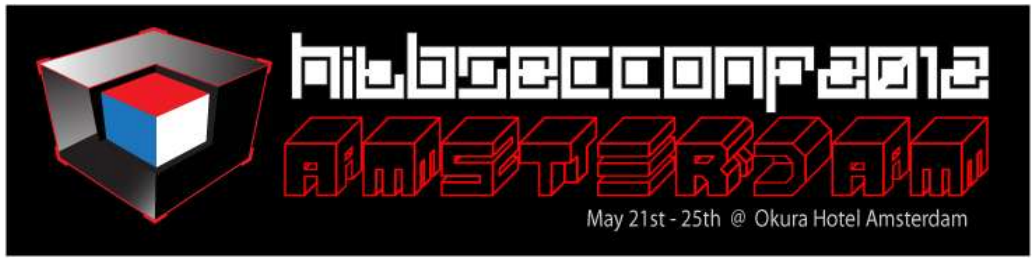

PostScript: Danger Ahead?!

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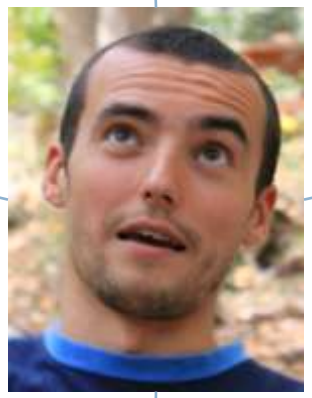
Affiliation - PhD student

whoami: in-between SW/HW hacker

Hacking MFPs (for fun & profit)

Mifare Classic MFCUK

Holistic Security Interest



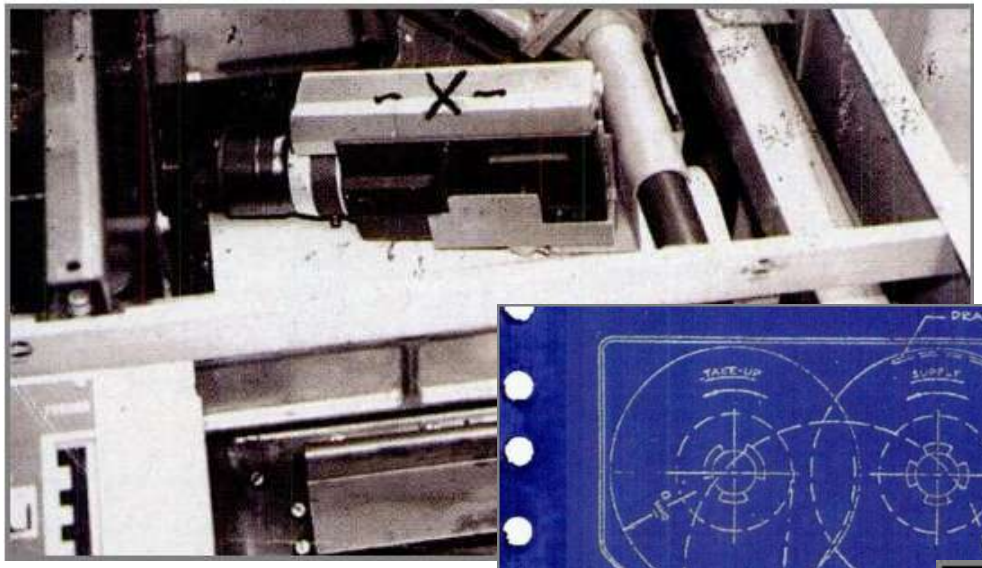
http://andreicostin.com/papers/

Agenda

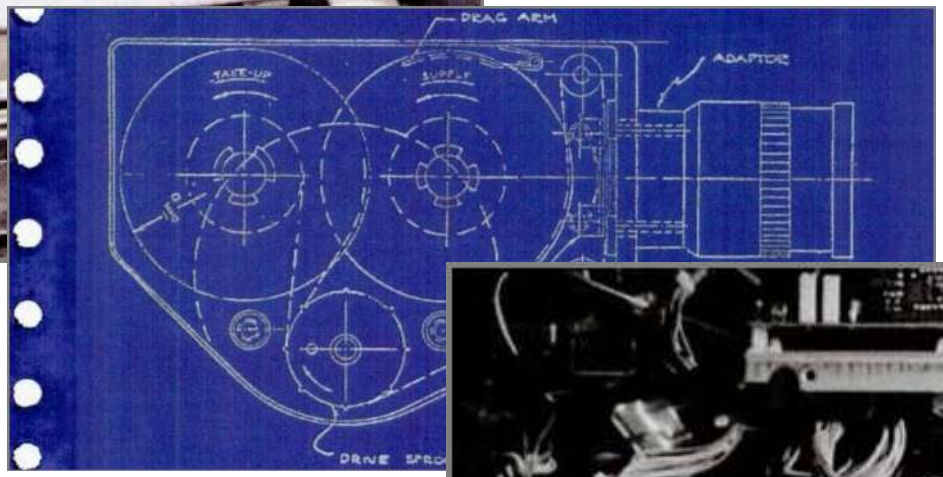
1. Quick refresher
2. What about PostScript?
3. So, what and how did you find?
4. Attacks in a nutshell
5. Solutions and conclusions

MFPs carry large abuse potential

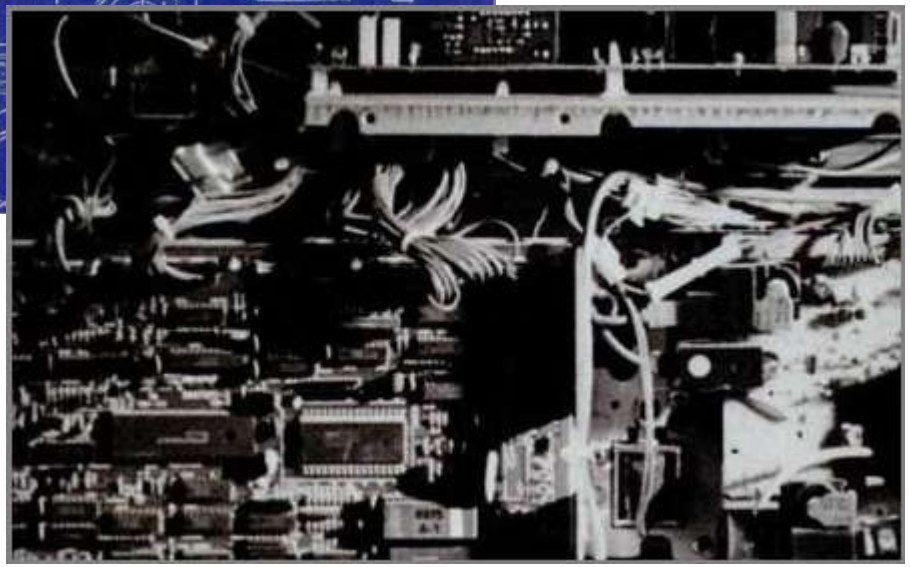
MFP hacking goes back to the 1960's



The "micro"-film camera, marked X



Patent drawing, 1967



Electronics/hardware hacking

"Spies in the Xerox machine"

