Linux from Scratch

Turing Completeness

[If] somebody says "my new thing is Turing Complete" that means in principle (although often not in practice) it could be used to solve any computation problem.



If something is said to be Turing-complete [...] it can be used to simulate any **Turing machine**



The Turing machine mathematically models a machine that mechanically operates on a tape. On this tape are symbols, which the machine can read and write, one at a time, using a tape head.

Operation is fully determined by a finite set of [...] instructions such as "in state 42, if the symbol seen is 0, write a 1; if the symbol seen is 1, change into state 17; in state 17, if the symbol seen is 0, write a 1 and change to state 6;" etc. [...]



RISC-V ARM (Advanced RISC Machine) x86

Mnemo	nic,	Decembration	Ovelas	14-	Bit Instr	ruction \	Word	Status	Nates
Operan	Ids	Description	Cycles	MSb			LSb	Affected	Notes
BYTE-ORIEI	NTED FI	LE REGISTER OPERATIONS	· ·	·					
ADDWF	f, d	Add W and f	1	00	0111	dfff	ffff	C,DC,Z	1,2
ANDWF	f, d	AND W with f	1	00	0101	dfff	ffff	Z	1,2
CLRF	f	Clear f	1	00	0001	lfff	ffff	z	2
CLRW	-	Clear W	1	00	0001	0xxx	XXXX	z	
COMF	f, d	Complement f	1	00	1001	dfff	ffff	z	1,2
DECF	f, d	Decrement f	1	00	0011	dfff	ffff	z	1,2
DECFSZ	f, d	Decrement f, Skip if 0	1(2)	00	1011	dfff	ffff		1,2,3
INCF	f. d	Increment f	1	00	1010	dfff	ffff	z	1.2
INCFSZ	f. d	Increment f. Skip if 0	1(2)	00	1111	dfff	ffff		1.2.3
IORWF	f. d	Inclusive OR W with f	1	00	0100	dfff	ffff	z	1.2
MOVE	f. d	Move f	1	00	1000	dfff	ffff	z	1.2
MOVWF	f	Move W to f	1	00	0000	lfff	ffff	_	',_
NOP	-	No Operation	1		0000	0xx0	0000		
RLF	fd	Rotate Left f through Carry	1		1101	dfff	ffff	C	12
RRF	f d	Rotate Right f through Carry	1		1100	dfff	ffff	c	12
SUBWE	f d	Subtract W from f	1		0010	dfff	 ffff		12
SWAPE	f d	Swap nibbles in f	1		1110	dfff	 ffff		12
XORWE	f d	Exclusive OR W with f	1		0110	dfff	 	7	1.2
					0110	arri		_	1,2
BII-ORIENT		REGISTER OFERATIONS						1	4.0
BCF	t, b	Bit Clear f	1	01	00bb	bfff	ffff		1,2
BSF	f, b	Bit Set f	1	01	01bb	bfff	ffff		1,2
BTFSC	f, b	Bit Test f, Skip if Clear	1 (2)	01	10bb	bfff	ffff		3
BTFSS	f, b	Bit Test f, Skip if Set	1 (2)	01	11bb	bfff	ffff		3
LITERAL AN	ND CONT	ROL OPERATIONS							
ADDLW	k	Add literal and W	1	11	111x	kkkk	kkkk	C,DC,Z	
ANDLW	k	AND literal with W	1	11	1001	kkkk	kkkk	Z	
CALL	k	Call subroutine	2	10	0kkk	kkkk	kkkk		
CLRWDT	-	Clear Watchdog Timer	1	00	0000	0110	0100	TO.PD	
GOTO	k	Go to address	2	10	1kkk	kkkk	kkkk		
IORLW	k	Inclusive OR literal with W	1	11	1000	kkkk	kkkk	z	
MOVLW	k	Move literal to W	1	11	00xx	kkkk	kkkk	_	
RETEIE	-	Return from interrunt	2		0000	0000	1001		
RETIW	k	Return with literal in W	2	11	01 x x	kkkk	kkkk		
RETURN	-	Return from Subroutine	2		0000	0000	1000		
SIFEP	_	Go into standby mode	1		0000	0110	0011		
	- -	Subtract W from literal	1		110	1-1-1-1-	10011		
	r. L	Evolutive OP literal with W			1010	KKKK	KKKK		
VOKLW	ĸ	Exclusive OR literal with W			TOTO	KKKK	кккк	L	



