Evolution of Smile

a genetic algorithm hardware implementation

PROJECT OVERVIEW

Genetic Algorithms:

- algorithms for complex optimization problems, learnt from biological evolution.

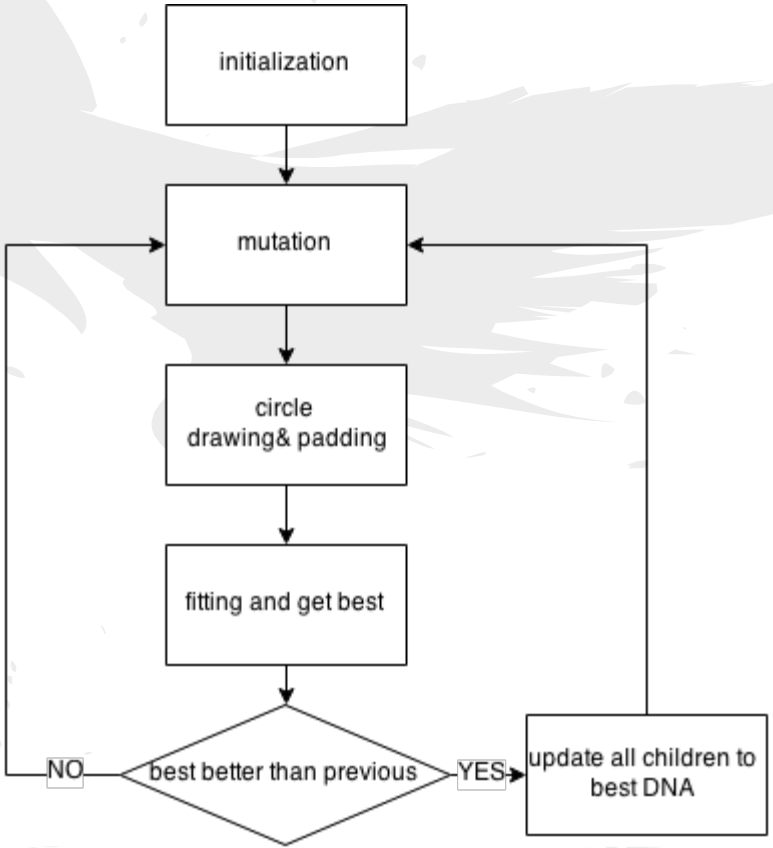
Objective:

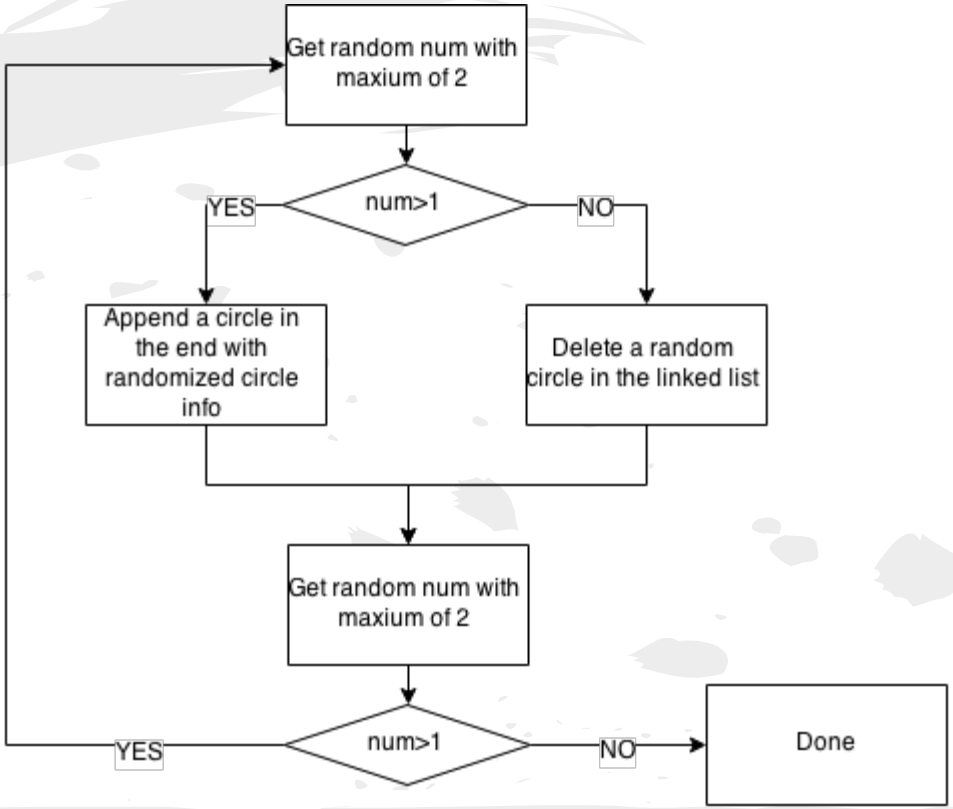
- Demonstrate Genetic Algorithm
- Accelerate the algorithm with FPGA implementation