Modern printer hacking goes back almost a decade

2002

Initial printer hacks (FX/pH)

2006

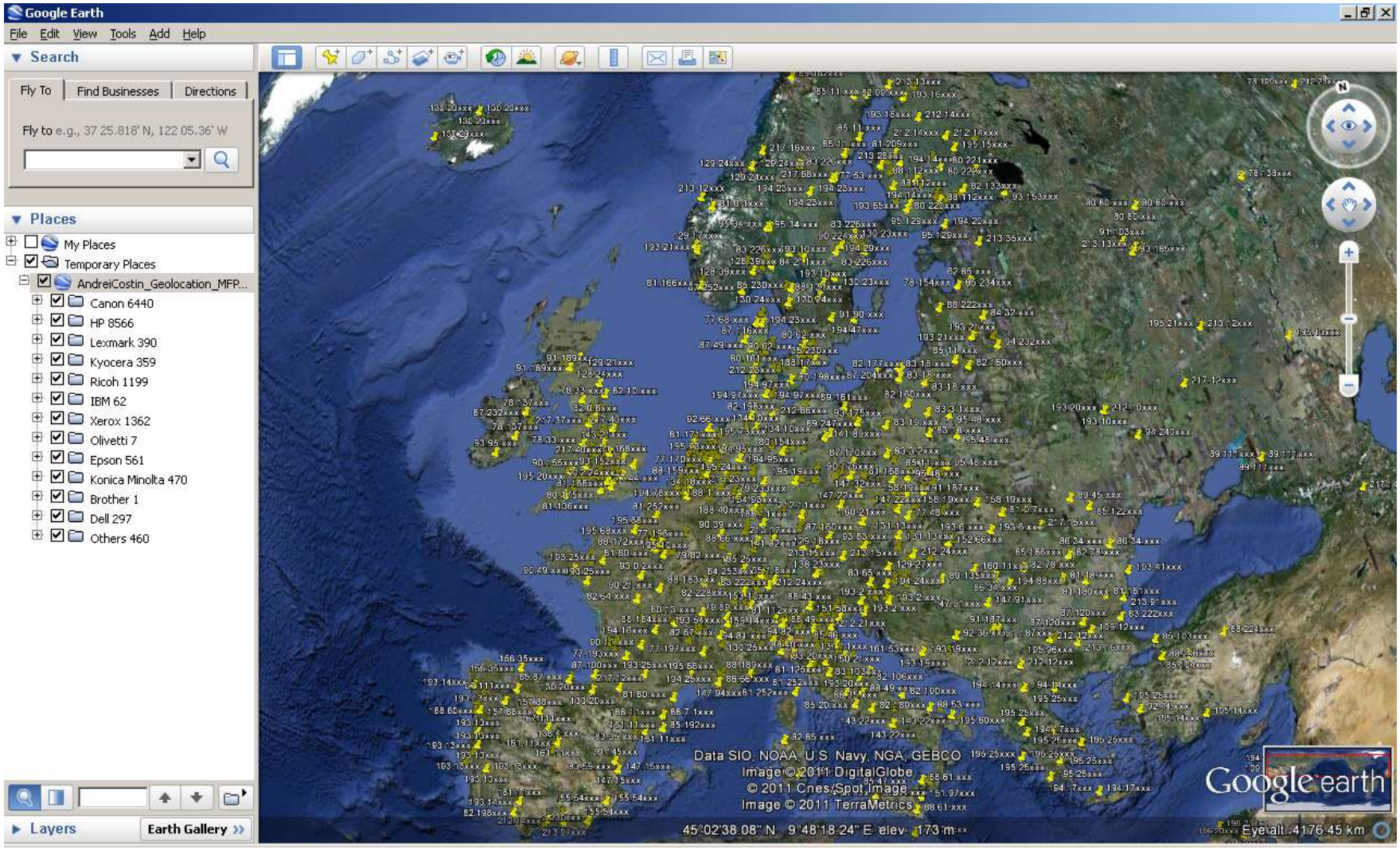
Broader & deeper printer hacking (irongeek)

