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AppSec EU
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Waterfront
Conference
Center

Printer Security

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hgi NDS

http://www.nds.rub.de/

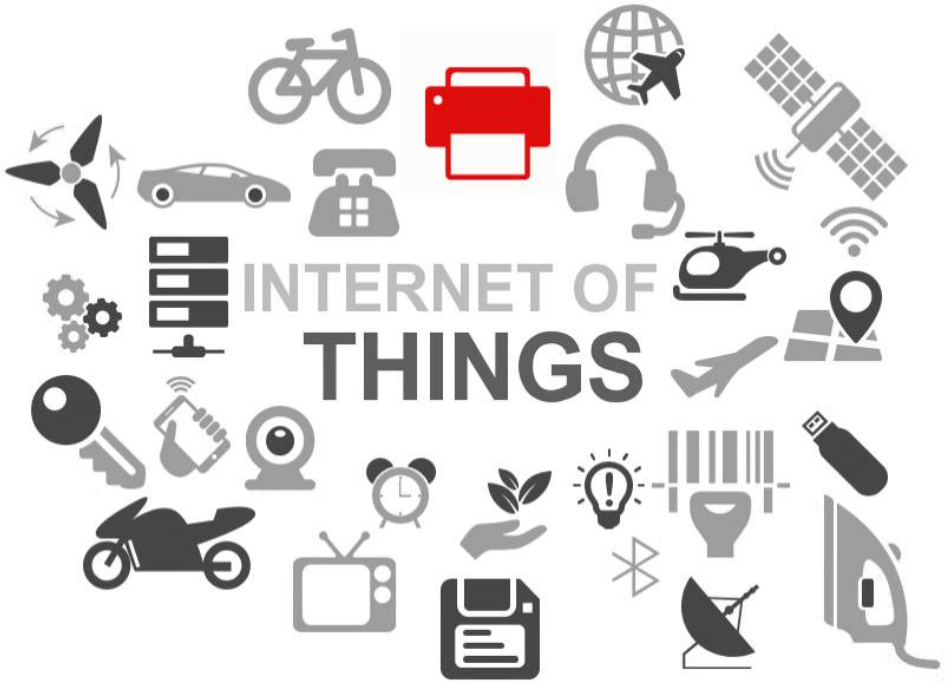
Why printers?

Evolution

1987

2017

Yet another T in the IoT?



Contributions

- Systematization of printer attacks
- Evaluation of 20 printer models
- PRinter Exploitation Toolkit (PRET)
- Novel attacks beyond printers
- New research directions

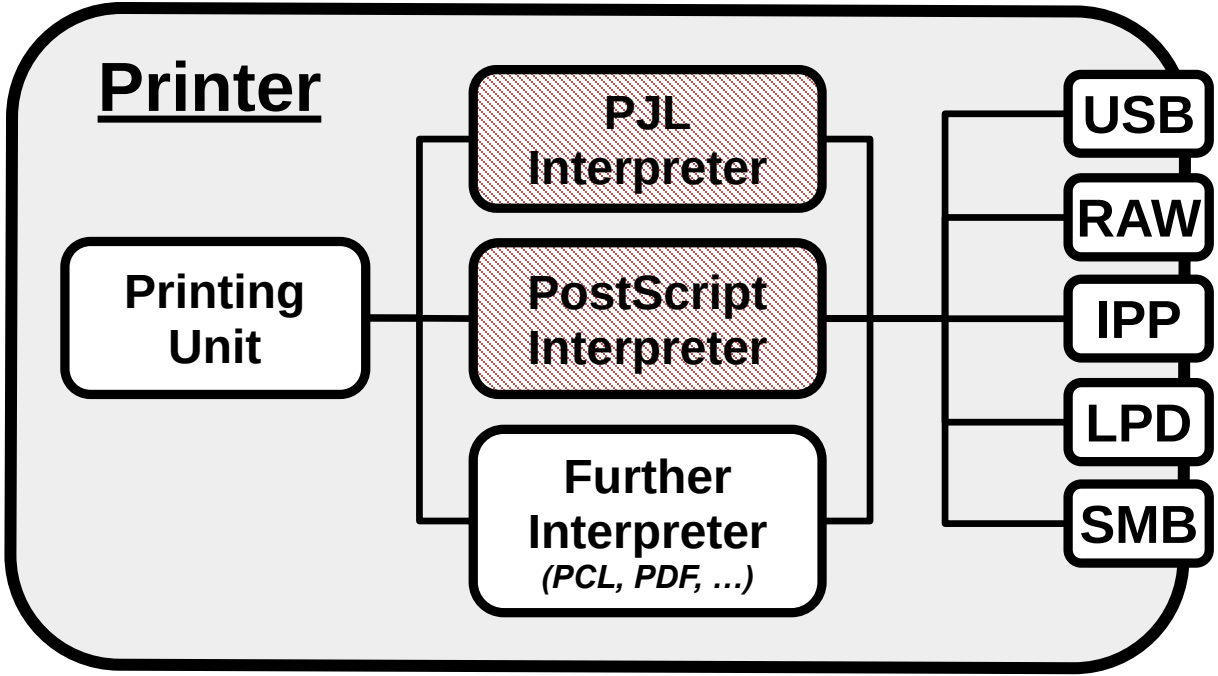
Overview

1. Background
2. Attacks
3. Evaluation
4. PRET
5. Beyond printers
6. Countermeasures

How to print?

