The Web/Local Boundary Is Fuzzy

A Security Study of Chrome's Process-based Sandboxing

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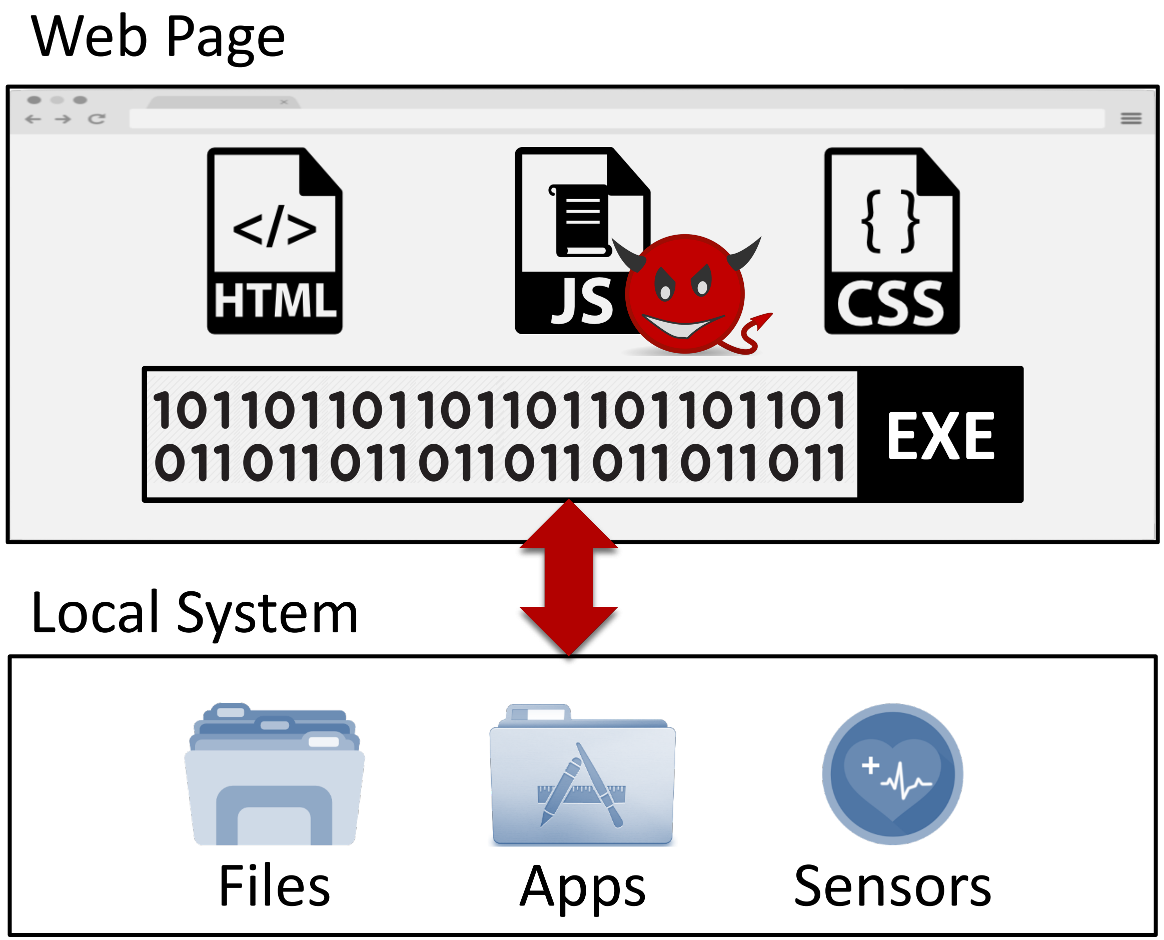
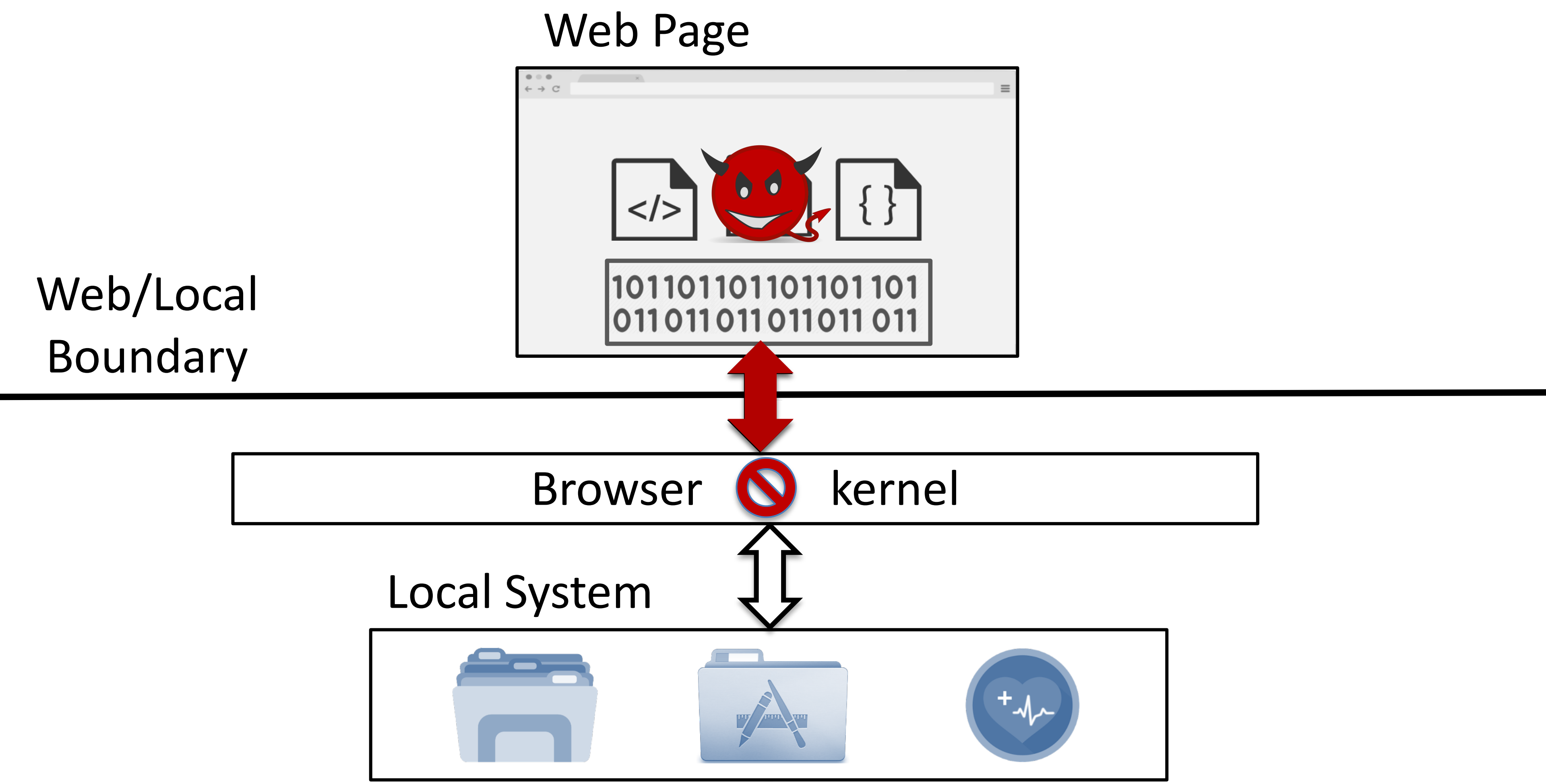
Monolithic Browser Design



