Security Engineering (5)

Email: christian.urban at kcl.ac.uk
Office: S1.27 (1st floor Strand Building)
Slides: KEATS (also homework is there)

Problems with Key Fobs

MONDAY 27 OCTOBER 2014 EVENING STANDARD

:ebook.com/eveningstandard
us on Twitter @standardnews

Insurers refuse to cover Range Rovers due to security flaw

Kiran Randhawa

INSURANCE companies are refusing to cover new Range Rovers in London after thieves found a way of bypassing the vehicles' keyless ignition systems.

Criminals use hand-held electronic devices, available on eBay, to get around the feature. Unless owners have secure parking, underwriters are now said to be refusing to insure them.

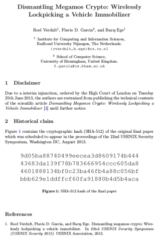
Insurers have asked to meet Jaguar Range Rover to discuss the growing problem. Thatcham Research, the motor insurers' automotive research centre, said that 294 Range Rover Evoque and Sport vehicles were stolen in London between January and July. In the same period, 63 BMW X5s, a rival to the Range Rover, were taken.

James Wasdell, co-founder of Quantum Underwriting, said: "If you are an owner of a street-parked Range Rover, nine out of 10 insurers will now say no. However, we have found a solution by combining the use of physical protection [for the car] and advising clients to insure all assets with one insurer."

Jaguar Land Rover said: "Our line-up continues to meet the insurance industry requirements. Nevertheless we are taking this issue very seriously."

Circumventing the ignition protection:

- either dismantling Megamos crypto,
- or use the diagnostic port to program blank keys



Dismantling Megamos Crypto: Wirelessly Lockpicking a Vehicle Immobilizer

Roel Verdult[1], Flavio D. Garcia[2], and Barış Ege[1]

[1] Institute for Computing and Information Sciences, Radboud University Nijmegen, The Netherlands. {rverdult,b.ege}@cs.ru.nl

[2] School of Computer Science, University of Birmingham, United Kingdom. f.garcia@cs.bham.ac.uk

1 Disclaimer

Due to a interim injunction, ordered by the High Court of London on Tuesday 25th June 2013, the authors are restrained from publishing the technical contents of the scientific article *Dismantling Megamos Crypto: Wirelessly Lockpicking a Vehicle Immobilizer* [1] until further notice.

2 Historical claim

Figure 1 contains the cryptographic hash (SHA-512) of the original final paper which was scheduled to appear in the proceedings of the 22nd USENIX Security Symposium, Washington DC, August 2013.

```
9d05ba88740499eecea3d8609174b444
43683da139f78b783666954ccc605da8
4601888134bf0c23ba46fb4a88c056bf
bbb629e1ddffcf60fa91880b4d5b4aca
```

Figure 1: SHA-512 hash of the final paper

References

1. Roel Verdult, Flavio D. Garcia, and Barış Ege. Dismantling megamos crypto: Wirelessly lockpicking a vehicle immobilizer. In *22nd USENIX Security Symposium (USENIX Security 2013)*. USENIX Association, 2013.

Nonces

1. I generate a nonce (random number) and send it to you encrypted with a key we share
2. you increase it by one, encrypt it under a key I know and send it back to me

I can infer:

- you must have received my message
- you could only have generated your answer after I have sent you my initial message
- if only you and me know the key, the message must have come from you

Protocols

- The point is that we have no control over the network
- We want to avoid that a message exchange (a protocol) can be attacked without detection

G20 Summit in 2009

- Snowden documents reveal "that during the G20 meetings...GCHQ used 'ground-breaking intelligence capabilities' to intercept the communications of visiting delegations. This included setting up internet cafes where they used an email interception program and key-logging software to spy on delegates' use of computers..."
- "The G20 spying appears to have been organised for the more mundane purpose of securing an advantage in meetings."