2010-2012

Revived printer hacking interest

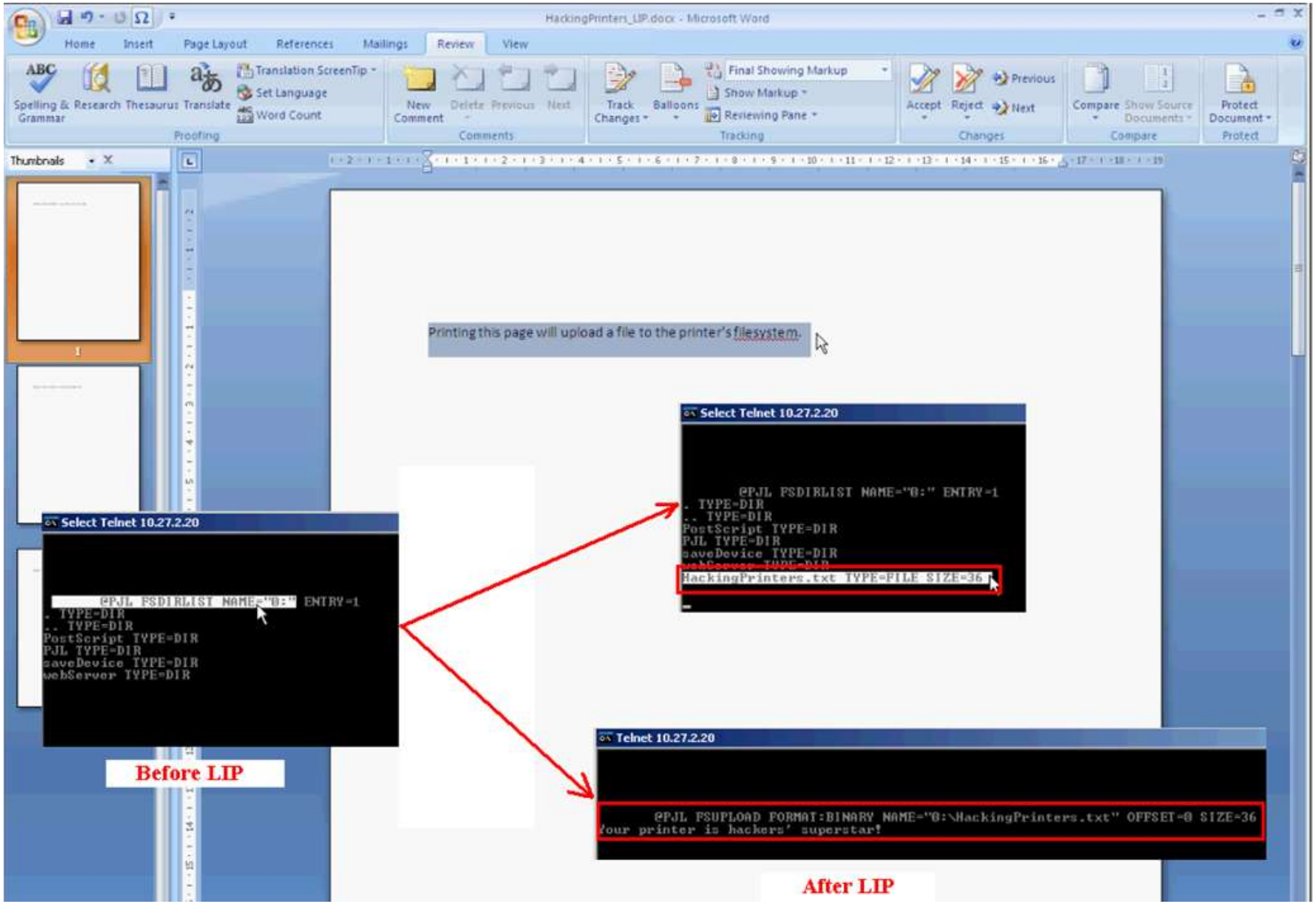
This talk focuses mainly on remote code execution inside MFPs/printers

In 2010 we demo'd : mapping public MFPs



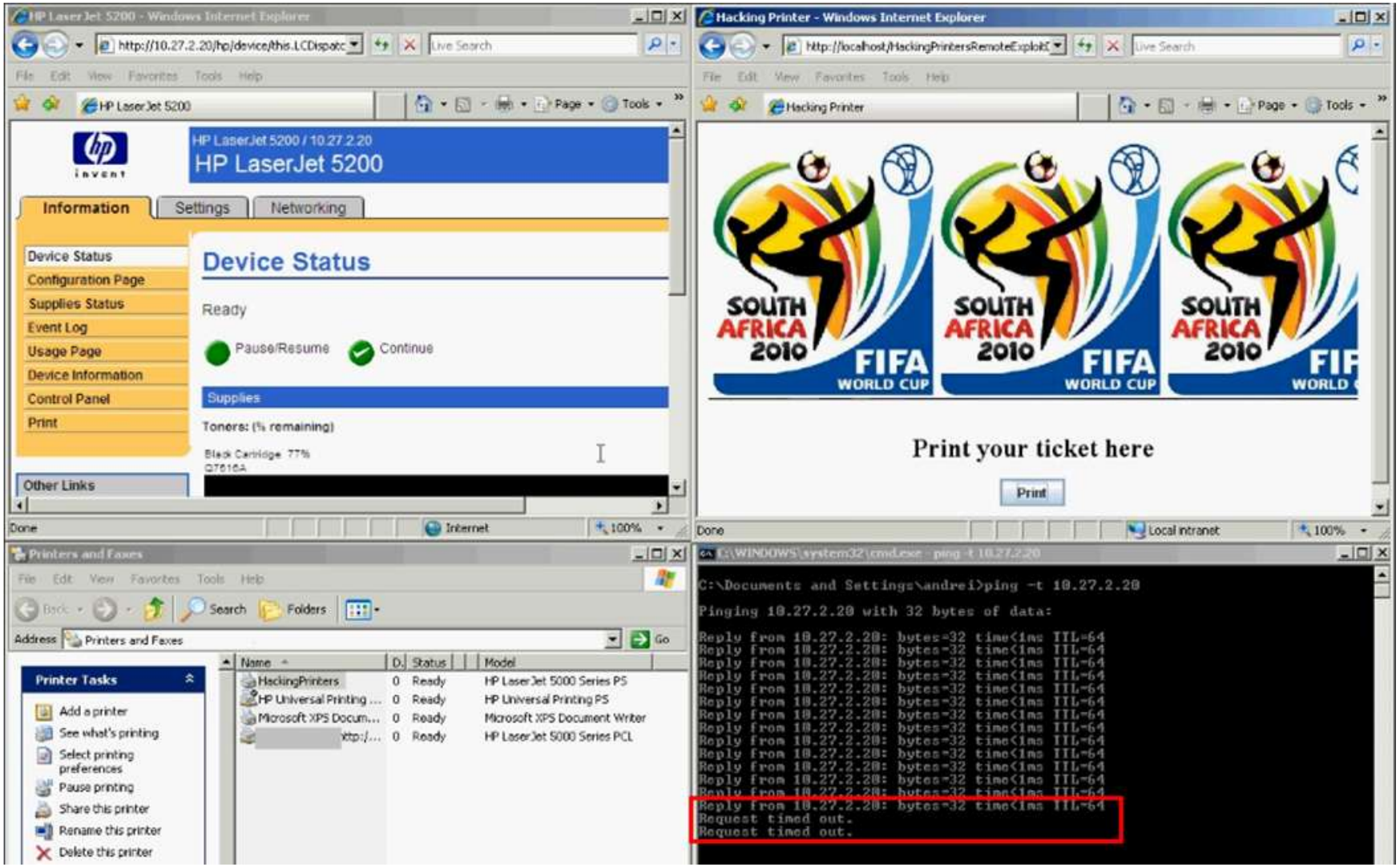
http://www.youtube.com/watch?v=t44GibiCoCM

… and generic MFP payload delivery using Word



http://www.youtube.com/watch?v=KrWFOo2RAnk (there are false claims on this discovery)