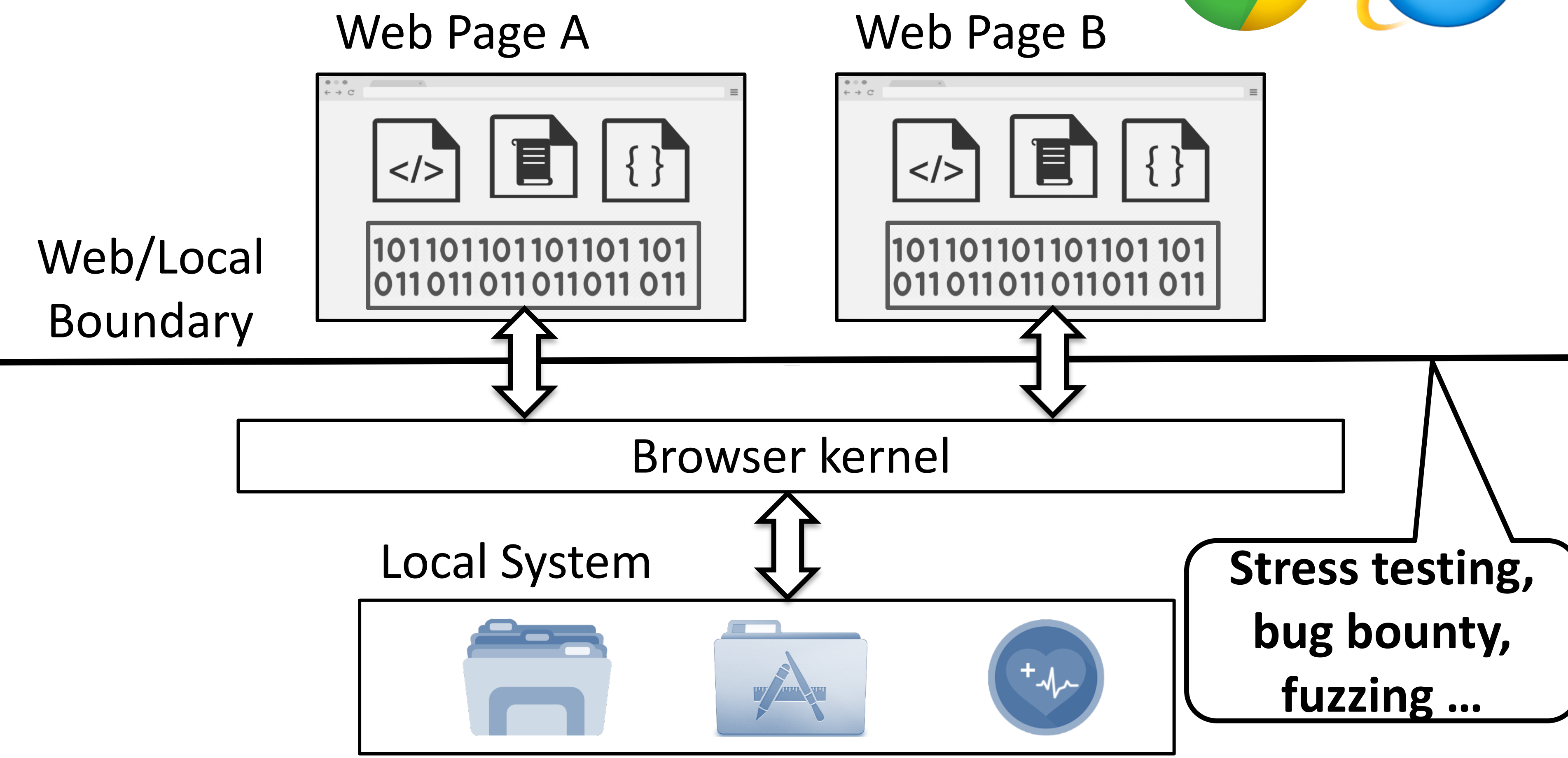
2nd Generation Browser: Process-based Isolation

- Process-based sandboxing – process boundary



Is the Web/Local Boundary Sufficient?

- Used by most modern browsers



Contributions

- The Web/Local Boundary is Fuzzy !

Concrete Attacks

- Access local files, system control
- Use 1 bug in renderer process

Attack Details

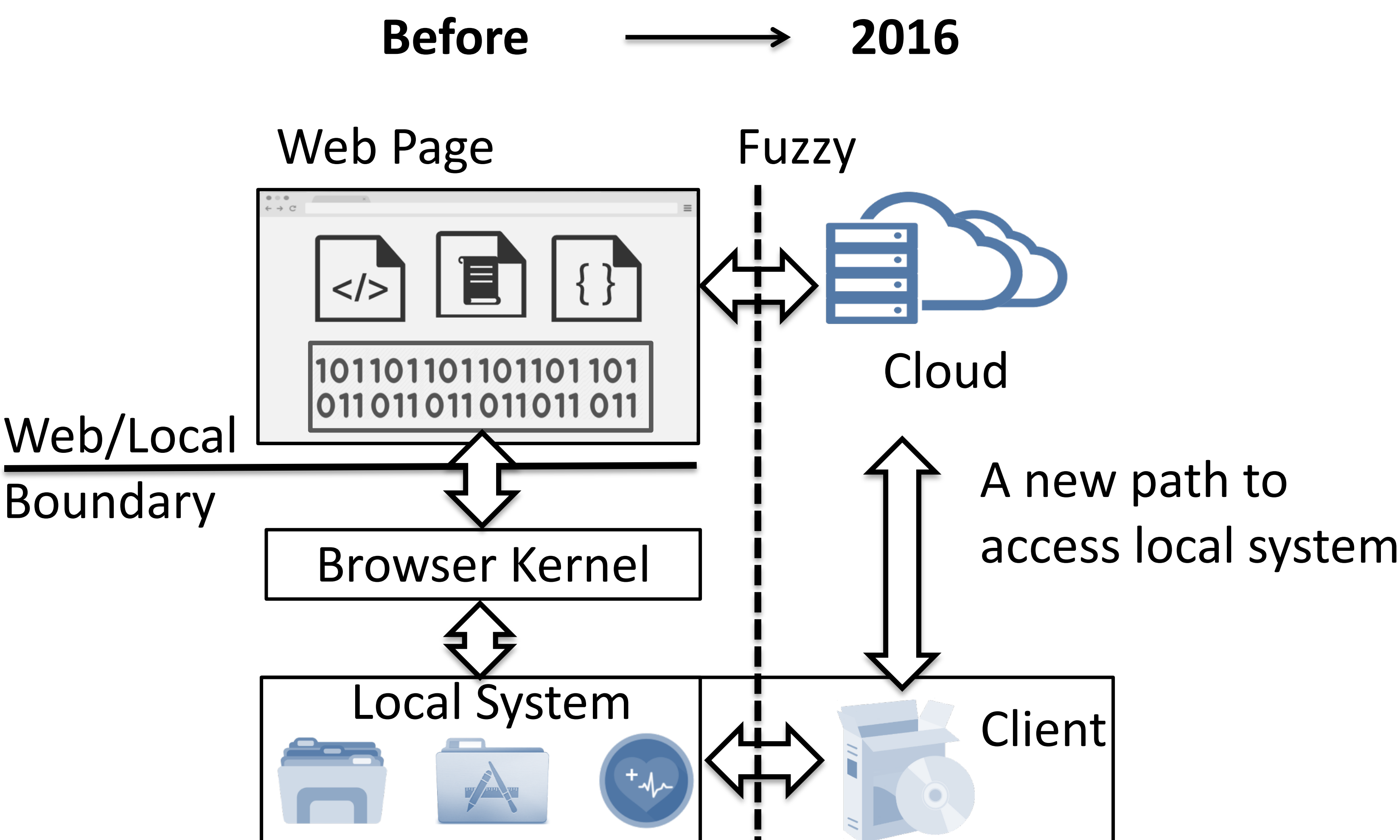
- Bypass in-memory protections using data-oriented attacks

Solutions

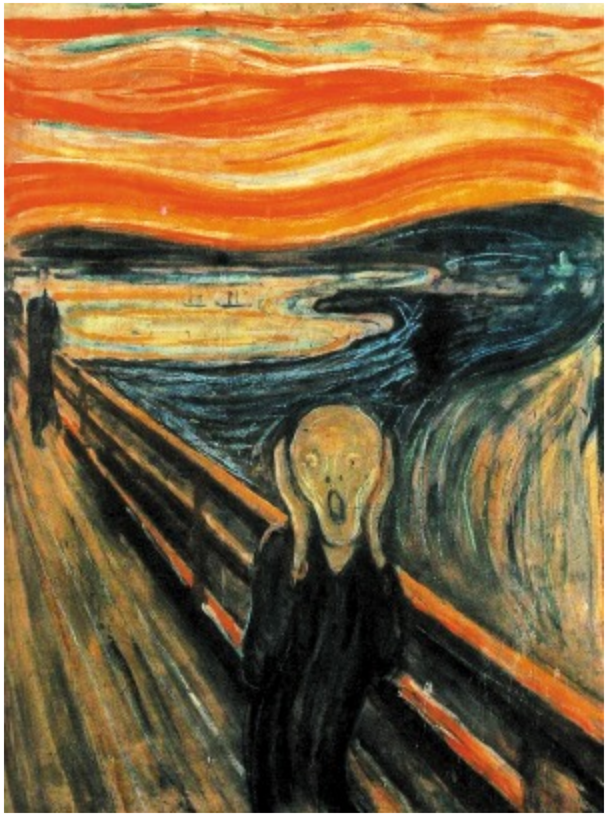
- Imperfect existing solutions
- Our light-weight mitigation