A Simple PK Protocol

1. $A \rightarrow B : K_A^{pub}$
2. $B \rightarrow A : K_B^{pub}$
3. $A \rightarrow B : \{A, m\}_{K_B^{pub}}$
4. $B \rightarrow A : \{B, m'\}_{K_A^{pub}}$

A Simple PK Protocol

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unfortunately there is a simple man-in-the-middle-attack

A MITM Attack

1. $A \to E : K_A^{pub}$
2. $E \to B : K_E^{pub}$
3. $B \to E : K_B^{pub}$
4. $E \to A : K_E^{pub}$
5. $A \to E : \{A, m\}_{K_E^{pub}}$
6. $E \to B : \{E, m\}_{K_B^{pub}}$
7. $B \to E : \{B, m'\}_{K_E^{pub}}$
8. $E \to A : \{E, m'\}_{K_A^{pub}}$

A MITM Attack

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7. $B \to E : \{B, m'\}_{K_E^{pub}}$
8. $E \to A : \{E, m'\}_{K_A^{pub}}$

and A and B have no chance to detect it

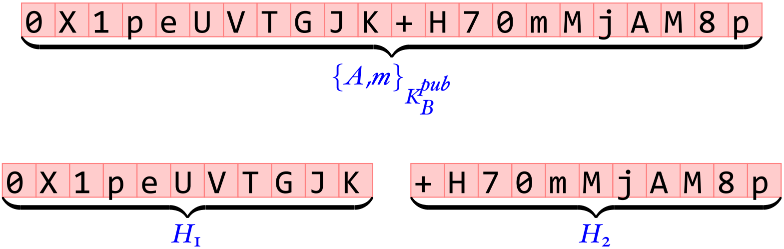
Interlock Protocol

The interlock protocol ("best bet" against MITM):

1. $A \to B : K_A^{pub}$
2. $B \to A : K_B^{pub}$
3. $\{A, m\}_{K_B^{pub}} \mapsto H_1, H_2$

   $\{B, m'\}_{K_A^{pub}} \mapsto M_1, M_2$
4. $A \to B : H_1$
5. $B \to A : \{H_1, M_1\}_{K_A^{pub}}$
6. $A \to B : \{H_2, M_1\}_{K_B^{pub}}$
7. $B \to A : M_2$

Splitting Messages



- you can also use the even and odd bytes
- the point is you cannot decrypt the halves, even if you have the key

$$A \to C : K_A^{pub}$$
$$C \to B : K_C^{pub}$$
$$B \to C : K_B^{pub}$$
$$C \to A : K_C^{pub}$$
$$\{A, m\}_{K_C^{pub}} \mapsto H_1, H_2$$
$$\{B, m'\}_{K_C^{pub}} \mapsto M_1, M_2$$

$$\{C, a\}_{K_B^{pub}} \mapsto C_1, C_2$$
$$\{C, b\}_{K_A^{pub}} \mapsto D_1, D_2$$

$$A \to C : H_1$$
$$C \to B : C_1$$
$$B \to C : \{C_1, M_1\}_{K_C^{pub}}$$
$$C \to A : \{H_1, D_1\}_{K_A^{pub}}$$
$$A \to C : \{H_2, D_1\}_{K_C^{pub}}$$
$$C \to B : \{C_2, M_1\}_{K_B^{pub}}$$
$$B \to C : M_2$$
$$C \to A : D_2$$

$$A \to C : K_A^{pub}$$
$$C \to B : K_C^{pub}$$
$$B \to C : K_B^{pub}$$
$$C \to A : K_C^{pub}$$

$$\{A, m\}_{K_C^{pub}} \mapsto H_1, H_2$$
$$\{B, m'\}_{K_C^{pub}} \mapsto M_1, M_2$$

$$\{C, a\}_{K_B^{pub}} \mapsto C_1, C_2$$
$$\{C, b\}_{K_A^{pub}} \mapsto D_1, D_2$$

$$A \to C : H_1$$
$$C \to B : C_1$$
$$B \to C : \{C_1, M_1\}_{K_C^{pub}}$$
$$C \to A : \{H_1, D_1\}_{K_A^{pub}}$$
$$A \to C : \{H_2, D_1\}_{K_C^{pub}}$$
$$C \to B : \{C_2, M_1\}_{K_B^{pub}}$$
$$B \to C : M_2$$
$$C \to A : D_2$$

m = How is your grandmother? m' = How is the weather today in London?

- you have to ask something that cannot be imitated (requires A and B know each other)
- what happens if m and m' are voice messages?

- you have to ask something that cannot be imitated (requires A and B know each other)
- what happens if m and m' are voice messages?

