Winning the Online Banking War

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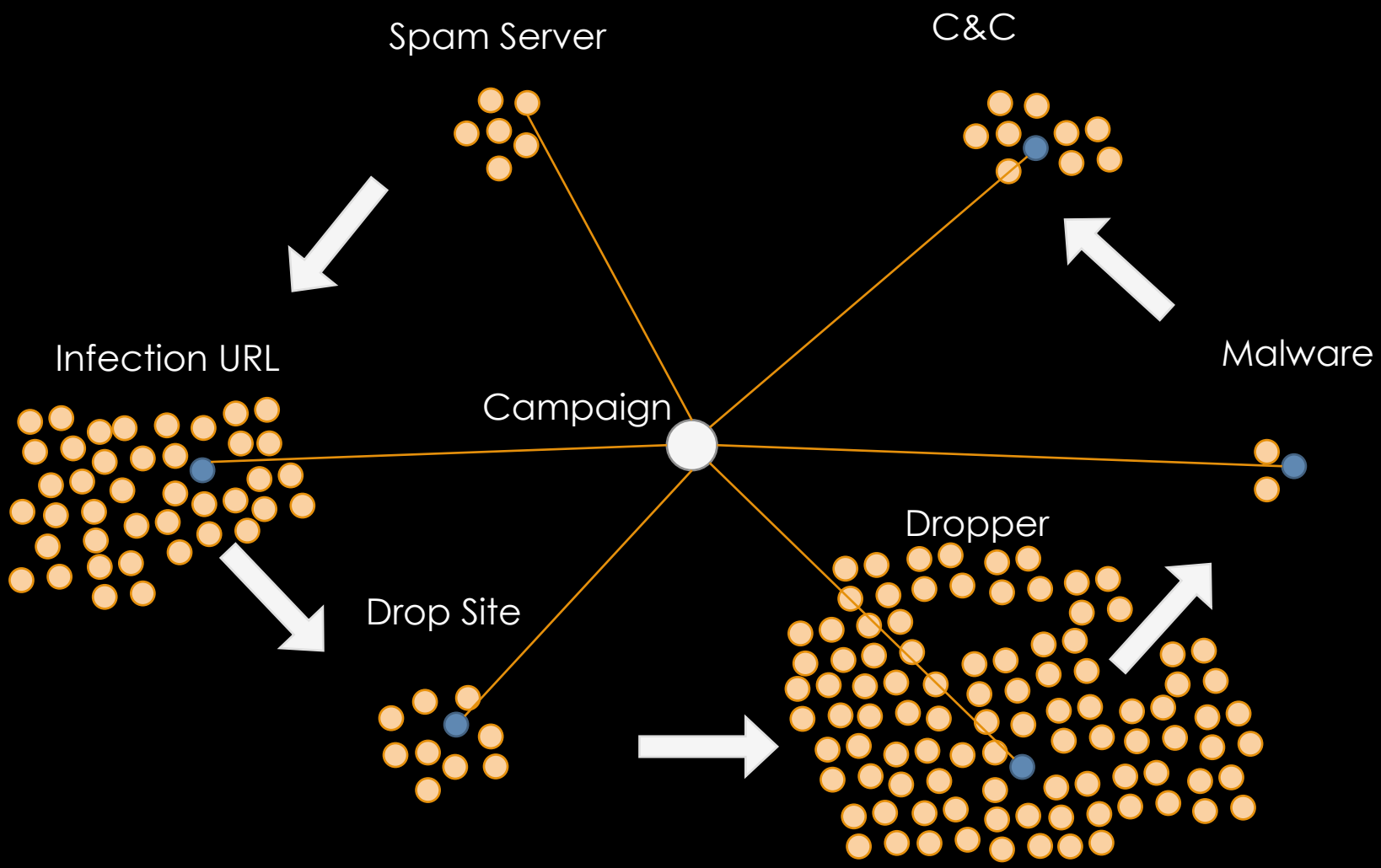
About Myself

- Worked for one of big 4 banks in Australia for 6 years as malware security consultant.
- Developed banking malware detection system
- Served at Sophos, Symantec, FireEye and Kaspersky
- Currently with TrendMicro

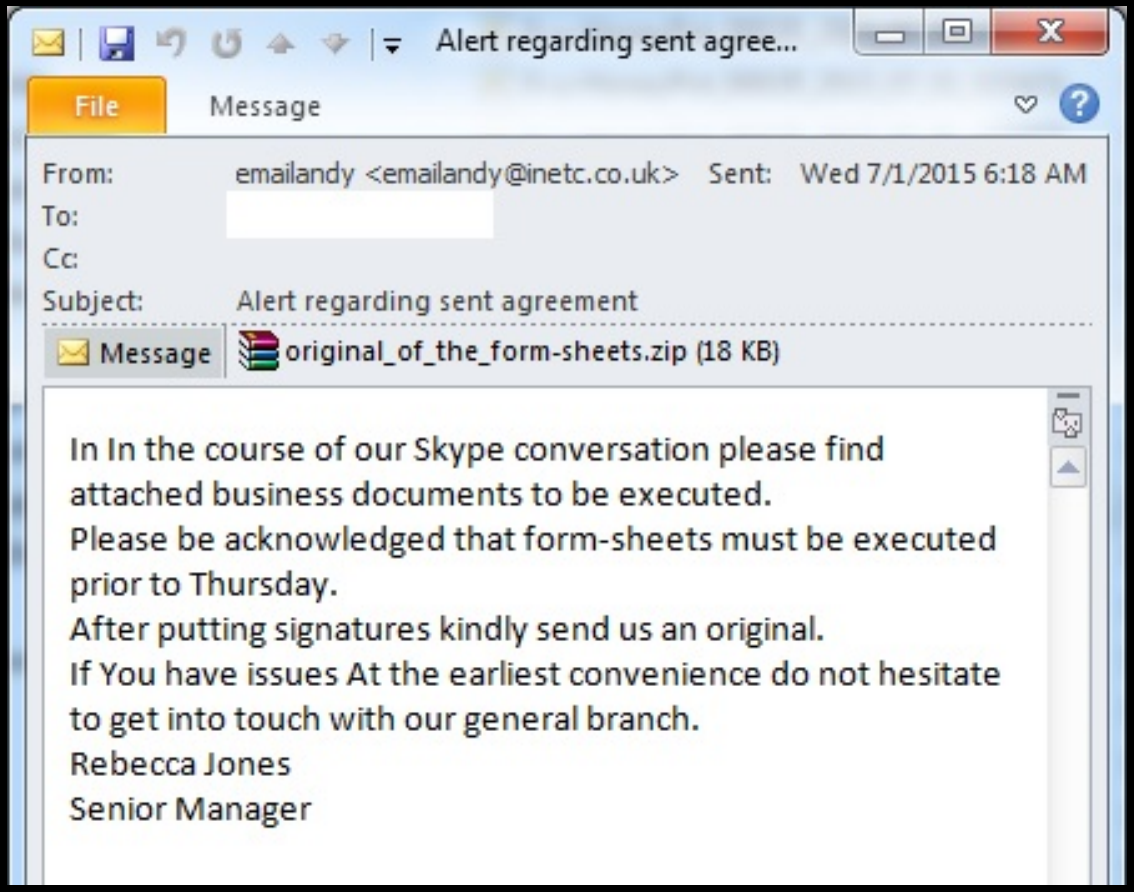
Goals

- Identify the crux of the online banking war
- Set the strategic defense framework
- PoC design & implementation: MIPS

