Will Computers Ever Be Secure?

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Pint of Science

Accessing The World's Information

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The University Of Sheffield.

Will Computers Ever Be Secure?:

Abstract

These days, it feels like news reports about data security breaches are commonplace. It looks like as if the attackers won and securing IT systems is a Sisyphean task.
In this talk, I will motivate the challenges of building secure systems and provide insights into the (fundamental) questions if we can build a computer program that decides if a system secure or not.

Information of more than

550,000,000

accounts leaked.

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Example (LinkedIn, May 2016)

- 164 million email addresses and passwords
- from an attack in 2012, offered for sale May 2016
- Compromised data:
  - email addresses
  - passwords

Information of more than

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Example (TalkTalk, October 2015)

- nearly 157,000 customer records leaked
- nearly 16,000 records included bank details
- more than 150,000 customers lost
  (home services market share fall by 4.4 percent
  in terms of new customers)
- Costs for TalkTalk: around any £60 million

Information of more than

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Example (Ashley Madison, July 2015)

- more than 30 million email addresses and much more
- Compromised data:
  - Dates of birth
  - Email addresses
  - Ethnicities, Genders
  - Sexual preferences
  - Home addresses, Phone numbers
  - Payment histories
  - Passwords, Usernames, Security questions and answers
  - Website activity
- **Similar Leak:** Mate1 in February 2016:
  27 million records with even more personal details
  (e.g., drinking/drug habits, parenting plans, political views)

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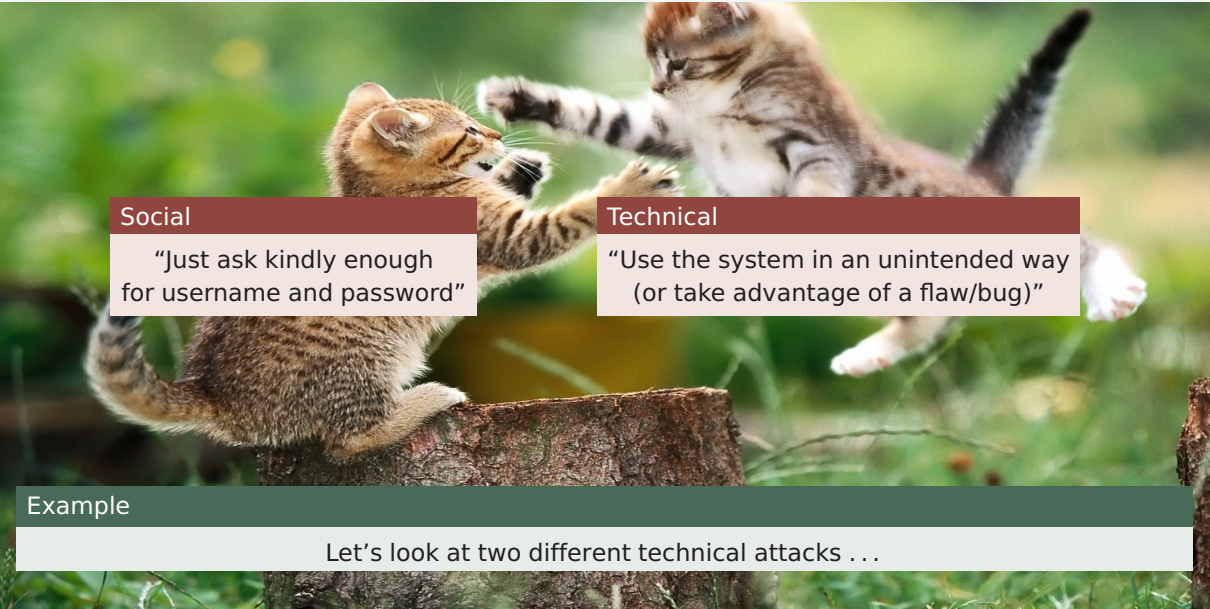

Social

"Just ask kindly enough for username and password"

Technical

"Use the system in an unintended way (or take advantage of a flaw/bug)"

Example

Let's look at two different technical attacks . . .

