Print to Play

Printers are possibly the most hated appliances, right up there with washing machines. However, high-end laser printers[1] can interpret PostScript, a vintage, stack-based, Turing-complete programming language[2]. Can we make printers cool again?

1 Interactive PostScript

PostScript printers[1] listen on port 9100 for raw printing. Quick test: print a blank page by sending this raw PostScript command using netcat: `echo "showpage" | nc 172.16.158.40 9100`.

While PostScript wasn't designed to be interactive, you can enter "executive mode" by sending two lines (or this one-liner[3]). After that, type commands directly – they'll be interpreted on the fly.

```
nc 172.16.158.40 9100
%!PS
executive

KONICA MINOLTA bizhub 4422
Version 3011.010
PS> 1 2 add ==
3
```

A PostScript program can even read user input as if from a file, using `(%lineedit) (r) file ( ) readline`. With that, you have everything needed to write advanced interactive programs such as "*Guess a number*".

2 Tic Tac Toe

By combining user interactions and PostScript's graphic capabilities, we can implement a Tic-Tac-Toe game[4]. Algorithm 1 is quite simple yet still "fun" to play against, featuring random behavior from the printer.

Algorithm 1 Printer Tic-Tac-Toe Logic

1: **loop**
2:     **if** game is over **then**
3:         **exit**
4:     **else if** printer can win with X **then**
5:         play X there
6:     **else if** human can win with O **then**
7:         play X there
8:     **else**
9:         play randomly
10:     **end if**
11:     get human input
12: **end loop**

[1]Tested on Konica Minolta Bizhub 4422 and RICOH M C240FW. Your mileage may vary.

[2]Unfamiliar with PostScript programming? check out https://seriot.ch/projects/programming_in_postscript.html

[3] `(echo $'%!PS\nexecutive\n'; cat) | nc 172.16.158.40 9100`

[4]https://github.com/nst/PSTicTacToe

3 Upload Game to Printer

We can even store programs directly inside the printer, exploiting a little known PostScript capability. Listing 1 embeds the minified Tic-Tac-Toe program. Save it in `x.ps`, then send it to the printer: `cat x.ps | nc 172.16.158.40 9100`. `x.ps` will act as a vector and leave its payload `ttt.ps` on the printer's file system[5].
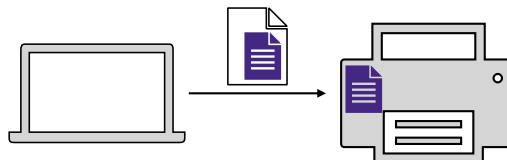

```
% a handwritten Tic-Tac-Toe program stored in a string
/prog(/d{def}def/e{exch}d/M{moveto}d/O{pop}d/g{getinterval
}d/l{length}d/L{lineto}d/I{if}d/P{putinterval}d/D(1234567\
89)d/nf{0 b{46 eq{1 add}I}forall}d/R{/q false d 0 1 8{/i e
d/A b dup l string cvs d A i 1 g(.)eq{[(X)(O)]{/p e d A i
p P A B{b i(X)P/q true d exit}I}forall}I q{exit}I}for q}d
/Q{/x rand nf mod d/c 0 d 0 1 b l 1 sub{/i e d b i 1 g(.)
eq{c x eq{b i(X)P exit}I/c c 1 add d}I}for}d/r{{(human (1\
-9)>)print flush(%lineedit)(r)file(_____)readline O dup
l 0 gt{0 1 g}{O ( )}ifelse/o e d D o search{O O O b o cvi
1 sub 1 g(.)eq{o cvi 1 sub exit}I}{O}ifelse(bad input)= S}
loop}d/B{/z e d/N[[0 1 2][3 4 5][6 7 8][0 3 6][1 4 7][2 5
8][0 4 8][2 4 6]]d/V false d[(O)(X)]{/p e d N{/T e d/V
true d T{/U e d/V z U 1 g p eq V and d}forall V{exit}I}
forall V{exit}I}forall V}d/S{0.2 setlinewidth 10 10 scale
20 70 M 20 40 L 30 70 M 30 40 L 10 60 M 40 60 L 10 50 M 40
50 L stroke 0 1 b l 1 sub{/i e d b i 1 g(.)ne{gsave 10 i 3
mod 10 mul add 3 add 70 i 3 idiv 10 mul sub 7 sub M b i 1
g show grestore}I}for m null ne{10 30 M m show}I showpage}
d/C{/E e d/K e d/m null d nf 0 eq{/m(TIE)d/E true d}I b B{
/m(_____WINS)d m 0 K P/E true d}I E{S}I m null ne{quit}
I}d/Courier findfont 5 scalefont setfont/b D d/m(HUMAN PL\
AYS O)d S/b(.........)d{/m null d b r(O)P(__HUMAN) false C
R not{Q}I(PRINTER)true C}loop)def

% leave the program on the printer's file system
/f (ttt.ps) (w) file def
f prog writestring f flushfile f closefile
```

Listing 1: A PostScript program that will save a Tic-Tac-Toe game as `ttt.ps` on the printer's file system.

4 Results and Future Work

You can now play against the printer by entering executive mode and typing `(ttt.ps) run`. Human starts and plays O, choosing squares 1–9 in the shell. Printer will print its own moves on paper. Good luck!

Next steps: go hunt for corporate printers waiting for your programs[6] on port 9100, and show your colleagues that printers *are* cool again. Washing machines? Not yet.

	O	X
	O	
O	X	X

[5]Type `(ttt.ps) deletefile` to delete `ttt.ps`.

[6]See also https://github.com/nst/PSChess