1. Printing channel (USB, network, …)
2. Printer language (PJL, PostScript, …)

What to attack?



PJL

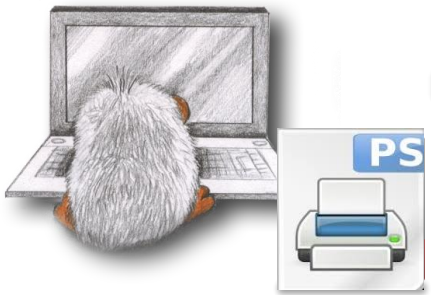
- Printer Job Language
- Manages settings like output tray or paper size

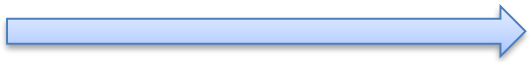
```
@PJL SET PAPER=A4
@PJL SET COPIES=10
@PJL ENTER LANGUAGE=POSTSCRIPT
```

- NOT limited to the current print job

PostScript

- Invented by Adobe (1982 – 1984)
- Heavily used on laser printers
- Turing complete language





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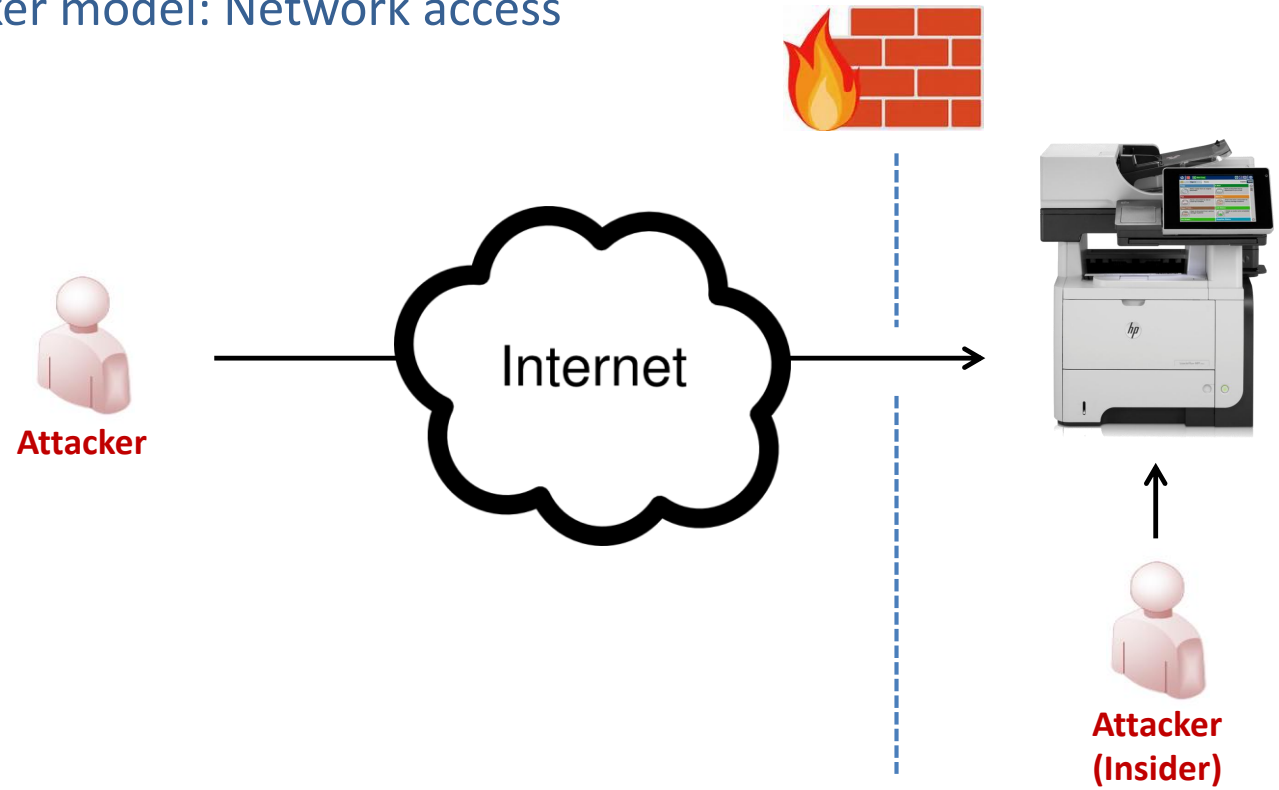
Attacker model: Physical access

- Is your copy room **always** locked?