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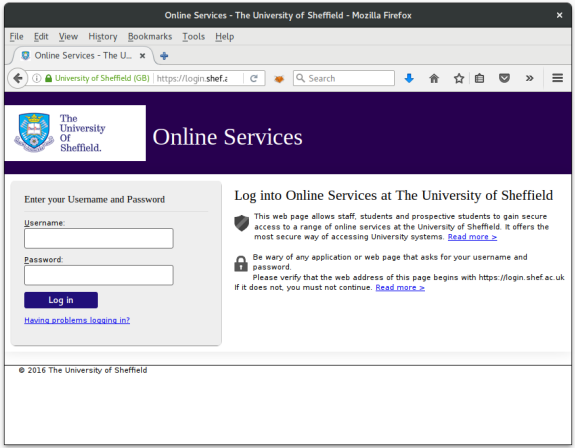

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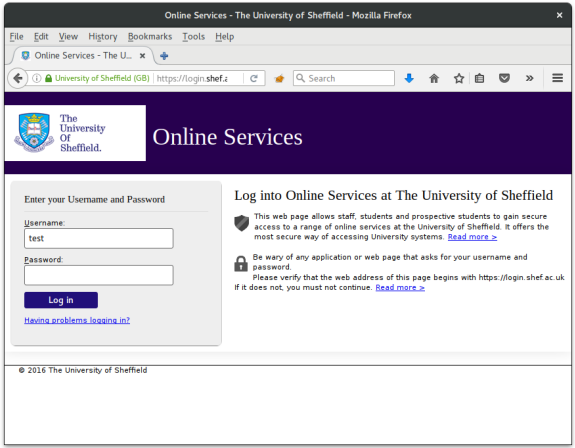

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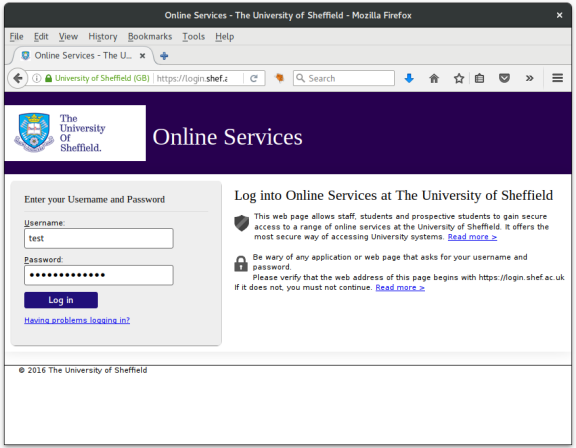

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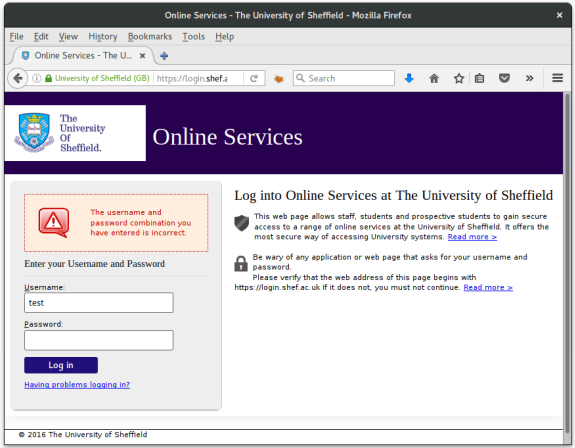

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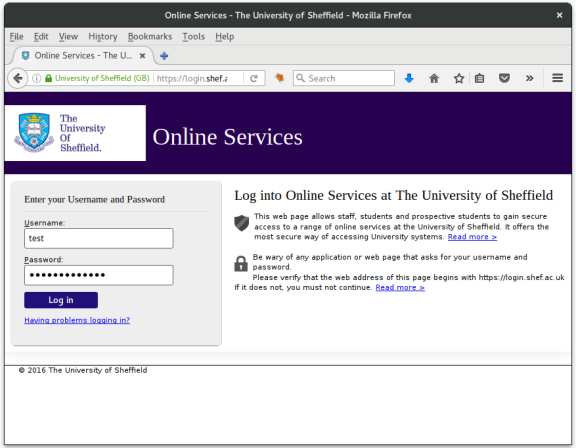

