

Counting to

698,438,863,898,480,640

in <1ms

The elephant in the room

How many passwords?



Counting is hard...



aaaaaaaa

aaaaaaaa

aaaaaaaaab

aaaaaaaa

aaaaaaaaab

aaaaaaaaac

**One
Eternity
Later**

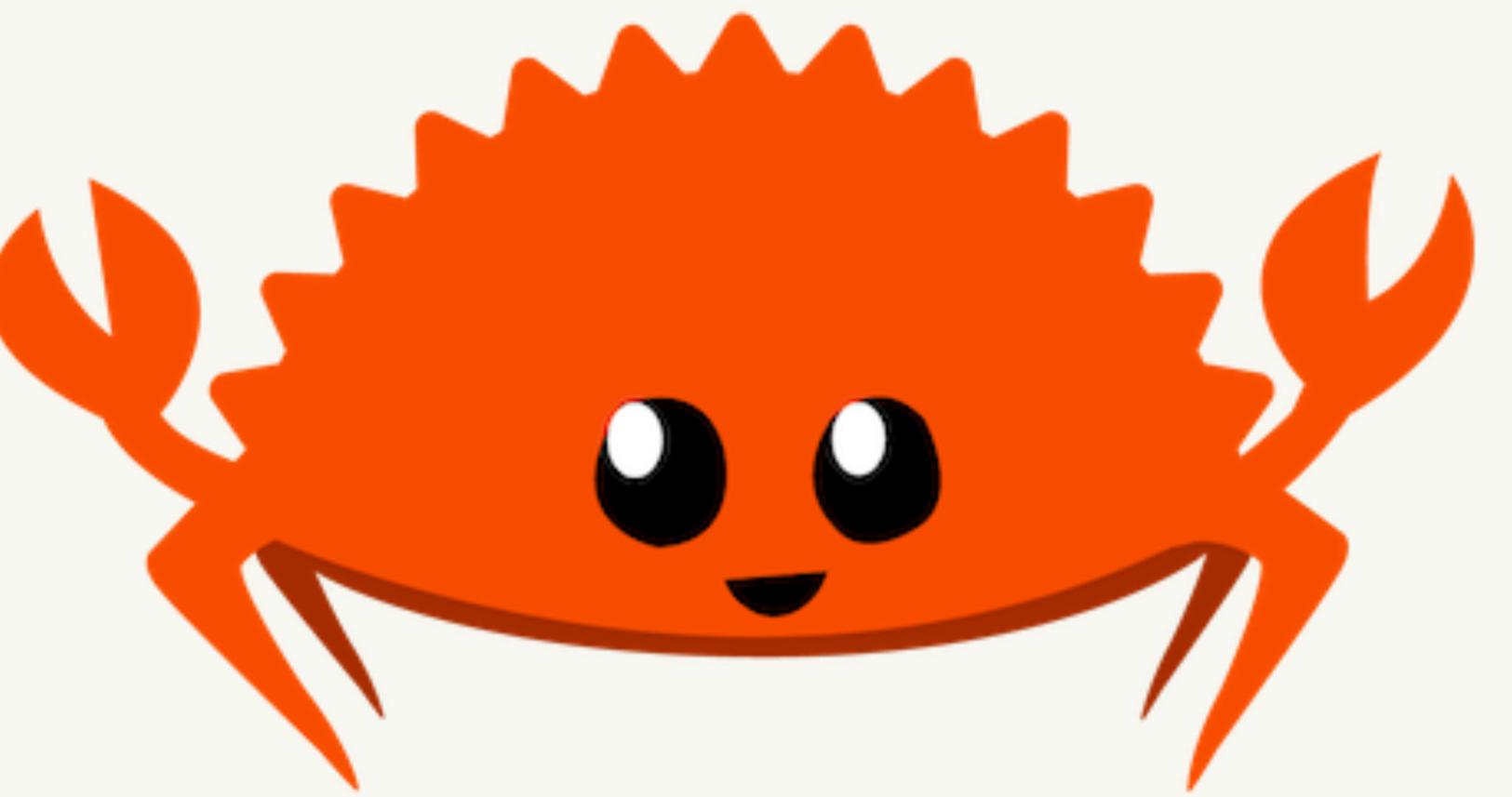
aaaaaaaaaa	aaaaaaaba	agAGRwaa	ZZZZZZZa	aaaaaaaaaa	aaaaaaaaba	923gaRbya	923gaRbya	923gaRbza	923gaRbAa	ZZZZZZZYa	ZZZZZZZZa	aaaaaaaaaaa	ZZZZZZZZXa	ZZZZZZZZYa	ZZZZZZZZZa		
aaaaaaaaab	aaaaaaabb	agAGRwb	aaaaaaaaab	aaaaaaaabb	923gaRbyb	923gaRbyb	923gaRbz	923gaRbAb	ZZZZZZZYb	ZZZZZZZZb	aaaaaaaaaaab	ZZZZZZZZXb	ZZZZZZZZYb	ZZZZZZZZZb		
aaaaaaaaac	aaaaaaabc	agAGRwac	ZZZZZZZr	aaaaaaaaac	aaaaaaaabc	923gaRbyc	923gaRbyc	923gaRbz	923gaRbAc	ZZZZZZZYc	ZZZZZZZZc	aaaaaaaaaaac	ZZZZZZZZXc	ZZZZZZZZYc	ZZZZZZZZZc		
aaaaaaaaad	aaaaaaabd	agAGRwad	ZZZZZZZs	aaaaaaaaad	aaaaaaaabd	923gaRbyd	923gaRbyd	923gaRbz	923gaRbAd	ZZZZZZZYd	ZZZZZZZZd	aaaaaaaaaaad	ZZZZZZZZXd	ZZZZZZZZYd	ZZZZZZZZZd		
aaaaaaaaae	aaaaaaabe	agAGRwae	ZZZZZZZt	aaaaaaaaae	aaaaaaaabe	923gaRbye	923gaRbye	923gaRbz	923gaRbAe	ZZZZZZZYe	ZZZZZZZZe	aaaaaaaaaaee	ZZZZZZZZXe	ZZZZZZZZYe	ZZZZZZZZZe		
aaaaaaaaaf	aaaaaabf	agAGRwf	ZZZZZZZu	aaaaaaaaaf	aaaaaaaabf	923gaRbyf	923gaRbyf	923gaRbz	923gaRbAf	ZZZZZZZYf	ZZZZZZZZf	aaaaaaaaaaaf	ZZZZZZZZXf	ZZZZZZZZYf	ZZZZZZZZZf		
aaaaaaaaag	aaaaaabg	agAGRwag	ZZZZZZZv	aaaaaaaaag	aaaaaaaabg	923gaRbyg	923gaRbyg	923gaRbz	923gaRbAg	ZZZZZZZYg	ZZZZZZZZg	aaaaaaaaaaag	ZZZZZZZZXg	ZZZZZZZZYg	...		
aaaaaaaaah	aaaaaabh	agAGRwah	ZZZZZZZw	aaaaaaaaah	aaaaaaaabh	923gaRbyh	923gaRbyh	923gaRbz	923gaRbAh	ZZZZZZZYh	ZZZZZZZZh	aaaaaaaaaaah	ZZZZZZZZXh	ZZZZZZZZYh	ZZZZZZZZZw		
