Prof. Philip Koopman

Carnegie Mellon University

Electrical & Computer ENGINEERING

Security Mitigation & Validation

"The trouble with programmers is that you can never tell what a programmer is doing until it's too late."

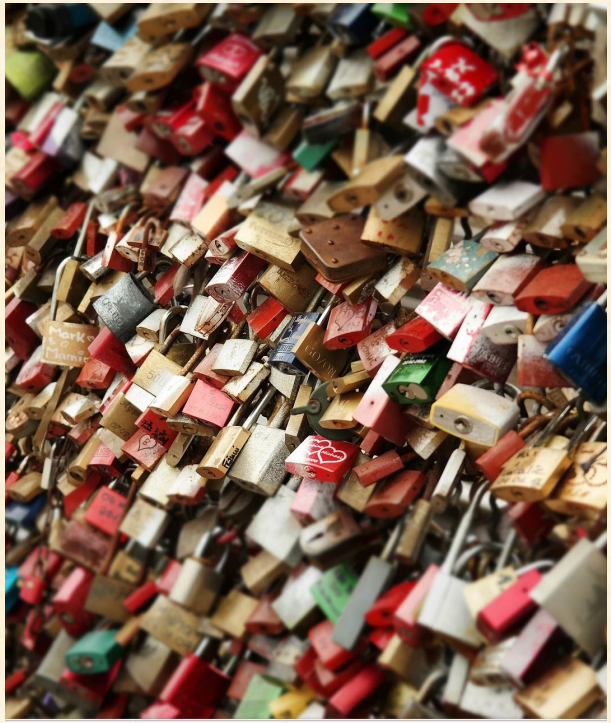
– Seymour Cray

© 2020 Philip Koopman

Security Migitation & Validation

Carnegie Mellon University

- Anti-Patterns for security mitigation & validation
  - Poorly considered password policy
  - Poorly considered privilege management
  - Assuming firewall or air gap is perfect security
  - No implementing secure update + secure boot
  - Just relying on penetration testing



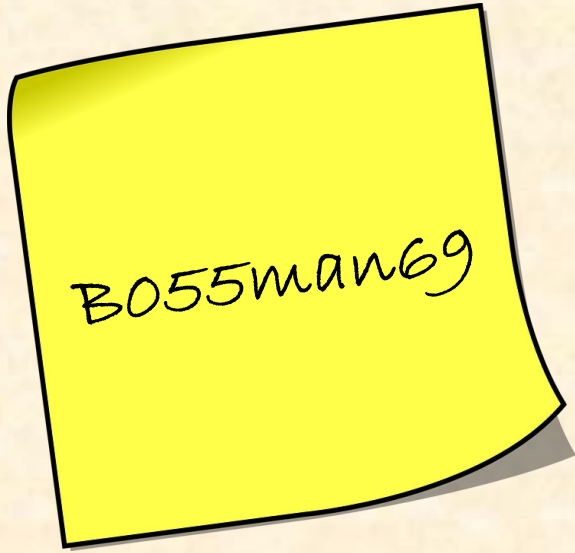
- Mitigation best practices
  - Keep up to date with good security practices
  - Secure update + secure boot
  - Penetration testing is only a starting point

© 2020 Philip Koopman

Principle: Password Strength

Carnegie Mellon University

- Typical failure scenarios
  - Same password used by everyone
  - Weak passwords ("1234")
  - Strong password policy ➔ post-it note work-around
- Possible solutions
  - Different password per person with reasonable strength
  - Two-factor authentication (e.g., RFID transponder)
- Balance between usability & security
  - Can you memorize: 7R#Ve9j3e@ahi7gjHr(*\pW4!X?
  - 2017 NIST guidelines (https://pages.nist.gov/800-63-3/)
    - Good ideas: long size, hash/salt/stretch for storage
    - Avoid: words in dictionary, requiring weird characters, password hints, timed expiry
    - Avoid SMS for 2fa (!) due to phone number hijacking (at least in some countries)