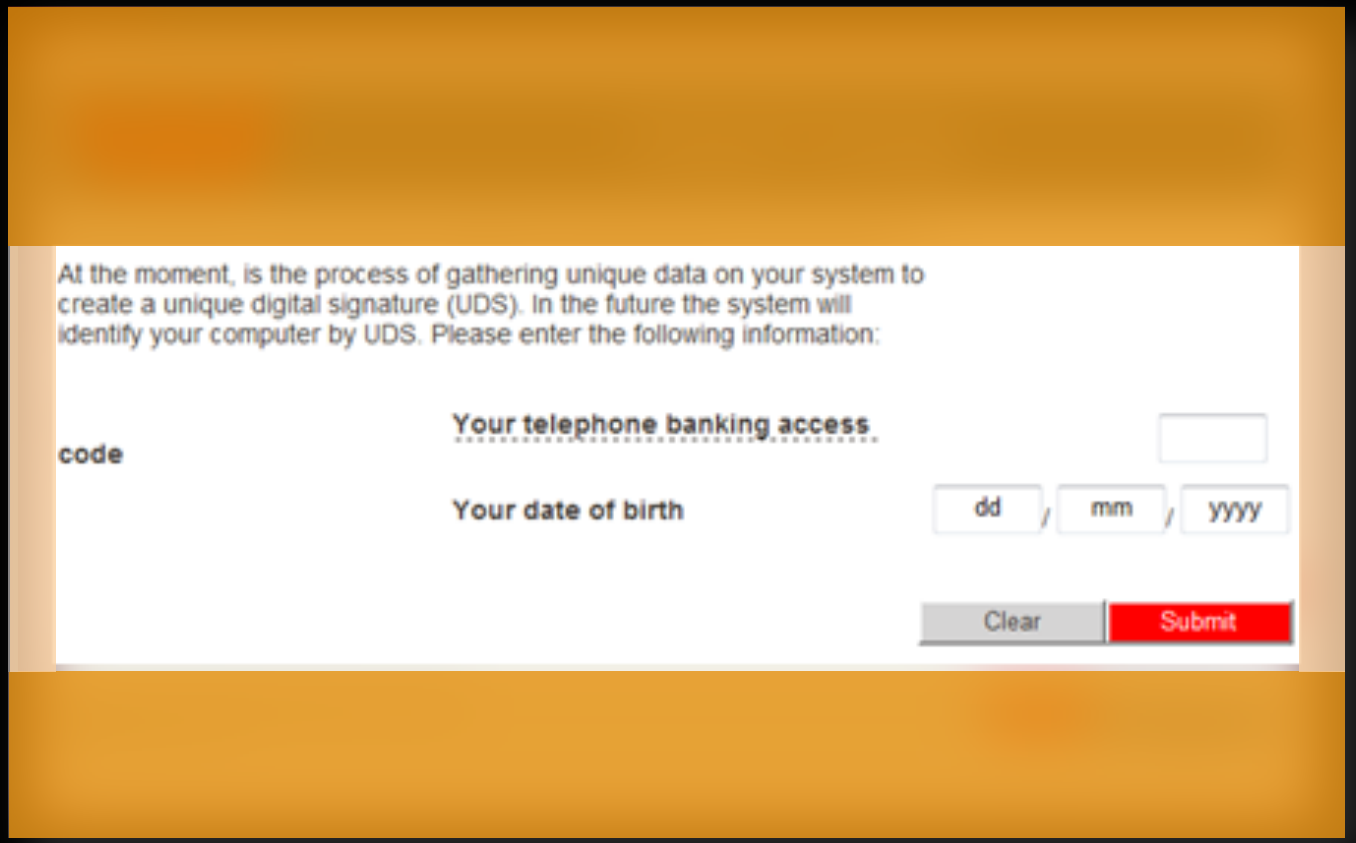
Banking Malware Campaigns



Customer Infection

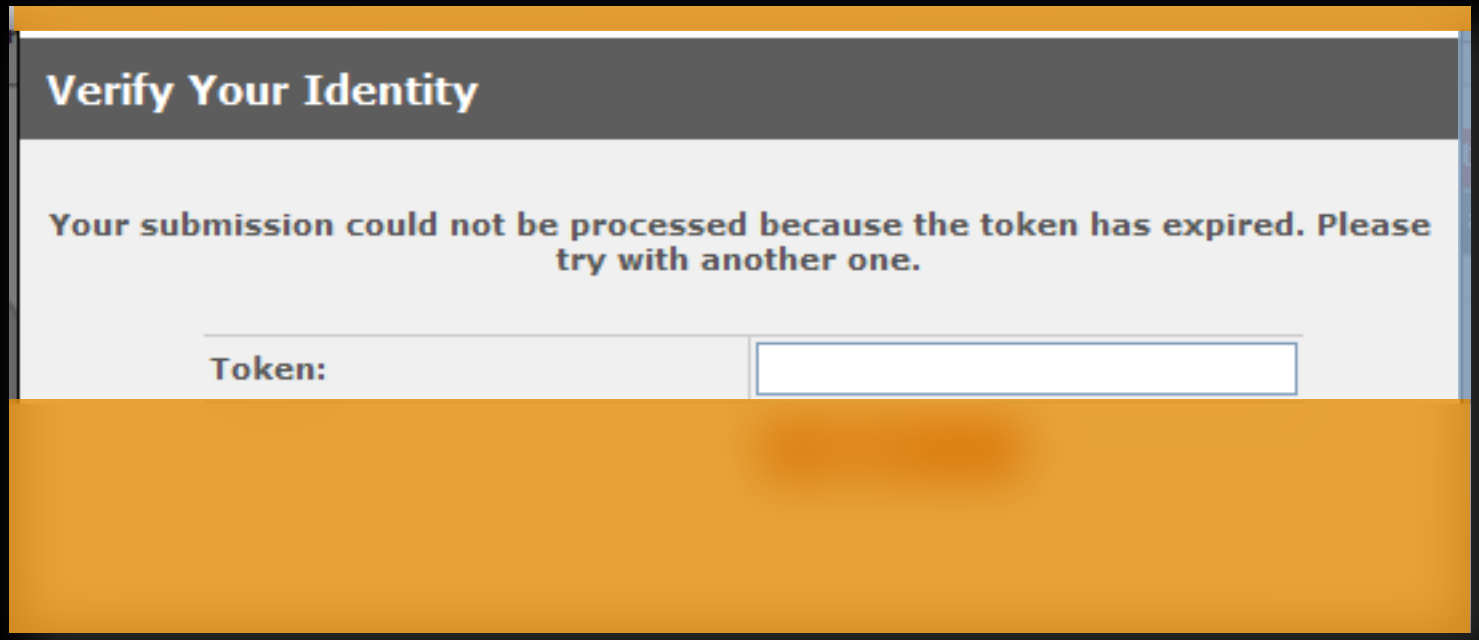


Sign In – Phone Banking Code



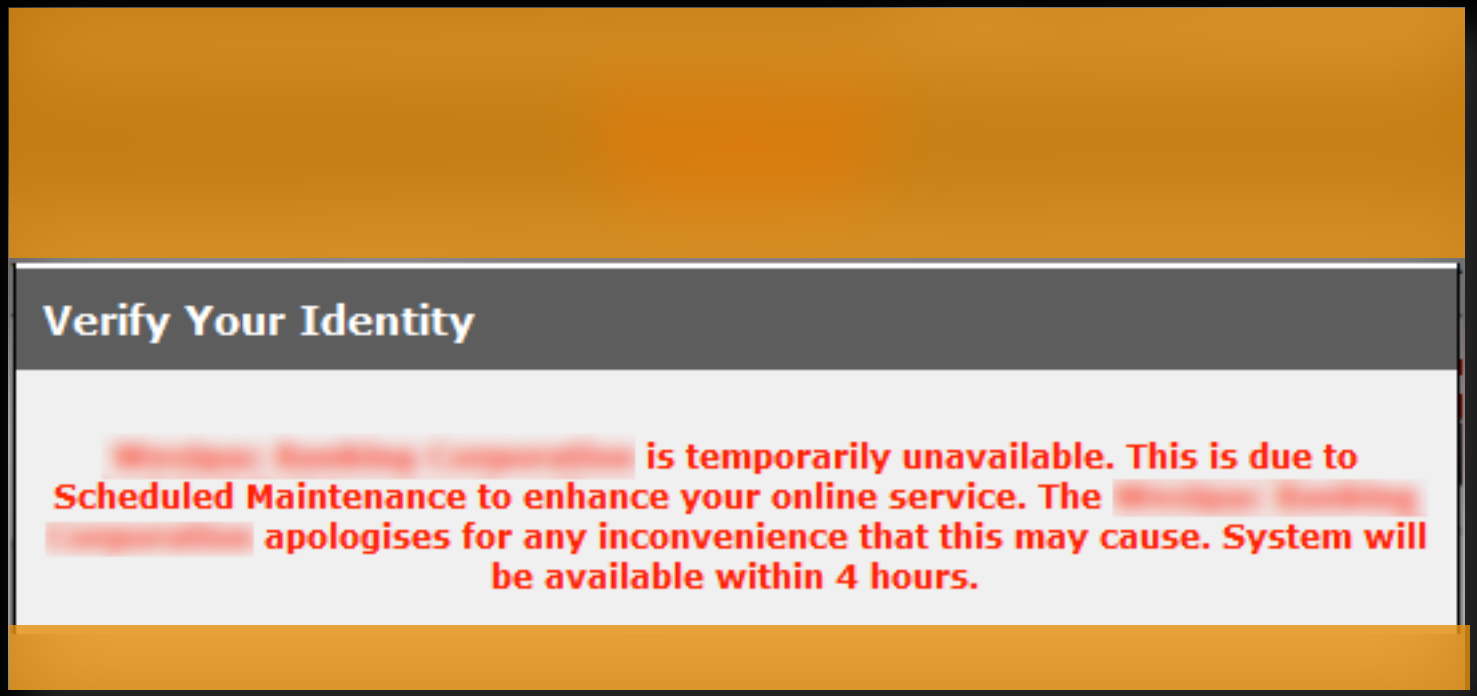
Sign In – Token

- Got a token for your corporate account? Do you still feel safe?



Sign In – Token

- Now you are locked out while they buy enough time to transfer money

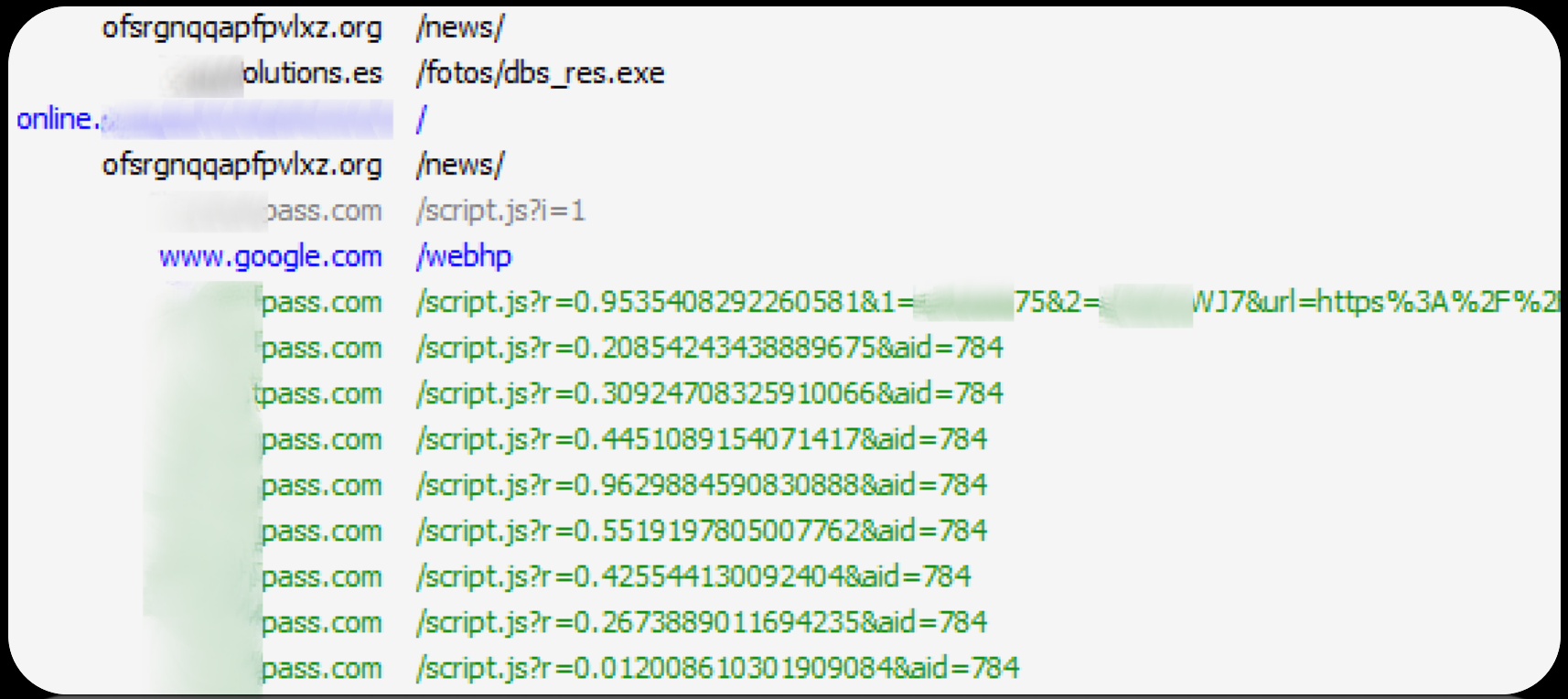


Sign In - MITM

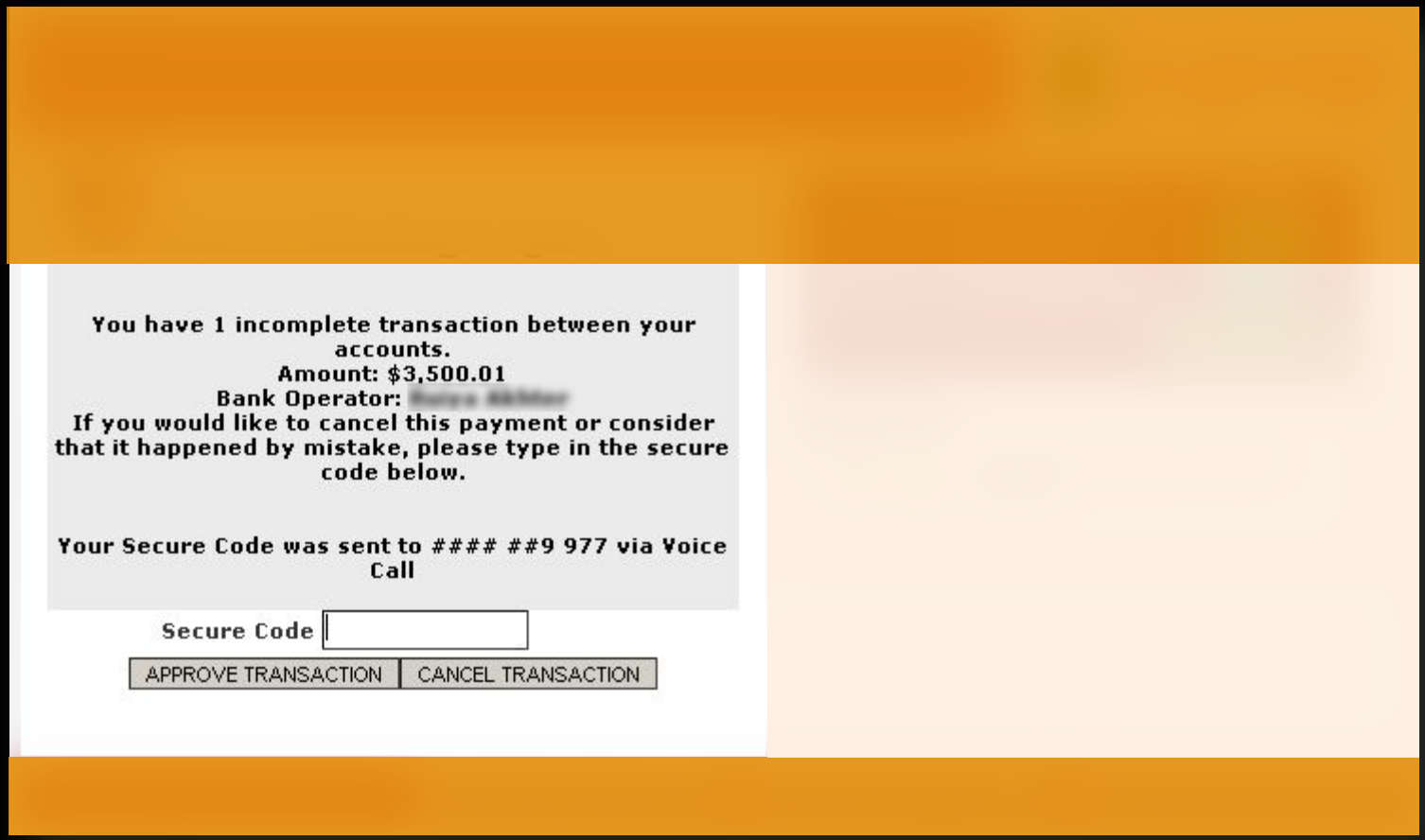
- There is no such a thing as ‘Please Wait’ in the online banking page.