aaaaaaaaai	aaaaabi	agAGRwai	ZZZZZZZx	aaaaaaaaai	aaaaaaaabi	923gaRbyi	923gaRbyi	923gaRbz	923gaRbAi	ZZZZZZZYi	ZZZZZZZZi	aaaaaaaaaaai	ZZZZZZZZXi	ZZZZZZZZYi	ZZZZZZZZZx		
aaaaaaaaaj	aaaaabj	agAGRwaj	ZZZZZZZy	aaaaaaaaaj	aaaaaaaabj	923gaRbyj	923gaRbyj	923gaRbz	923gaRbAj	ZZZZZZZYj	ZZZZZZZZj	aaaaaaaaaaaj	ZZZZZZZZXj	ZZZZZZZZYj	ZZZZZZZZZy		
aaaaaaaaak	aaaaabk	agAGRwak	ZZZZZZZz	aaaaaaaaak	aaaaaaaabk	923gaRbyk	923gaRbyk	923gaRbz	923gaRbAk	ZZZZZZZYk	ZZZZZZZZk	aaaaaaaaaaak	ZZZZZZZZXk	ZZZZZZZZYk	ZZZZZZZZZz		
aaaaaaaaal	aaaaabl	agAGRwal	ZZZZZZZA	aaaaaaaaal	aaaaaaaabl	923gaRbyl	923gaRbyl	923gaRbz	923gaRbAl	ZZZZZZZYl	ZZZZZZZZl	aaaaaaaaaaal	ZZZZZZZZXI	ZZZZZZZZYl	ZZZZZZZZZa		
aaaaaaaaam	aaaaabm	agAGRwam	ZZZZZZZB	aaaaaaaaam	aaaaaaaabm	923gaRbym	923gaRbym	923gaRbz	923gaRbAm	ZZZZZZZYm	ZZZZZZZZm	aaaaaaaaaaam	ZZZZZZZZXm	ZZZZZZZZYm	ZZZZZZZZZB		
aaaaaaaaan	aaaaabn	agAGRwan	ZZZZZZZC	aaaaaaaaan	aaaaaaaabn	923gaRbyn	923gaRbyn	923gaRbz	923gaRbAn	ZZZZZZZYn	ZZZZZZZZn	aaaaaaaaaaan	ZZZZZZZZXn	ZZZZZZZZYn	ZZZZZZZZZC		
aaaaaaaaao	aaaaabobo	agAGRwao	ZZZZZZZD	aaaaaaaaao	aaaaaaaabo	...	923gaRbyo	923gaRbzo	923gaRbAo	ZZZZZZZYo	ZZZZZZZZo	aaaaaaaaaaao	ZZZZZZZZXo	ZZZZZZZZYo	ZZZZZZZZZD		
aaaaaaaaap	aaaaabp	agAGRwap	ZZZZZZZE	aaaaaaaaap	aaaaaaaabp	923gaRbyE	923gaRbyp	923gaRbz	923gaRbAp	ZZZZZZZYp	ZZZZZZZZp	aaaaaaaaaaap	ZZZZZZZZXp	ZZZZZZZZYp	ZZZZZZZZZE		
aaaaaaaaaq	aaaaabq	agAGRwaq	ZZZZZZZF	aaaaaaaaaq	aaaaaaaabq	923gaRbyF	923gaRbyq	923gaRbz	...	ZZZZZZZYq	ZZZZZZZZq	aaaaaaaaaaaq	ZZZZZZZZXq	ZZZZZZZZYq	ZZZZZZZZZF		