Project Introduction:

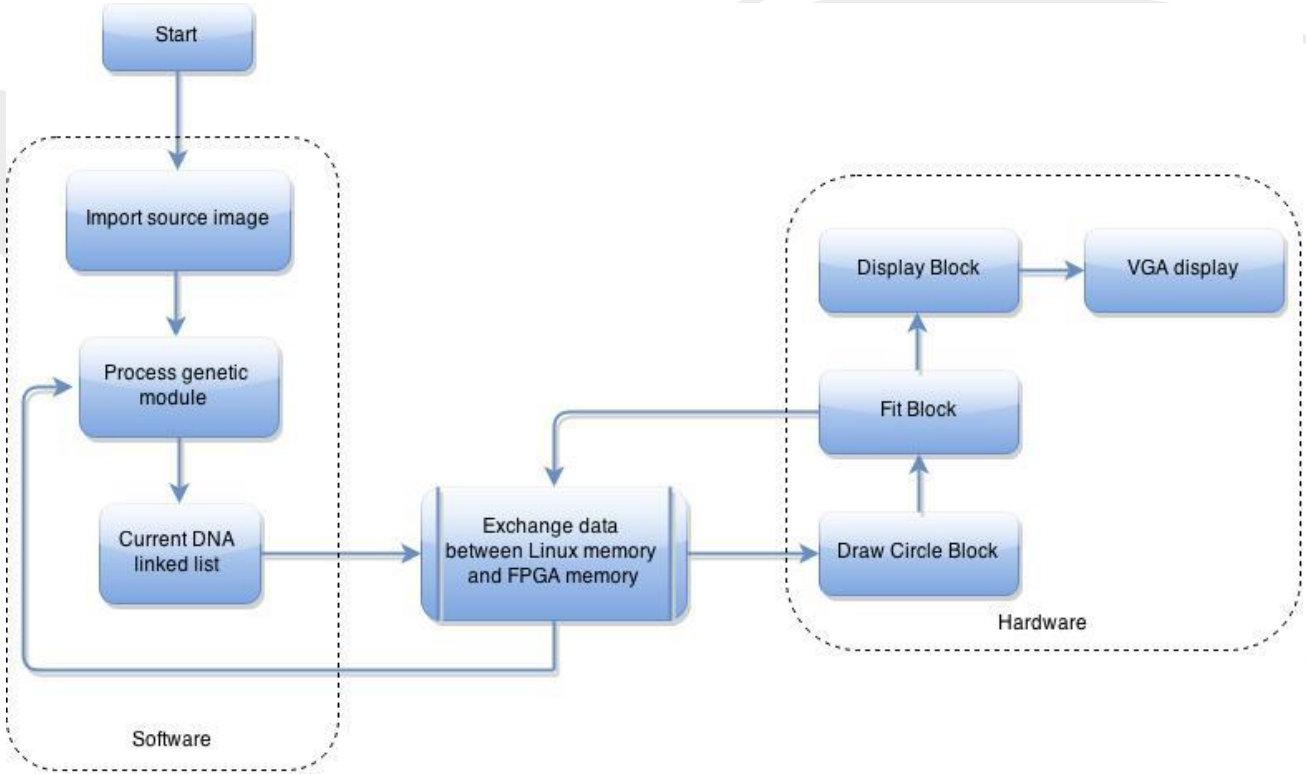
- generate Mona Lisa or any other images with circles which are generated randomly in DNA sequence