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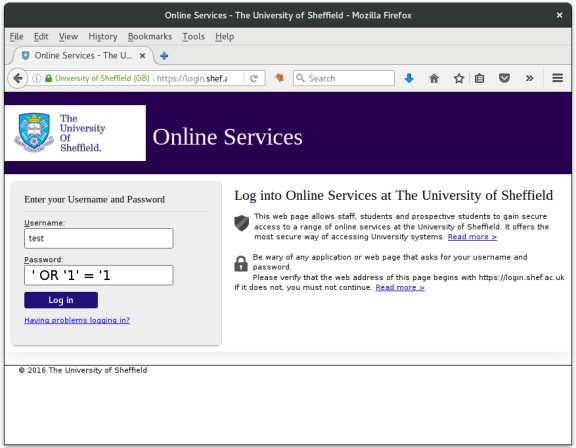

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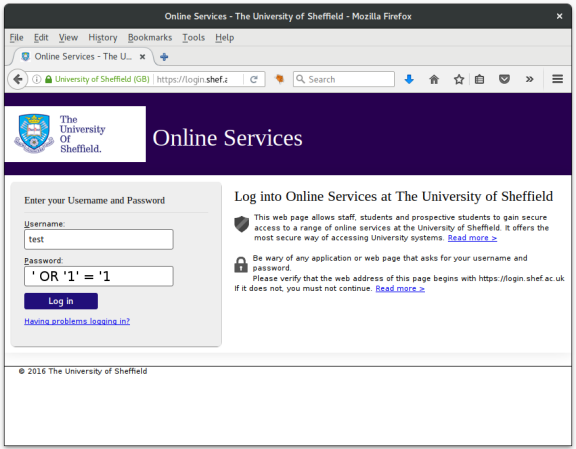

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```
SELECT * FROM ‘users‘ WHERE
‘name‘ = ’test’ AND ‘pwd‘ = ’’ OR ’1’=’1’;
```

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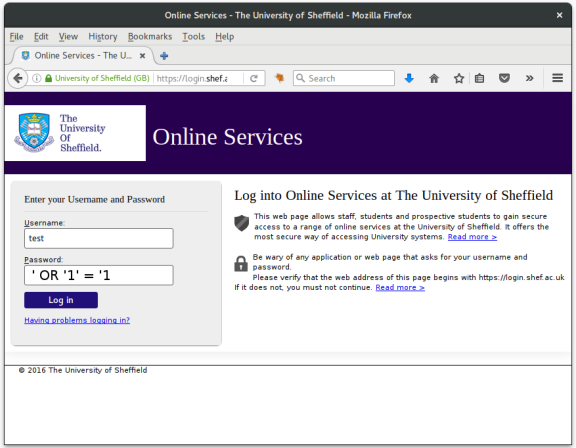

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SELECT * FROM ‘users‘ WHERE
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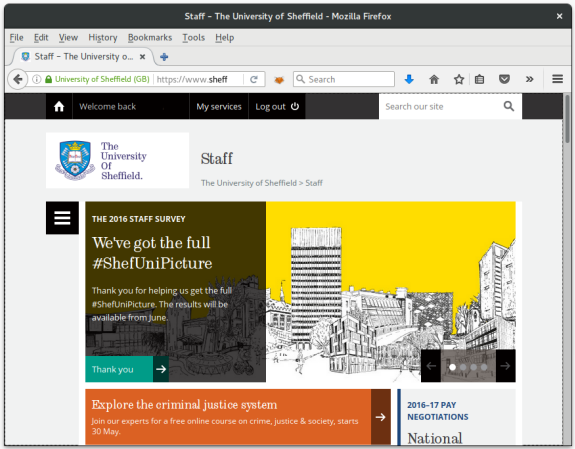

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```

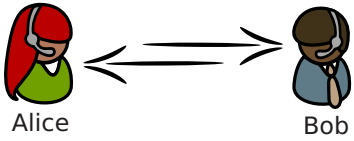
- Now let’s try something different