- So C can either leave the communication unchanged (Hellman-Diffie), or invent a complete new conversation

- the moral: establishing a secure connection from "zero" is almost impossible—you need to rely on some established trust
- that is why PKI relies on certificates, which however are badly, badly realised

Trusted Third Parties

Simple protocol for establishing a secure connection via a mutually trusted 3rd party (server):

$$
\begin{aligned}
A &\rightarrow S : A, B \\
S &\rightarrow A : \{K_{AB}, \{K_{AB}\}_{K_{BS}}\}_{K_{AS}} \\
A &\rightarrow B : \{K_{AB}\}_{K_{BS}} \\
A &\rightarrow B : \{m\}_{K_{AB}}
\end{aligned}
$$

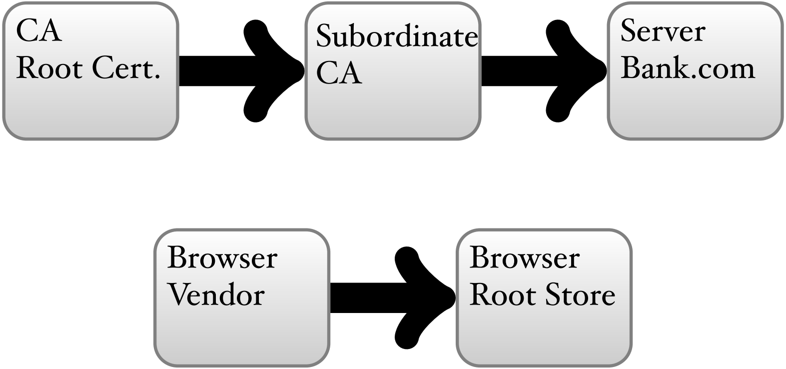
PKI: The Main Idea

- the idea is to have a certificate authority (CA)
- you go to the CA to identify yourself
- CA: “I, the CA, have verified that public key P^{pub}_{Bob} belongs to Bob”

- CA must be trusted by everybody

- certificates are time limited, and can be revoked
- What happens if CA issues a false certificate? Who pays in case of loss? (VeriSign explicitly limits liability to $100.)

PKI: Chains of Trust



- CAs make almost no money anymore, because of stiff competition
- browser companies are not really interested in security; only in market share

PKI: Weaknesses

CAs just cannot win (make any profit):

- there are hundreds of CAs, which issue millions of certificates and the error rate is small
- users (servers) do not want to pay or pay as little as possible

- a CA can issue a certificate for any domain not needing any permission (CAs are meant to undergo audits, but...DigiNotar)
- if a CA has issued many certificates, it "becomes too big to fail"
- Can we be sure CAs are not just frontends of some government organisation?

PKI: Weaknesses

- many certificates are issued via Whois...if you hijacked a domain, it is easy to obtain certificates
- the revocation mechanism does not work (Chrome has given up on general revocation lists)
- lax approach to validation of certificates (Have you ever bypassed certification warnings?)
- sometimes you want to actually install invalid certificates (self-signed)

PKI: Attacks

- Go directly after root certificates
  - governments can demand private keys
  - 10 years ago it was estimated that breaking a 1024 bit key takes one year and costs 10 - 30 Mio $; this is now reduced to 1 Mio $
- Go after buggy implementations of certificate validation
- Social Engineering
  - in 2001 somebody pretended to be from Microsoft and asked for two code-signing certificates

The eco-system is completely broken (it relies on thousands of entities to do the right thing). Maybe DNSSEC where keys can be attached to domain names is a way out.

Real Attacks

- In 2011, DigiNotar (Dutch company) was the first CA that got compromised comprehensively, and where many fraudulent certificates were issued to the wild. It included approximately 300,000 IP addresses, mostly located in Iran. The attackers (in Iran?) were likely interested "only" in collecting gmail passwords.
- The Flame malware piggy-bagged on this attack by advertising malicious Windows updates to some targeted systems (mostly in Iran, Israel, Sudan).

PKI is Broken

- PKI and certificates are meant to protect you against MITM attacks, but if the attack occurs your are presented with a warning and you need to decide whether you are under attack.
- Webcontent gets often loaded from 3rd-party servers, which might not be secured
- Misaligned incentives: browser vendors are not interested in breaking webpages with invalid certificates

Why are there so many invalid certificates?