aaaaaaaaar	aaaaabr	agAGRwar	ZZZZZZZG	aaaaaaaaar	aaaaaaaabr	923gaRbyG	923gaRbyr	923gaRbz	923gaRbAG	ZZZZZZZYr	ZZZZZZZZr	aaaaaaaaaaar	ZZZZZZZZXr	ZZZZZZZZYr	ZZZZZZZZZG		
aaaaaaaaas	...	agAGRwas	ZZZZZZZH	aaaaaaaaas	aaaaaaaabs	923gaRbyH	923gaRbys	923gaRbz	923gaRbAH	ZZZZZZZYs	ZZZZZZZZs	aaaaaaaaaaas	ZZZZZZZZXs	ZZZZZZZZYs	ZZZZZZZZZH		
aaaaaaaaat	aaaaaabI	agAGRwat	ZZZZZZZI	aaaaaaaaat	aaaaaaaabt	923gaRbyI	923gaRbyt	923gaRbz	923gaRbAI	ZZZZZZZYt	ZZZZZZZZt	aaaaaaaaaaat	...	ZZZZZZZZYt	ZZZZZZZZZI		
aaaaaaaaau	aaaaaabJ	agAGRwau	ZZZZZZZJ	aaaaaaaaau	aaaaaaaabu	923gaRbyJ	923gaRbyu	923gaRbz	923gaRbAJ	ZZZZZZZYu	ZZZZZZZZu	aaaaaaaaaaau	ZZZZZZZZXJ	ZZZZZZZZYu	ZZZZZZZZZJ		
aaaaaaaaav	aaaaaabK	...	ZZZZZZZK	aaaaaaaaav	...	923gaRbyK	923gaRbyv	923gaRbz	923gaRbAK	ZZZZZZZYv	ZZZZZZZZv	aaaaaaaaaaav	ZZZZZZZZXK	ZZZZZZZZYv	ZZZZZZZZZK		
aaaaaaaaaw	aaaaaabL	agAGRwaL	ZZZZZZZL	aaaaaaaaaw	aaaaaaaabL	923gaRbyL	923gaRbyw	923gaRbz	923gaRbAL	ZZZZZZZYw	ZZZZZZZZw	aaaaaaaaaaaw	ZZZZZZZZXL	ZZZZZZZZYw	ZZZZZZZZZL		
aaaaaaaaax	aaaaaabM	...	agAGRwaM	...	ZZZZZZZM	aaaaaaaaax	aaaaaaaabM	...	923gaRbyM	923gaRbyx	...	923gaRbz	923gaRbAM	...	ZZZZZZZYx	ZZZZZZZZx	aaaaaaaaaaax
aaaaaaaaay	aaaaabN	agAGRwaN	ZZZZZZZN	aaaaaaaaay	aaaaaaaabN	923gaRbyN	923gaRbyy	923gaRbz	923gaRbAN	ZZZZZZZYy	ZZZZZZZZy	aaaaaaaaaaay	ZZZZZZZZXN	ZZZZZZZZYy	ZZZZZZZZZN		
aaaaaaaaaz	aaaaabO	agAGRwaO	ZZZZZZZO	aaaaaaaaaz	aaaaaaaabO	923gaRbyO	923gaRbyz	923gaRbz	923gaRbAO	ZZZZZZZYz	ZZZZZZZZz	aaaaaaaaaaaz	ZZZZZZZZXO	ZZZZZZZZYz	ZZZZZZZZZO		
aaaaaaaaA	aaaaaabP	agAGRwaP	ZZZZZZZP	aaaaaaaaA	aaaaaaaabP	923gaRbyP	923gaRbyA	923gaRbz	923gaRbAP	ZZZZZZZYA	ZZZZZZZZA	aaaaaaaaaaA	ZZZZZZZZXP	ZZZZZZZZYA	ZZZZZZZZZP		