Sign In - MITM

- What's happening while you are waiting…

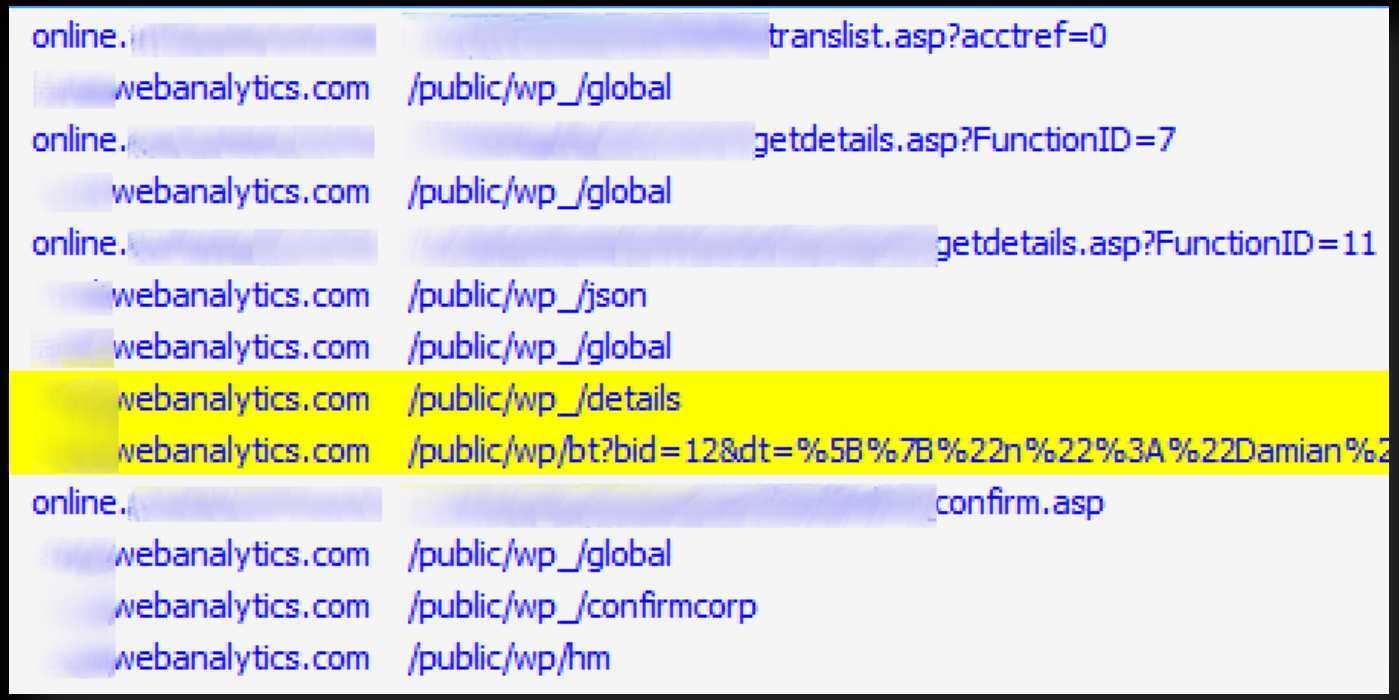


Transaction Injection - SMS



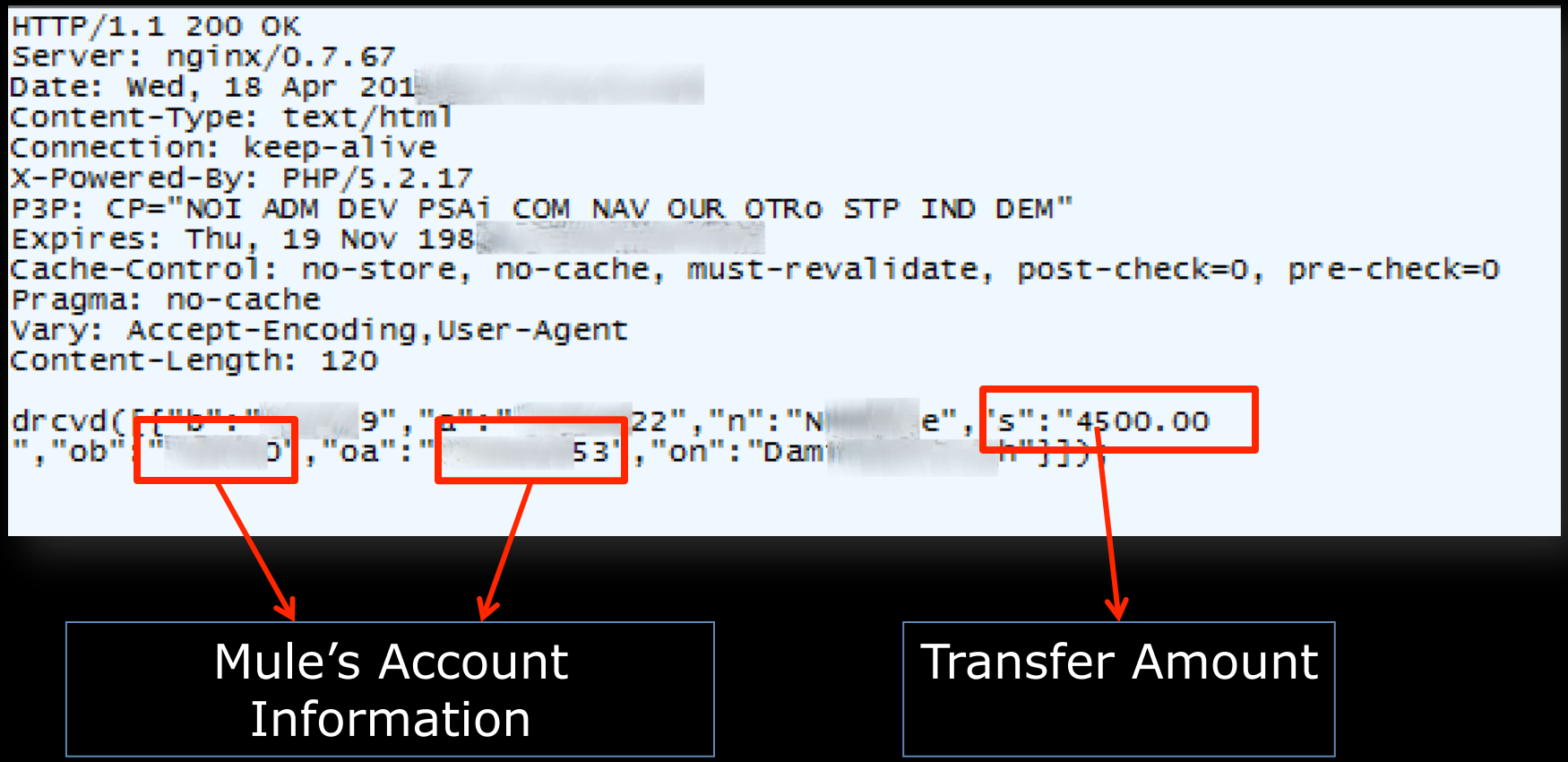
Transaction Manipulation

- Even when there is no visual sign of infection, it can happen silently.
- C&C communication during Tx pages