Mnemonic, Operands				14-Bit Instruction Word				Status		Register	Symbolic		0	
		Description	Cycles	MSb		LSb	Affected	Notes	name	name	Description	Saved by		
BYTE-ORIEN	NTED FI	LE REGISTER OPERATIONS												
ADDWF	f, d	Add W and f	1		0111	dfff	ffff	C,DC,Z	1,2					
ANDWF	f, d	AND W with f	1	00	0101	dfff	ffff	Z	1,2	x0	zero	Always zero		
CLRF	f	Clearf	1	00	0001	lfff	ffff	Z	2			Detum eddress	Caller	
CLRW	- f d	Clear vv	1		1001	UXXX	XXXX		1.2	XI	ra	Return address	Caller	
	i, d f d	Decrement f	1		1001	dIII	IIII		1,2	x2	sn	Stack pointer	Callee	
DECESZ	i, u f. d	Decrement f Skin if 0	1(2)		1011	dIII	IIII fff	2	1,2	~~	50		Gallee	
INCE	i, u f d	Increment f	1		1011	dIII	IIII FFFF	7	1,2,3	xЗ	gp	Global pointer		
INCES7	f d	Increment f Skin if 0	1(2)		1111	dfff	1111 ffff	2	1,2	~	01			
IORWE	f, d	Inclusive OR W with f	1		0100	dfff	ffff	Z	1,2,0	x4	tp	Thread pointer		
MOVE	f. d	Move f	1	00	1000	dfff	ffff	z	1.2		10	To see a second dia la seconda seconda de la s	Oallan	
MOVWF	f	Move W to f	1	00	0000	lfff	ffff	-	.,_	X5	tO	Temporary / alternate return address	Caller	
NOP	-	No Operation	1	00	0000	0xx0	0000			x6_7	t1_2	Temporaries	Caller	
RLF	f, d	Rotate Left f through Carry	1	00	1101	dfff	ffff	С	1,2	<u></u>		Temporaries	Caller	
RRF	f, d	Rotate Right f through Carry	1	00	1100	dfff	ffff	С	1,2	x8	s0/fp	Saved register / frame pointer	Callee	
SUBWF	f, d	Subtract W from f	1	00	0010	dfff	ffff	C,DC,Z	1,2			J		
SWAPF	f, d	Swap nibbles in f	1	00	1110	dfff	ffff		1,2	x9	s1	Saved register	Callee	
XORWF	f, d	Exclusive OR W with f	1	00	0110	dfff	ffff	Z	1,2	10.11			0.11	
BIT-ORIENT	ED FILE	REGISTER OPERATIONS	-					1		X10–11	a0–1	Function arguments / return values	Caller	
BCF	f, b	Bit Clear f	1	01	00bb	bfff	ffff		1,2	x12–17	a2–7	Function arguments	Caller	
BSF	f, b	Bit Set f	1	01	01bb	bfff	ffff		1,2					
BTFSC	f, b	Bit Test f, Skip if Clear	1 (2)	01	10bb	bfff	ffff		3	x18–27	s2–11	Saved registers	Callee	
BIESS	f, D	Bit lest f, Skip if Set	1 (2)	01	11bb	bfff	ffff		3	×09.01	±0. C	Temperariae	Coller	
								0.007		x28-31	13-0	Temporaries	Caller	
	k k	Add literal and W	1		111x 1001	kkkk kkkk	kkkk	C,DC,Z			32 f	oating-point extension registers		
CALL	k	Call subroutine	2		1001 0222	KKKK VVV	~~~~			10 -	(10 -			
CLRWDT	-	Clear Watchdog Timer	1		0000	0110	0100	TOPD		t0-7	ft0-7	Floating-point temporaries	Caller	
GOTO	k	Go to address	2	10	1kkk	kkkk	kkkk			f8_9	fs0_1	Floating-point saved registers	Callee	
IORLW	k	Inclusive OR literal with W	1	11	1000	kkkk	kkkk	z		10-5	130-1		Callee	
MOVLW	k	Move literal to W	1	11	00xx	kkkk	kkkk			f10–11	fa0-1	Floating-point arguments/return values	Caller	
RETFIE	-	Return from interrupt	2	00	0000	0000	1001							
RETLW	k	Return with literal in W	2	11	01xx	kkkk	kkkk			f12–17	fa2–7	Floating-point arguments	Caller	
RETURN	-	Return from Subroutine	2	00	0000	0000	1000			£10.07	fo0 11	Election point could registere	Celles	
SLEEP	-	Go into standby mode	1	00	0000	0110	0011	TO,PD		118-27	IS2-11	Floating-point saved registers	Callee	
SUBLW	k	Subtract W from literal	1	11	110x	kkkk	kkkk	C,DC,Z		f28_31	ft8_11	Eloating-point temporaries	Caller	
XORLW	k	Exclusive OR literal with W	1	11	1010	kkkk	kkkk	Z		120-01	10-11	rioating-point temporaries	Callel	



What is Turing Complete?

