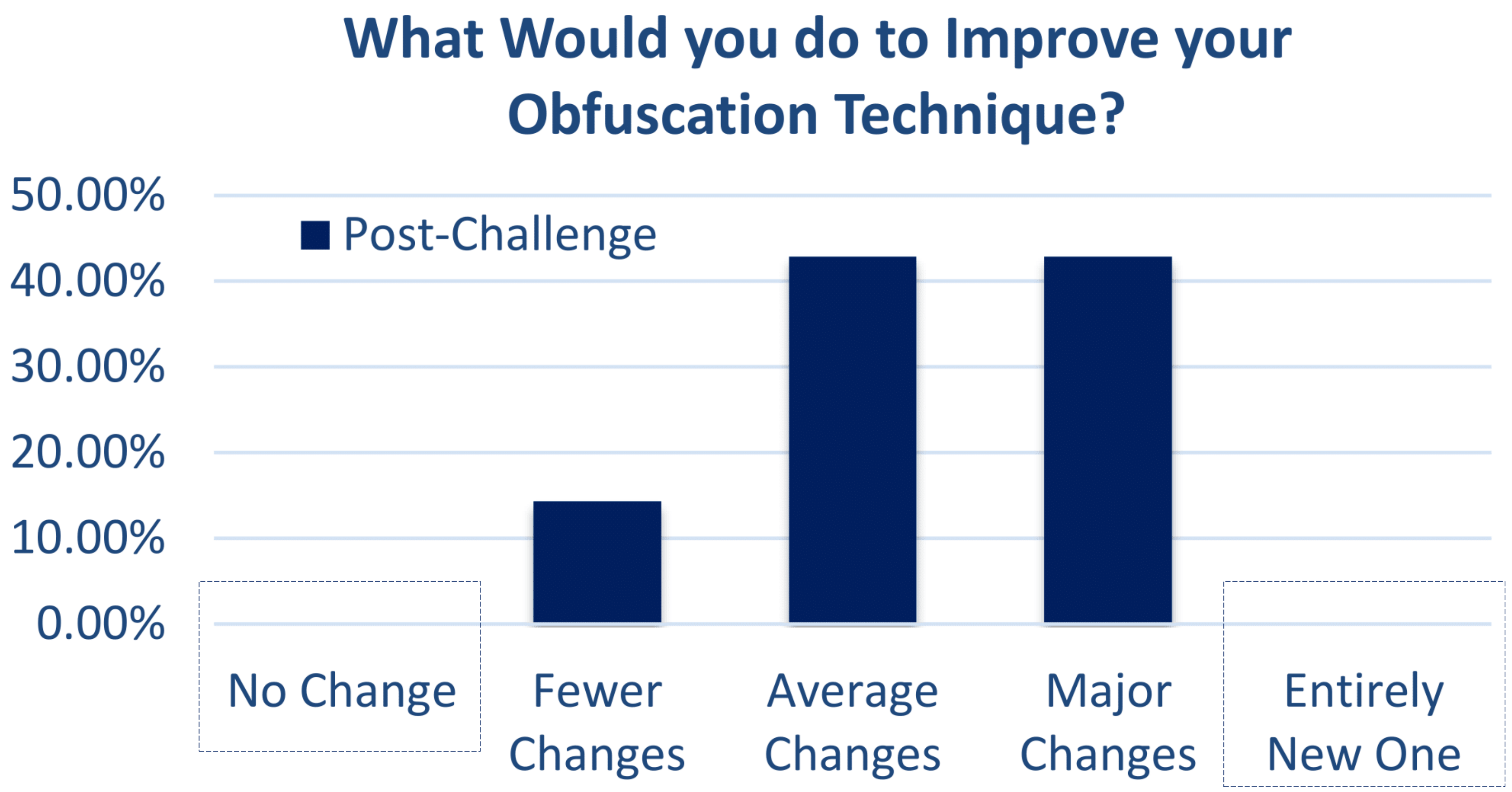


2-tailed Mann-Whitney U test: **alpha=.05 > p-value=.01596**