ALGORITHM INTRODUCTION





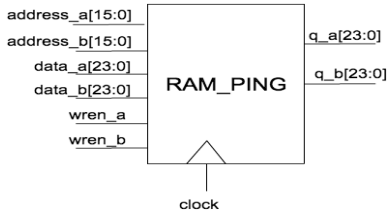
ARCHITECTURE

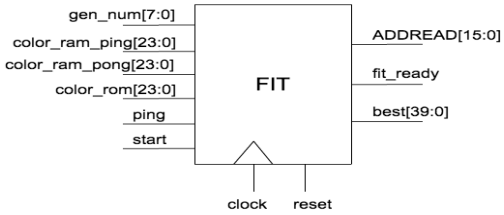


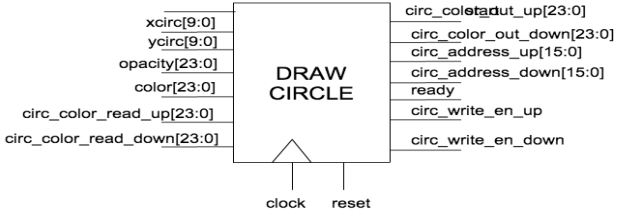
Software Timing

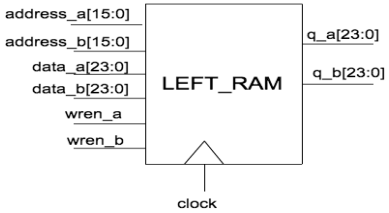
- Draw circle pipelining
- Rest parts in sequential