… and generic MFP payload delivery using Java



http://www.youtube.com/watch?v=JcfxvZml6-Y

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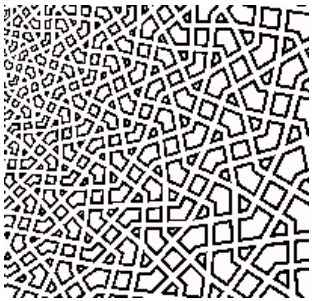
PostScript who? It's Adobe's PDF big brother

Adobe PostScript and the **future**

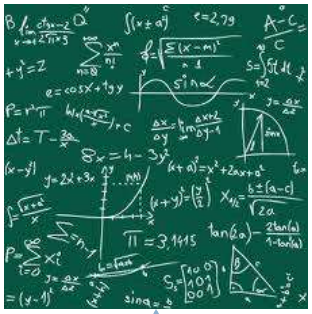
PostScript is a living language. Since introducing PostScript in 1985 as an open standard, Adobe has continually made improvements to the software. This has yielded powerful new capabilities such as Adobe PostScript Fax printers and the coming generation of multifunction products, which will include fax, copying, and

PS is build to handle complex processing tasks

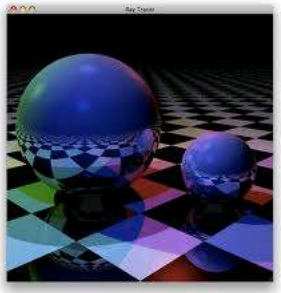
Graphics & patterns



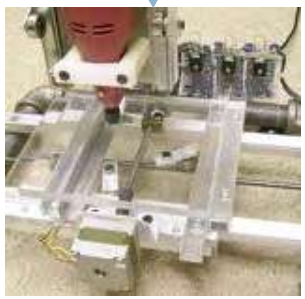
Complex math



Web servers



Ray-tracing, OpenGL



Milling machine

XML Parsers

Then, what exactly is PostScript?

- PostScript IS NOT just a static data stream like

- PostScript IS a
  - Dynamically typed & concatenative
  - Stack-based
  - Turing-complete
  - **Programming language**
  - What does it all mean? Exactly!

What happens when printing PS?

- User writes the doc and hits Print
  - PS printer driver transforms it to PS stream for specific device
  - PS data stream on PRN
- User Opens a PS file from email/hdd
  - PC-based PS interpreter processes it
  - PS data stream executes on PC
- In both cases, PS data stream IS A PS program
  - **Program != static data**

Demo
“Programming language” aspect

- Programming languages 101:
  - Control statements
    - if/else
    - loop
    - while

- Simplest DoS attack is an “infinite loop”
  - *!%*
  - *{} loop*

Demo
“Dynamically typed concatenative" aspect

- You wonder why your smart IDS/IPS rules stopped working?

- Here is why:
  - ps_dynamic_statement_construction_and_execution.ps

- Solution:
  - Bad news: Need dynamic execution sandbox
  - Good news: It’s coming in upcoming weeks

Demo
Real world application – MSOffice PS crash

- Submitted to MS
- Apparently this one is not exploitable as in smash stack attacks
- But it opens an interesting perspective on MS Office…

Demo
Real world application – GhostScript autoprn

- One got to love custom extensions
- Send a print-job stream directly by mere opening the file
- Requires more investigation, but perspective is interesting…

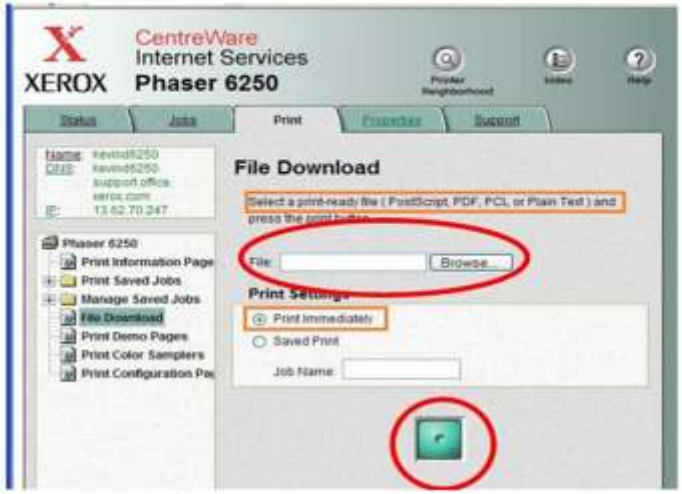
Dynamic document forging/generation + SocEng

```
product
(GPL Ghostscript) eq
{
userdict begin
DisplayImage
0 0
574 960
12
574 960
0
0
62689A5F659761649764679A6365985E6093606094656599616195626296606295 5E60935C5F92
...
}
{
% The malicious stuff goes here
}
ifelse
```

Computer side

The printer driver encountered an unexpected error – it has been logged.

Please print this document directly using printer convenient user interface.



Printer/MFP side

Dynamic document forging/generation + SocEng

User computer	User printout
Page 128 of 1024	Page 128 of 1024
...(some legal clauses trololo)...	...(some legal clauses trololo)...
The customer X agrees, by **signing the printout,**	The customer X agrees, by **signing the printout,**
to pay 100 EUR to the vendor Y	to pay 1000 EUR to the vendor Y
...(some more legal clauses trololo)...	...(some more legal clauses trololo)...