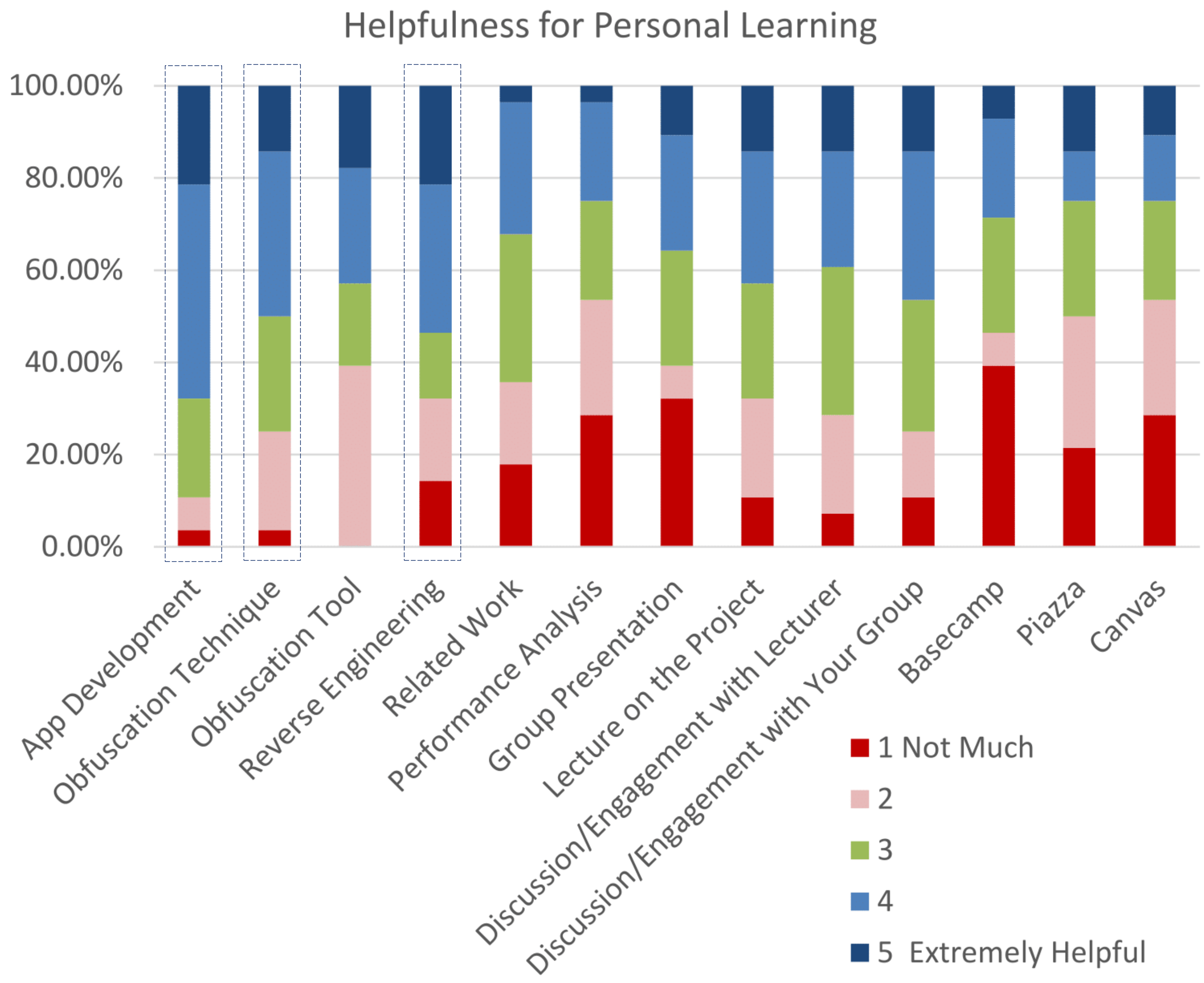
Performance of Groups in Challenge Phase