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	move 10 steps										
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Sound	turn 🖒 15 degrees			forever							
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Variables	glide 1 secs to x: -112	y: -70									
My Blocks	point in direction 90										
	point towards mouse-point										
	change x by 10										
	set x to -112										
	change y by 10										
	set y to -70										
	if on edge, bounce										
	set rotation style left-right	-									
	x position										

Scratch





Linux in Scratch

)•)	File	Edit	Addons	Advanc	ed		Linux	6.1.	14-r	v32ir	na O	n S.,		Γ	Turb	oWar	p Fee	edbad	k
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-rv32ima On Scratch - TurboWarp Desktop 0.000000] riscv: base ISA extensions aim 0.000000] riscv: ELF capabilities aim 0.000000] Built 1 zonelists, mobility grouping on. Total pages: 16252 0.000000] Kernel command line: earlycon=uart8250,mmio,0x10000000,1000000 console=ttyS0 0.000000] Dentry cache hash table entries: 8192 (order: 3, 32768 bytes, linear) 0.000000] Inode-cache hash table entries: 4096 (order: 2, 16384 bytes, linear) 0.000000] Sorting __ex_table... 0.000000] mem auto-init: stack:off, heap alloc:off, heap free:off 0.000000] Memory: 60604K/65520K available (1486K kernel code, 281K rwdata, 157K rodata, 2233K init, 145K bss, 491 reserved, 0K cma-reserved) 0.000000] SLUB: HWalign=64, Order=0-3, MinObjects=0, CPUs=1, Nodes=1 0.000000] NR_IRQS: 64, nr_irqs: 64, preallocated irqs: 0 0.000000] riscv-intc: 32 local interrupts mapped 0.000000] clint: clint@11000000: timer running at 1000000 Hz 0.000000] clocksource: clint_clocksource: mask: 0xffffffffffffffffffffmax_cycles: 0x1d854df40, max_idle_ns: 35263616 60 ns 0.000000] sched_clock: 64 bits at 1000kHz, resolution 1000ns, wraps every 2199023255500ns 0.051000] Console: colour dummy device 80x25 0.051000] Calibrating delay loop (skipped), value calculated using timer frequency.. 2.00 BogoMIPS (lpj=10000) 0.051000] pid_max: default: 4096 minimum: 301 0.112000] Mount-cache hash table entries: 1024 (order: 0, 4096 bytes, linear) 0.112000] Mountpoint-cache hash table entries: 1024 (order: 0, 4096 bytes, linear) 0.417000] devtmpfs: initialized 0.469000] clocksource: jiffies: mask: 0xffffffff max_cycles: 0xffffffff, max_idle_ns: 19112604462750000 ns 0.661000] futex hash table entries: 16 (order: -5, 192 bytes, linear) 1.317000] clocksource: Switched to clocksource clint_clocksource 7.825000] workingset: timestamp_bits=30 max_order=14 bucket_order=0 14.201000] Serial: 8250/16550 driver, 1 ports, IRQ sharing disabled 14.359000] printk: console [ttyS0] disabled 14.359000] 1000000.uart: ttyS0 at MMIO 0x10000000 (irq = 0, base_baud = 1048576) is a XR16850 14.359000] printk: console [ttyS0] enabled 14.359000] printk: console [ttyS0] enabled 14.359000] printk: bootconsole [uart8250] disabled 14.359000] printk: bootconsole [uart8250] disabled 15.214000] Freeing unused kernel image (initmem) memory: 2232K 15.271000] This architecture does not have kernel memory protection. 15.271000] Run /init as init process . come to Linux On Scratch! _1 00:00:22 login[29]: root login on 'console' Stage 🕽 у (28 Empty ↔ x 36 100 Run! Run button Terminal RISCV



References & sources

- https://stackoverflow.com/questions/7284/what-is-turing-complete $(\mathbf{0})$
- https://en.wikipedia.org/wiki/Turing_completeness (1)
- https://en.wikipedia.org/wiki/Turing_machine (2)
- https://ww1.microchip.com/downloads/en/DeviceDoc/31029a.pdf (3)
- https://en.wikipedia.org/wiki/RISC-V (4)
- (5) https://scratch.mit.edu/projects/10128067/editor/
- https://experiments.turbowarp.org/next/892602496 (6)



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