```
SELECT * FROM ‘users‘ WHERE
 TRUE;
```

- disabling the `WHERE`-clause (condition)

Example 2: How To Pretend To Be Somebody Else?

- Alice wants to be sure that she talks to Bob (authenticity)



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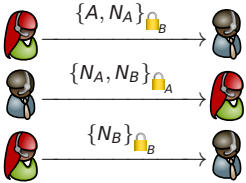
- Needham and Schroeder proposed in 1978 the following protocol (NSPK):



"I am Alice and here is my Nonce N_A."

"Here is your Nonce N_A and I have one for you."

"I got it! It is N_B."

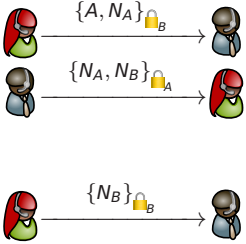
A Nonce is a fresh secret only known to the person generating it.

Example 2: How To Pretend To Be Somebody Else? (Correctness)

Goal

After executing the protocol successfully,
Alice and **Bob** can be sure to talk to each other (and not to somebody else).

Correctness argument (informal):



"This is Alice and I have chosen a nonce N_A."

"Here is your nonce N_A.
Since I could read it, I must be Bob.
I also have a challenge N_B for you."

"You sent me N_B. Since only Alice can read this and I sent it back, you must be Alice."

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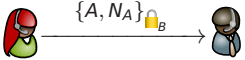