The Web/Local Boundary is Fuzzy

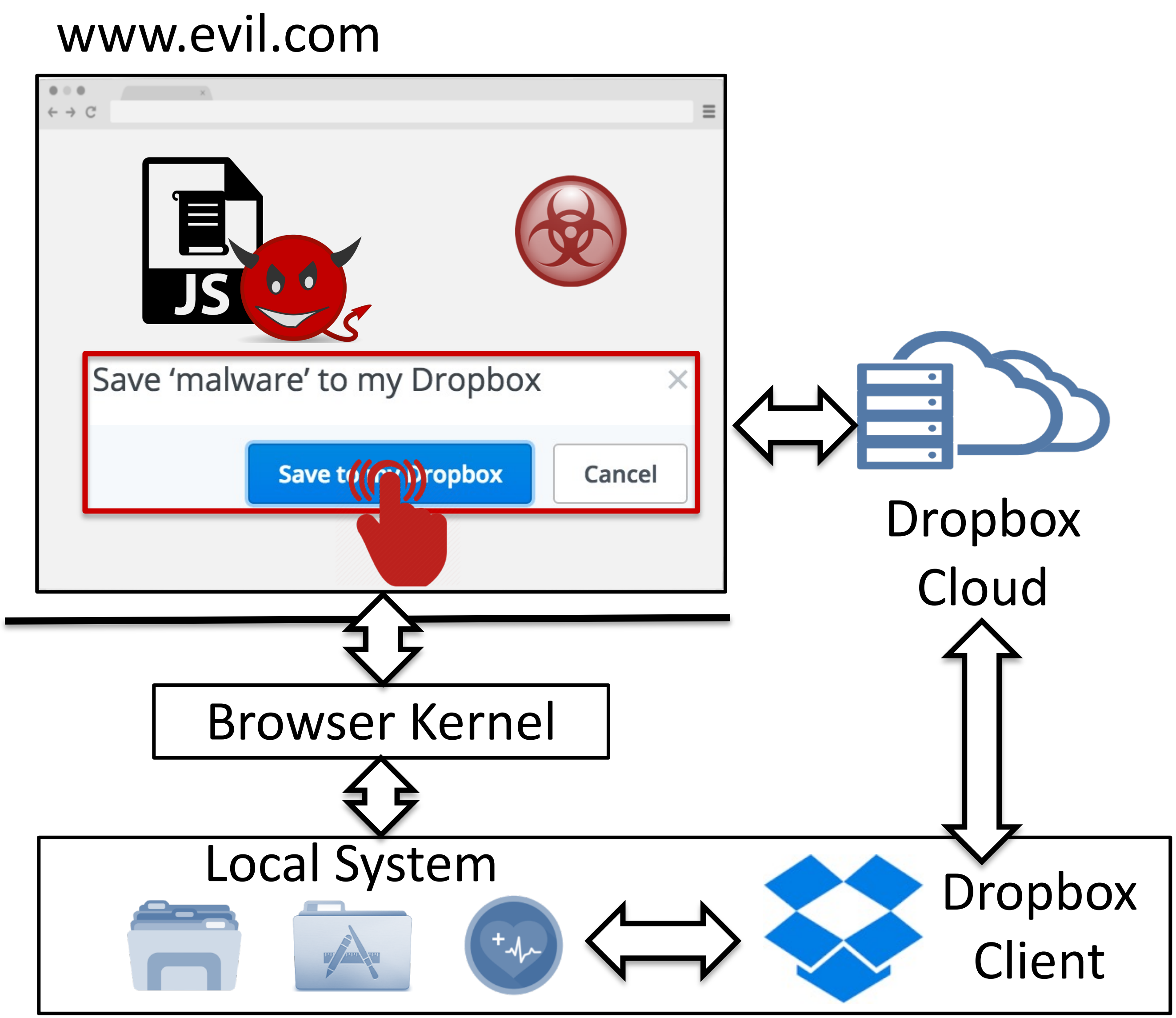
- Landscape changes --- Rise of the cloud services