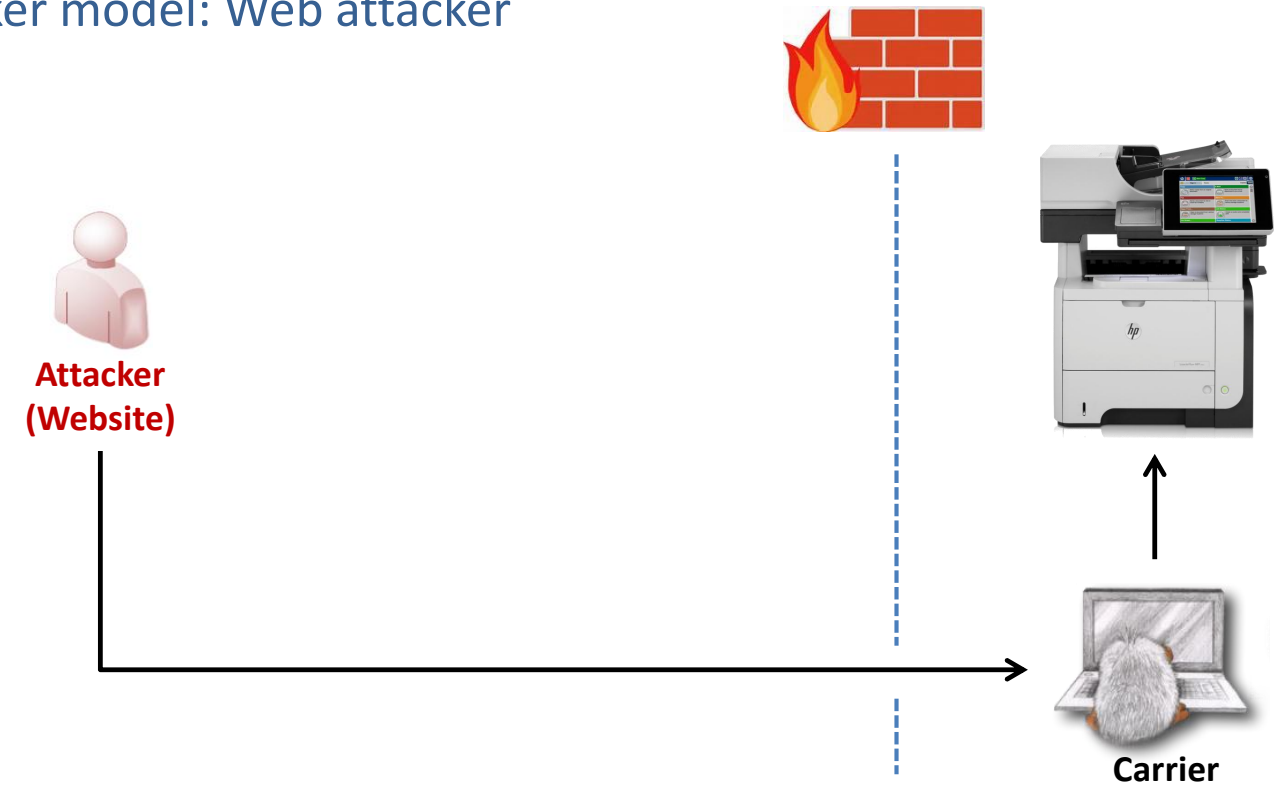
Attacker model: Network access

- Who would connect a printer to the Internet?

Attacker model: Network access



Attacker model: Web attacker



Four classes of attacks

- Denial of service
- Protection bypass
- Print job manipulation
- Information disclosure

Denial of service

- Postscript infinite loop

```
{} loop
```

Protection bypass

- Reset to factory defaults
- Can be done with a print job (HP)

```
@PJL DMCMD ASCIIHEX=
"040006020501010301040106"
```