aaaaaaaaB	aaaaaabQ	agAGRwaQ	ZZZZZZZQ	aaaaaaaaB	aaaaaaaabQ	923gaRbyQ	...	923gaRbz	923gaRbAQ	ZZZZZZZYB	ZZZZZZZZB	aaaaaaaaaaB	ZZZZZZZZXQ	ZZZZZZZZYB	ZZZZZZZZZQ		
aaaaaaaaC	aaaaaabR	agAGRwaR	ZZZZZZZR	aaaaaaaaC	aaaaaaaabR	923gaRbyR	923gaRbyR	923gaRbz	923gaRbAR	ZZZZZZZYC	ZZZZZZZZC	aaaaaaaaaaC	ZZZZZZZZXR	ZZZZZZZZYC	ZZZZZZZZZC		
aaaaaaaaD	aaaaaabS	agAGRwaS	ZZZZZZZS	aaaaaaaaD	aaaaaaaabS	923gaRbyS	923gaRbyS	923gaRbz	923gaRbAS	...	ZZZZZZZZD	aaaaaaaaaaD	ZZZZZZZZXS	ZZZZZZZZYD	ZZZZZZZZZS		
aaaaaaaaE	aaaaaabT	agAGRwaT	ZZZZZZZT	aaaaaaaaE	aaaaaaaabT	923gaRbyT	923gaRbyT	923gaRbz	923gaRbAT	ZZZZZZZYT	ZZZZZZZZE	aaaaaaaaaaE	ZZZZZZZZXT	ZZZZZZZZYE	ZZZZZZZZZT		
...	aaaaaabU	agAGRwaU	ZZZZZZZU	...	aaaaaaaaU	923gaRbyU	923gaRbyU	...	923gaRbz	923gaRbAU	ZZZZZZZYU	ZZZZZZZZF	aaaaaaaaaaF	ZZZZZZZZXU	ZZZZZZZZYF	ZZZZZZZZZU	
aaaaaaaaV	aaaaaabV	agAGRwaV	ZZZZZZZV	aaaaaaaaV	aaaaaaaabV	923gaRbyV	923gaRbyV	923gaRbz	923gaRbAV	ZZZZZZZYV	ZZZZZZZZG	aaaaaaaaaaG	ZZZZZZZZXV	ZZZZZZZZYG	ZZZZZZZZZV		
aaaaaaaaW	aaaaaabW	agAGRwaW	ZZZZZZZW	aaaaaaaaW	aaaaaaaabW	923gaRbyW	923gaRbyW	923gaRbz	923gaRbAW	ZZZZZZZYW	ZZZZZZZZH	aaaaaaaaaaH	ZZZZZZZZXW	ZZZZZZZZYH	ZZZZZZZZZW		
aaaaaaaaX	aaaaaabX	agAGRwaX	ZZZZZZZX	aaaaaaaaX	aaaaaaaabX	923gaRbyX	923gaRbyX	923gaRbz	923gaRbAX	ZZZZZZZYX	ZZZZZZZZI	aaaaaaaaaaI	ZZZZZZZZXX	ZZZZZZZZYI	ZZZZZZZZZX		
aaaaaaaaY	aaaaaabY	agAGRwaY	ZZZZZZZY	aaaaaaaaY	aaaaaaaabY	923gaRbyY	923gaRbyY	923gaRbz	923gaRbAY	ZZZZZZZYY	ZZZZZZZZJ	aaaaaaaaaaJ	ZZZZZZZZXY	ZZZZZZZZYJ	ZZZZZZZZZY		
aaaaaaaaZ	aaaaaabZ	agAGRwaZ	ZZZZZZZZ	aaaaaaaaZ	aaaaaaaabZ	923gaRbyZ	923gaRbyZ	923gaRbz	923gaRbAZ	ZZZZZZZYZ	ZZZZZZZZK	aaaaaaaaaaK	ZZZZZZZZXZ	ZZZZZZZZYK	ZZZZZZZZZZ		