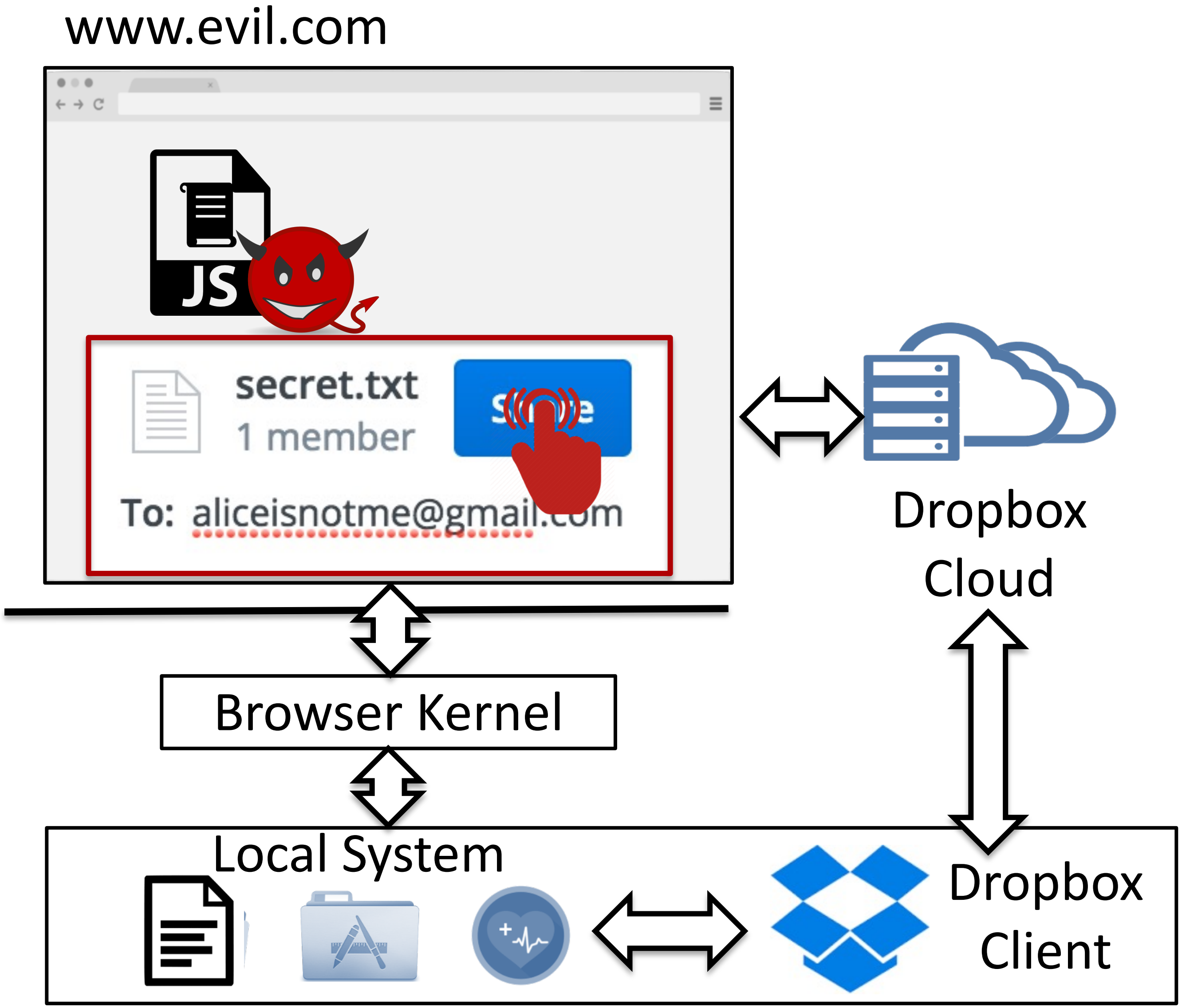
Attacks due to Fuzzy Web/Local Boundary



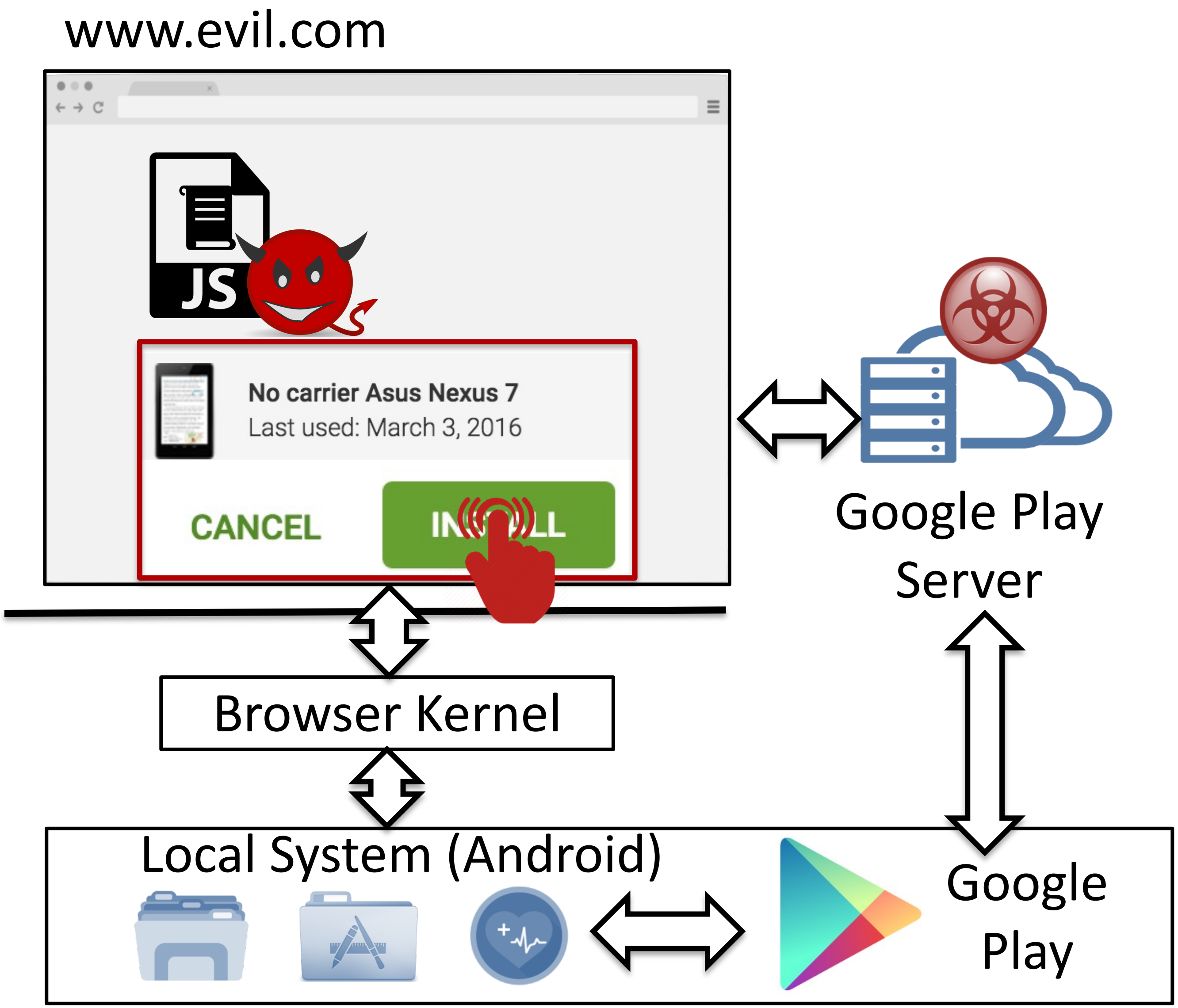
Attack Example 1: Drop a Malware



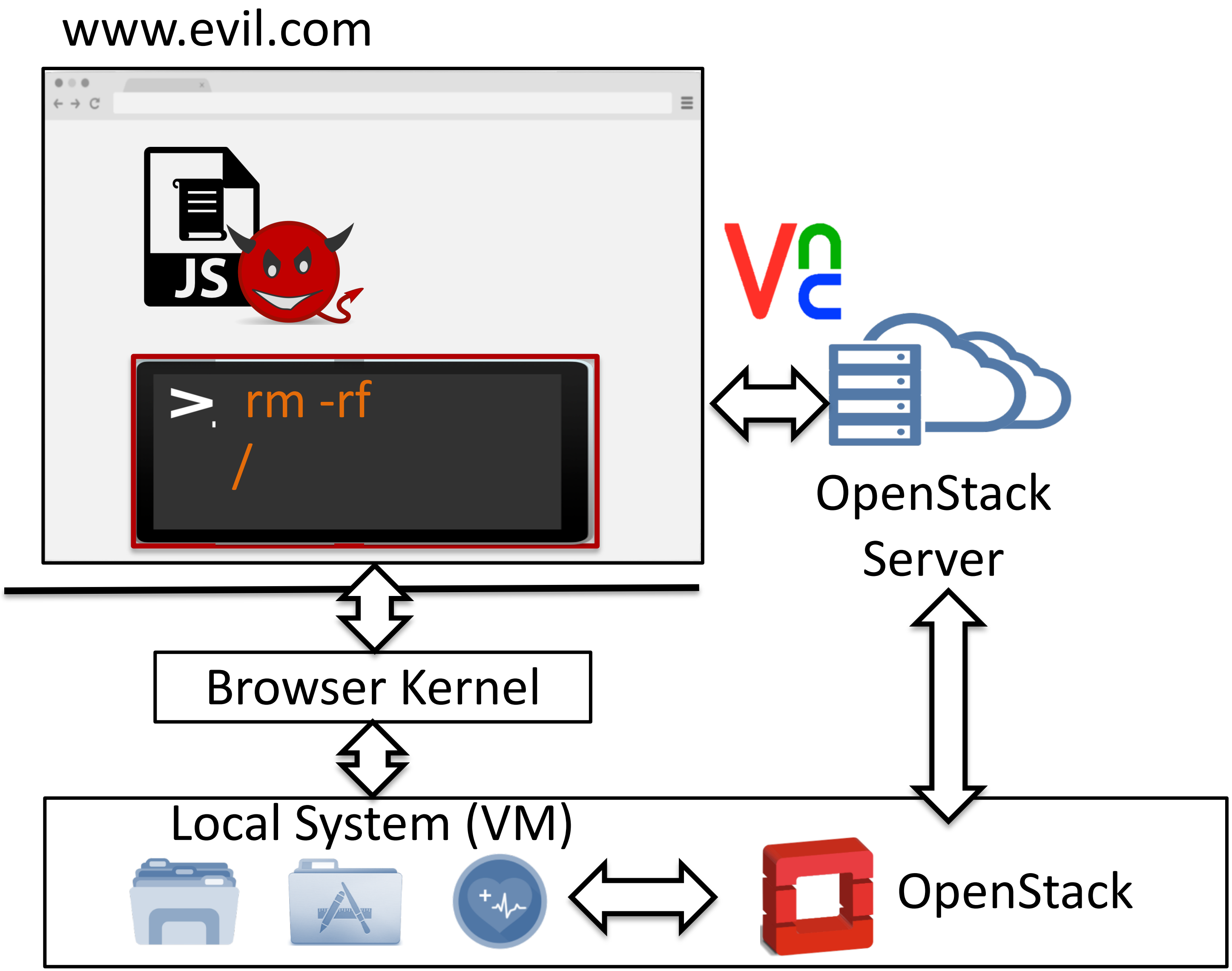
Example 2: Steal a Local File



Example 3: Install Malware



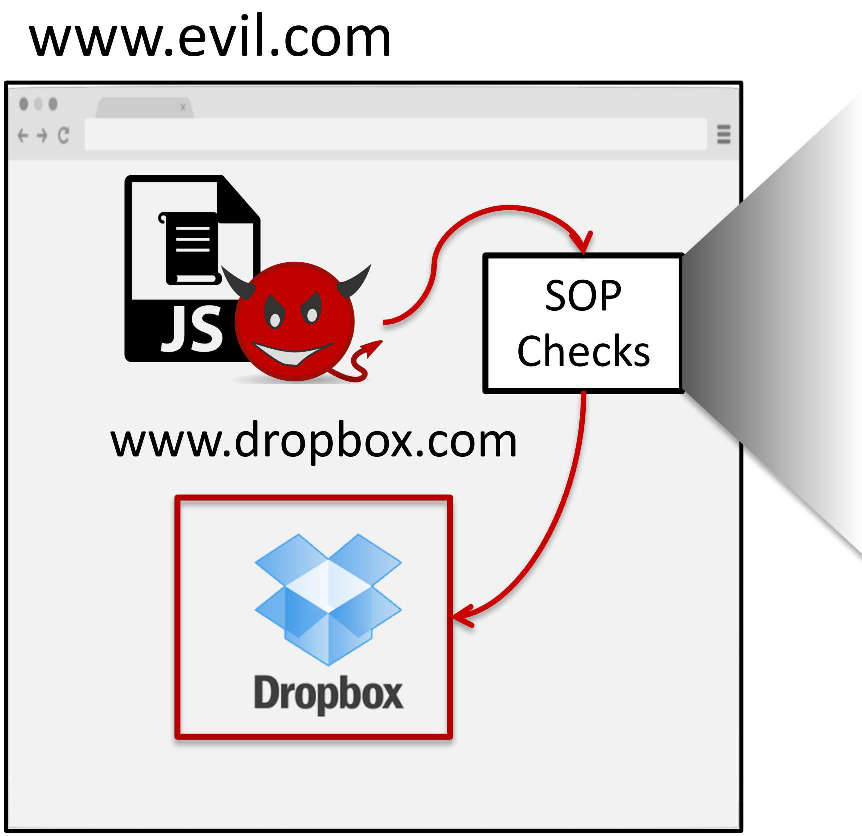
Example 4: Remote System Control



But … Chrome’s Protections

- Same-Origin Policy (SOP)
- Control-Flow Integrity (CFI) *on the way*
- In-Memory Partitioning
- Internal Randomization

SOP Enforcement in Chrome

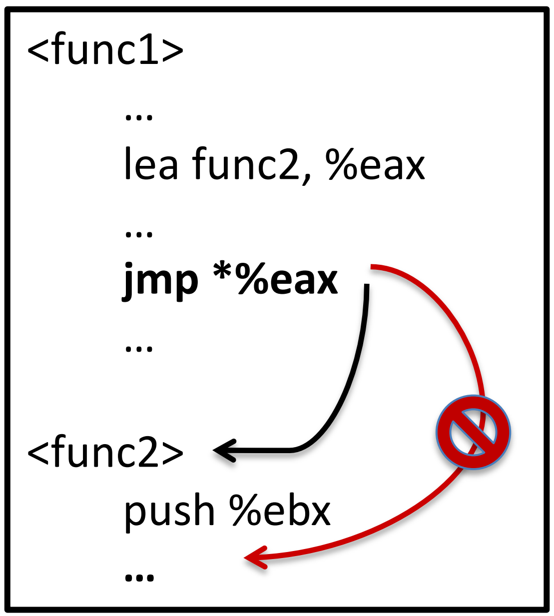


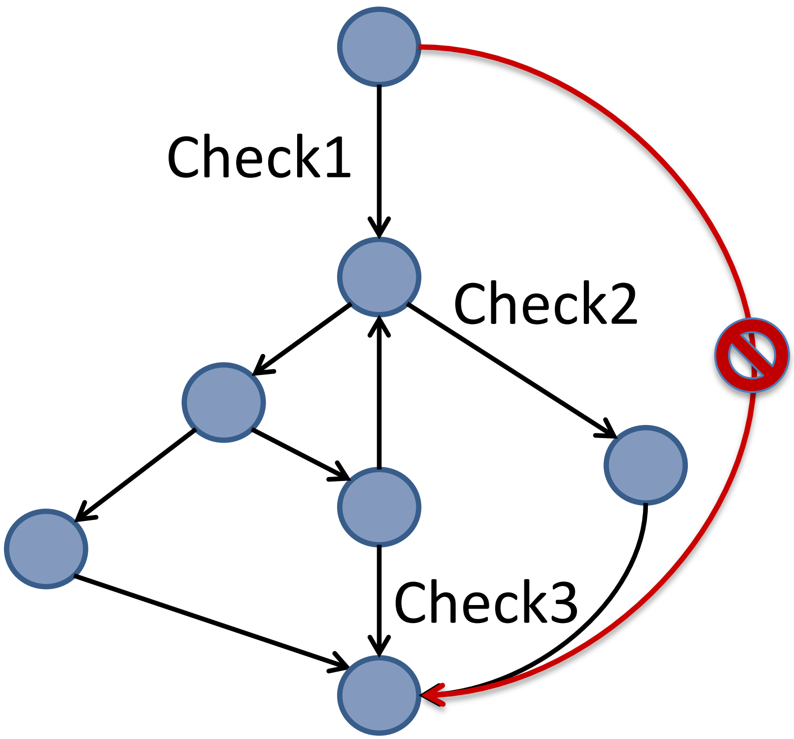

```
bool SecurityOrigin::canAccess() {