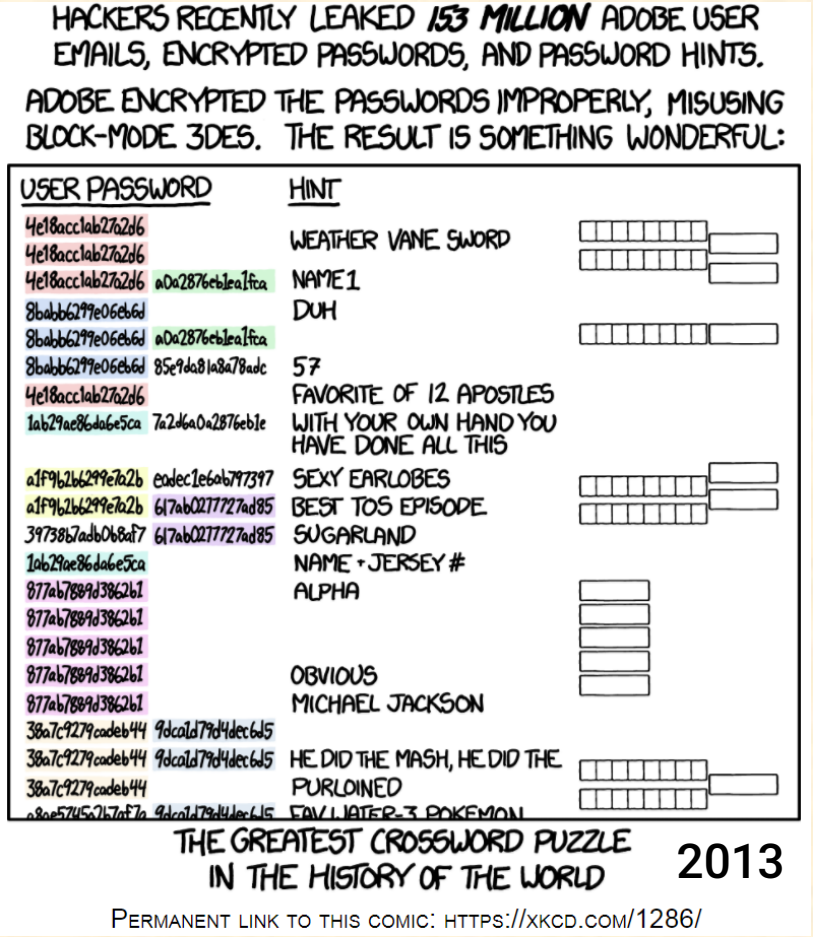


© 2020 Philip Koopman

Storing Passwords

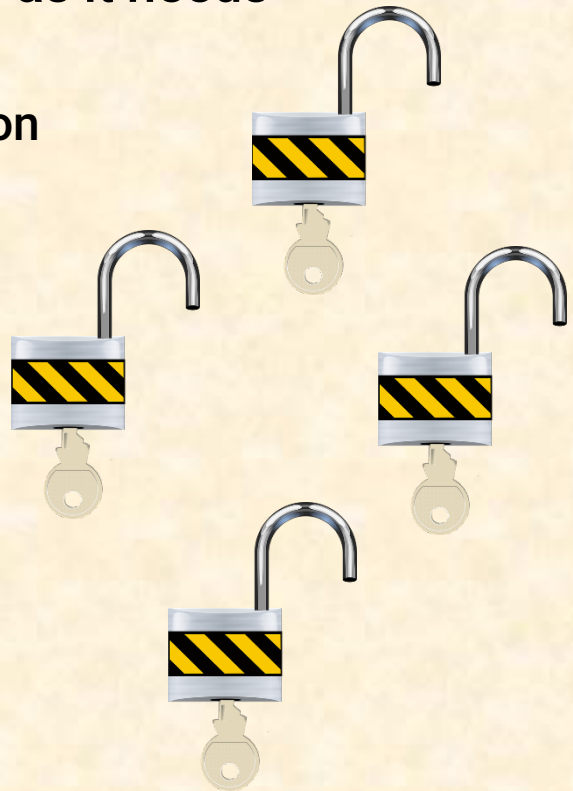
Carnegie Mellon University

- Don't store them as plain text!
  - Don't just encrypt them either
- Hash:
  - Store a digest of password
  - But, dictionary attacks are a problem
  - Rainbow table: precomputed hashes
- Salting & pepper:
  - Salt: random extra text
  - Pepper: systematic extra text
  - Can be secret or public (tradeoffs)
- Generically, key stretching:
  - E.g., PBKDF2 stretching
  - Use up to date techniques!



Principle: Least Privilege

- Each user & task should only have as much capability as it needs
  - Commonly, “user,” “administrator,” “factory”
  - Better: per-user fine-grain bit map of function permission
  - Related: helpful to log who did what (forensics)
- Common mistakes
  - Make a common task high privilege
    - Everyone used to log in as admin for Windows
  - Give everyone the same password
    - Once someone has admin, can’t roll them back
  - Make risky operations too easy (no confirmation)