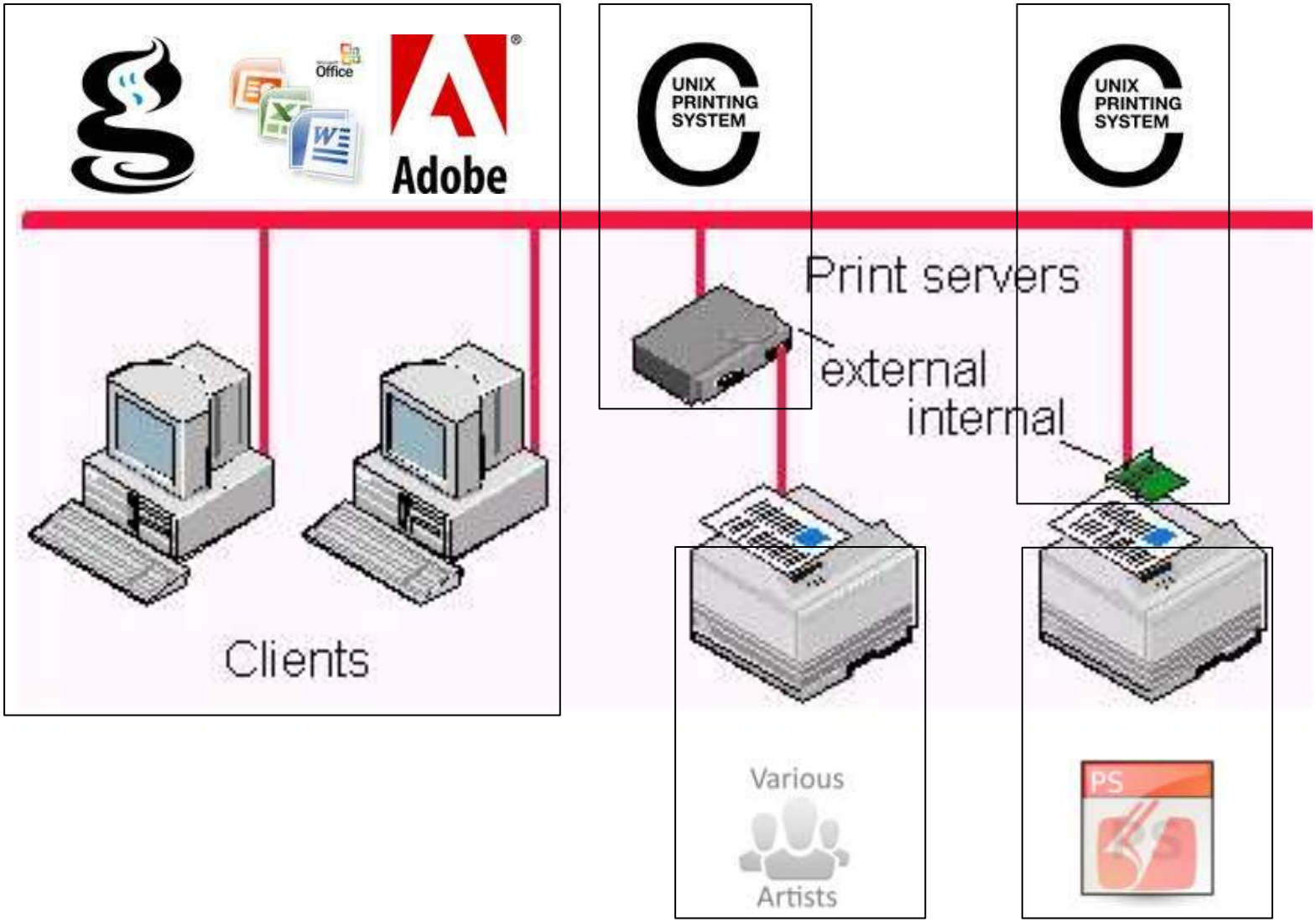
Where is PostScript? (Vendor-wise view)

Applications incorporating the PS interpreter

Applications/vendors producing the PS interpreter

The PS interpreter specifications and standards

Where is PostScript? (Role-wise view)



PostScript Web 2.0 Style

- PostScript made it into the web as well
- Around 20+ services found to be vulnerable to various degrees
  - Google was one them -> Bounty reward ☺
- Some fun facts
  - Effective for host exploitation and information gathering
  - Some ran GS as root user
  - Some ran GS without –dSAFER
  - All of them ran vulnerable GS versions
    - Heap and stack overflows
- More details to come…

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A PS-based firmware upload was required

Click the "Browse" button. In the resulting file open window, select the firmw
update file that is provided as part of this update package. Firmware update file
will have a file extension of ".ps". *Shown in the upper red oval.*