   if (m_universalAccess)
      return true;
   if (this == other)
      return true;
      ......
   return canAccess;}
```

Various SOP checks for cross-origin read/write: contentDocument, frames, etc.

Control-Flow Integrity

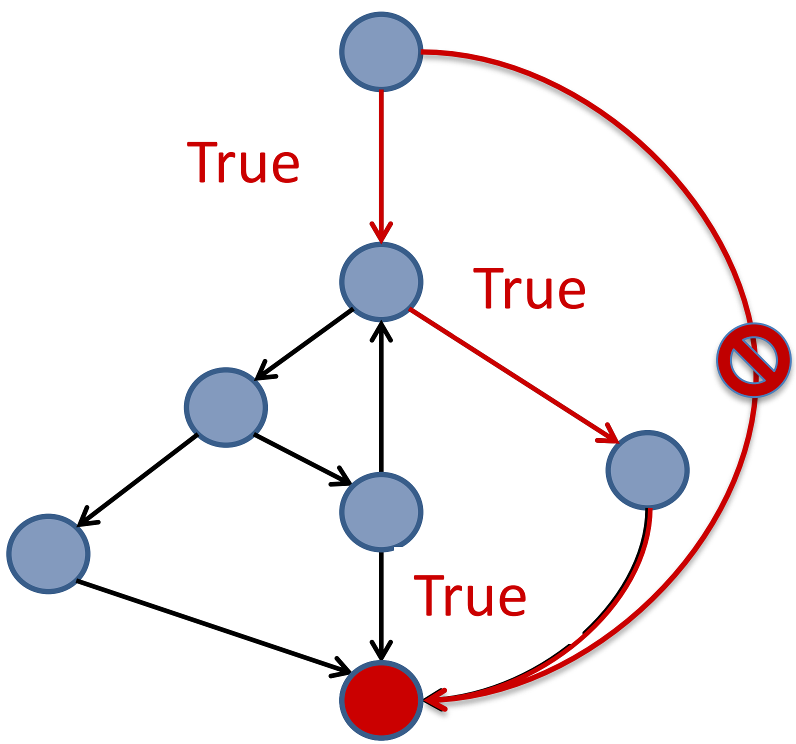
- CFI: control flows cannot be modified (on the way)





Bypass SOP & CFI

- Corrupt critical data
  - Not modify control flow
  - Bypass SOP checks

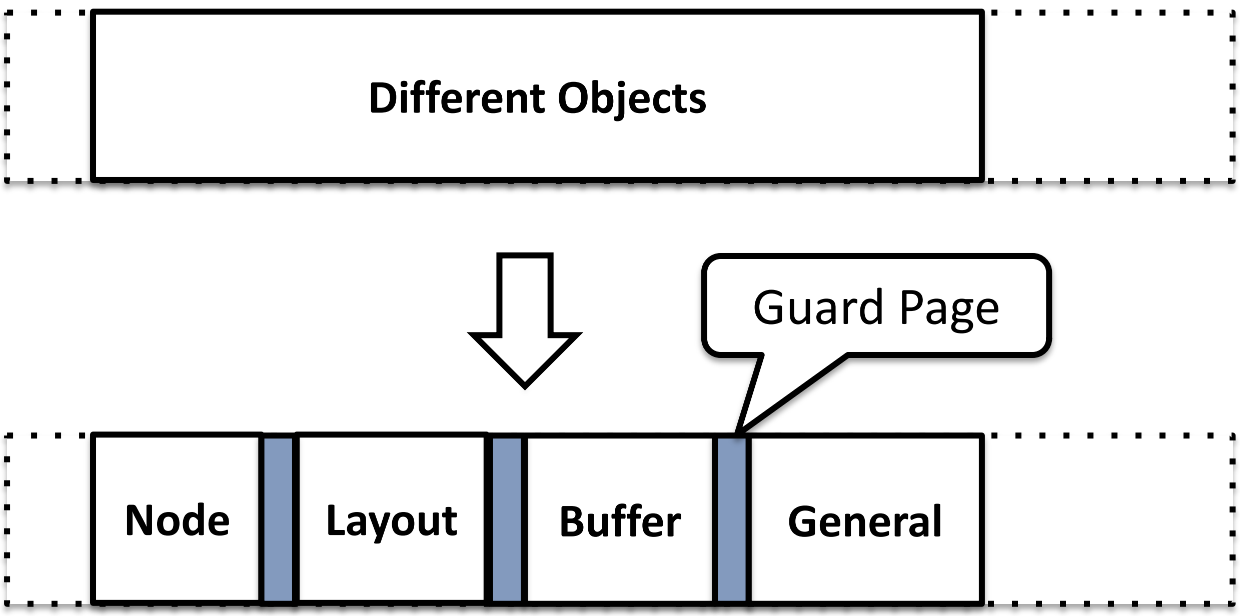



```
bool SecurityOrigin::canAccess() {
  if (m_universalAccess)
    return true;
  if (this == other)
    return true;
    ......
  return canAccess;
}
```