- In general, think through permissions
  - Customers may push back, but this is important

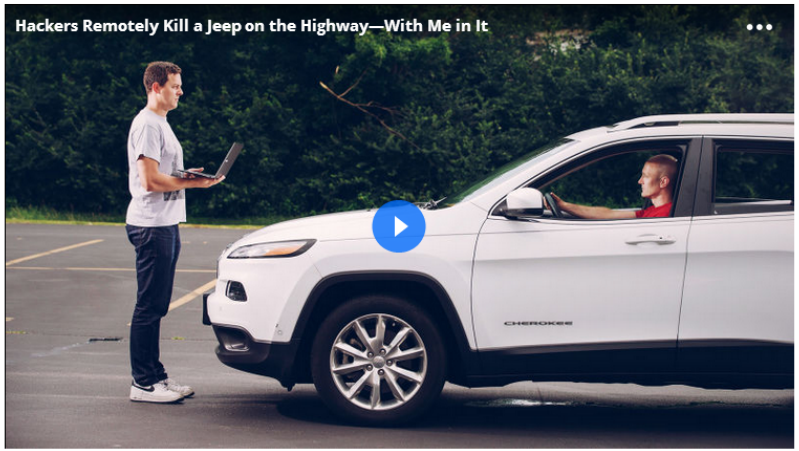


© 2020 Philip Koopman

What Happens With Unsigned Updates

Carnegie Mellon University

HACKERS REMOTELY KILL A JEEP ON THE HIGHWAY—WITH ME IN IT



SHARE

SHARE 202560
TWEET 23226
PIN 186
COMMENT 717
EMAIL

I WAS DRIVING 70 mph on the edge of downtown St. Louis when the exploit began to take hold.

Though I hadn't touched the dashboard, the vents in the Jeep Cherokee started blasting cold air at the maximum setting, chilling the sweat on my back through the in-seat climate control system. Next the radio switched to the local hip hop station and began blaring Skee-lo at full volume. I spun the control knob left and hit the power button, to no avail. Then the windshield wipers turned on, and wiper fluid blurred the glass.

As I tried to cope with all this, a picture of the two hackers performing these stunts appeared on the car's digital display: Charlie Miller and Chris Valasek, wearing their trademark track suits. A nice touch, I thought.