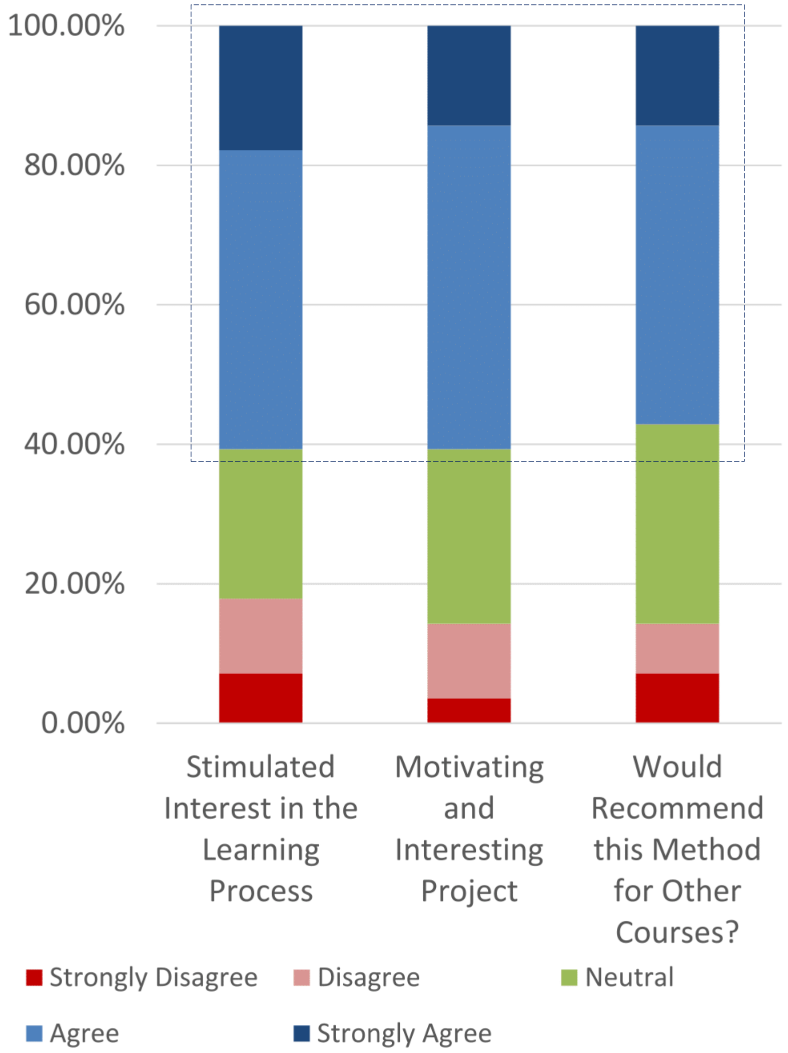
Potential Improvements



Personal Learning



Learning and Interest



Summary

- A **novel** approach to teaching and learning cyber security
- Based on **competitive** group projects
- A **positive change in student** perception and learning activities
- Students appear to have **more realistic** expectations about the difficulty of effectively obfuscating apps
- **More** administrative work
- A **positive experience** for both students and teaching staff

Exercise on Reverse Engineering

- Reverse engineer Hello World Android app
- Reverse engineer any other app of your choice
- Observe control flow and data assets

Consider a C Program

```
#include <stdio.h>
void main() {
   char firstname[10];
   char lastname[10] = "changeme";
   printf("Enter your name: ");
   gets(firstname);
   printf("Your name is: %s\n", lastname);
}
```

Exercise on Buffer Overflow

- Download the C program and run it by providing input that overwrites the lastname string (i.e., "changeme")
- The program must print your last name
- You can run it using this environment https://www.onlinegdb.com/online_c_compiler

Resources

- [Balachandran TIFS13] Balachandran, Vivek, and Sabu Emmanuel. "Potent and stealthy control flow obfuscation by stack based self-modifying code." IEEE Transactions on Information Forensics and Security (TIFS) 8, no. 4 (2013): 669-681.

- Asghar, Muhammad Rizwan, and Andrew Luxton-Reilly. "Teaching cyber security using competitive software obfuscation and reverse engineering activities." In Proceedings of the 49th ACM Technical Symposium on Computer Science Education, pp. 179-184. 2018.

Resources Cont.

- Apk decompiler
  - http://www.javadecompilers.com/apk
- Mobile security wiki
  - https://appsecwiki.com/#/mobilesecurity

Questions?

Thanks for your attention!