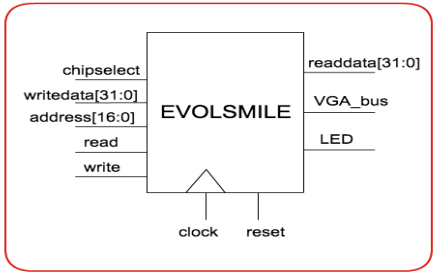
Hardware Overview

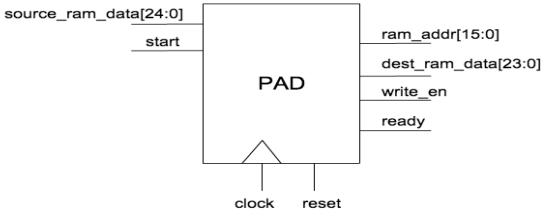


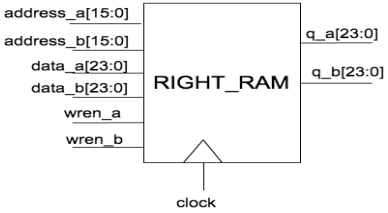


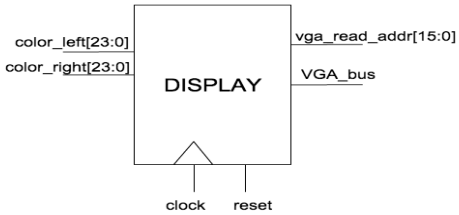


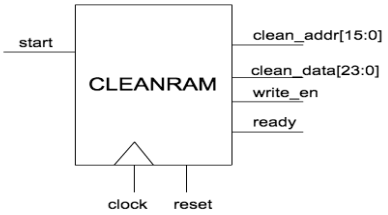




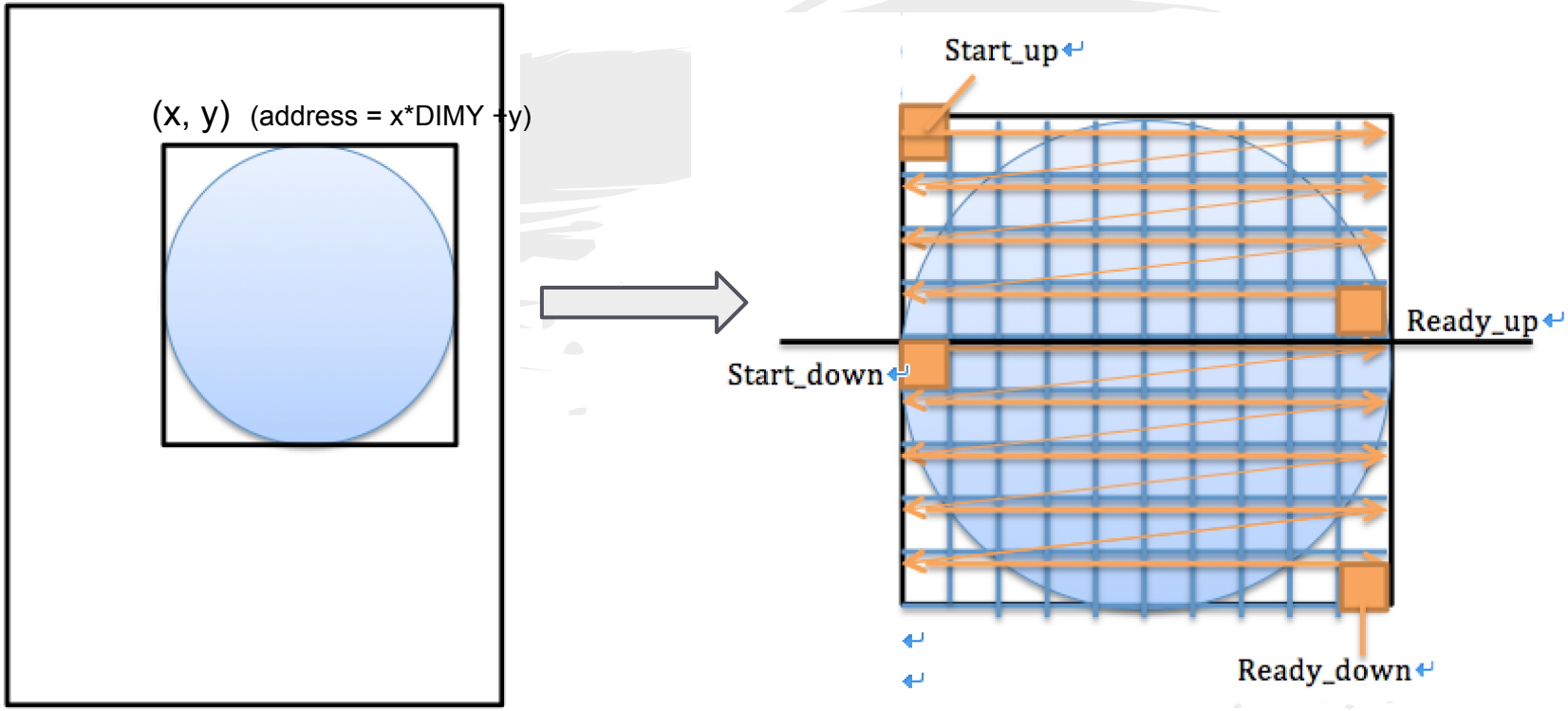