LATEST NEWS

OBSESSIONS
Wickedly Cool Space Book Comes Personalized to Your... 46 MINS

ANIMAL SCIENCE
Absurd Creatures: Bats Are Totally Legit. Trust Me, I'm a Vampire 3 HOURS

BRANDED CONTENT
How the Adventure Capitalist Gets More Out of Every Trip
THE MARRIOTT REWARDS® PREMIER CREDIT CARD

http://www.wired.com/2015/07/hackers-remotely-kill-jeep-highway/

- **Infotainment-to-CAN Firewall CPU non-secured update**
  - Attackers reflashed firewall to access CAN

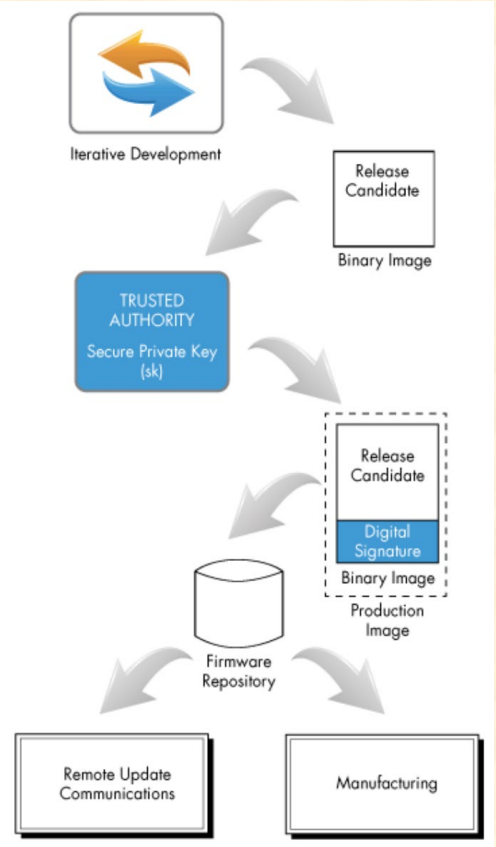
http://illmatics.com/Remote%20Car%20Hacking.pdf

© 2020 Philip Koopman

Secure Update

Carnegie Mellon University

- You'll need to deploy security patches
  - Your code might have a vulnerability
  - 3rd party code (library, OS, communications) might be vulnerable
- Secure update good practices:
  - Bootloader that does updates
    - First stage: integrity check for 2nd stage; *can't* be changed(!)
    - Second stage: knows how to load application image
  - Bootloader checks image public key signature
    - Public key hard-coded into bootloader
    - Only properly signed images are loaded
    - Consider limited date ranges (key revocation is hard)
      - » E.g., pre-deploy public key every 3 months for 20 years
    - Consider hard-coding repository IP addresses



https://www.allegrosoft.com/wp-content/uploads/Secure-Firmware-Updates-Paper.pdf

© 2020 Philip Koopman

Example Mitigation: Secure Boot

Carnegie Mellon University

- If your firmware is compromised, you are insecure
  - Need a way to make sure you only run factory-authorized code
  - Use public key signature to check firmware image integrity
    - Note: symmetric hash exposes signing key to attack