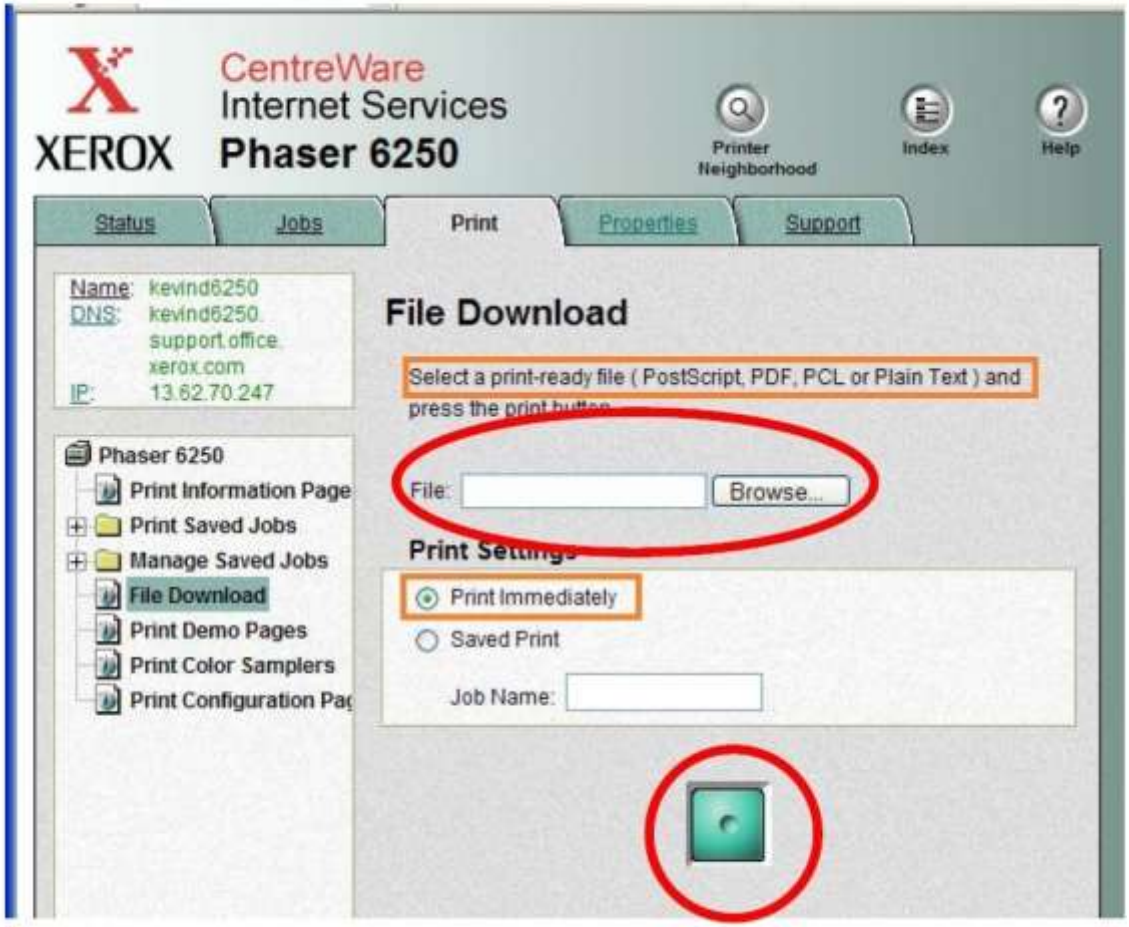
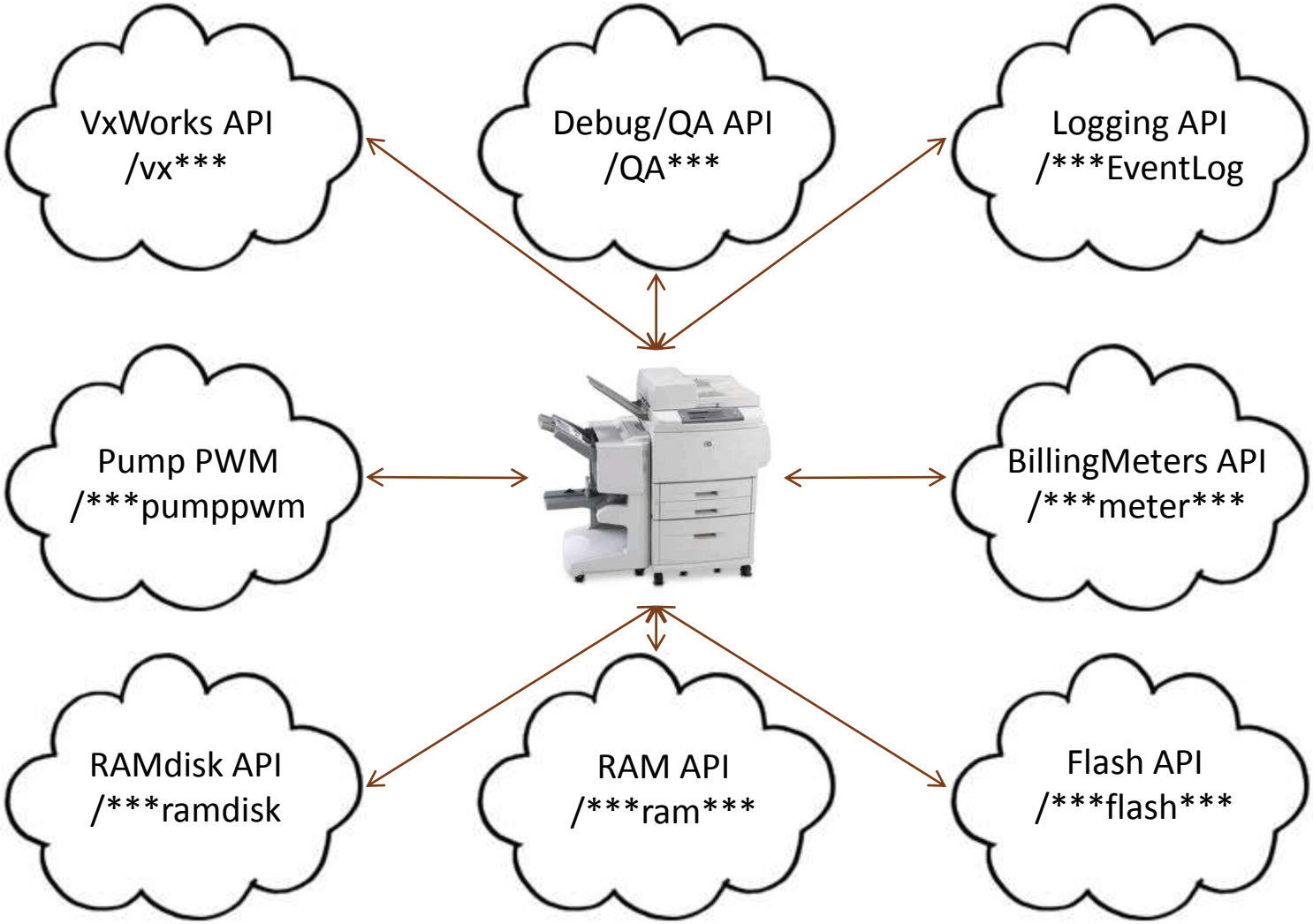
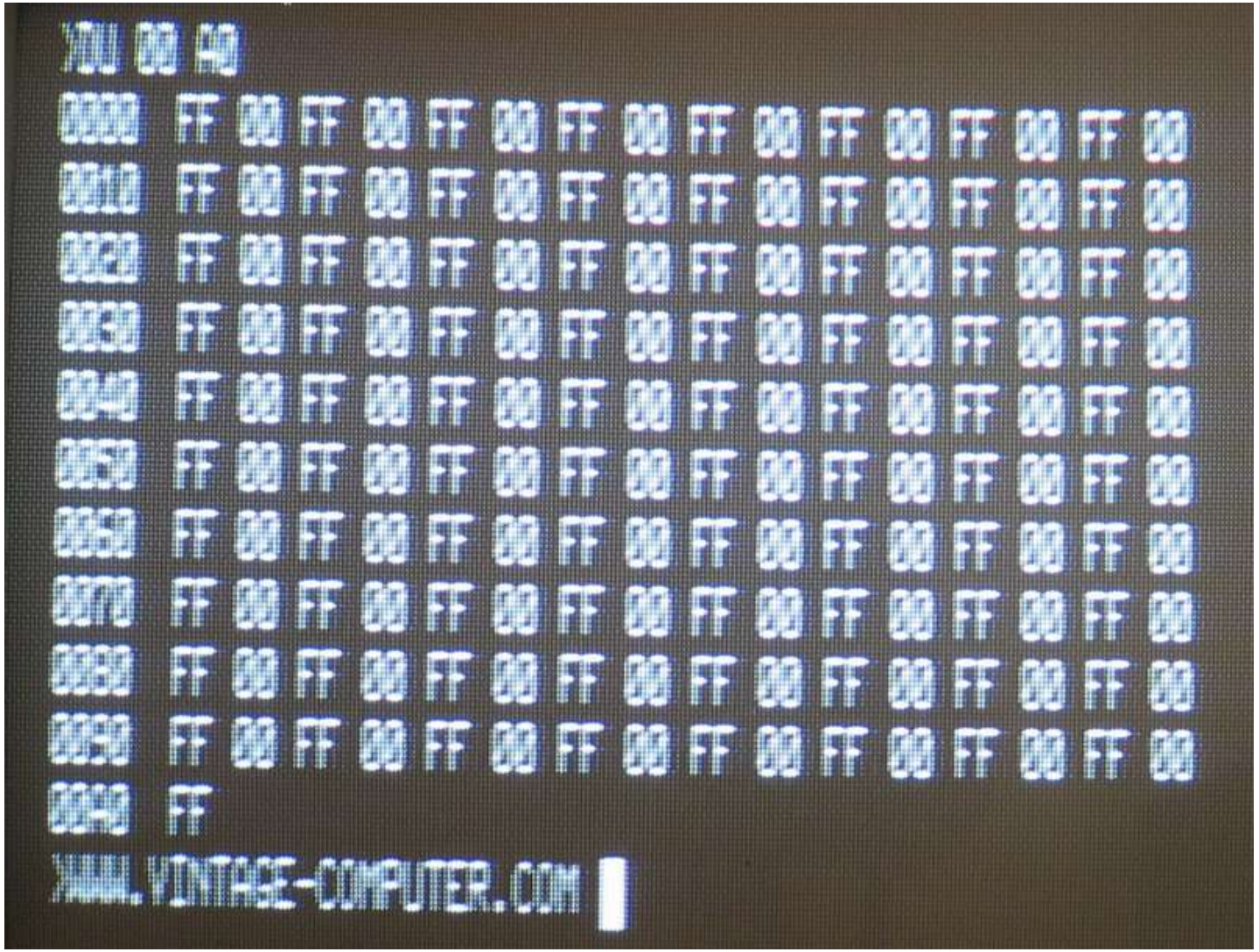