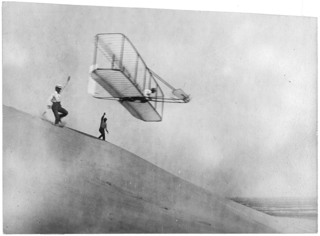
- insufficient name coverage (www.example.com should include example.com)
- IoT: manny appliances have web-based admin interfaces; the manufacturer cannot know under which IP and domain name the appliances are run (so cannot install a valid certificate)
- expired certificates, or incomplete chains of trust (servers are supposed to supply them)

Mid-Term

- homework, handouts, programs...

Any Questions?

Security Engineering



Wright brothers, 1901

Airbus, 2005

1st Lecture

- chip-and-pin, banks vs. customers

  the one who can improve security should also be liable for the losses

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- chip-and-pin, banks vs. customers

  the one who can improve security should also be liable for the losses

- hashes and salts to guarantee data integrity
- storing passwords (you should know the difference between brute force attacks and dictionary attacks; how do salts help?)

1st Lecture: Cookies

- good uses of cookies?
- bad uses of cookies: snooping, tracking, profiling...the "disadvantage" is that the user is in control, because you can delete them

"Please track me using cookies."

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  "Please track me using cookies."

- fingerprinting beyond browser cookies

  Pixel Perfect: Fingerprinting Canvas in HTML5
  (a research paper from 2012)
  http://cseweb.ucsd.edu/~hovav/papers/ms12.html

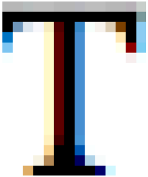
1st Lecture: Cookies

- a bit of JavaScript and HTML5 + canvas

Firefox

`55b2257ad0f20ecbf927fb66a15c61981f7ed8fc`

Safari



`17bc79f8111e345f572a4f87d6cd780b445625d3`

- no actual drawing needed

1st Lecture: Cookies

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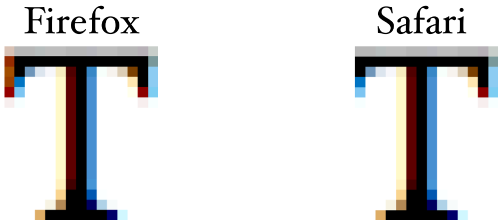

55b2257ad0f20ecbf927fb66a15c61981f7ed8fc 17bc79f8111e345f572a4f87d6cd780b445625d3

- no actual drawing needed
- in May 2014 a crawl of 100,000 popular webpages revealed 5.5% already use canvas fingerprinting

https://securehomes.esat.kuleuven.be/~gacar/persistent/the_web_never_forgets.pdf

1st Lecture: Cookies

Remember the small web-app I showed you where a cookie protected a counter?

- NYT, the cookie looks the "resource" - harm
- imaginary discount unlocked by cookie - no harm

2nd Lecture: E-Voting

Where are paper ballots better than voice voting?

- Integrity
- Ballot Secrecy
- Voter Authentication
- Enfranchisement
- Availability

2nd Lecture: E-Voting

- recently an Australian parliamentary committee found: e-voting is highly vulnerable to hacking and Australia will not use it any time soon

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- Alex Halderman, Washington D.C. hack

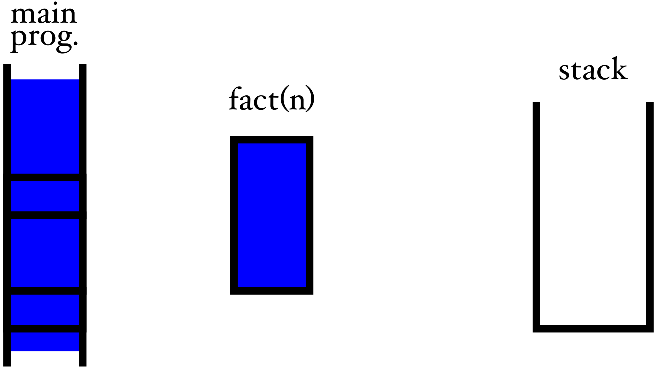
  https://jhalderm.com/pub/papers/dcvoting-fc12.pdf