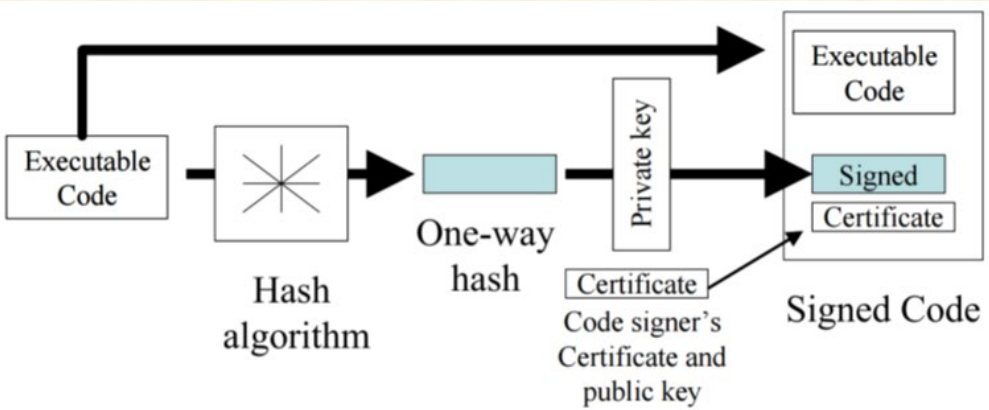


Figure 24. Code- and Document-Signing Process

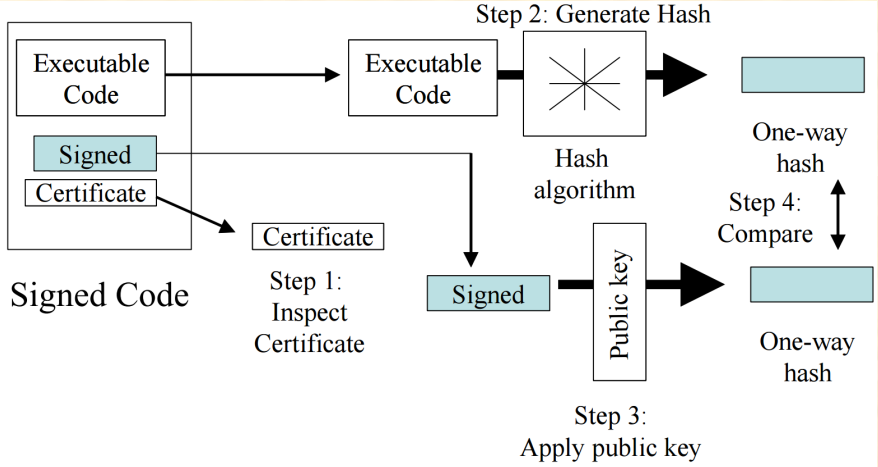


Figure 25. Code- and Document-Signing Verification Process

https://www.faa.gov/aircraft/air_cert/design_approvals/air_software/media/AR-08-31.pdf

© 2020 Philip Koopman

Encrypting vs. Signing

Carnegie Mellon University

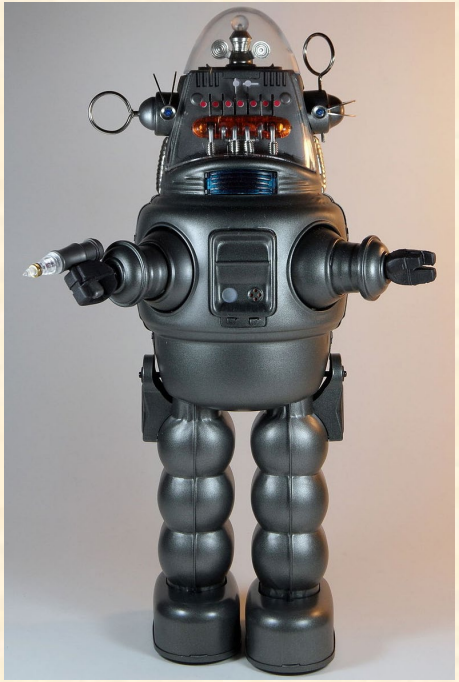
- Misconception: "Encryption Equals Security"
  - Encryption provides secrecy – but you might need integrity!
  - Encryption invokes export controls
  - What are the actual security requirements?
- Example for firmware distribution
  - Symmetric key encryption of firmware is a bad idea
    - Key recovery permits adversary to sign malicious images
  - Public key encryption of firmware addresses secrecy
    - Reverse engineering will recover firmware image and/or decrypt key
    - But strong crypto secrecy tends to invoke export controls!
  - Secure signature (Public Key Digest) works well
    - A digest is a small hash of the entire message (like a checksum, but crypto-secure)
    - Sign image off-line one time; all devices can use public key to validate
    - Use per-download encryption as defense in depth