Figure 4: Select the firmware update file and press the green button to send it.

This is too good to be true….



Memory dumping reveals computing secrets



Admin restriction fail to prevent memory dumping

Password setup is sniffed by the attacker

Basic auth password can be dumped

3) Encoded password sniffed

1) Authorization: Basic YWRtaW4yO…

2) HTTP/1.1 200 OK

HTTPS / IPsec secrets are “defaulty” & “leaky”

```
IPSec AUTHKEY
    6630663066306630663066306630663066302222

/ramDrv/../ssl/private/clientkey.pem
    BJBgkqhkiG9w0BBQQwPDAbBgkqhkiG9w0BBQwwDgQIt/VXBECuFwMCAggA
    MB0GCWCGSAFlAwQBAgQQObFFTwd+A[illegible]+9U31Ngp/bgSCAoDoth9xVwlUwwLGrnPX
    ................................................................
    ................................................................
    ................................................................
    /zT8zr+wt1OHxSBj6WFqVXOwNFPkcsqfuUXxVJ+HcuaUuUpTsTlelBSDC2m5MM76
    hlTxO/Z9/pfF09zFXqOEdOukc3wRlU76b56fhupORKtyH9woAgT8a4pb8hYPUgsJ
```

0x6630663066306630663066306630663066302222

Attacker has access to printed document details

Attacker has access to network topology – no-scan

2) Network topology, attackable devices

1) Device discovery (SDP, UPnP)

Attacker has access to BSD-style sockets…

Two-way BSD-style sockets communication

Analyzed MFP cannot protect effectively

Protection measures	Fail / warn / ok
Privilege level separation	
Secure password setup	
Secure (basic) auth	
HTTPS, IPSEC secrets protection	
Network topology protection	
In-memory document protection	
Restrict sockets on unprivileged modules	

Plenty of Xerox printers share affected PS firmware update mechanism

Xerox Phaser 8560DN	Xerox ColorQube 8570DN
Xerox Phaser 8560DX	Xerox ColorQube 8570DT
Xerox Phaser 8560N	Xerox ColorQube 8870DN
Xerox Phaser 8560DT	Xerox Phaser 7760DN
Xerox Phaser 8560MFP/D	Xerox Phaser 7760DX
Xerox Phaser 8560MFP/T	Xerox Phaser 7760GX
Xerox Phaser 8560MFP/N	Xerox Phaser 7760GXM
Xerox Phaser 8560MFP/X	Xerox Phaser 4510B B/W
Xerox Phaser 8500N	Xerox Phaser 4510N B/W
Xerox Phaser 8500DN	Xerox Phaser 4510DT B/W
Xerox Phaser 8550DP	Xerox Phaser 4510DX B/W
Xerox Phaser 6360N	Xerox Phaser 5550B B/W
Xerox Phaser 6360DN	Xerox Phaser 5550N B/W
Xerox Phaser 6360DT	Xerox Phaser 5550DN B/W
Xerox Phaser 6360DX	Xerox Phaser 5550DT B/W
Xerox ColorQube 8570N	Xerox Phaser 8510