When m_universalAccess is true, the check always passes

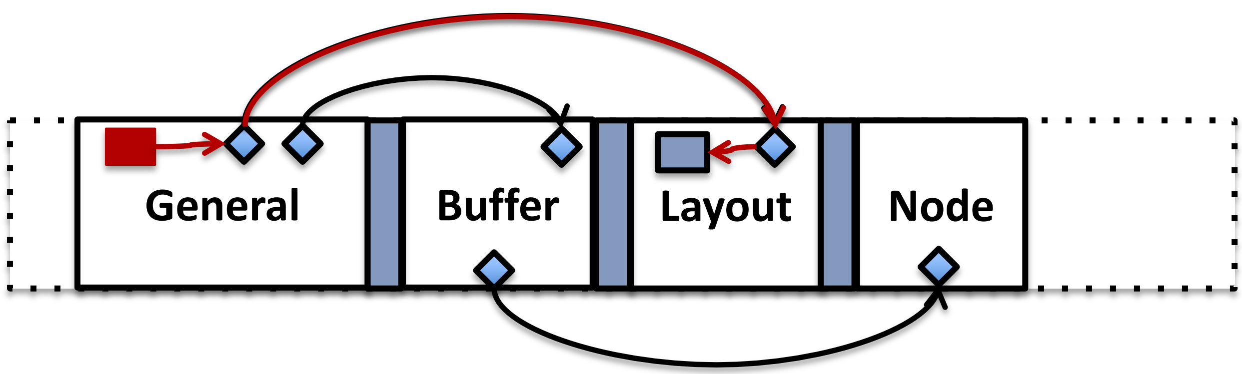
In-Memory Partitioning

- Separate different types of objects in 4 partitions
- Surrounded by inaccessible guard pages



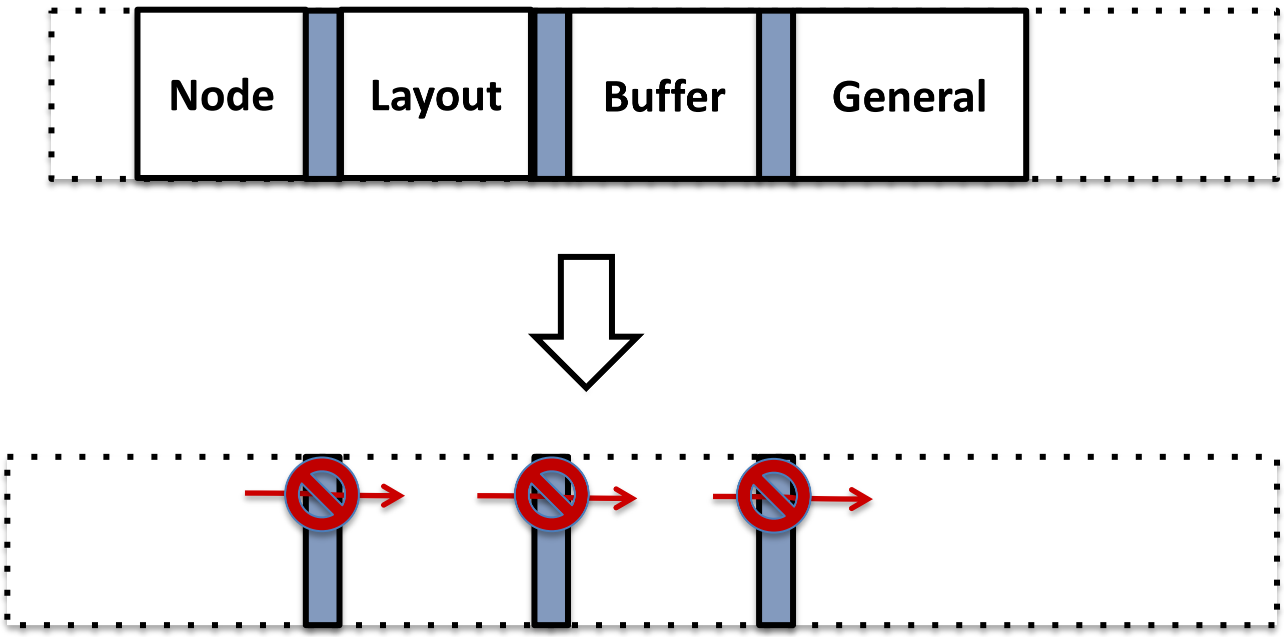
Cross-Partition References to Bypass Partitioning

- Link objects in one partition to another
- Pervasive & often under the control of scripts
  - Dereference pointers to cross partition boundaries



Partition-based Randomization

- Randomize the base address of each partition
- Guard pages cannot be read/written