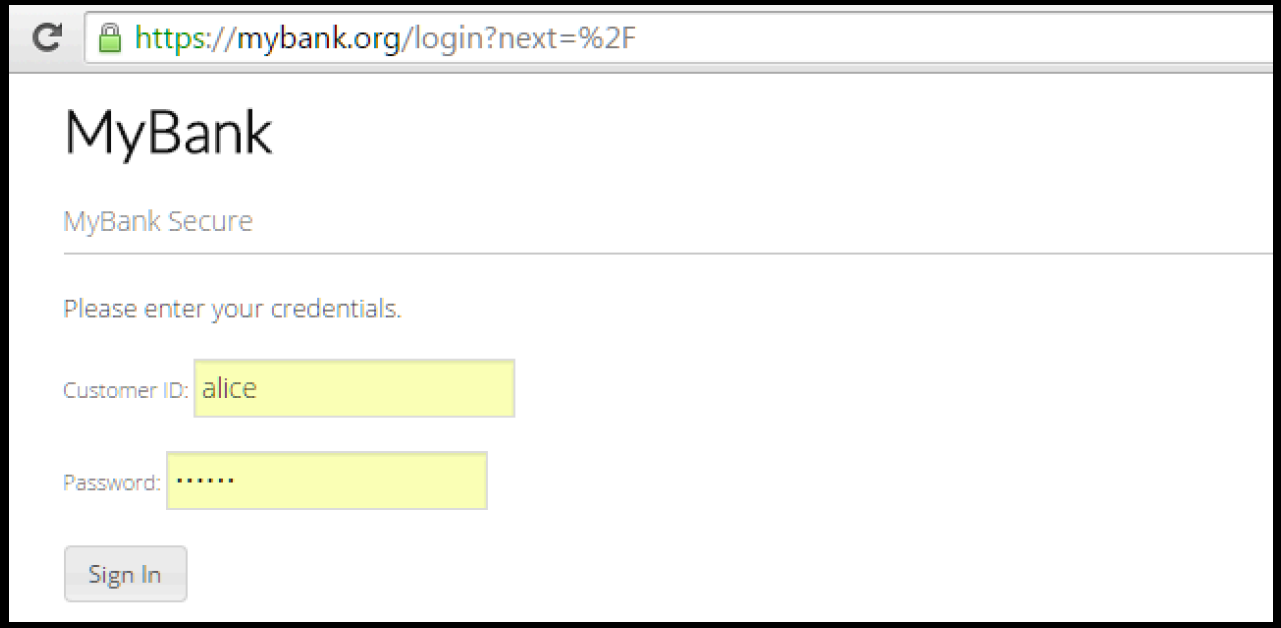
Transaction Manipulation

- What is the malware receiving? → Inject and Mule



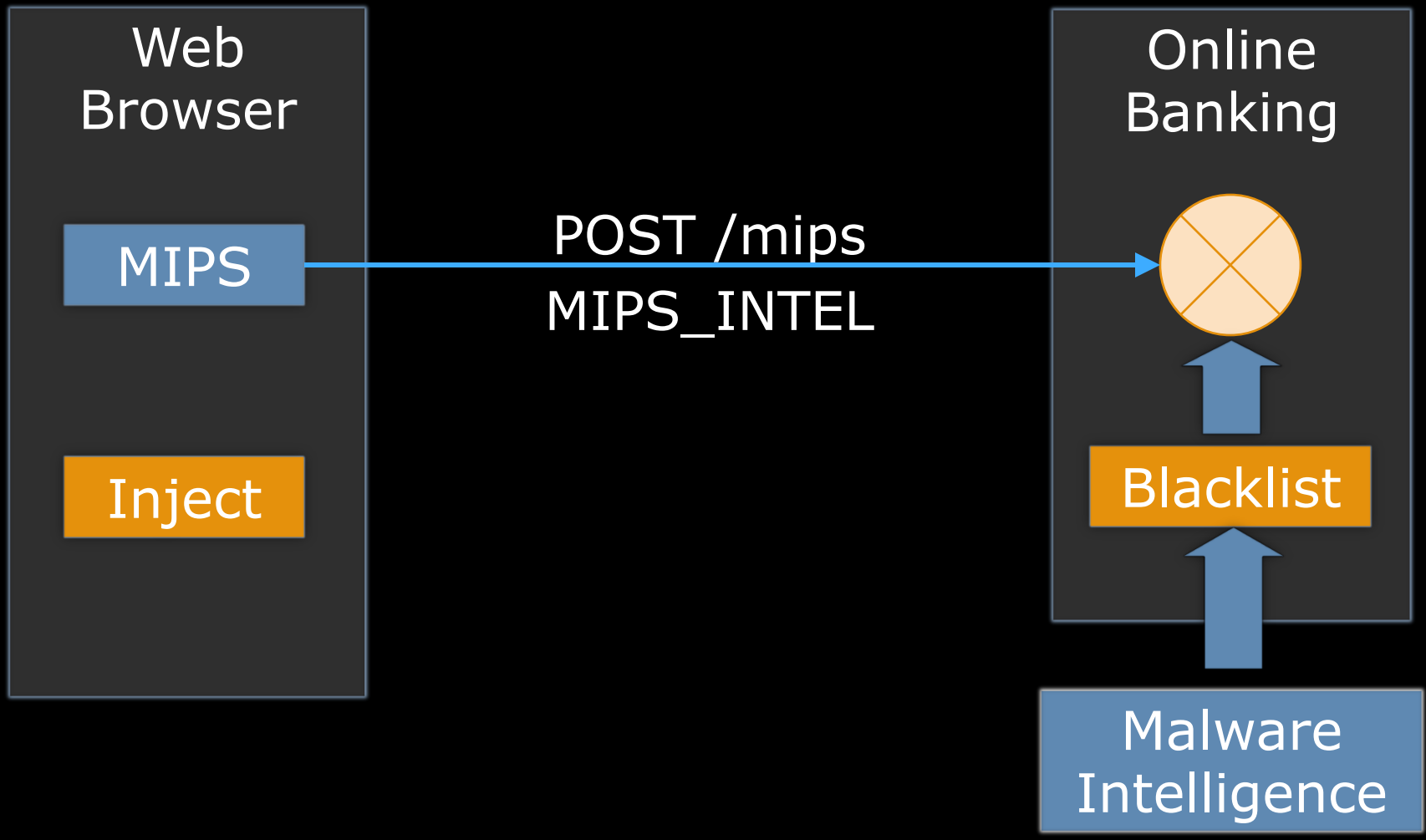
Phase I
DOM Injection

Attack: DOM Injection




```
$("#submit").on("click", function(){
    var id = $("#signin-id").val();
    var pw = $("#signin-password").val();
    console.log(">> DOM Inject: "+id+":"+pw);
});
```

Defense: DOM Scan

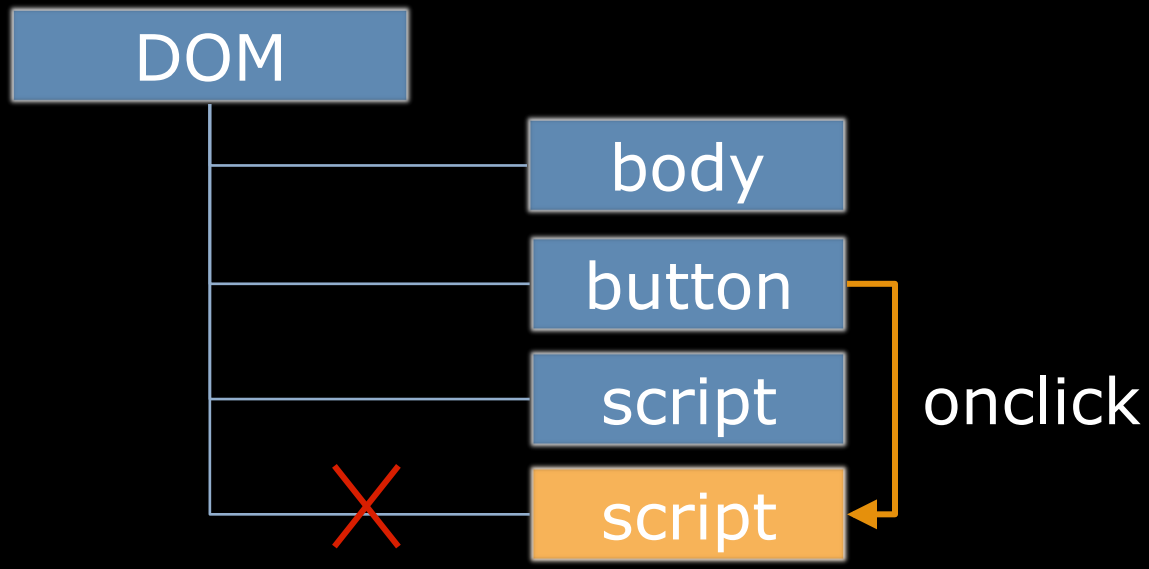


Phase II
DOM Stealth

Attack: How It Works

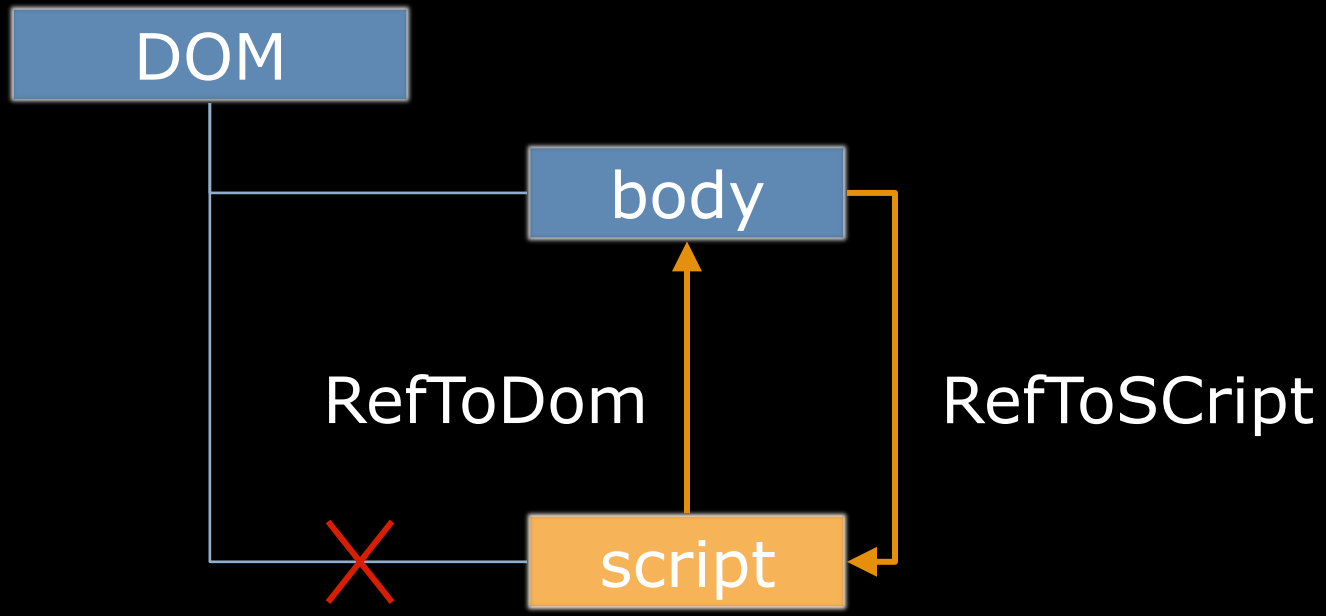
- Malware inject removes itself, but it still remains in the memory
- Exploit memory leak patterns
  - Dangling references
  - Circular references
  - Closures

Attack: Dangling References



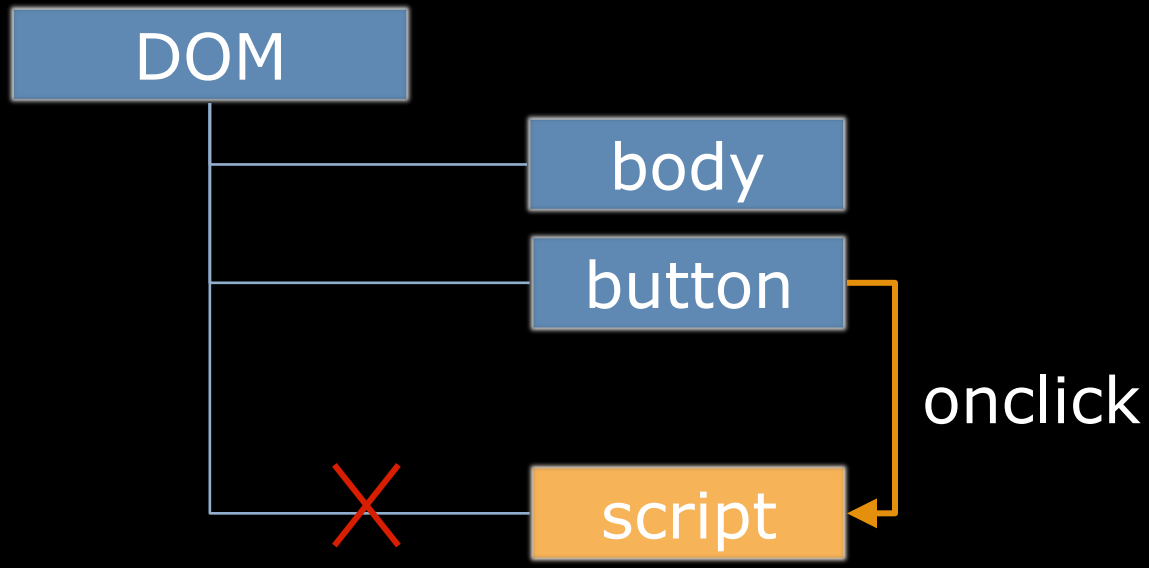

```
var me = document.currentScript;
me.parentNode.removeChild(me);
```

Attack: Circular References




```
var refToDom = document.body;
document.body["refToScript"] = refToDom;
```

Attack: Closures




```
function AttachEvent(element) {
  element.attachEvent("onclick", MyClickHandler);
  function MyClickHandler() {
    /* This closure references element*/}
}
```

Defense: DOM Event Scan

- Identify entry points (unload, click, timer)
- Enumerate event handlers

element.onclick = handler

```
Scan: element.onclick
```

element.addEventListener

```
Scan: getEventListeners(element, “click”)
```

$(element).on(“click”, handler)

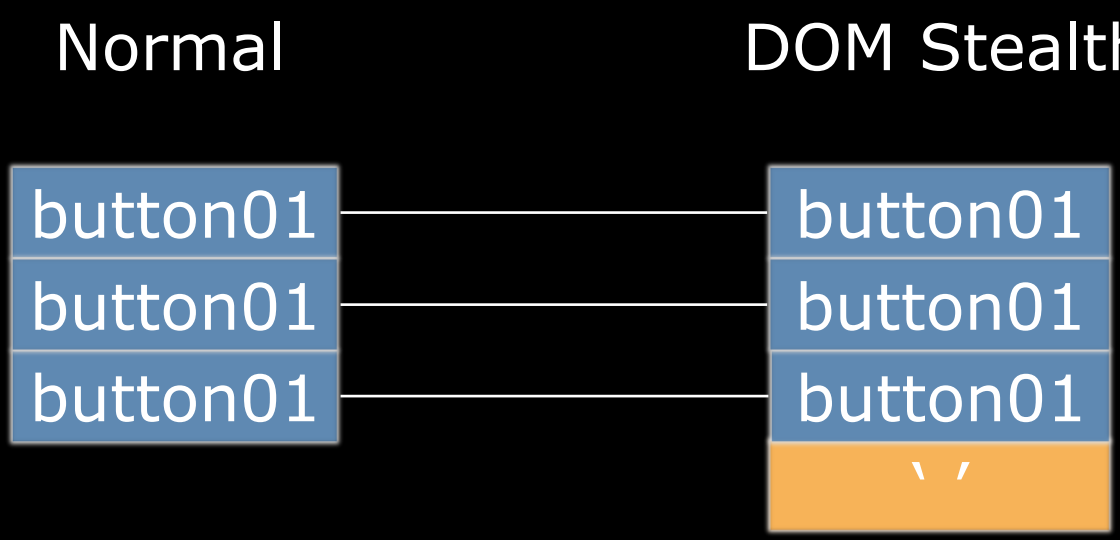
```
Scan: $._data(element, "events" )
```