- PDF-ballot tampering at the wireless router (the modification is nearly undetectable and leaves no traces; MITM attack with firmware updating)

  http://galois.com/wp-content/uploads/2014/11/technical-hack-a-pdf.pdf

3rd Lecture: Buffer Overflow Attacks

- the problem arises from the way C/C++ organises its function calls



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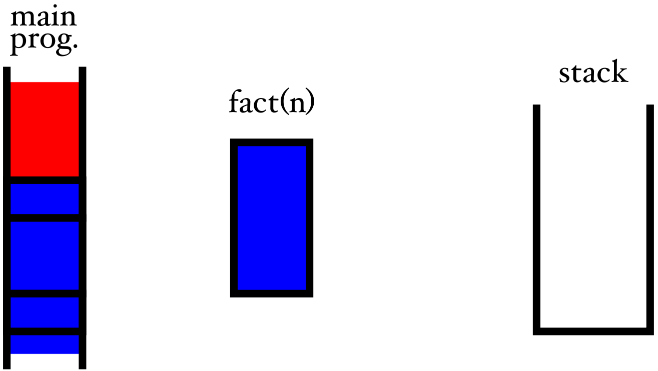

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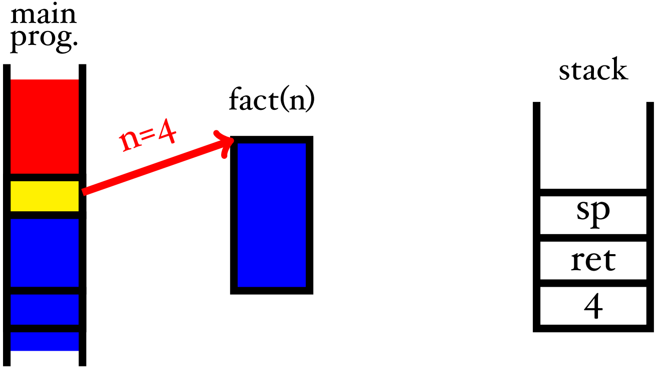

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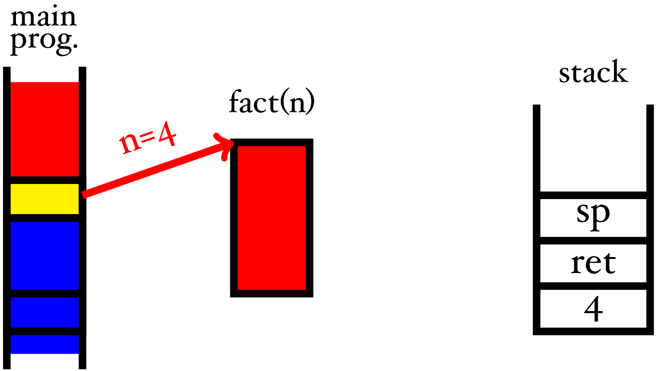

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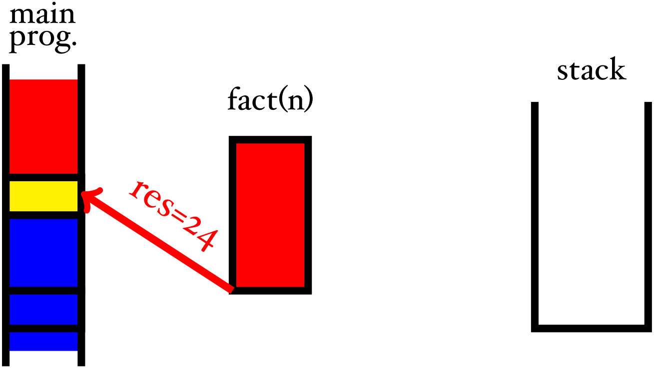

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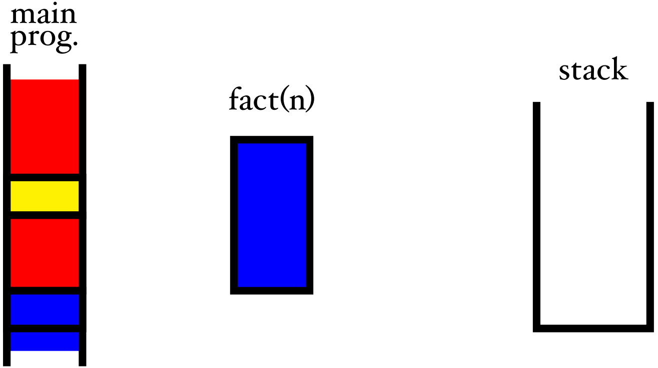