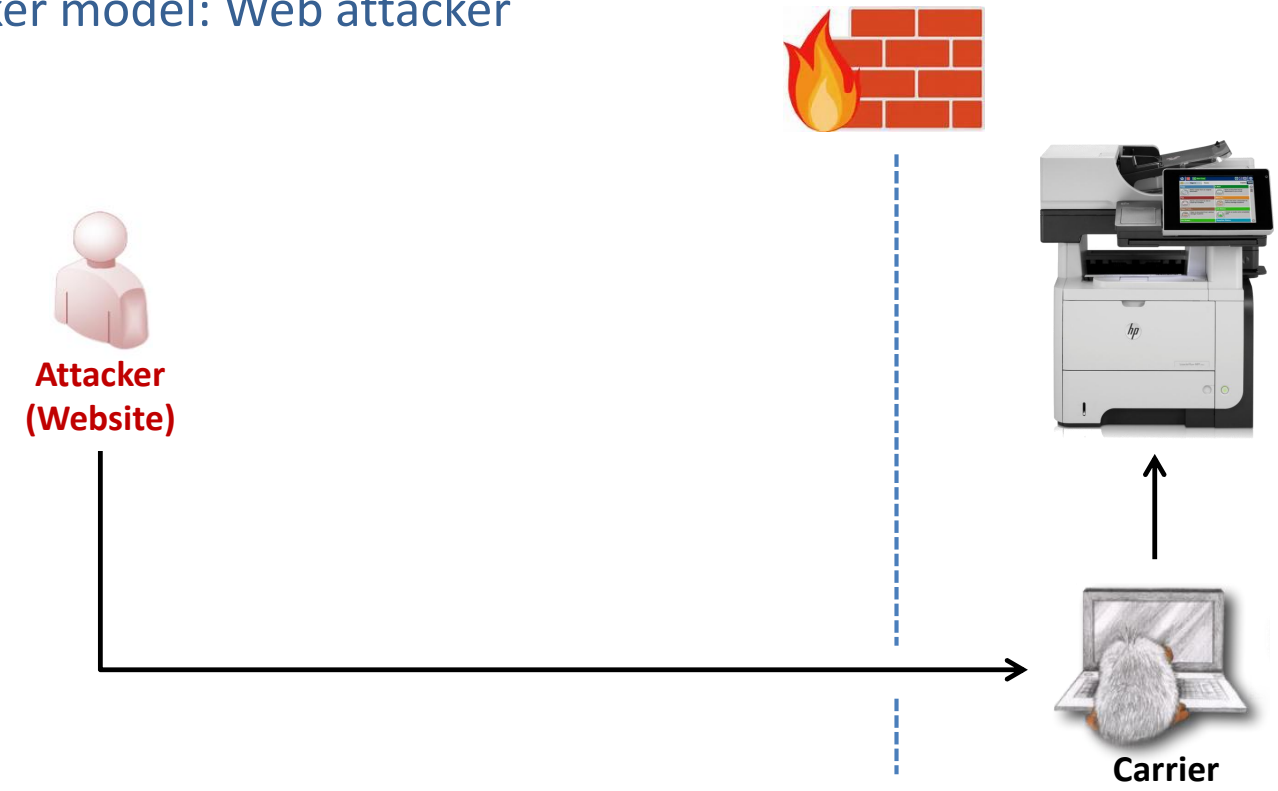
Print job manipulation

- Redefinition of Postscript *showpage* operator

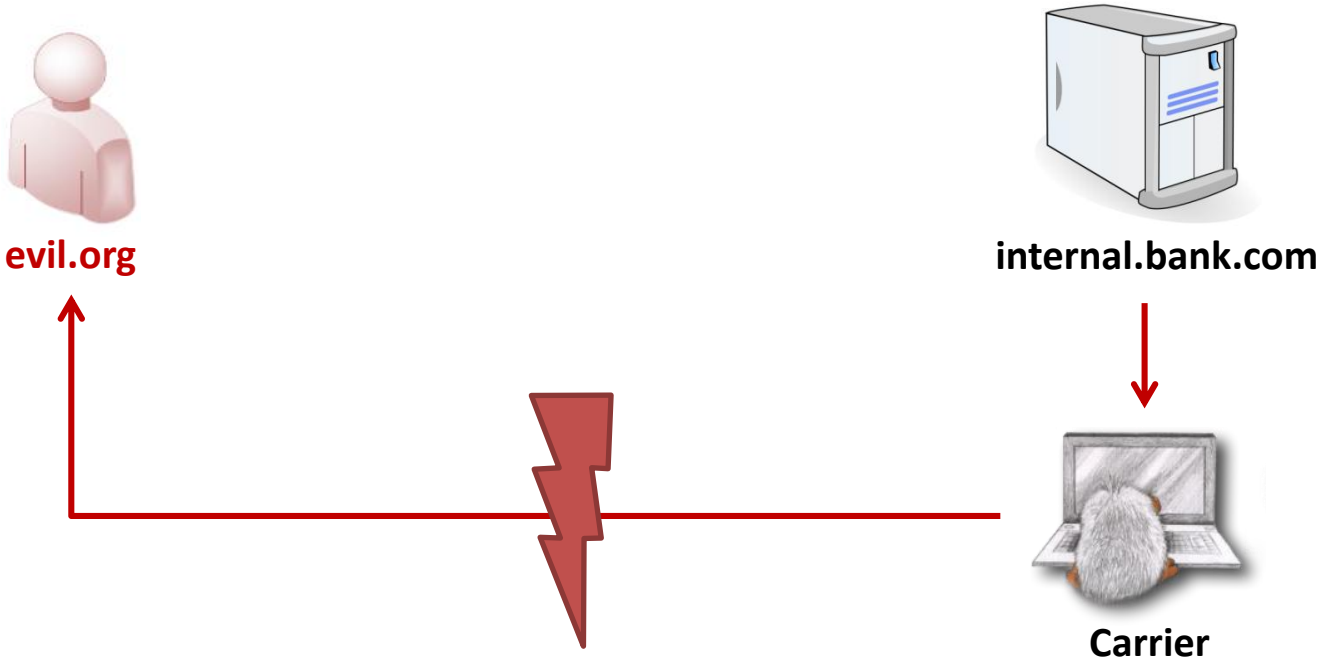
Information disclosure

- Access to memory
- Access to file system
- Capture print jobs
  - Save on file system or in memory