$(element).observe(“click”, handler)

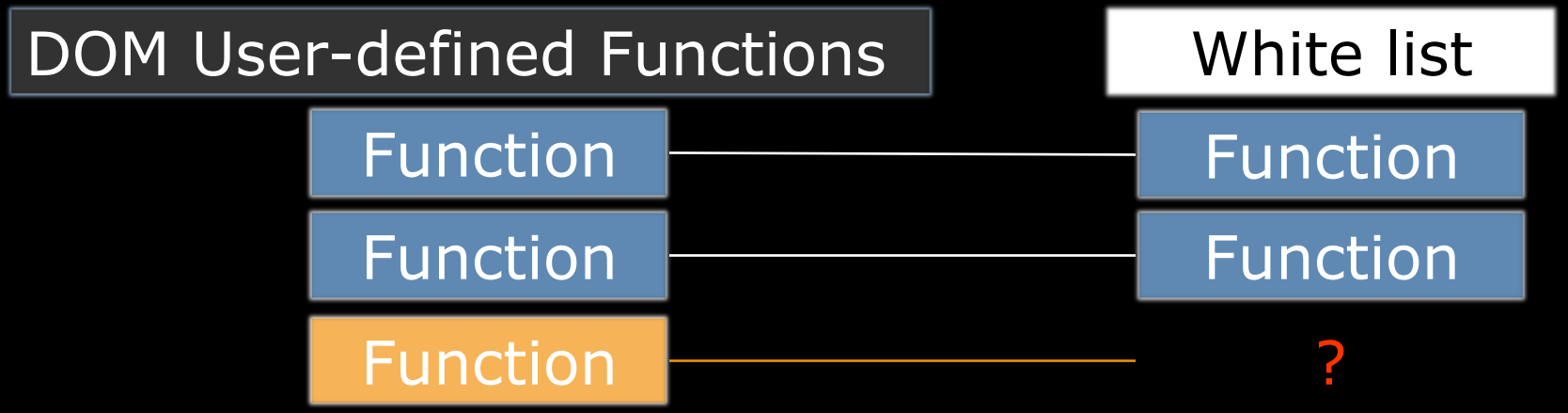
```
Scan: element.getStorage().
get('prototype_event_registry').get('click')
```

Defense: Artefact Analysis

For $(‘#submit’),‘click‘,
Event handler’s namespace property is missing



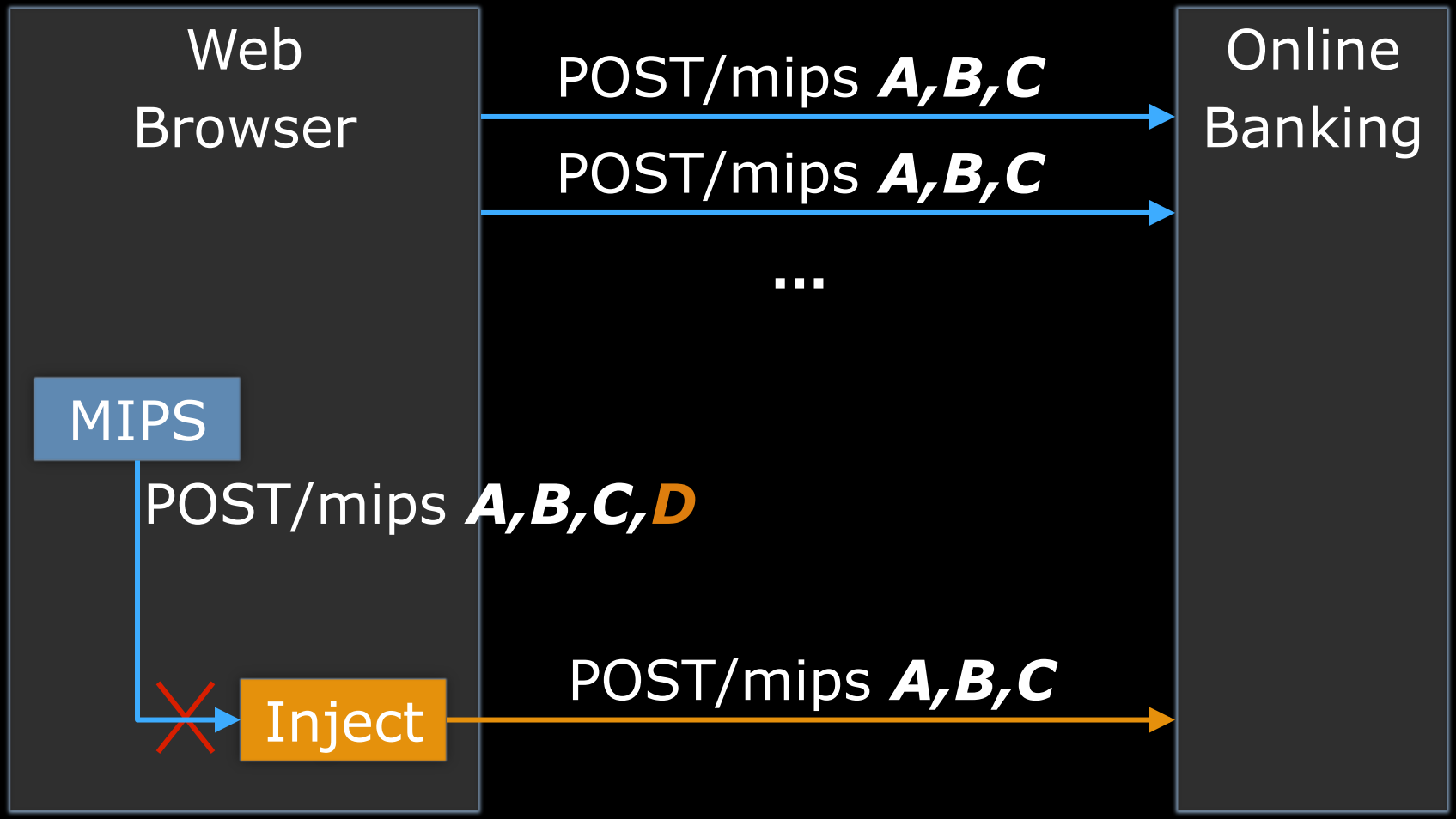
Defense: Function Integrity Check



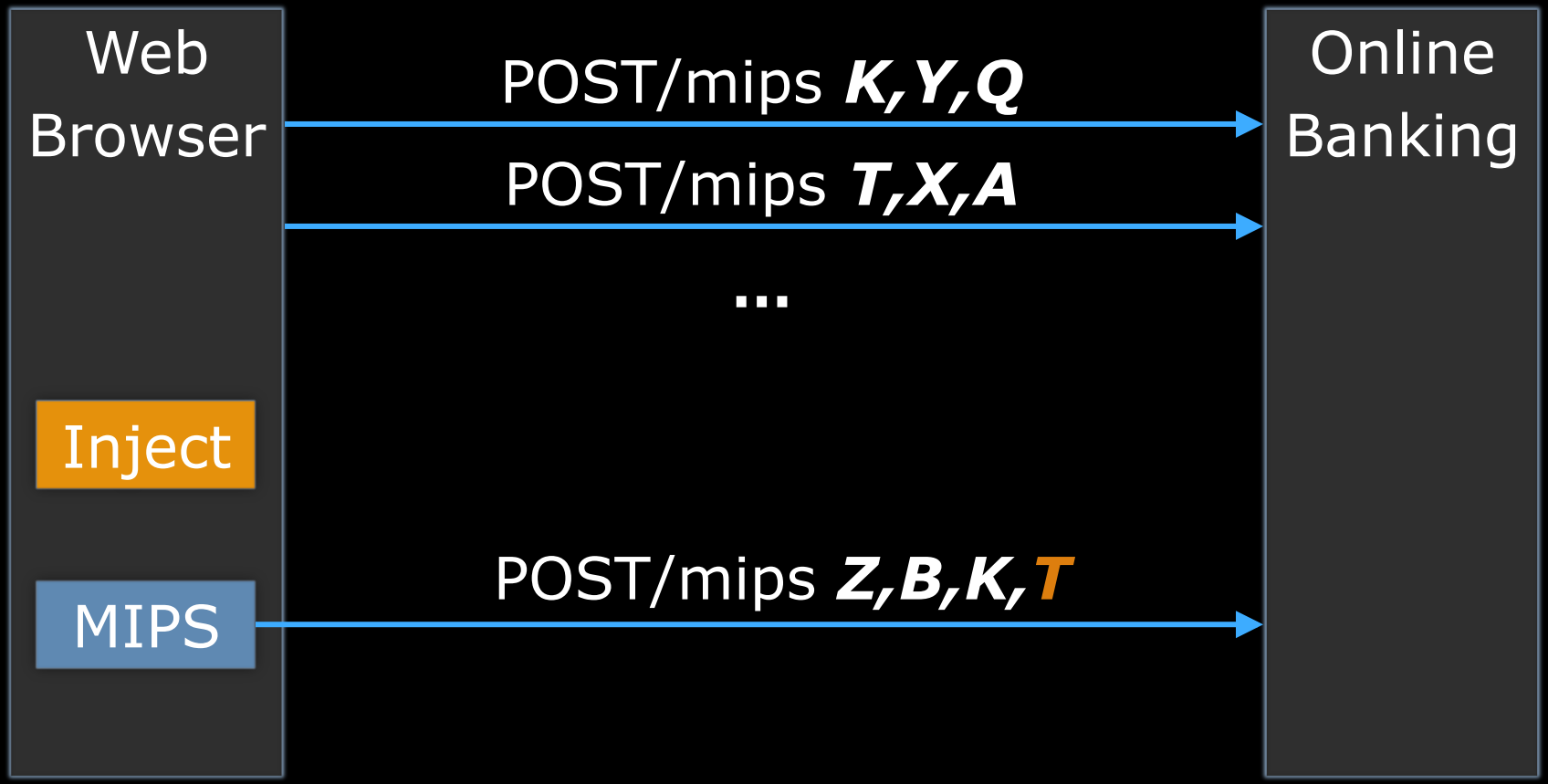
- Enumerate user-defined functions
  - *Object.keys(window).filter(!/\[native code\]/)*
- Compare functions discovered in DOM against whitelist
- Implementation challenges
  - Check on server side or client side?
  - Reducing data size