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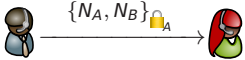

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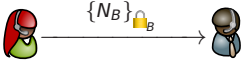

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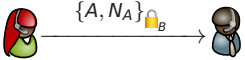

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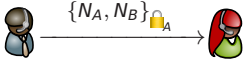

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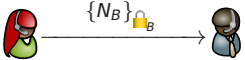

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Protocols are typically *small* and *convincing* . . . **and often wrong!**

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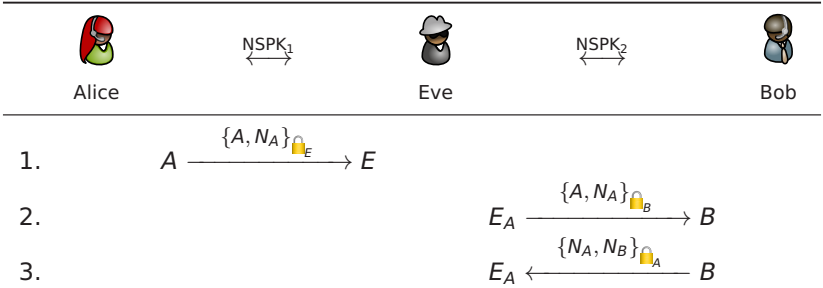

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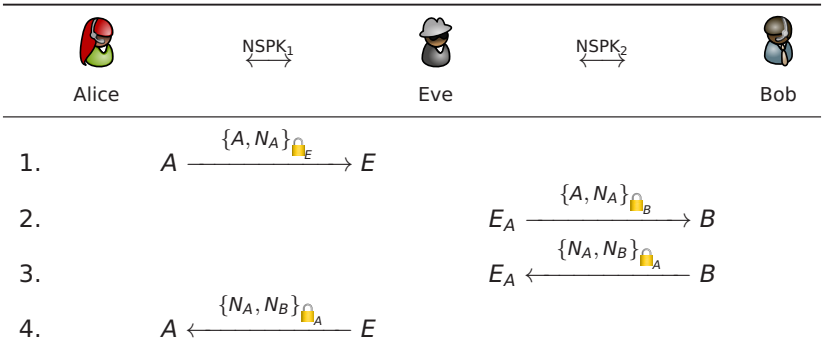

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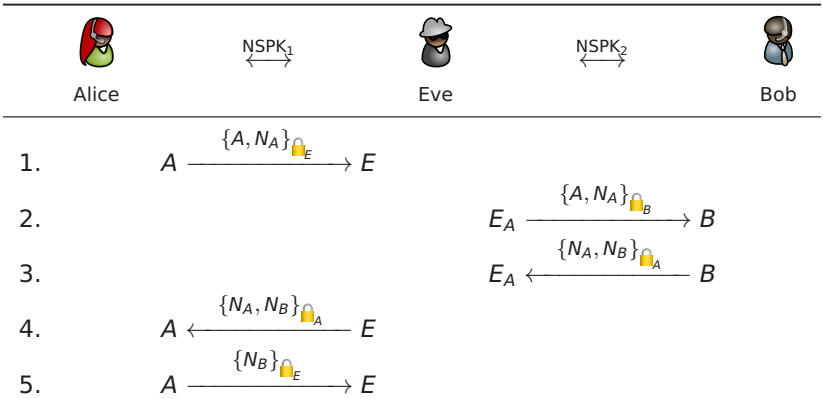

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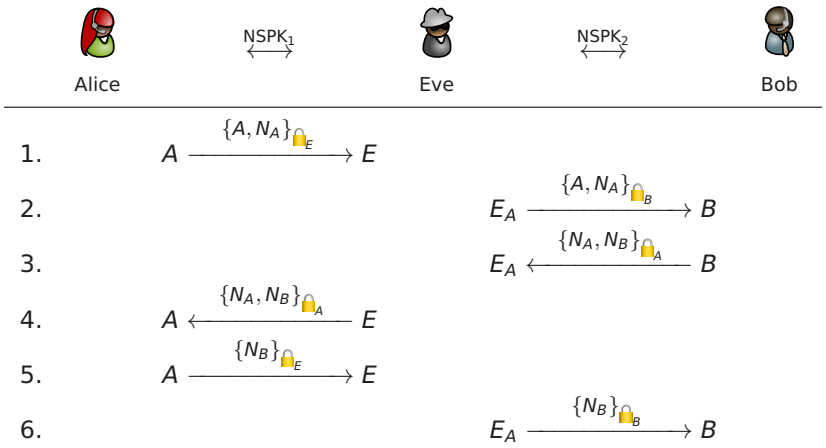
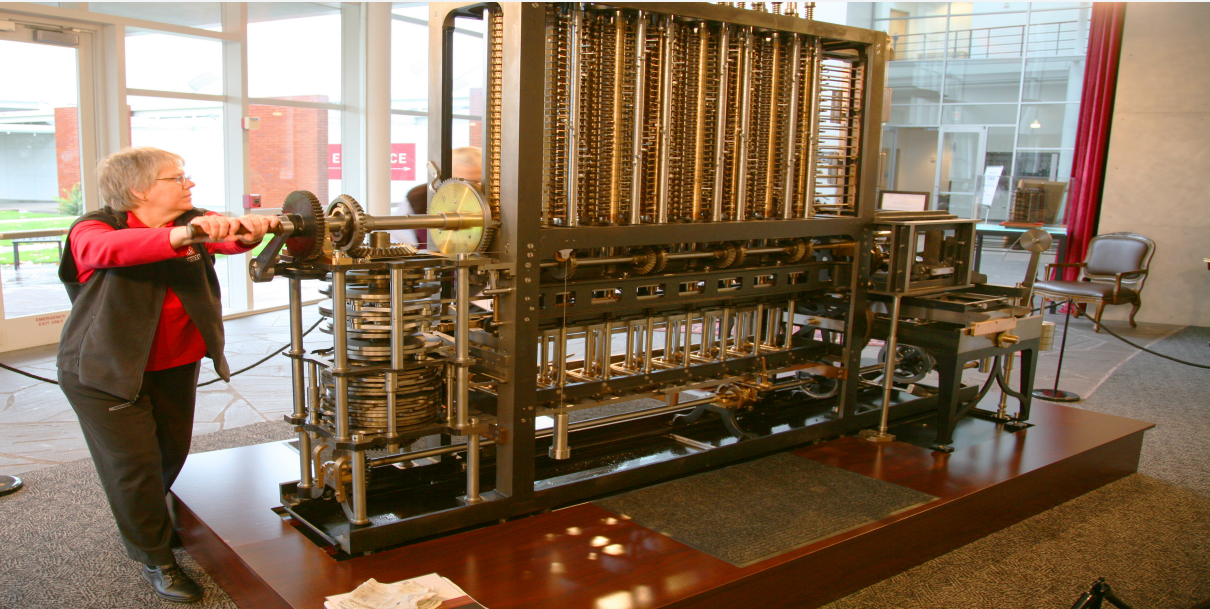


Bob **believes** he is speaking with Alice!