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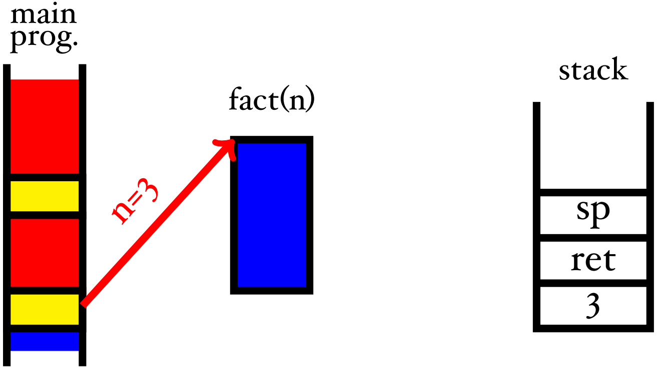

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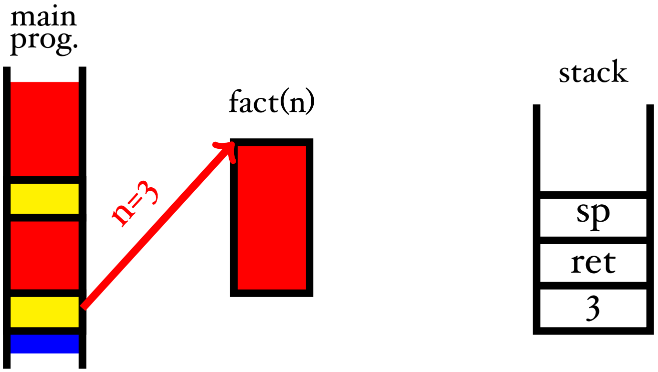

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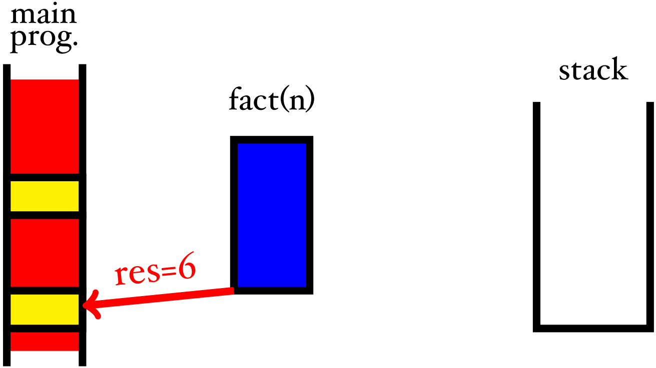
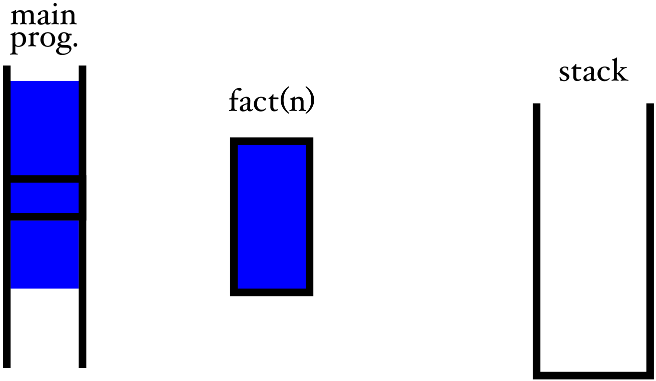
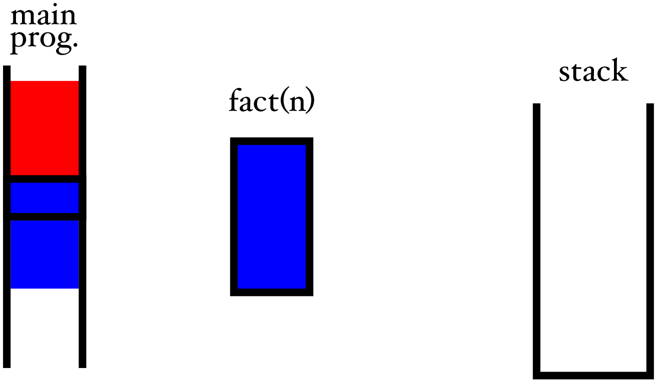