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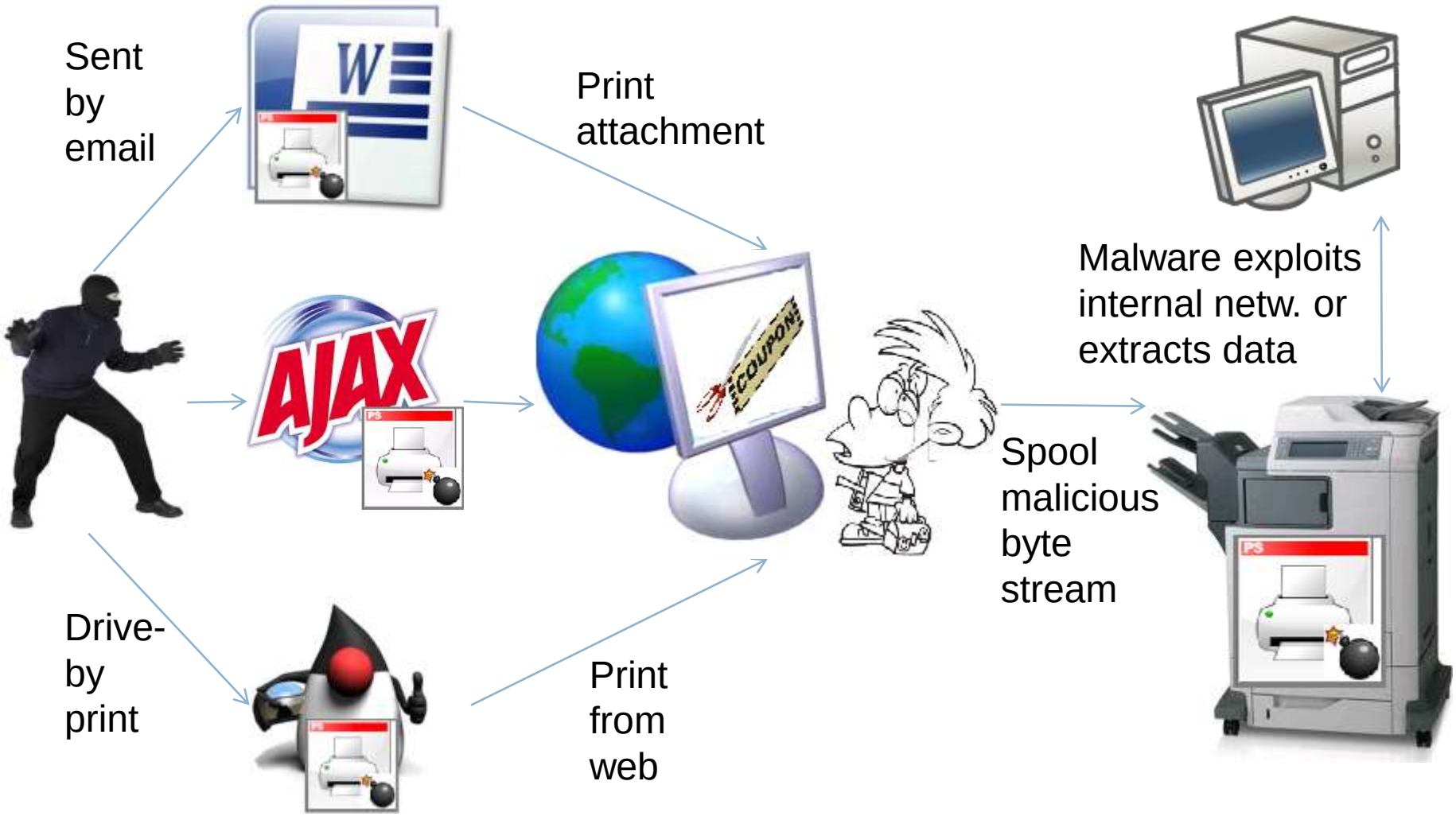
Remote attacks can be used to extract data

Stage 1 – SocEng **Stage 2 - Printing** **Stage 3 – Exploiting/spying**



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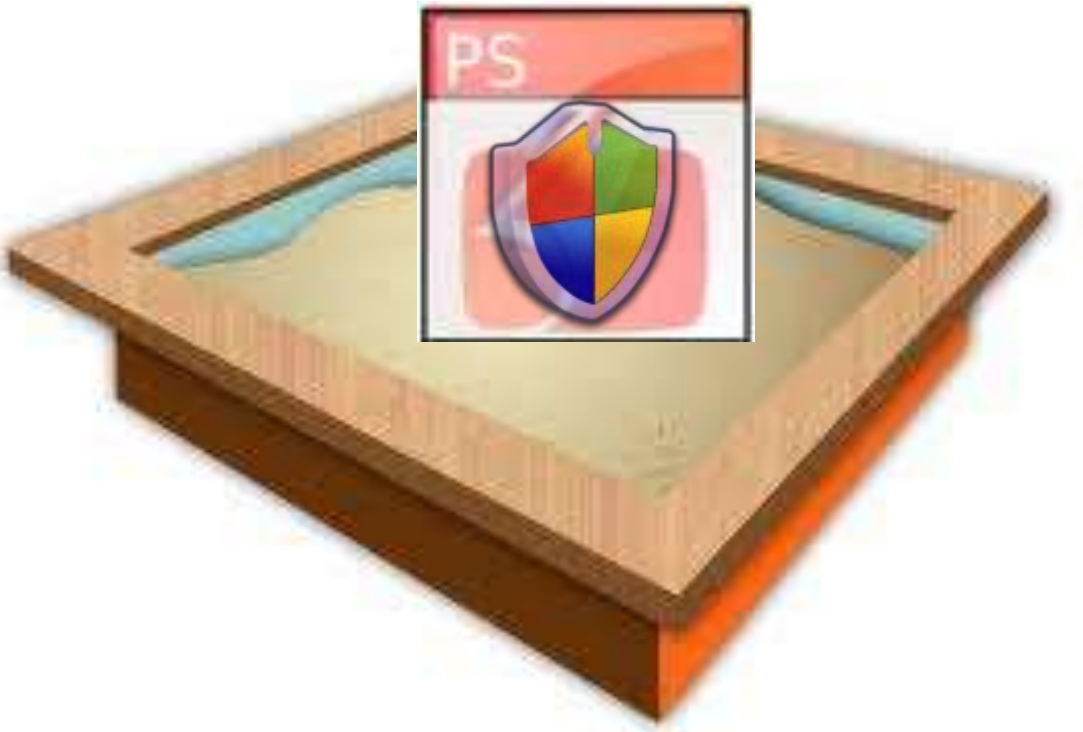
What's next? Upcoming weeks

- **Secure PostScript Execution/Interpreter Sandbox**
- Set of online/offline tools for analysis & reporting
- Wepawet-like, but for PostScript related data
- Perhaps have it part/along of IDS/IPS/AV/PrintServer data-flows



What's next? PS + MSF + FS + Sockets = PWN!

Solutions

Actor	Suggested actions
Admins	• **Disable PS processing on printers** • **Route print-jobs thru sandboxed print-servers** • **Replace PS drivers with PCL ones (well…)** • Disable Language Operator Authorization • Look for security bulletins and patch • Sandbox printers in your network • Include MFPs in security audit lifecycle
Users	• Do not print from untrusted sources • Be suspicious on PostScript files
Vendors	• Create realistic MFP threat models • Do not enable/expose super-APIs

Acknowledgements

The Xerox-related PostScript work & research done under support of

Thanks/resources

Xerox Security Team	Positive responses, active mitigation
www.tinaja.com	Insanely large free postscript resources dir
www.anastigmatix.net	Very good postscript resources
www.acumentraining.com	Very good postscript resources

Personal thanks

Igor Marinescu, MihaiSa	Great logistic support and friendly help

Take aways

- MFPs are badly secured computing platforms with large abuse potential
- Upcoming MFP attack could include viruses in Office and PS documents that extract organization data
- Securing the MFP infrastructure requires better segmentation, strong credentials, and continious vulnerability patching
- **Check upcoming research papers**
- **Check www.youtube.com/user/zveriu**

Questions?

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