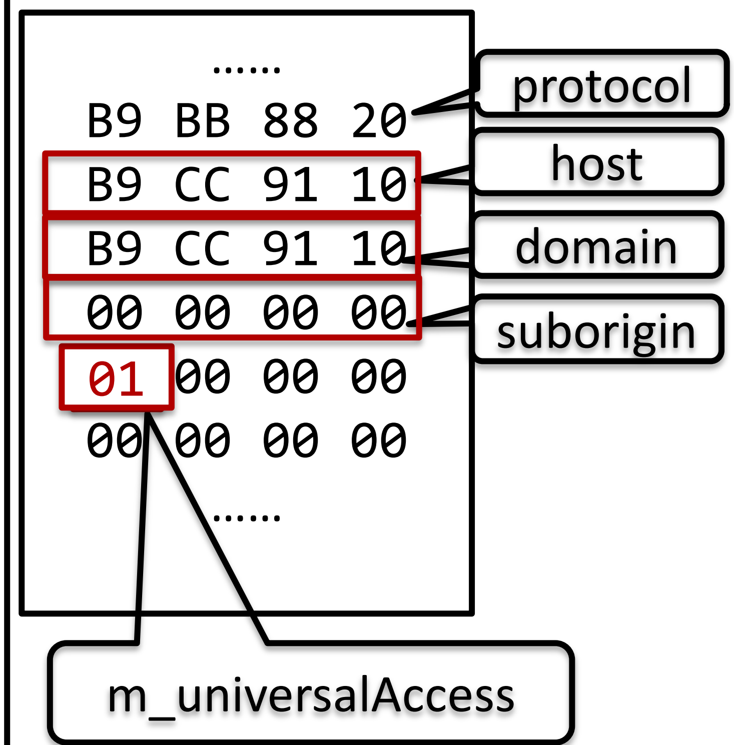


Fingerprinting Technique to Bypass ASLR & Find Critical Data

- Special pattern for security monitor objects
- Linearly scan memory

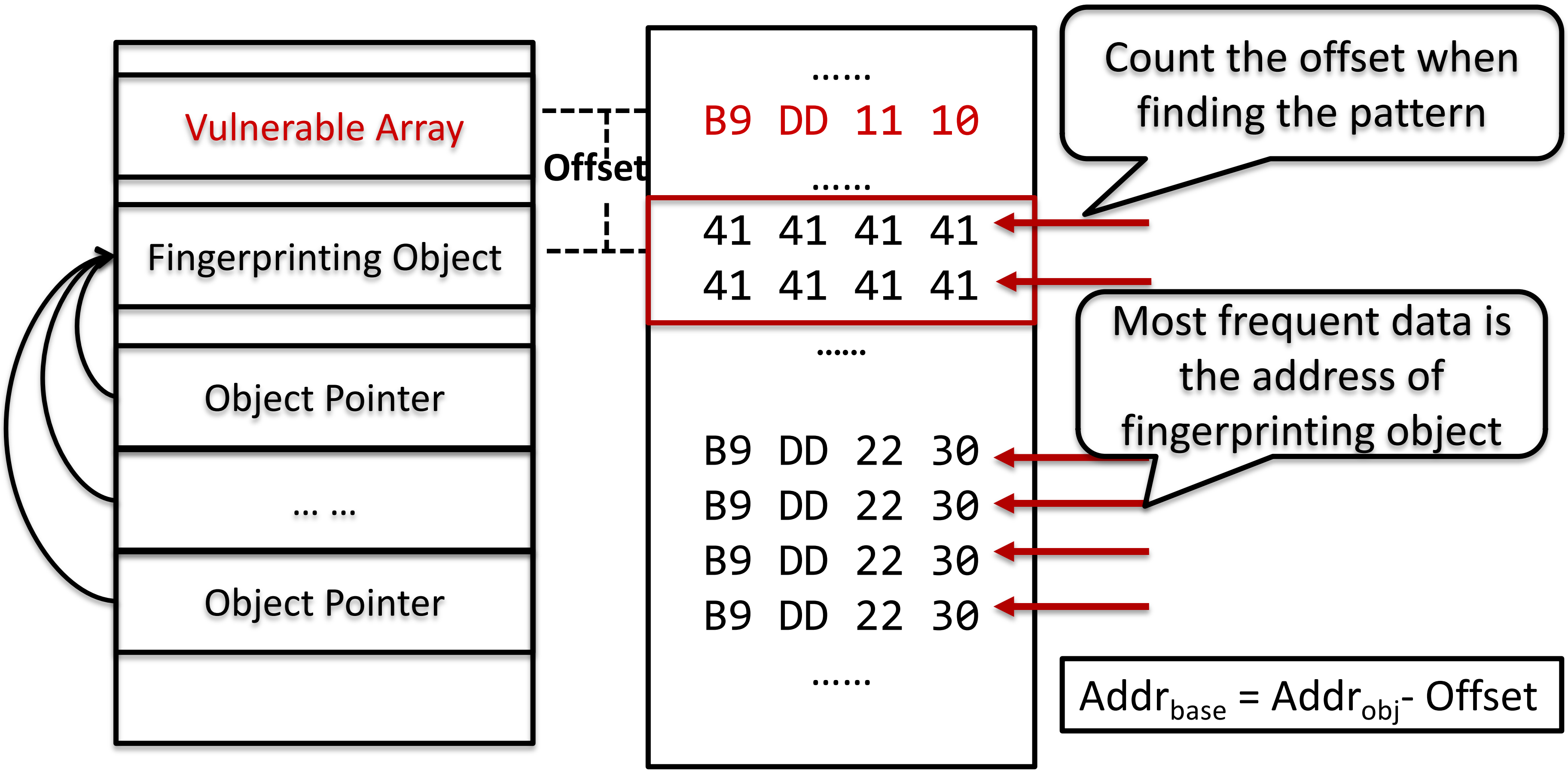
```
class PLATFORM_EXPORT SecurityOrigin
 {  ......
    String m_protocol;
    String m_host;
    String m_domain;
    String m_suboriginName;
    unsigned short m_port;
    bool m_isUnique;
    bool m_universalAccess;
    bool m_domainWasSetInDOM;
    bool m_canLoadLocalResources;
    bool m_blockLocalAccessFromLocalOrigin;
    bool m_needsDatabaseIdentifierQuirkForFiles;
};
```

Match the pattern



Find the Address of Vulnerable Array

- Create a predictable "fingerprinting" object
- Linearly scan memory to find the object's location



Bypass SOP & In-Memory Protections

- SOP

  Data-oriented attacks

- CFI

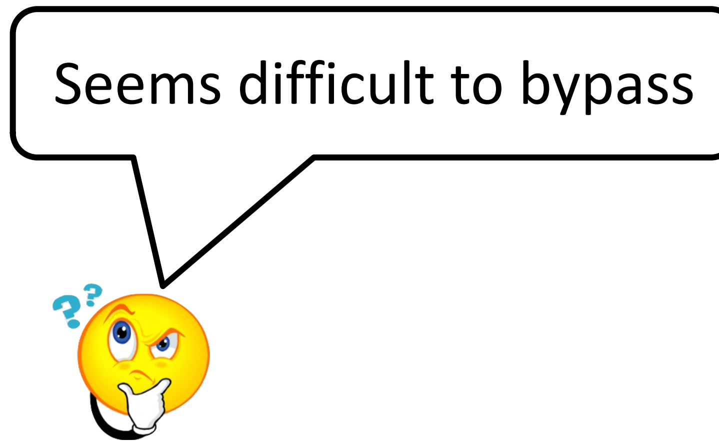
  Data-oriented attacks

- In-memory partitioning

  Cross-partition references

- Internal ASLR

  Fingerprinting technique



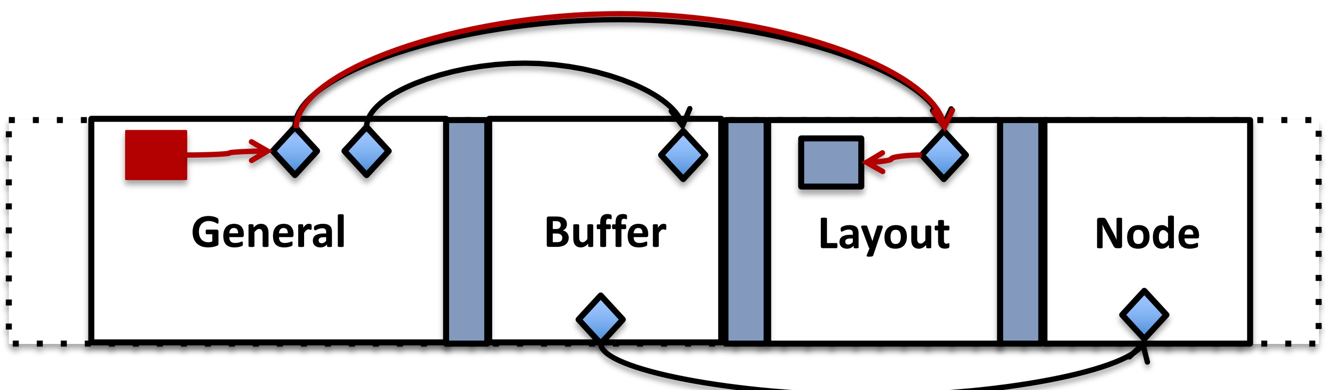
Attack Implementation

- Work on proper memory error vulnerabilities
  - ✓ POC: CVE 2014-1705 heap overflow in V8 (Chrome 33)
- Over 10 SOP-related flags (Chrome 45)
- End-to-end attacks
  - ✓ Access files on the local system
    - ➢ Dropbox, Google Drive
  - ✓ Interact with local system
    - ➢ OpenStack, Google Play
  - ✓ Misuse system sensors
    - ➢ Fitbit, Runkeeper

Protections against Web/Local Attacks

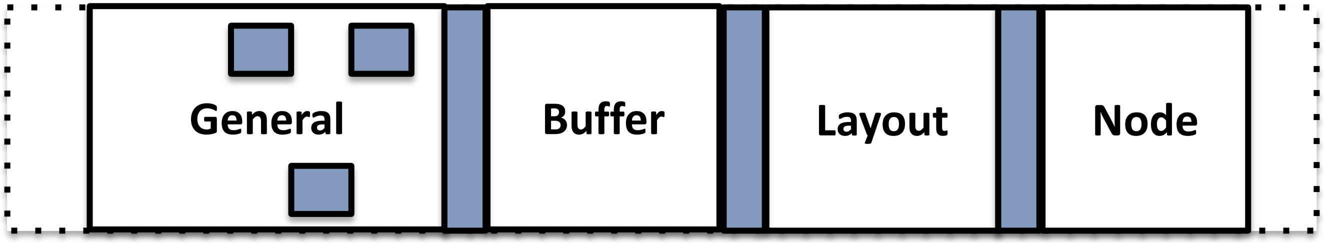
Web Browser-Side Protection

- Memory safety
  - ✓ Huge code base, e.g., +5 million LOC for Chrome
- Software-based fault isolation (SFI)
  - ✓ Cross-partition references