My Research Vision



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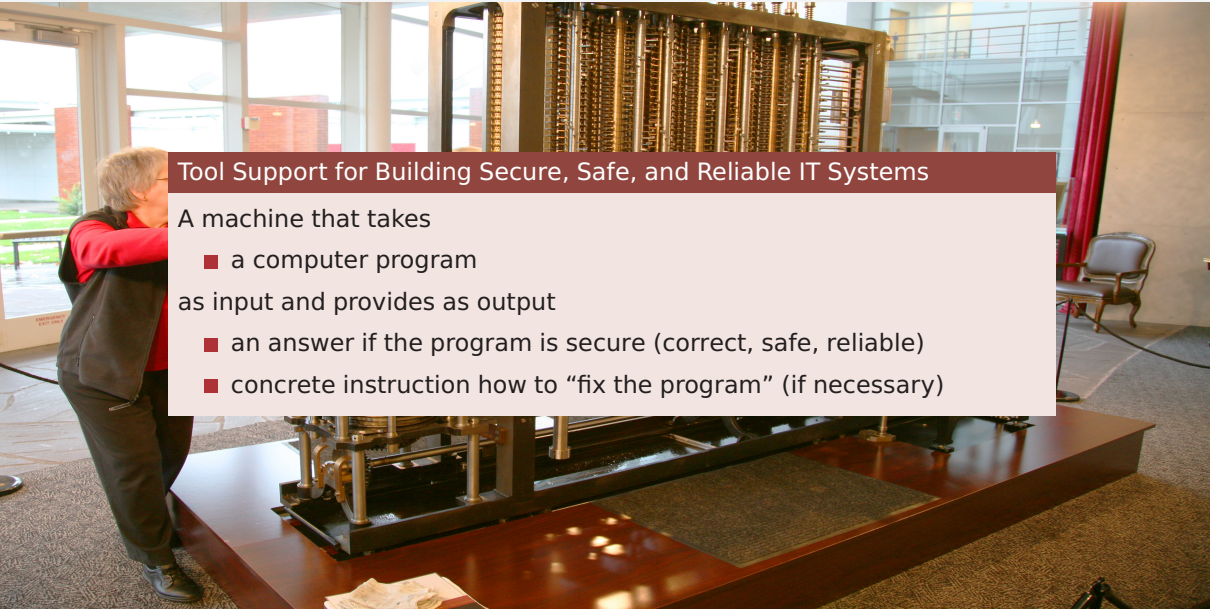


Tool Support for Building Secure, Safe, and Reliable IT Systems

A machine that takes

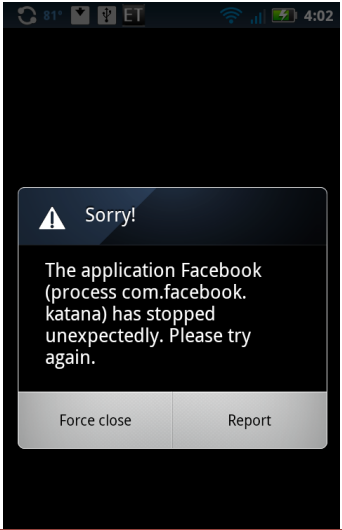
- a computer program

as input and provides as output

- an answer if the program is secure (correct, safe, reliable)
- concrete instruction how to “fix the program” (if necessary)

Question: Can We Realise My Dream?

https://thorehusfeldt.net/2012/06/25/the-freeze-app-does-not-exist/



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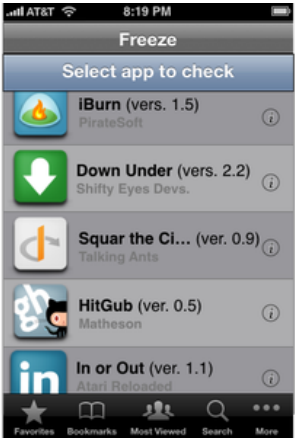

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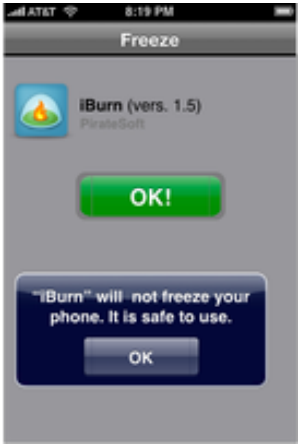

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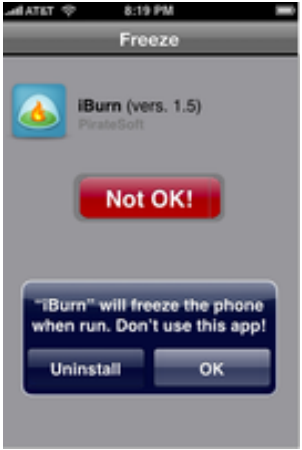

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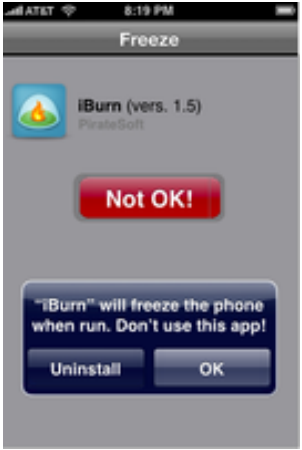

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- Can you build Freeze?

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https://thorehusfeldt.net/2012/06/25/the-freeze-app-does-not-exist/