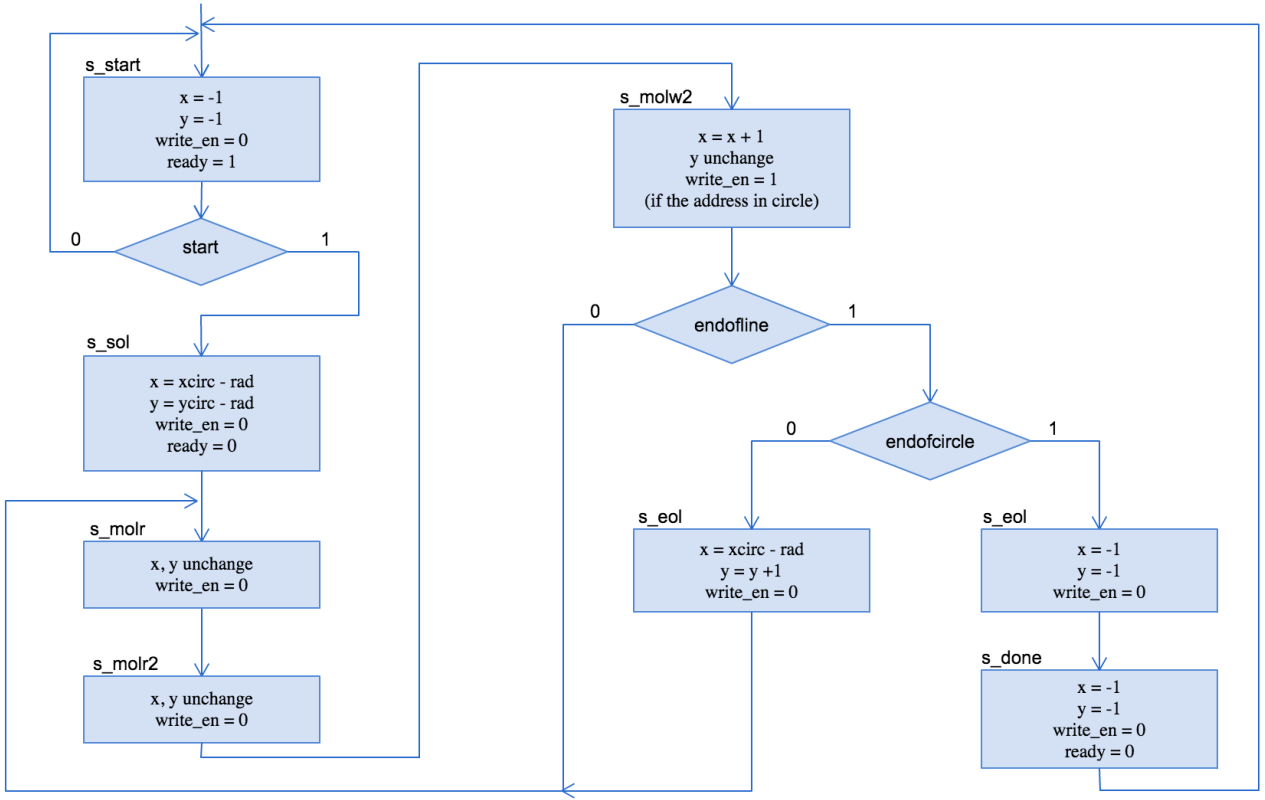




HARDWARE----DRAWCIRCLE



HARDWARE----DRAWCIRCLE

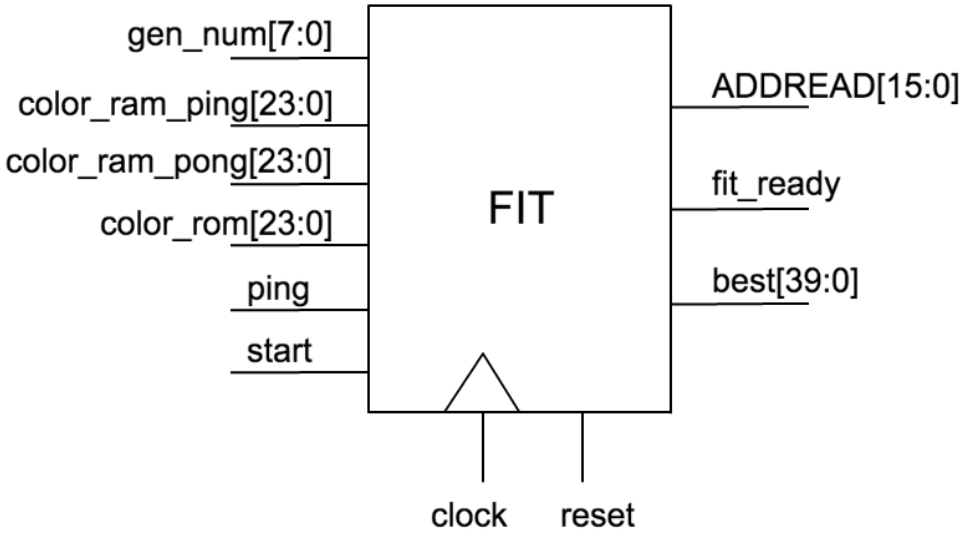


HARDWARE----FIT

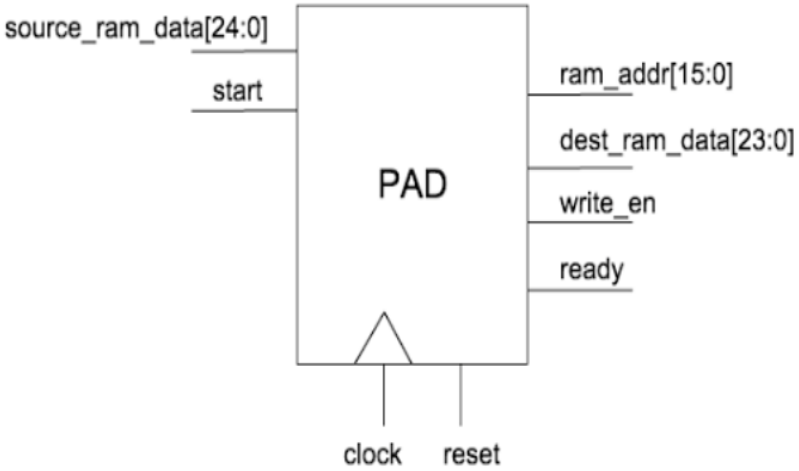
- Coordinate x, y indicate address
- best[39:32]: index of the best case
- best[31:0]: optimal difference
- Challenge:

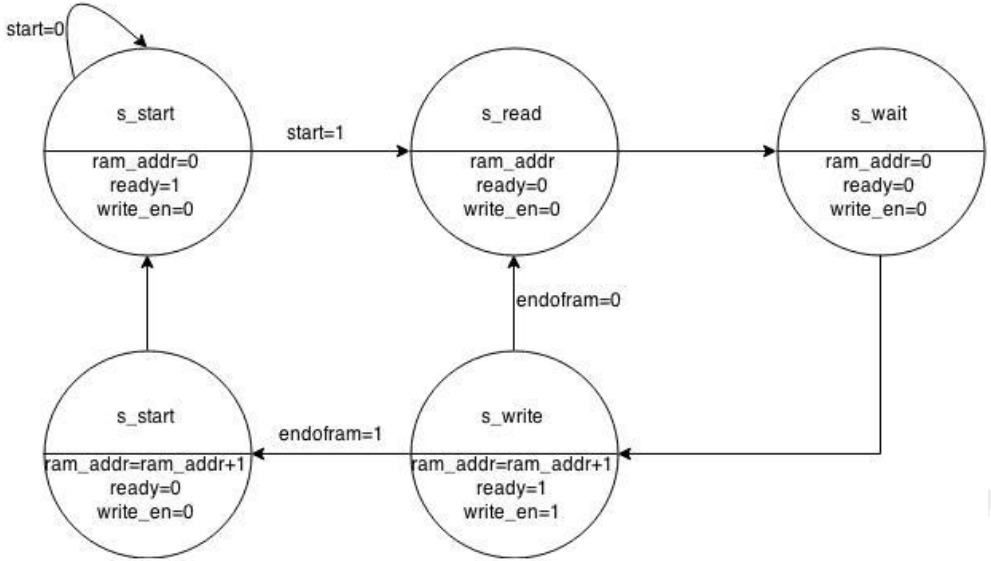
  RAM reading timing

  Parallelism (port limited)



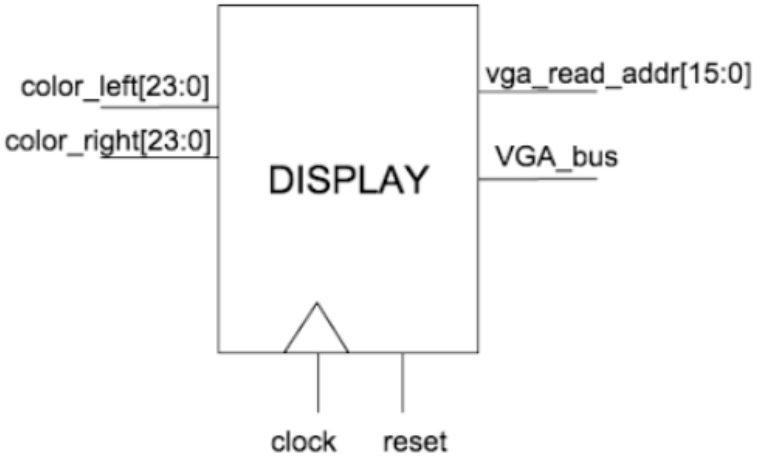
HARDWARE----PAD





HARDWARE----VGA display

- vga_emulator module
- display module
- vga_read_addr = (x - XL) * DIMY + (y - YL)



HARDWARE----EVOLSMILE

- Moore State Machine

```
typedef enum{s_draw_on_ping,
                s_clean_ping,
                s_cp_ping_disp,
                s_fit_ping,
                s_write_left,
                s_write_right,
                s_write_tmp} state;
```