main prog.
fact(n)
stack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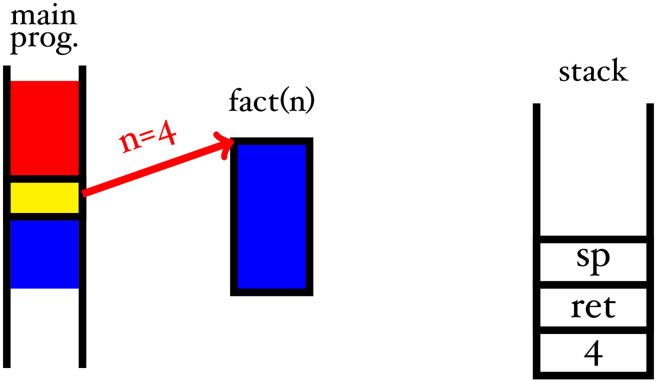
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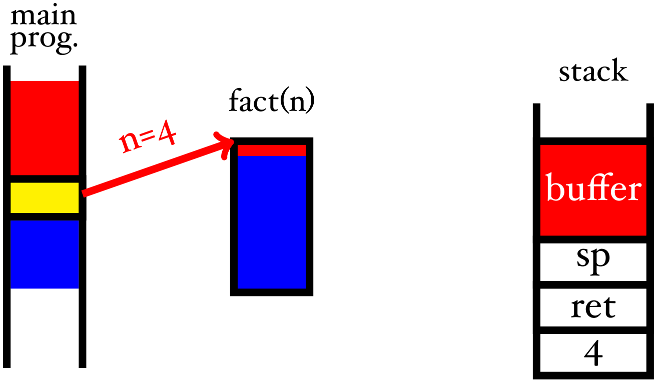
prog.
n=4
fact(n)
stack
sp
ret
4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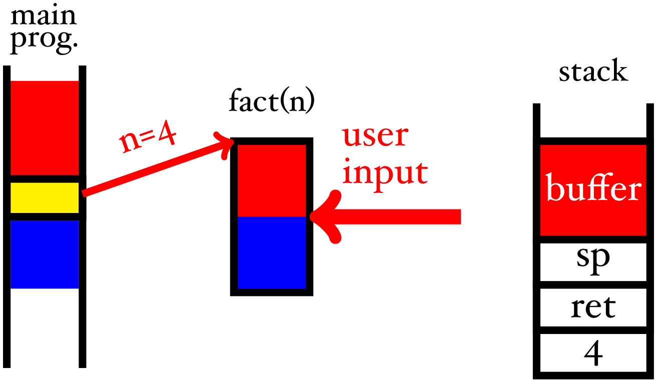
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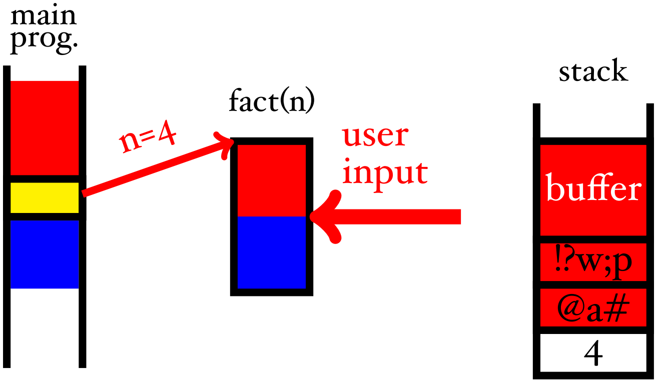
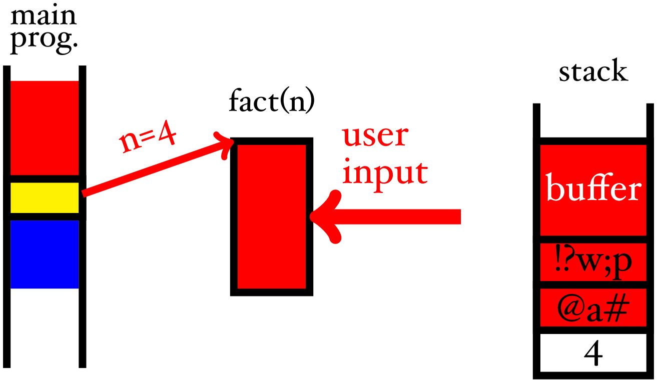
prog.
n=4
fact(n)
user
input
stack
buffer
sp
ret
4