Phase III
MIPS Infiltration

Attack: Replay

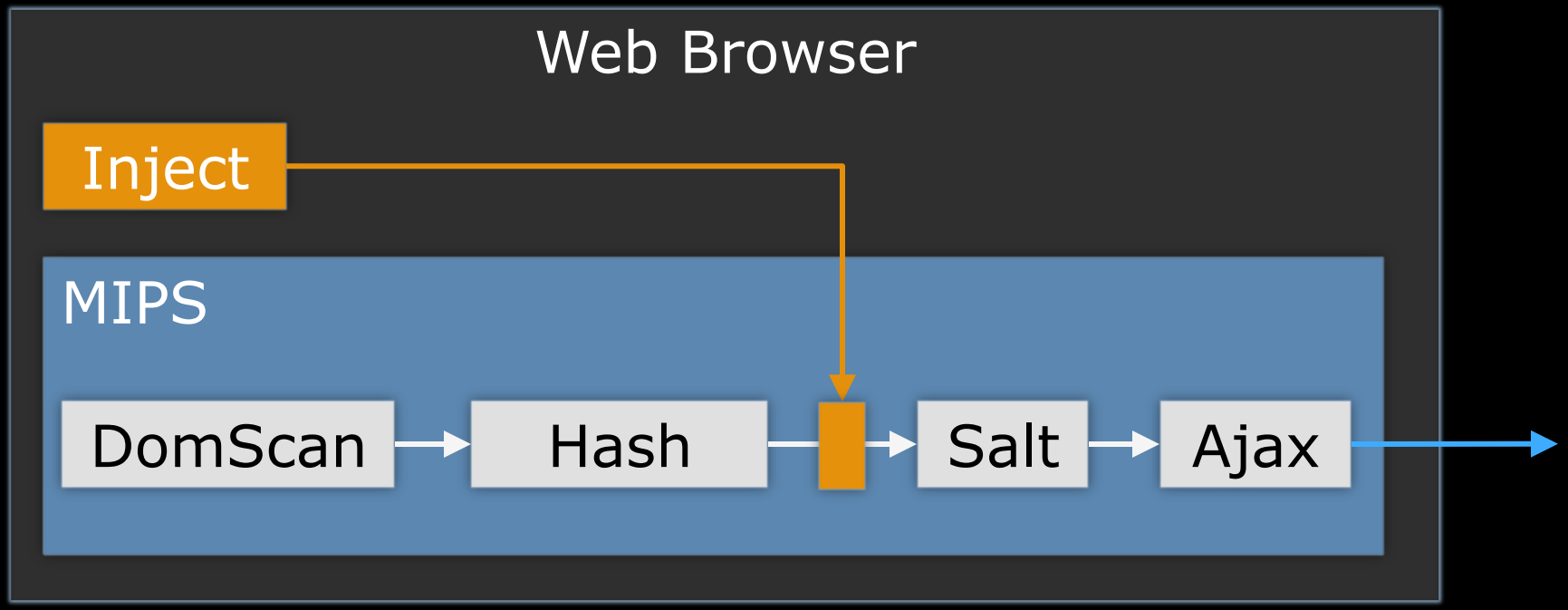


Defense: Salting



- Original MIPS intel gets transformed differently each time using the random variable

Attack: Forging MIPS Intel



- Hook Salt() and modify hashes OR
- Block MIPS & call MIPS functions as necessary

Attack: Model 1

- Insert or replace with bypass code within MIPS code
- Tamper with intermediate MIPS data

```
var scripts = DomScan(mips_code);
scripts = Modify(scripts);
var hashes = Hash(scripts);
var salted_hashes = Salt(hashes);
var check = CheckIntegrity();
check = Modify(check)
Ajax(mips, salted_hashes, check);
```

Attack: Model 2

- Reverse engineer MIPS
- Deactivate MIPS and Reconstruct MIPS code

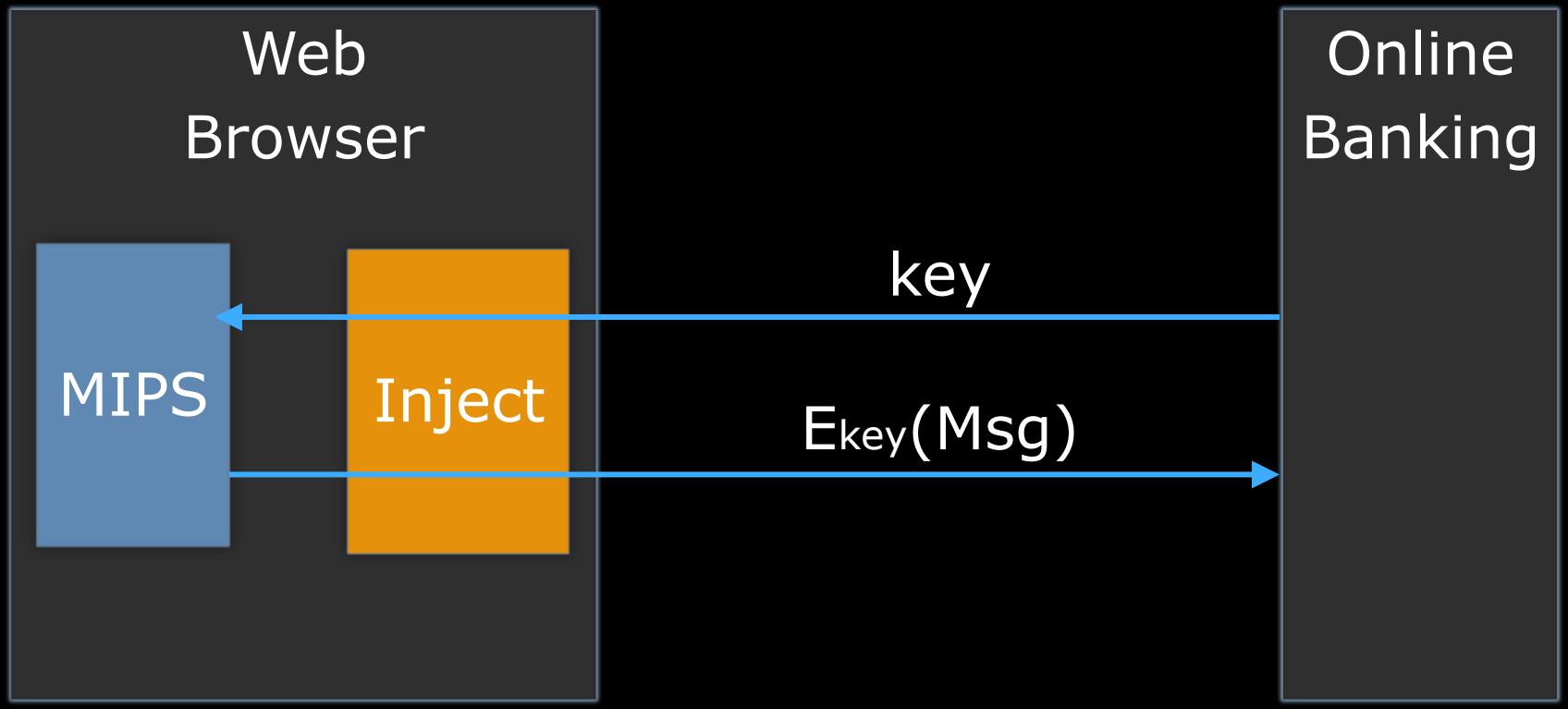
```
var scripts = DomScan(mips_code);
var hashes = Hash(scripts);
var salted_hashes = Salt(hashes);
var check = CheckIntegrity();
Ajax(mips, salted_hashes, check);

Var hashes = clean_hash_set;
var salted_hashes = Salt(hashes);
Ajax(mips, salted_hashes, clean_integrity_check);
```

Bad Defense: Obfuscation

- What you are up against
  - Dynamic analysis
    - Use static analysis tools (Google closure compiler, spider monkey, custom tools, etc)
    - Understand program structure by setting breakpoints and evaluating expressions
    - Bypass dead code
    - Monitor network traffic
    - Targeted reverse engineering by searching keywords (i.e. ‘script’, ‘/mips’)
  - Activity monitoring
- Blind obfuscation is not resistant to targeted code inspection/modification

Bad Defense: Encryption



- Malware has all info to simulate outcome
  - key, encryption algorithm

Bad Defense: More

- ***Blind application*** of traditional metamorphic/polymorphic techniques without understanding the attack vector will fail
  - Dead code insertion
  - Polymorphic variable/function names
  - Control flow manipulation
  - Function restructuring
  - Opaque predicate
  - etc

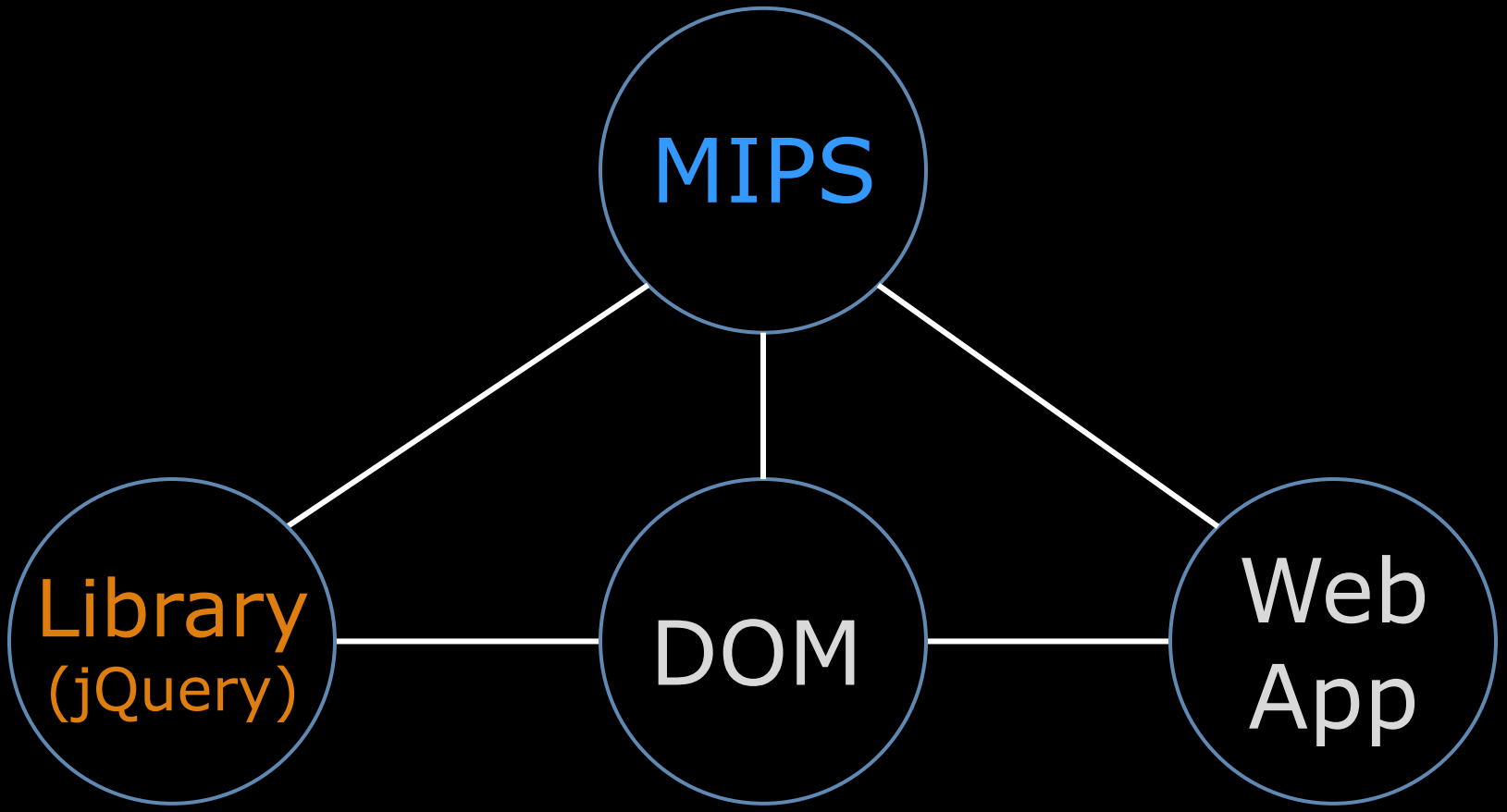
Defense: Code Integrity Check

- Call stack context

```
var Check = function(na, nb) {
  var SecureCheck = function(na, nb) {
    var callee = na ^ crc32(arguments.callee);
    var caller = nb ^ crc32(arguments.callee.caller);
    return callee ^ caller ^ DomCheck();
  };
  return SecureCheck(na, nb);
};

var na = 32053221, nb = 4321053;
result = Check(na, nb);
```