```
set Result to
    tell application "Freeze" to
        check application "Paradox"
    end tell
if Result is "OK" then
    display 5/0
else display "Freeze␣detected
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣that␣Paradox␣freezes"
end if
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  and "computes" if
  - an app is safe to use
  - an app freezes your phone
- Can you build Freeze?
- I cannot, but I can build "Paradox", which
  1. runs Freeze and ask it to inspect Paradox.
  2. if Freeze returns "OK" then freeze the phone
     (e.g., by computing 5/0)
  3. if Freeze returns "Not OK" then print
     "Freeze detected that Paradox freezes"
     and terminate gracefully

Answer: Can We Realise My Dream?

https://thorehusfeldt.net/2012/06/25/the-freeze-app-does-not-exist/

Is the “Paradox” app malicious? Let’s test it with Freeze:

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- Let’s assume Paradox freezes the phone
  - Freeze will detect this
  - Paradox’s computations continues
    - printing the result
    - and terminates

Answer: Can We Realise My Dream?

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end if
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Is the “Paradox” app malicious? Let’s test it with Freeze:

- Let’s assume Paradox freezes the phone
  - Freeze will detect this
  - Paradox’s computations continues
    - printing the result
    - and terminates
- Let’s assume Paradox does **not** freeze the phone
  - Freeze will detect this
  - Paradox’s computations continues
    - and freezes the phone (computing 5/0)

Answer: Can We Realise My Dream?

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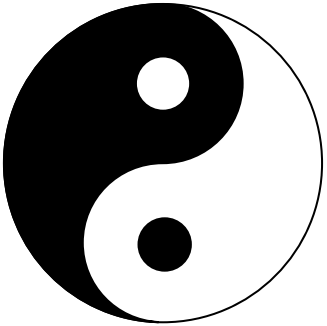
    display 5/0
else display "Freeze␣detected
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣that␣Paradox␣freezes"
end if
```

Is the “Paradox” app malicious? Let’s test it with Freeze:

- Let’s assume Paradox freezes the phone
  - Freeze will detect this
  - Paradox’s computations continues
    - printing the result
    - and terminates
- Let’s assume Paradox does **not** freeze the phone
  - Freeze will detect this
  - Paradox’s computations continues
    - and freezes the phone (computing 5/0)

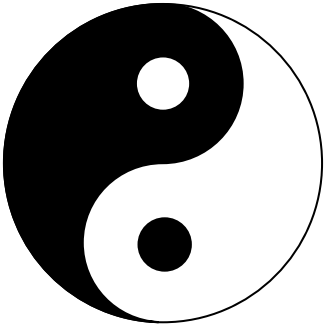
There is no app for that.

Where Do We Go From Here?



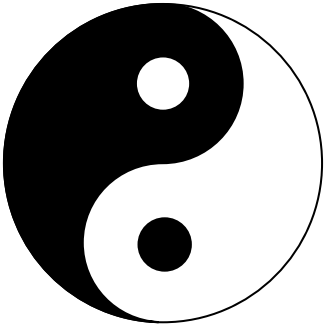
- This is a negative result, right?

Where Do We Go From Here?



- This is a negative result, right?
- No, it is not. It
  - motivates and
  - provides opportunities for research

Where Do We Go From Here?



- This is a negative result, right?
- No, it is not. It
  - motivates and
  - provides opportunities for research
- Possible solutions:
  - Analyses that approximate
    - i.e., missing a few problems
    - i.e., reporting a few spurious issues
  - Interactive analysis methods
  - Make it easier to build secure systems

Thank you for your attention!

Any questions or remarks?

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Fixing NSPK

1. $A \longrightarrow B$: $\{A, N_A\}_{B}$
2. $B \longrightarrow A$: $\{N_A, N_B\}_{A}$
3. $A \longrightarrow B$: $\{N_B\}_{B}$

- Problem in step 2:

$$B \rightarrow A : \{N_A, N_B\}_{A}$$

- Fix (proposed by Lowe:
  Agent B should also give his name: $\{B, N_A, N_B\}_{A}$:

1. $A \longrightarrow B$: $\{A, N_A\}_{B}$
2. $B \longrightarrow A$: $\{B, N_A, N_B\}_{A}$
3. $A \longrightarrow B$: $\{N_B\}_{B}$