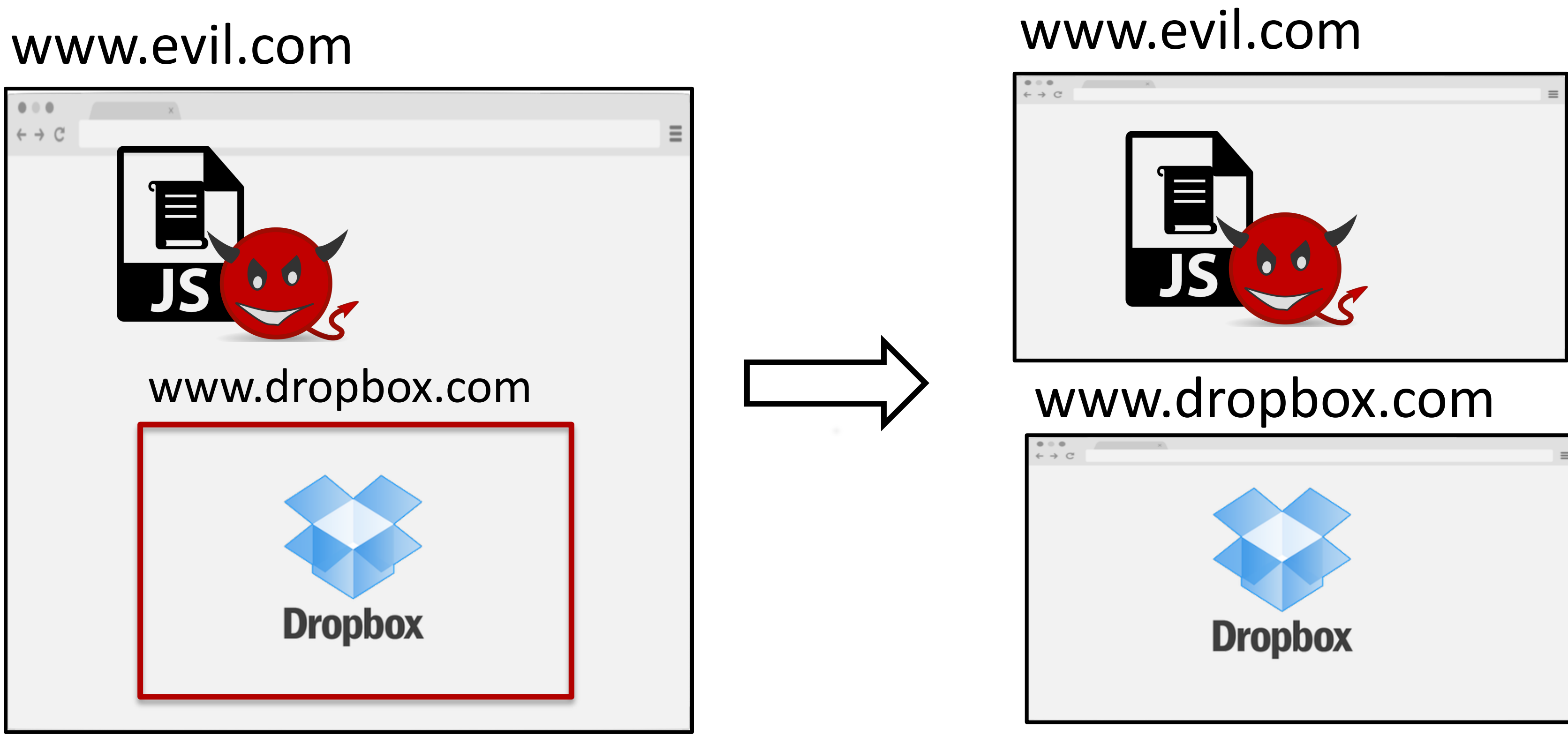
Light-Weight Mitigation

- Identify critical data
- ASLR to hide the address of critical data
  - ✓ Address of the critical data is not saved in user space
  - ✓ Average 3.8% overhead
- Raise the bar of Web/Local attacks



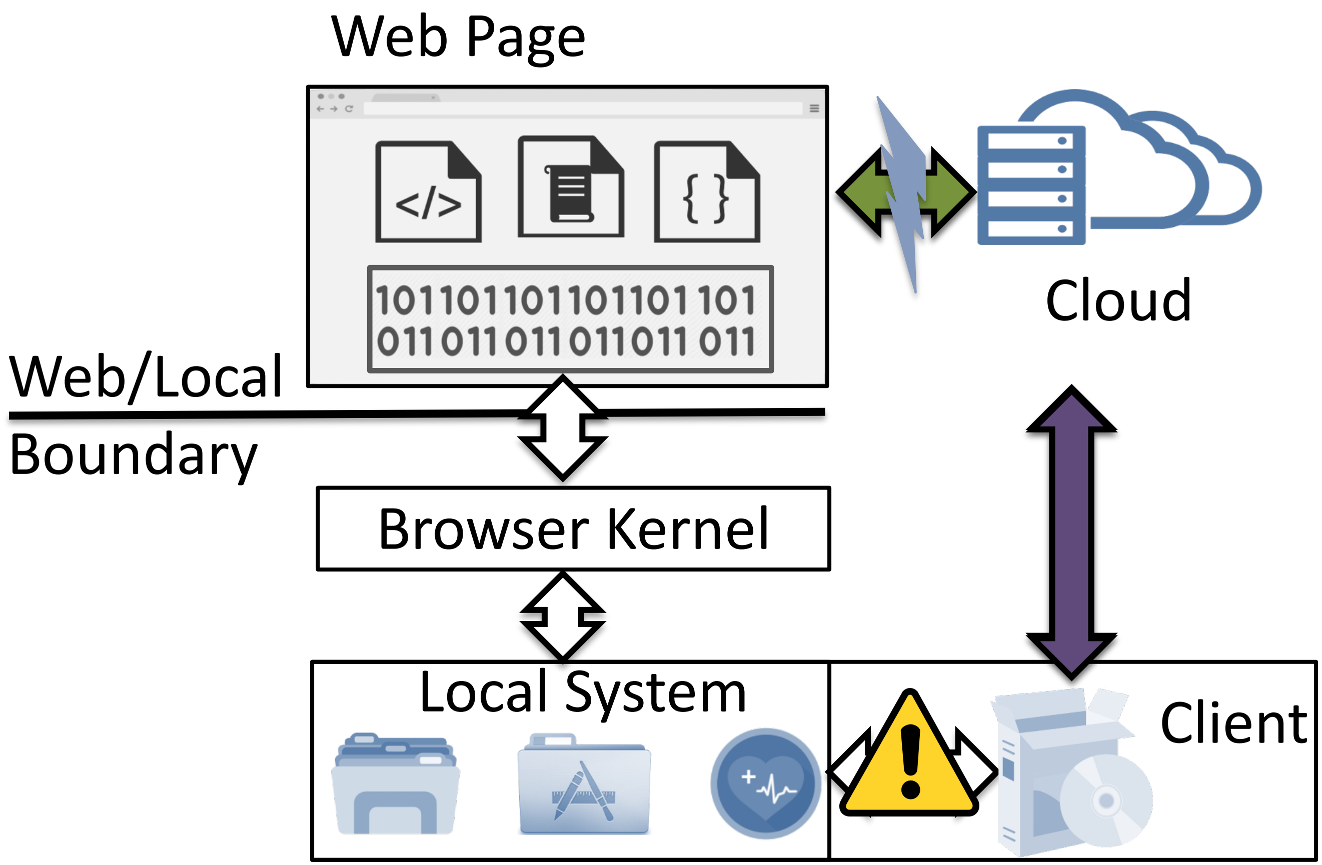
Disclosure to Google

- Fine-grained process-based isolation
  - ➢Chrome's Out-of-Process iframes
  - ➢Performance overhead and massive refactoring



Cloud Service-Side Protection

- Distinguish requests of its site from client
- Restrict the privileges for the web interface
- Require the user’s consent



Conclusion

- Concrete Attacks on Web/Local Boundary
  - ✓Access local files, system control
  - ✓Using 1 bug in renderer process
- Attack Details
  - ✓Bypass in-memory protections

Video at https://youtu.be/fIHaiQ4btok

POC at https://github.com/jiayaoqijia/Web-Local-Attacks

- Solutions
  - ✓Imperfect existing solutions
  - ✓Open to researchers

Thanks

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