© 2020 Philip Koopman

Penetration Testing

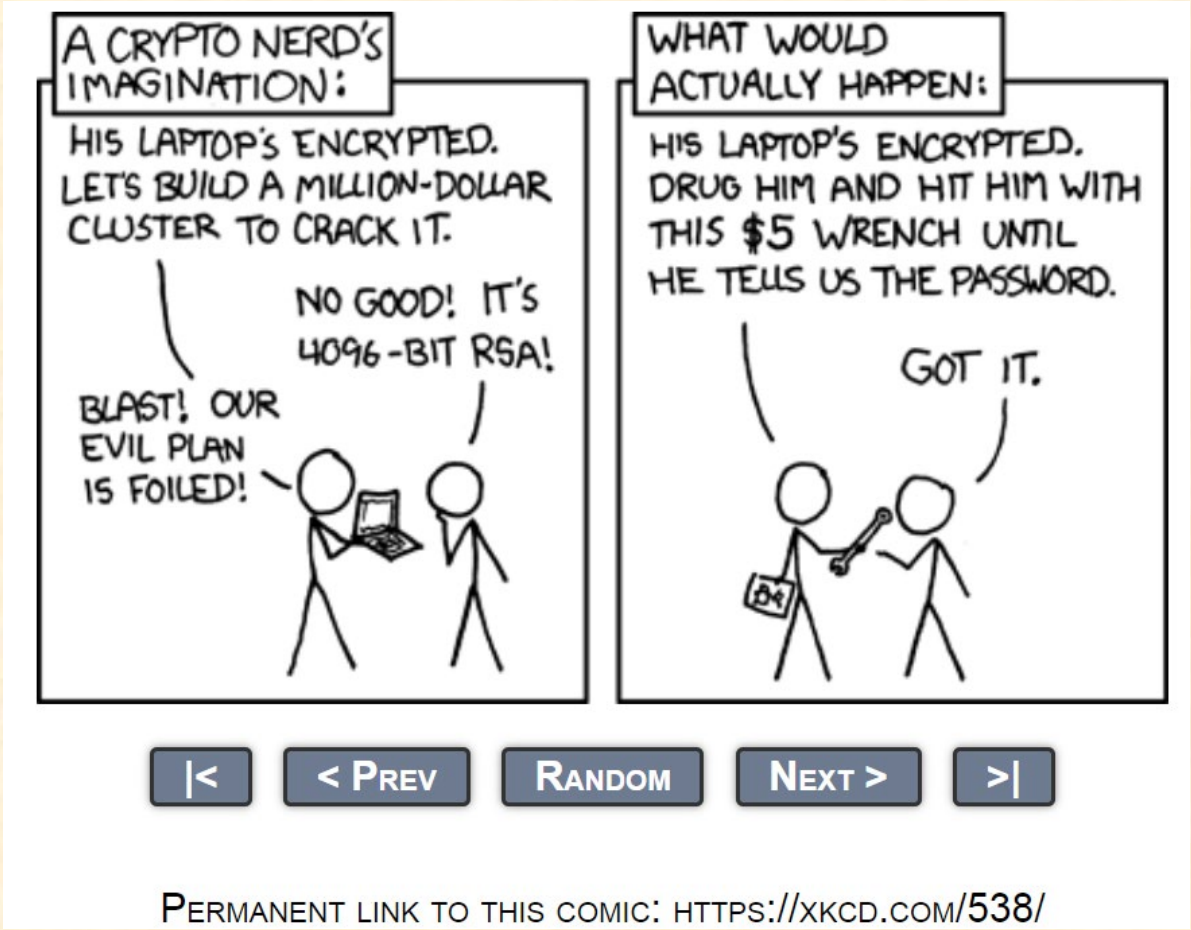
"Pen test" – attempt to attack system to look for problems

- Automated vulnerability testing
  - Test known security exploits to see if they succeed
  - Test for bug fixes for known non-exploited bugs
  - Port scanning for dangerous open (unnecessary) Ethernet ports
- Penetration analysis
  - Hire a "red team" to attempt to penetrate system
  - Fuzz testing – send random inputs; see what breaks
- Looks for likely-to-be-exploited vulnerabilities
  - Does not guarantee perfect security



© 2020 Philip Koopman

See Also: "Rubber Hose Attack"