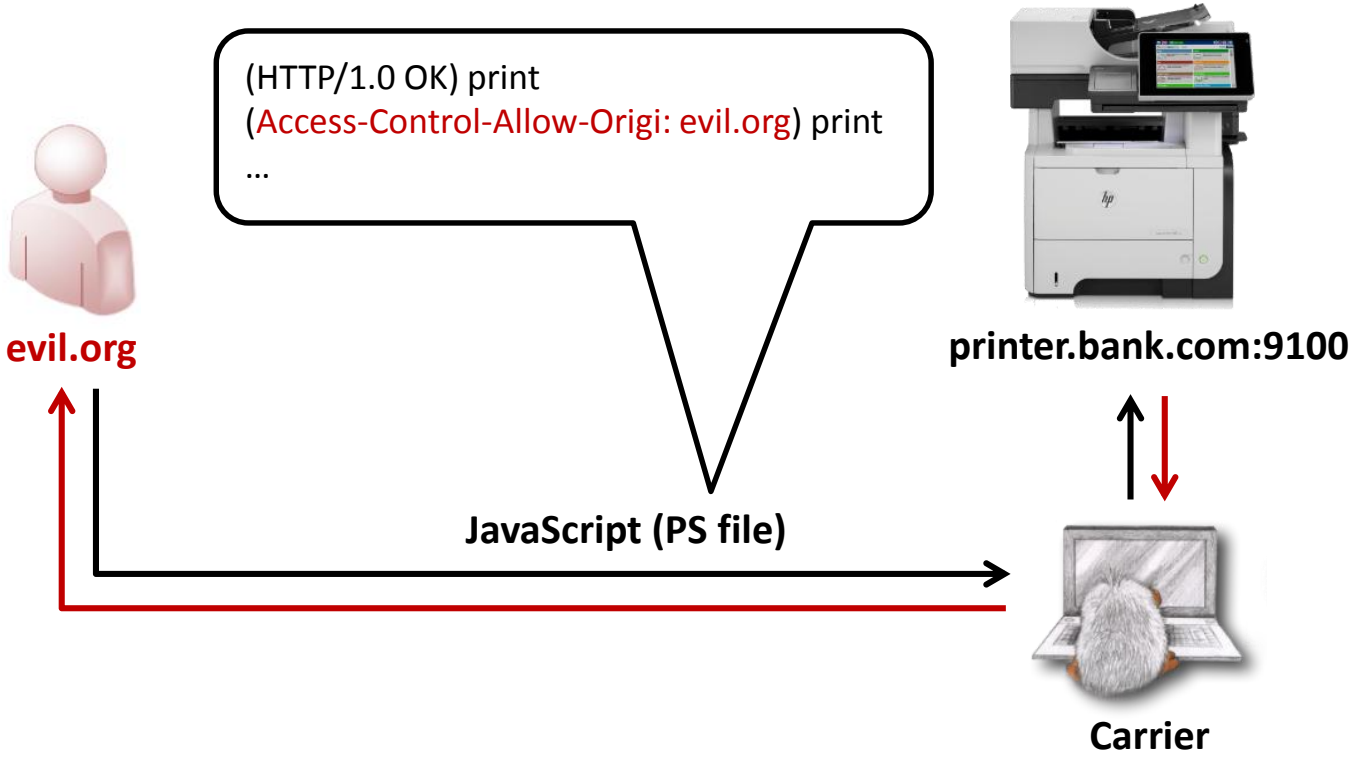
Attacker model: Web attacker



Same-origin policy



CORS spoofing



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Obtaining printers

- How would you proceed?