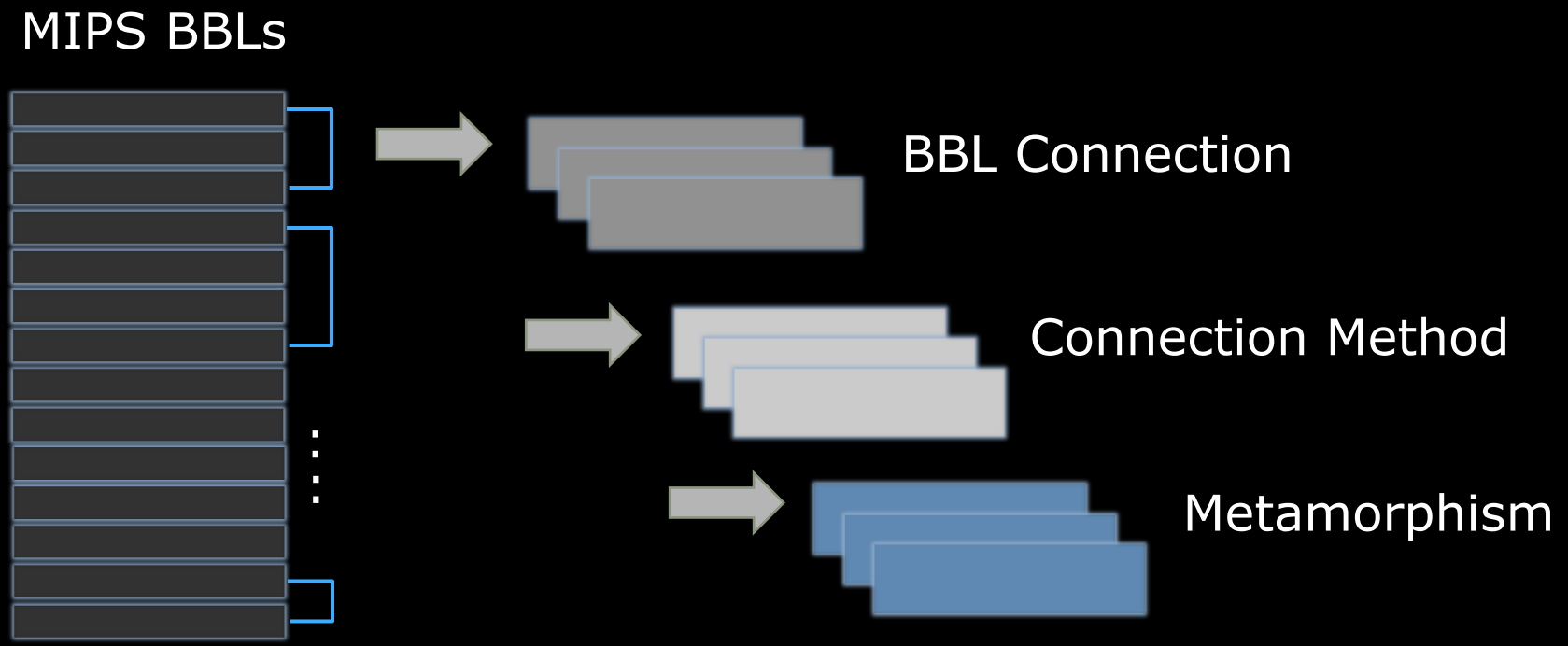
Defense: Code Integrity Check



Defense: Randomisation

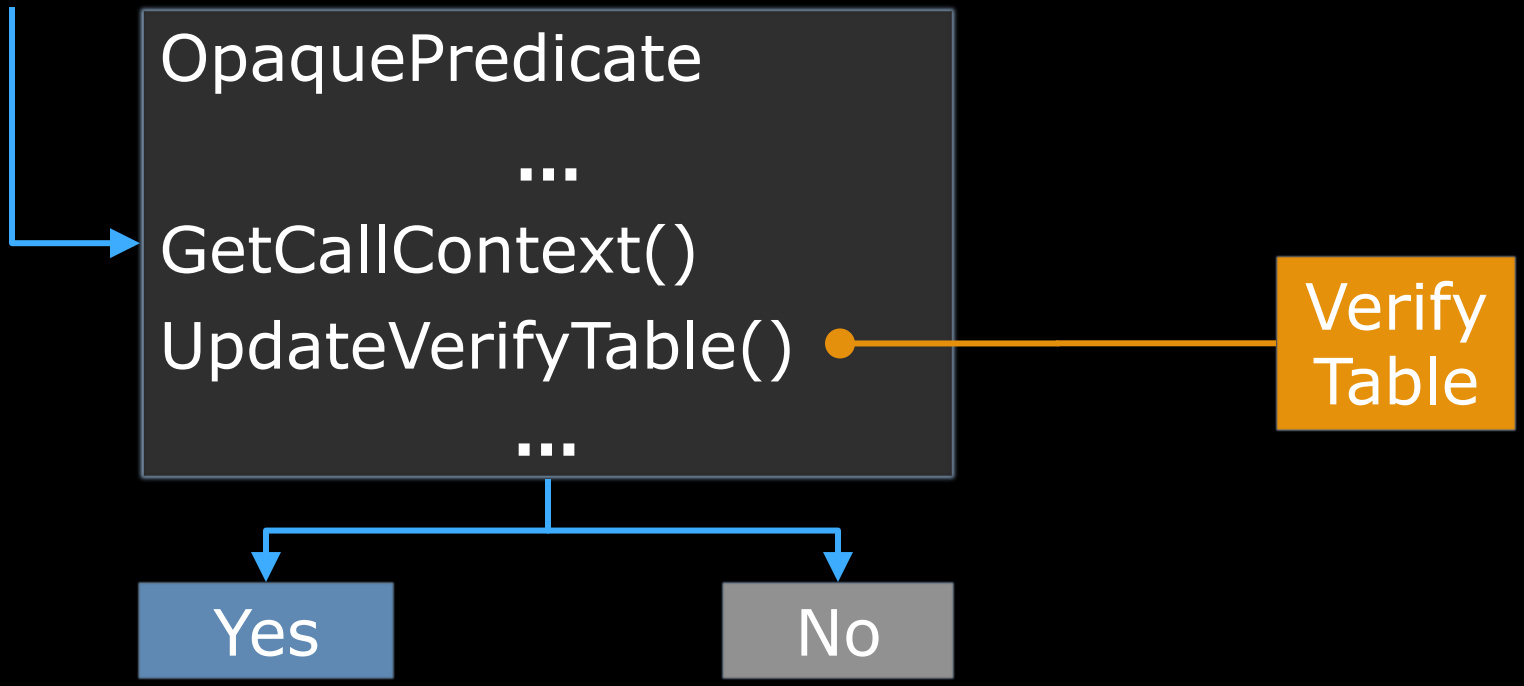
- Problem with integrity check
  - Malware Regexes, modifies and reconstruct MIPS
  - Malware simulates MIPS with bypass code
- Strategy
  - Polymorphism
  - Maintain a set of ***algorithmically heterogeneous*** MIPS code
  - Fragmented random MIPS scripts with different names

Defense:
Control Flow Randomisation



- Chain of Randomisations starting with basic blocks (BBLs) of MIPS code

Defense:
Opaque Predicates



- Retrieve call context in deeply buried OP
- Insert part of main logic within OP

Phase IV
Rootkit

Attack: How It Works

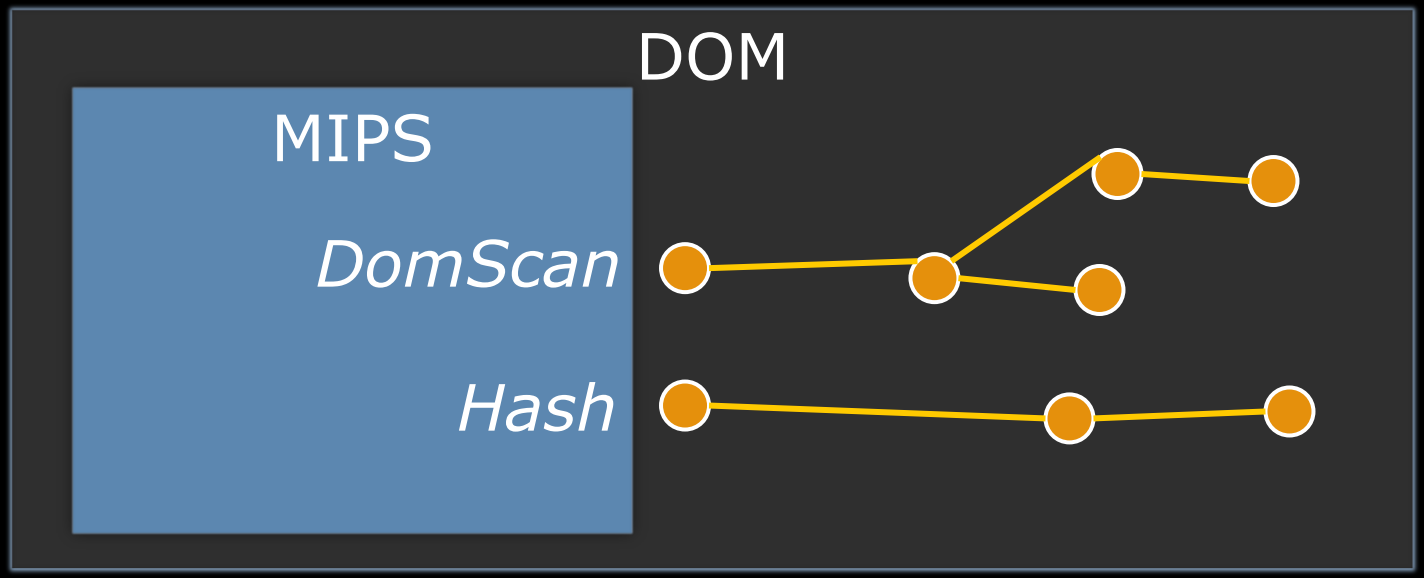
```
var original_func = document.getElementsByTagName;
document.getElementsByTagName = function () {
  r = original_func.apply(document, arguments);
  for(var i=0; i<r.length; i++) {
    var inject_signature = 'string_in_my_inject';
    if(r[i].text.search(inject_signature) != -1) {
      r[i].remove();
      console.log('Injejct Rootkitted!');
      break;
    }
  }
  return r;
};
```

Attack: How It Works

- Hook critical MIPS functions
  - DomScan(), Hash(), Salt()
- Hook DOM/jQuery
  - *document.getElementsByTagName(selector)*
    - Modify the returned HTMLCollection
  - *jQuery.find(selector, doc, ret)*
    - Modify the returned array
- Hook system information
  - *Object.keys()*
  - *Function.prototype.toString()*

Defense: DOM Integrity Check

- Collect signatures of chain of functions used by MIPS in multiple different ways.
- Online banking server detects any change



Defense: Detecting Rootkits

- Deliberately trigger exception → Call stack

```
var hooked = Function.prototype.toString;
Function.prototype.toString = function() {
      hooked.apply(this, arguments);
} // DOM Rootkit
```

```
var TriggerException = function(){
    try {
        Function.prototype.toString.call('hooktest')
    }
    catch(err) {
        console.log(err.stack);
    }
}
TriggerException();
```