- 17-bit address bus

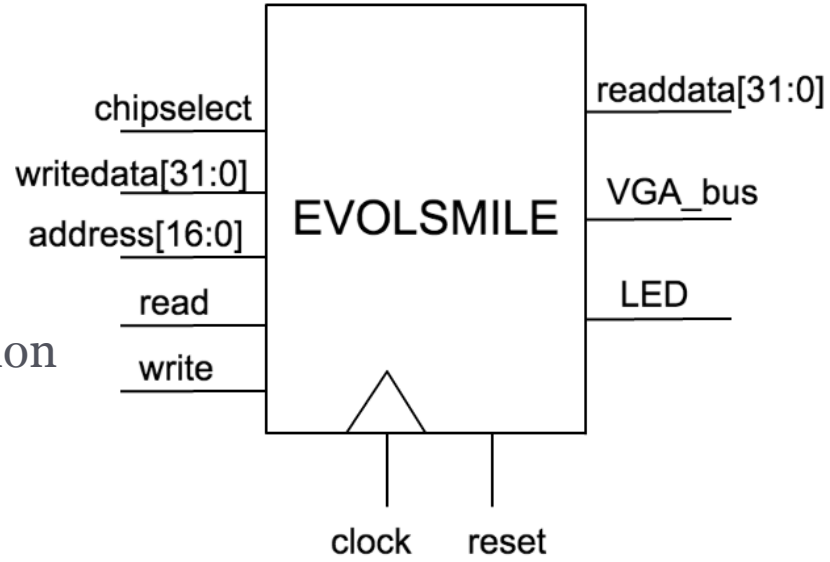
  write: State transition; Data configuration

  read: Start signal; Data read out

- Debug:

  LED indicate state

  Extra states test sub-module



Performance(Memory)

Pure software version

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM
1039	root	20	0	26384	24m	376	R	99.0	2.4

Accelerated version

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM
1034	root	20	0	1676	828	348	R	94.0	0.1

Performance(Time)

% time	cumulative seconds	self seconds	calls	self ms/call	total ms/call	name
81.56	1.15	1.15	100	11.50	11.50	fitness
10.64	1.30	0.15	100	1.50	1.50	allocateImage
3.55	1.35	0.05	85815	0.00	0.00	resolveColor
2.13	1.38	0.03	89	0.34	0.90	drawCircle
0.71	1.39	0.01	124400	0.00	0.00	write_reg
0.71	1.40	0.01	1	10.00	15.00	loadTarget
0.71	1.41	0.01	1	10.00	11.80	redraw
0.00	1.41	0.00	793	0.00	0.00	rnd
0.00	1.41	0.00	193	0.00	0.00	countCircles
0.00	1.41	0.00	103	0.00	0.00	cloneCircles
0.00	1.41	0.00	100	0.00	0.90	mutate
0.00	1.41	0.00	99	0.00	0.00	cloneImage
0.00	1.41	0.00	99	0.00	0.00	freeCircles
0.00	1.41	0.00	1	0.00	0.00	init
0.00	1.41	0.00	1	0.00	5.00	writebest
0.00	1.41	0.00	1	0.00	5.00	writetest

% time	cumulative seconds	self seconds	calls	self ms/call	total ms/call	name
40.00	0.02	0.02	339011	0.00	0.00	read_reg
40.00	0.04	0.02	1	20.00	20.00	loadTarget
20.00	0.05	0.01	102	0.10	0.16	clean
0.00	0.05	0.00	60660	0.00	0.00	write_reg
0.00	0.05	0.00	793	0.00	0.00	rnd
0.00	0.05	0.00	102	0.00	0.16	redraw
0.00	0.05	0.00	100	0.00	0.00	cloneCircles
0.00	0.05	0.00	100	0.00	0.13	fit
0.00	0.05	0.00	100	0.00	0.00	mutate
0.00	0.05	0.00	99	0.00	0.00	freeCircles
0.00	0.05	0.00	93	0.00	0.00	countCircles
0.00	0.05	0.00	89	0.00	0.00	draw
0.00	0.05	0.00	1	0.00	0.19	copy
0.00	0.05	0.00	1	0.00	0.00	init
0.00	0.05	0.00	1	0.00	0.00	writeright

Further improvement

- Not enough storage space
- Further pipelining
- Internal state auto-switching

SUMMARY

- Large extent speed accelerated
- More in system memory saved