Our approach: Contacted university system administraators

Printers. Lots of printers

Evaluation results

Attack Categories		Denial of Service				Protection Bypass			Print Job Manipulation		Information Disclosure						# Printer Vulnerabilities
Attacks		infinite loop	showpage redefinition	offline mode	physical damage	restoring factory defaults			content overlay	content replacement	memory access	file system access		print job capture	credential disclosure		
Printers \ Printer Languages		PS	PS	PJL	PJL	SNMP	PML	PS	PS		PJL	PS	PJL	PS	PS	PJL	
1	HP LaserJet 1200	1	1						1	1				1	1*	1	7
2	HP LaserJet 4200N	1	1	1		1	1		1	1		1	1	1	1*	1	12
3	HP LaserJet 4250N	1	1	1		1	1		1	1		1	1	1	1*	1	12
4	HP LaserJet P2015dn	1	1			1	1	1*	1	1				1	1*	1	10
5	HP LaserJet M2727nfs	1*	1		1	1		1*	1	1				1	1*	1	10
6	HP LaserJet 3392 AiO	1	1			1	1	1*	1	1				1	1*	1	10
7	HP Color LaserJet CP1515n	1	1			1	1	1*	1	1				1	1*	1	10
8	Brother MFC-9120CN	1			1*			1*			1	1*			1	1	7
9	Brother DCP-9045CDN	1			1*			1*			1	1*			1	1	7
10	Lexmark X264dn	1	1	1		1			1	1		1*		1	1*	n/a	9
11	Lexmark E360dn	1	1	1	1*	1			1	1		1*		1	1*	n/a	10
12	Lexmark C736dn	1	1	1	1*	1			1	1		1*		1	1*	n/a	10
13	Dell 5130cdn	1	?		1				?	?		1*		1	1*	n/a	5
14	Dell 1720n	1	1	1	1	1		1*	1	1		1*		1	1*	n/a	11
15	Dell 3110cn	1	1					1*	1	1			1*			n/a	6
16	Kyocera FS-C5200DN	1	1	1		1			1	1		1*			n/a	1	8
17	Samsung CLX-3305W	1	?						?	?						n/a	1
18	Samsung MultiPress 6345N	1	?						?	?						n/a	1
19	Konica bizhub 20p	1		1	1*						1	1*			1	1	7
20	OKI MC342dn	1	1						1	1		1*	1*	1	1*	n/a	8
	# Vulnerable Printers	20	14	8	8	11	5	8	14	14	3	12	4	13	16	11	

Legend:

1	device vulnerable
1*	vulnerability is limited
	not vulnerable/PostScript feedback not available
?	not tested – physically broken printing functionality
n/a	no support for PostScript or PJL password protection

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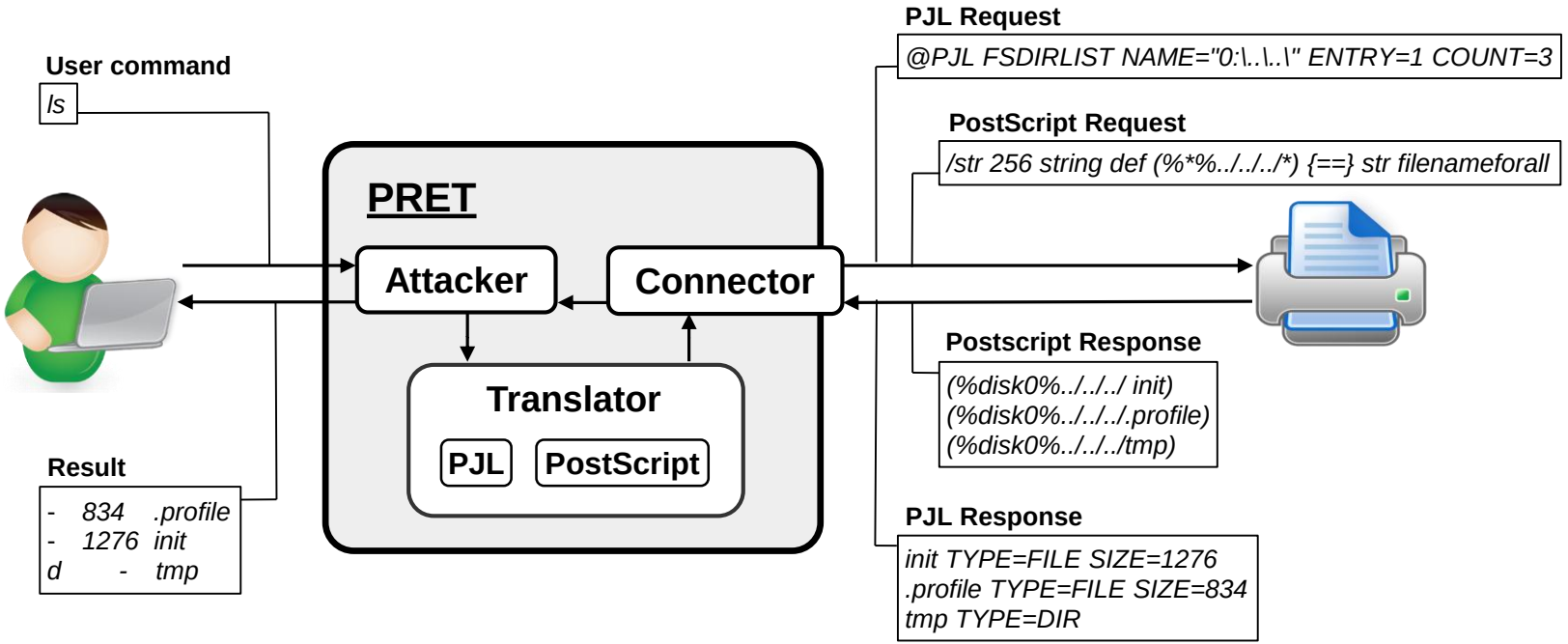
PRinter Exploitation Toolkit (PRET)



PRET commands

Command	PS	PJL	Description
`ls`	✓	✓	List contents of remote directory.
`get`	✓	✓	Receive file: get <file>
`put`	✓	✓	Send file: put <local file>
`append`	✓	✓	Append to file: append <file> <str>
`delete`	✓	✓	Delete remote file: delete <file>
`rename`	✓		Rename remote file: rename <old> <new>
`find`	✓	✓	Recursively list directory contents.
`mirror`	✓	✓	Mirror remote file system to local dir.
`touch`	✓	✓	Update file timestamps: touch <file>
`mkdir`	✓	✓	Create remote directory: mkdir <path>
`cd`	✓	✓	Change remote working directory.
`pwd`	✓	✓	Show working directory on device.
`chvol`	✓	✓	Change remote volume: chvol <volume>
`format`	✓	✓	Initialize printer's file system.
`fuzz`	✓	✓	File system fuzzing: fuzz <category>
`df`	✓	✓	Show volume information.
`free`	✓	✓	Show available memory.