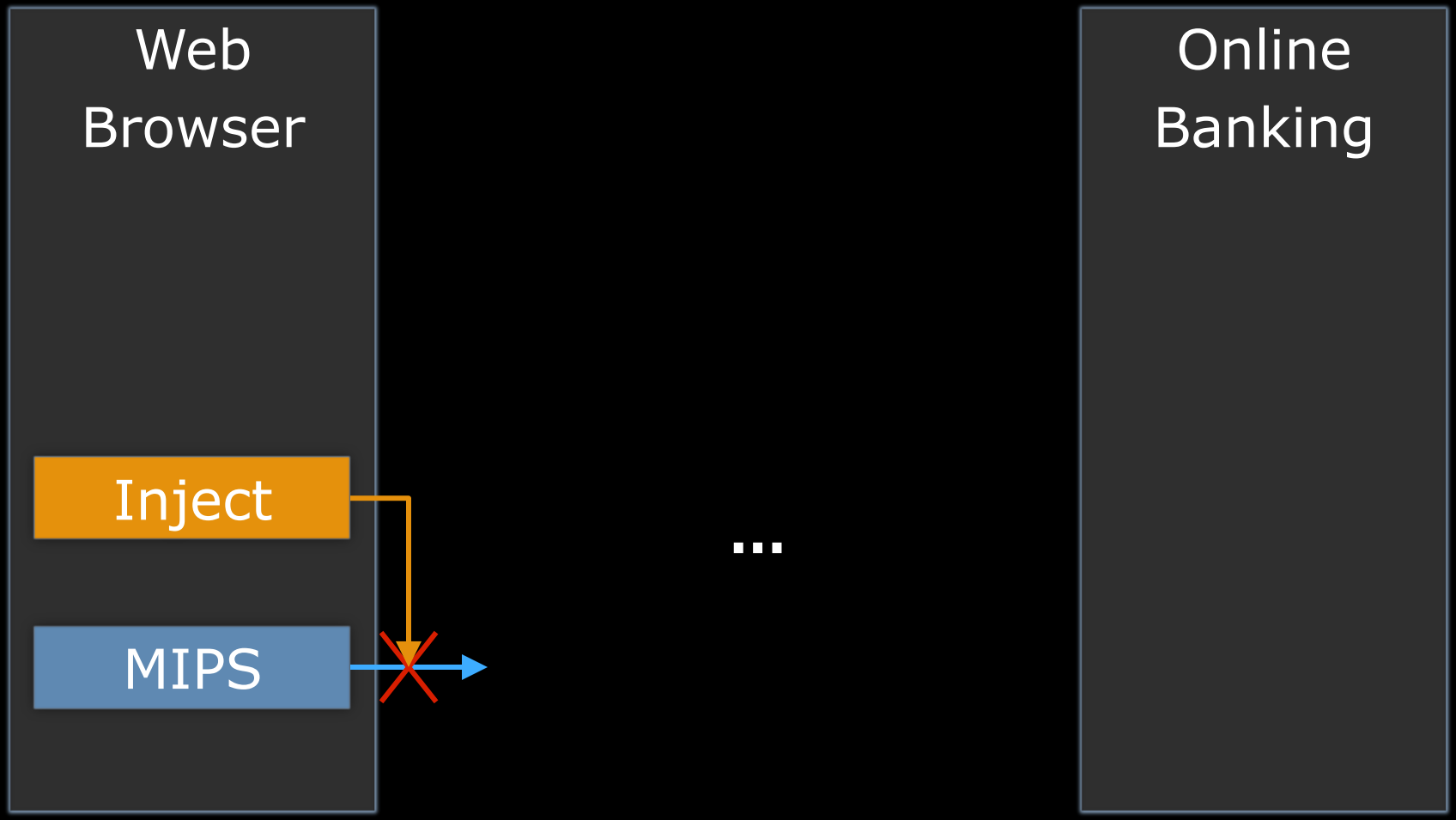
Defense: Detecting Rootkits

- Is the red line present in a clean session?

```
TypeError: Function.prototype.toString is not
generic
    at String.toString (native)
    at String.Function.toString(/login?next=%2F:173:7)
    at TriggerException (/login?next=%2F:177:29)
    at https://mybank.org/login?next=%2F:183:1
```

Phase V
Fraud Analytics

Attack: Blocking MIPS



Defense: MISSING_MIPS Event

- MISSING-MIPS Event should be implemented on the online banking server side if MIPS is not the integral part of online banking logic
- Method
  - Ensure MIPS intel is not cached by the proxy in-between
  - Correlate web access log with MIPS log

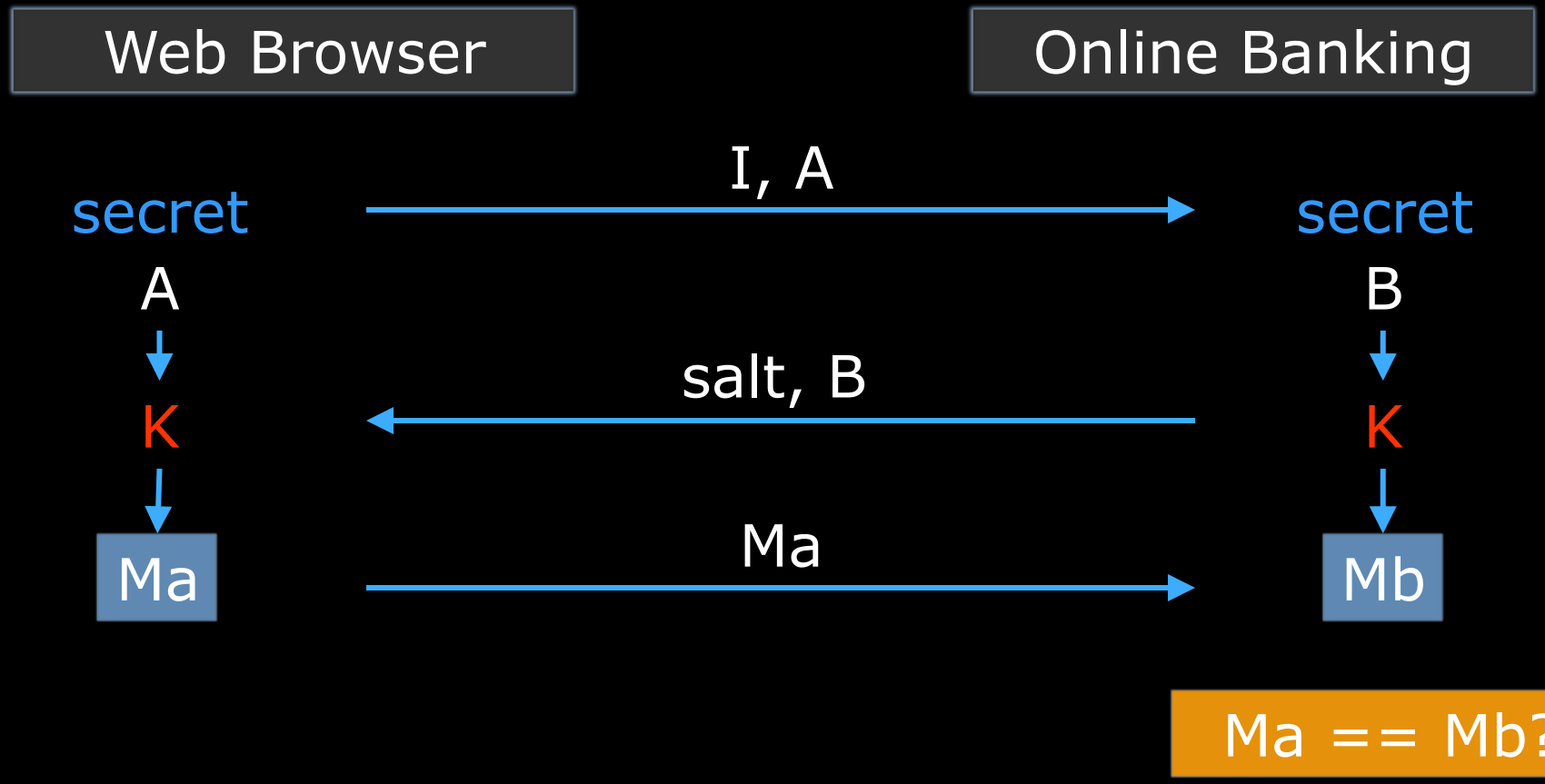
Detecting Moving Targets

- Detect evolving injects
  - Effective on minor inject upgrade
- Methods
  - Locality sensitive hashing (i.e. TLSH)

Phase VI
Zero Knowledge Proof

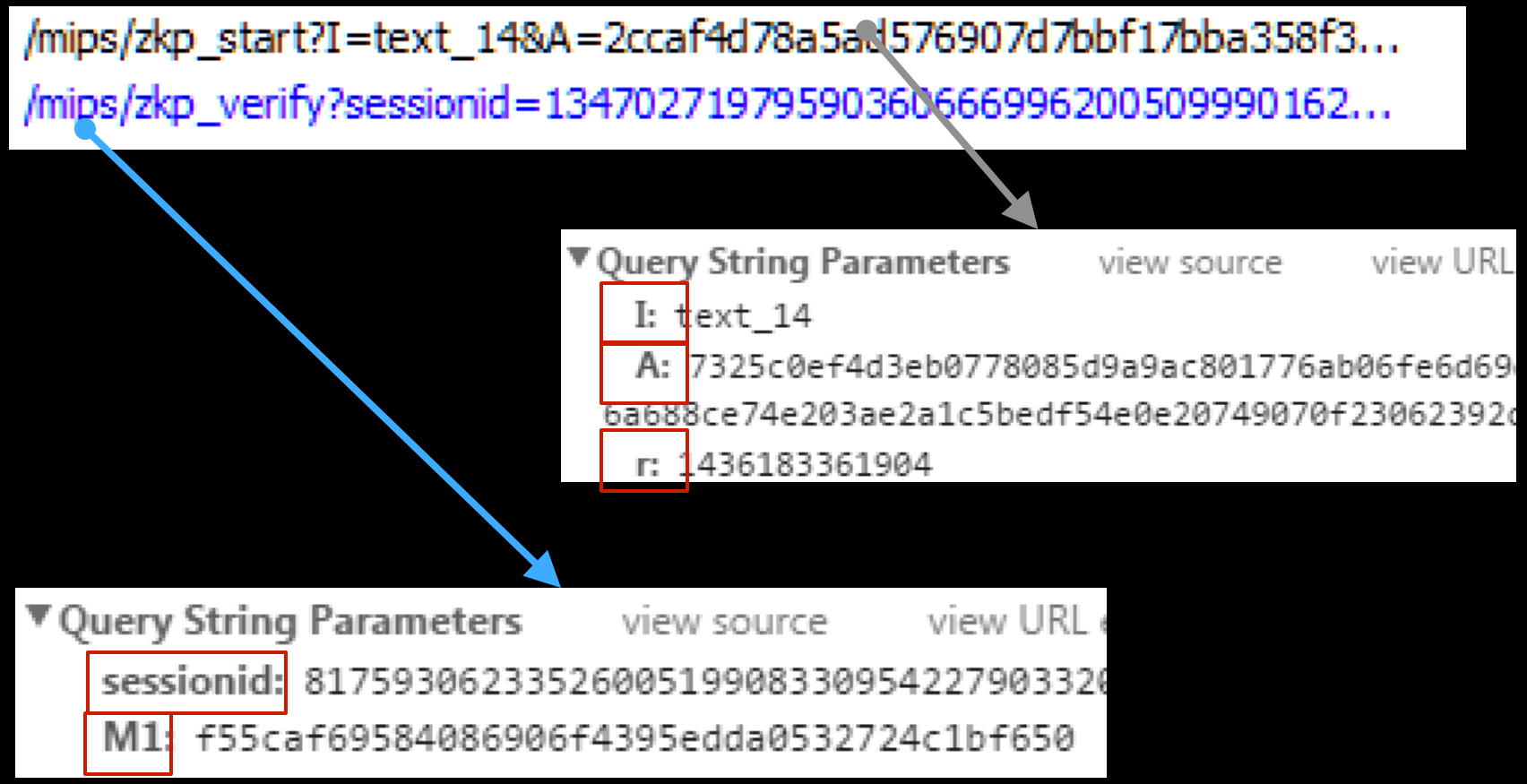
ZKP: SRP

- Over-simplified Secure Remote Password



ZKP: SRP

- No secrets on the wire any more!



Use Cases

- MITM attack
  - No shared secrets get transmitted on the wire (password, OTP code)
- Passive sniffing
  - Force attackers to place injects (so we can detect it!)
- MIPS hardening
  - DOM function integrity data
  - MIPS integrity data
  - MIPS rootkit detection data
  - MIPS intelligence format

Conclusion

- Diversity of implementation is the key for survival
- Be creative and out-smart the cybercriminals!
- Perform application security check
- Never explicitly block on the spot on detection!

Live Demo

MIPS

Black Hat Sound Bytes

- Majority of the attacks presented came from the observation in real online banking war
- DOM stealth, rootkit and MIPS infiltration are a natural evolution of the attack
- Online banking must respond with superior defense including at least code randomisation, MIPS integrity verification and rootkit detection

Thank You

Sean Park
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