main
prog.
n=4
fact(n)
user
input
stack
buffer
!?w;p
@a#
4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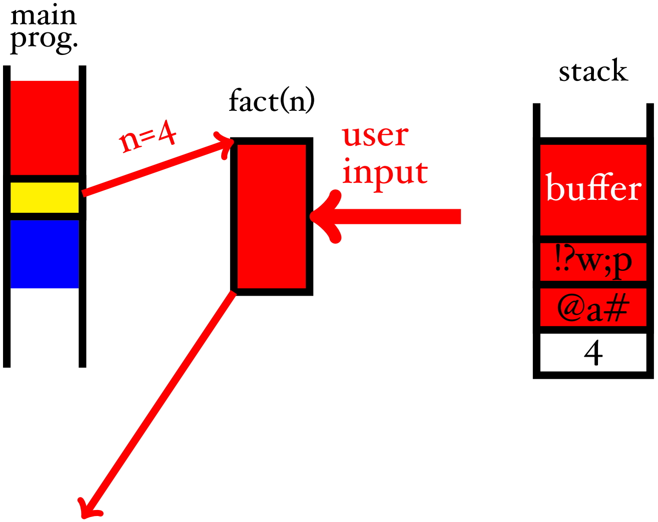
main
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n=4
fact(n)
user
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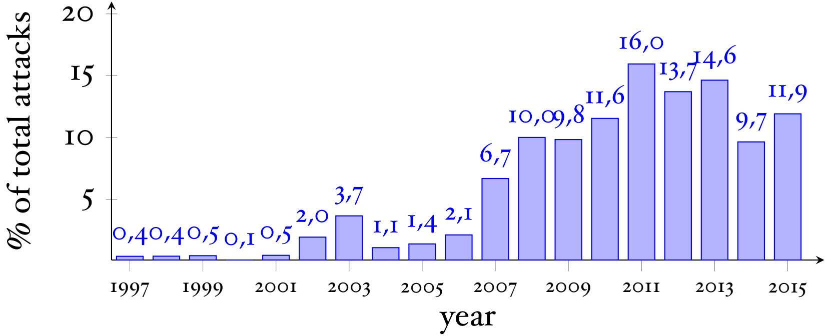
!?w;p
@a#
4

3rd Lecture: Buffer Overflow Attacks

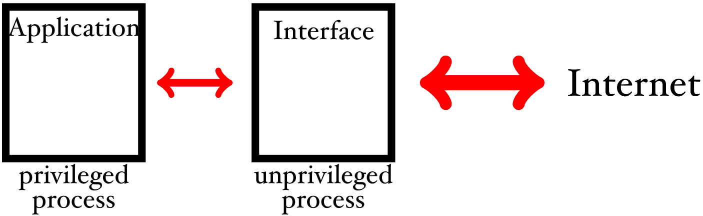
US National Vulnerability Database
(636 out of 6675 in 2014)



http://web.nvd.nist.gov/view/vuln/statistics

4th Lecture: Unix Access Control

- privileges are specified by file access permissions ("everything is a file")



- the idea is to make the attack surface smaller and mitigate the consequences of an attack

4th Lecture: Unix Access Control

- when a file with setuid is executed, the resulting process will assume the UID given to the owner of the file

```
$ ls -ld . * */*
drwxr-xr-x 1 ping staff  32768 Apr  2 2010 .
-rw----r-- 1 ping students  31359 Jul 24 2011 manual.txt
-r--rw--w- 1 bob students   4359 Jul 24 2011 report.txt
-rwsr--r-x 1 bob students  141359 Jun  1 2013 microedit
dr--r-xr-x 1 bob staff     32768 Jul 23 2011 src
-rw-r--r-- 1 bob staff     81359 Feb 28 2012 src/code.c
-r--rw---- 1 emma students   959 Jan 23 2012 src/code.h
```

4th Lecture: Unix Access Control

- Alice wants to have her files readable, except for her office mates.
- make sure you understand the setuid and setgid bits; why are they necessary for login and passwd