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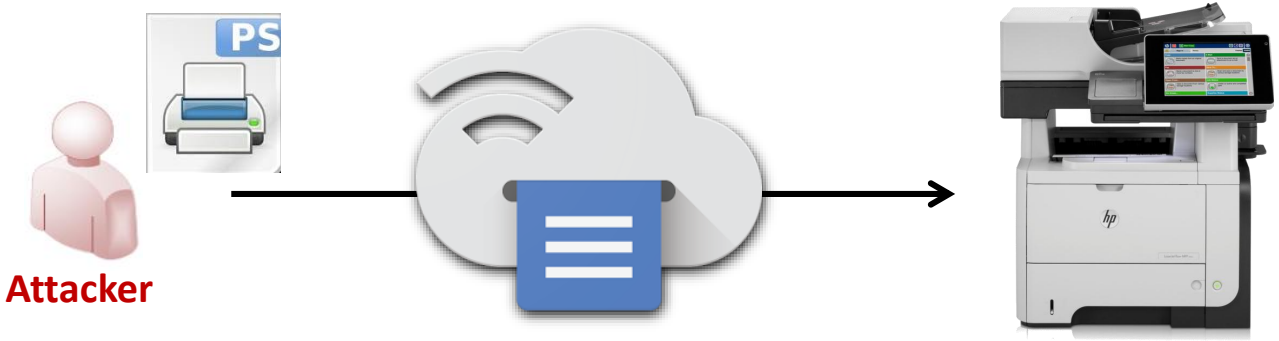
Google Cloud Print

Target: Google

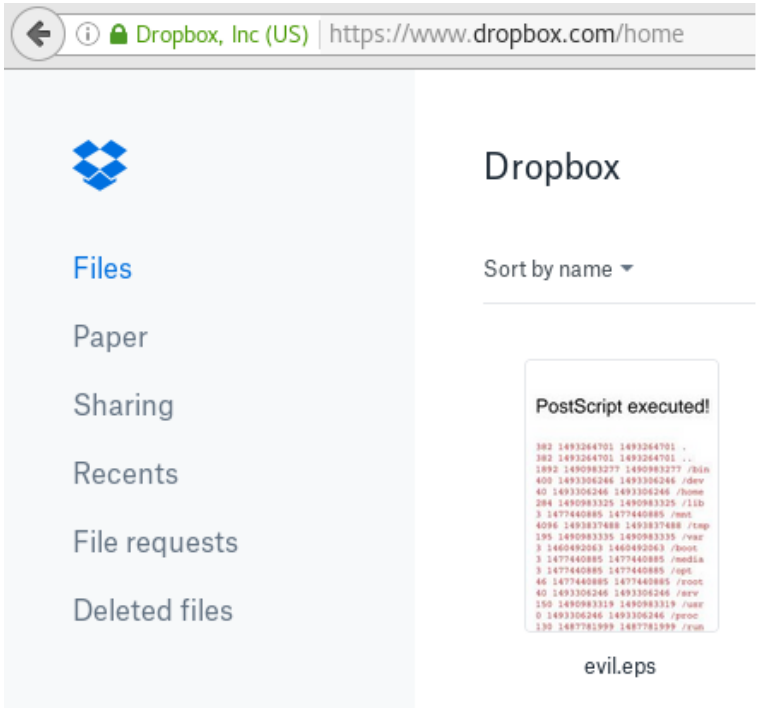
$ 3133.7



Converting PostScript = interpreting PostScript

PostScript in the web?