© 2020 Philip Koopman

Code Analysis

- Static & dynamic code analysis
  - General code quality tools: Coverity, PC-Lint
  - Security-specific security tools
    - Look for violations of checkable secure coding rules
    - Various tools for thread safety, bounds checking, …
  - Potential problem:
    - False positives (many warnings are not actual vulnerabilities)

- Peer review
  - Security-oriented review of source code
  - E.g., Cert C 98 Coding Standard
    - http://www.open-std.org/jtc1/sc22/wg14/www/docs/n1255.pdf
    - E.g., use strcpy_s() instead of strcpy()

© 2020 Philip Koopman

Many Other Approaches

Carnegie Mellon University

- Intrusion detection
  - Detect abnormal patterns of system operation
  - False positives are expensive; no such system is perfect

- Monitor Black Hat sites
  - Look for published exploits against your product
- Honey pot systems
  - Deploy a monitored decoy system and look for successful attacks
- Bug bounties
  - Pay anyone who finds an exploit so you can fix it

© 2020 Philip Koopman

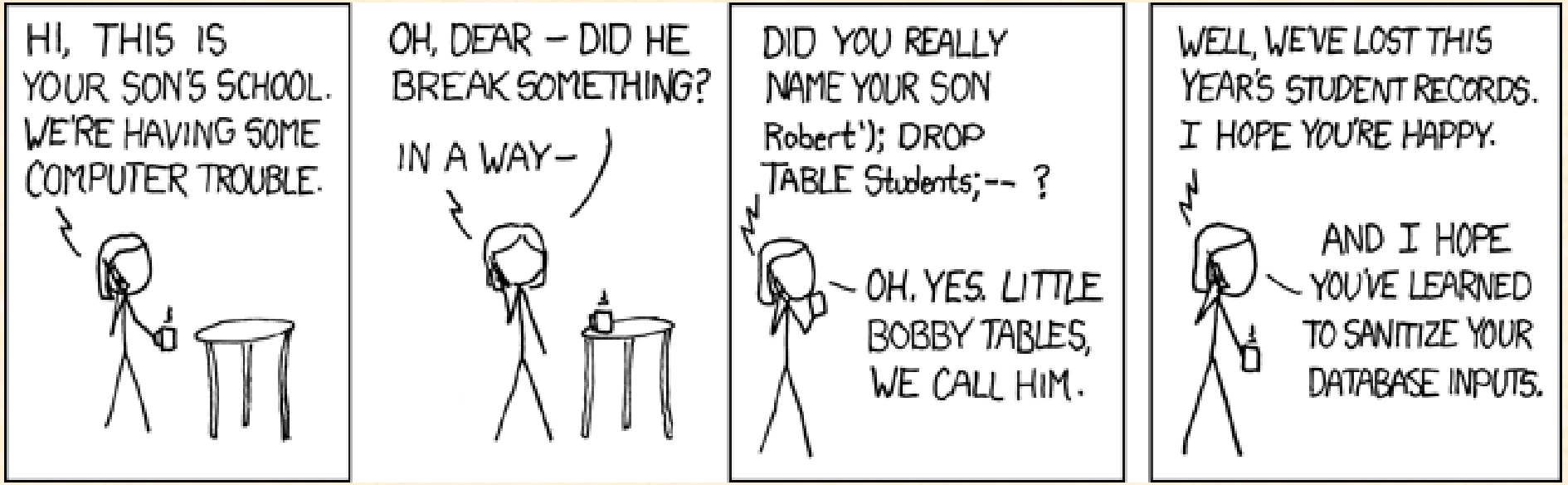
Security Mitigation & Validation

Carnegie Mellon University

- Good practices:
  - Encourage strong but usable passwords
  - Use fine-grain permissions
  - Be careful storing password information
  - Respect limitations of firewall approaches
  - Use secure update and secure boot
  - Use more than just penetration testing

- Pitfalls:
  - Thinking security is easy
  - Using intuition instead of doing your homework

© 2020 Philip Koopman



https://xkcd.com/327/

© 2020 Philip Koopman