- PS conversion websites
- Image conversion sites
- Thumbnail preview



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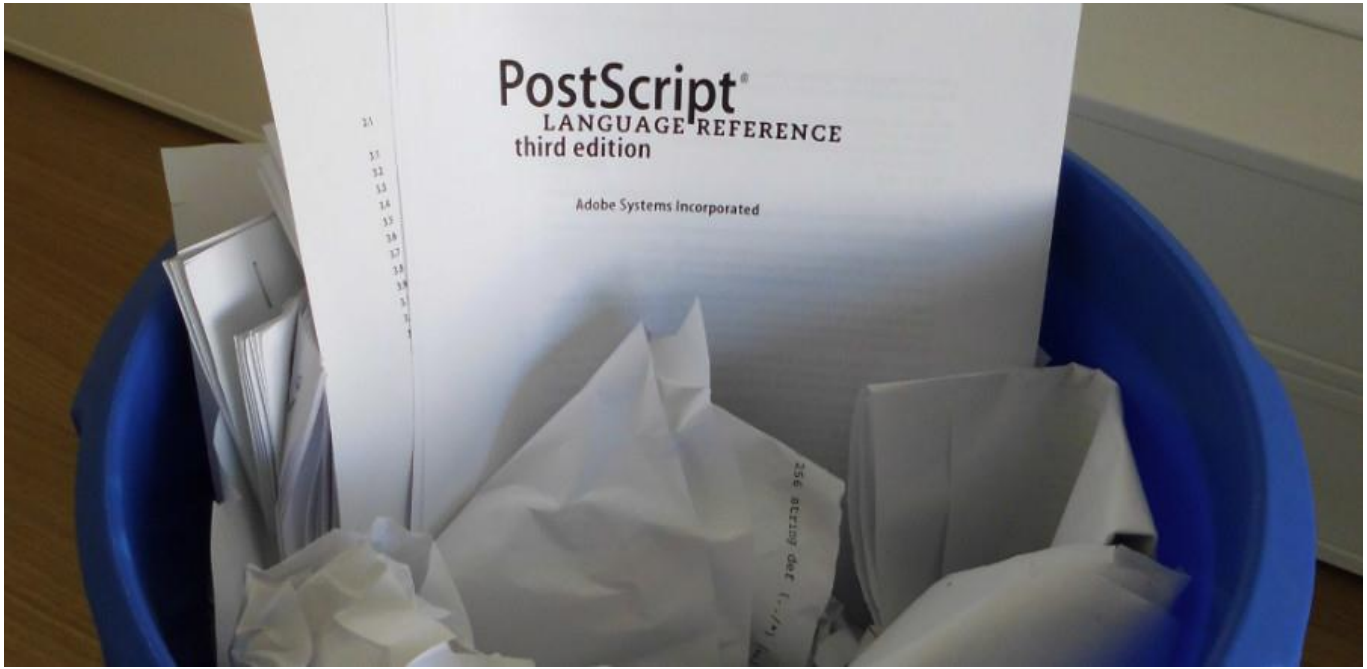
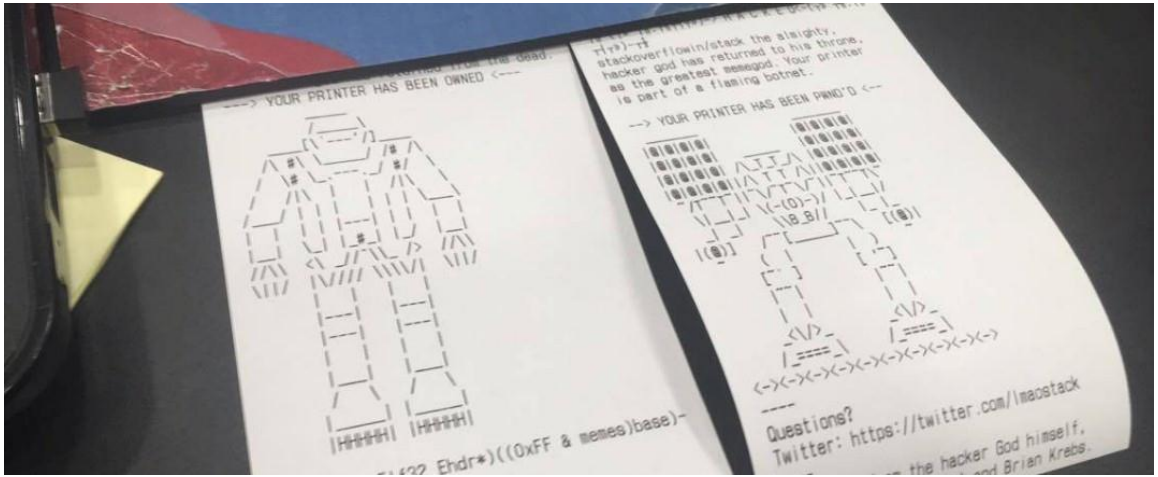
Countermeasures



Do not connect printers to the Internet

"Hacker Stackoverflowin made 160,000 printers spew out ASCII art around the world" -- [theregister.co.uk]



Countermeasures

- ***Employees***: always lock the copy room
- ***Administrators:*** sandbox printers in a VLAN accessible only via print server
- ***Printer vendors:*** undo insecure design decisions (PostScript, proprietary PJL)
- ***Browser vendors:*** block port 9100

Conclusions and future work

- Systematic analysis of network printers and printing standards
- Insecurity of Postscript and PJL
- Attacks applied to different areas
- TODO:
  - Firmware Updates, Fax, 3D printing

Thanks for your attention...

PRET („**Pr**inter **E**xploitation **T**oolkit“)

- https://github.com/RUB-NDS/PRET

Hacking Printers Wiki

- http://hacking-printers.net/

Questions?