aaaaaaaa@	aaaaaab@	agAGRwa@	ZZZZZZZ@	aaaaaaaa@	aaaaaaaab@	923gaRby@	923gaRby@	923gaRbz	923gaRbA@	ZZZZZZZY@	...	aaaaaaaaaaL	ZZZZZZZZX@	ZZZZZZZZYL	ZZZZZZZZZZ@		
aaaaaaaa1	aaaaaab1	agAGRwa1	ZZZZZZZ1	aaaaaaaa1	aaaaaaaab1	923gaRby1	923gaRby1	923gaRbz	923gaRbA1	ZZZZZZZY1	ZZZZZZZZ1	aaaaaaaaaaM	ZZZZZZZZX1	ZZZZZZZZYM	ZZZZZZZZZ1		
aaaaaaaa2	aaaaaab2	agAGRwa2	ZZZZZZZ2	aaaaaaaa2	aaaaaaaab2	923gaRby2	923gaRby2	923gaRbz	923gaRbA2	ZZZZZZZY2	ZZZZZZZZ2	aaaaaaaaaaN	ZZZZZZZZX2	ZZZZZZZZYN	ZZZZZZZZZ2		
aaaaaaaa3	aaaaaab3	agAGRwa3	ZZZZZZZ3	aaaaaaaa3	aaaaaaaab3	923gaRby3	923gaRby3	923gaRbz	923gaRbA3	ZZZZZZZY3	ZZZZZZZZ3	aaaaaaaaaaO	ZZZZZZZZX3	ZZZZZZZZYO	ZZZZZZZZZ3		
aaaaaaaa4	aaaaaab4	agAGRwa4	ZZZZZZZ4	aaaaaaaa4	aaaaaaaab4	923gaRby4	923gaRby4	923gaRbz	923gaRbA4	ZZZZZZZY4	ZZZZZZZZ4	aaaaaaaaaaP	ZZZZZZZZX4	...	ZZZZZZZZZ4		
aaaaaaaa5	aaaaaab5	agAGRwa5	ZZZZZZZ5	aaaaaaaa5	aaaaaaaab5	923gaRby5	923gaRby5	923gaRbz	923gaRbA5	ZZZZZZZY5	ZZZZZZZZ5	aaaaaaaaaaQ	ZZZZZZZZX5	ZZZZZZZZY5	ZZZZZZZZZ5		
aaaaaaaa6	aaaaaab6	agAGRwa6	ZZZZZZZ6	aaaaaaaa6	aaaaaaaab6	923gaRby6	923gaRby6	923gaRbz	923gaRbA6	ZZZZZZZY6	ZZZZZZZZ6	aaaaaaaaaaR	ZZZZZZZZX6	ZZZZZZZZY6	ZZZZZZZZZ6		
aaaaaaaa7	aaaaaab7	agAGRwa7	ZZZZZZZ7	aaaaaaaa7	aaaaaaaab7	923gaRby7	923gaRby7	923gaRbz	923gaRbA7	ZZZZZZZY7	ZZZZZZZZ7	aaaaaaaaaaS	ZZZZZZZZX7	ZZZZZZZZY7	ZZZZZZZZZ7		
aaaaaaaa8	aaaaaab8	agAGRwa8	ZZZZZZZ8	aaaaaaaa8	aaaaaaaab8	923gaRby8	923gaRby8	923gaRbz	923gaRbA8	ZZZZZZZY8	ZZZZZZZZ8	...	ZZZZZZZZX8	ZZZZZZZZY8	ZZZZZZZZZ8		
aaaaaaaa9	aaaaaab9	agAGRwa9	ZZZZZZZ9	aaaaaaaa9	aaaaaaaab9	923gaRby9	923gaRby										

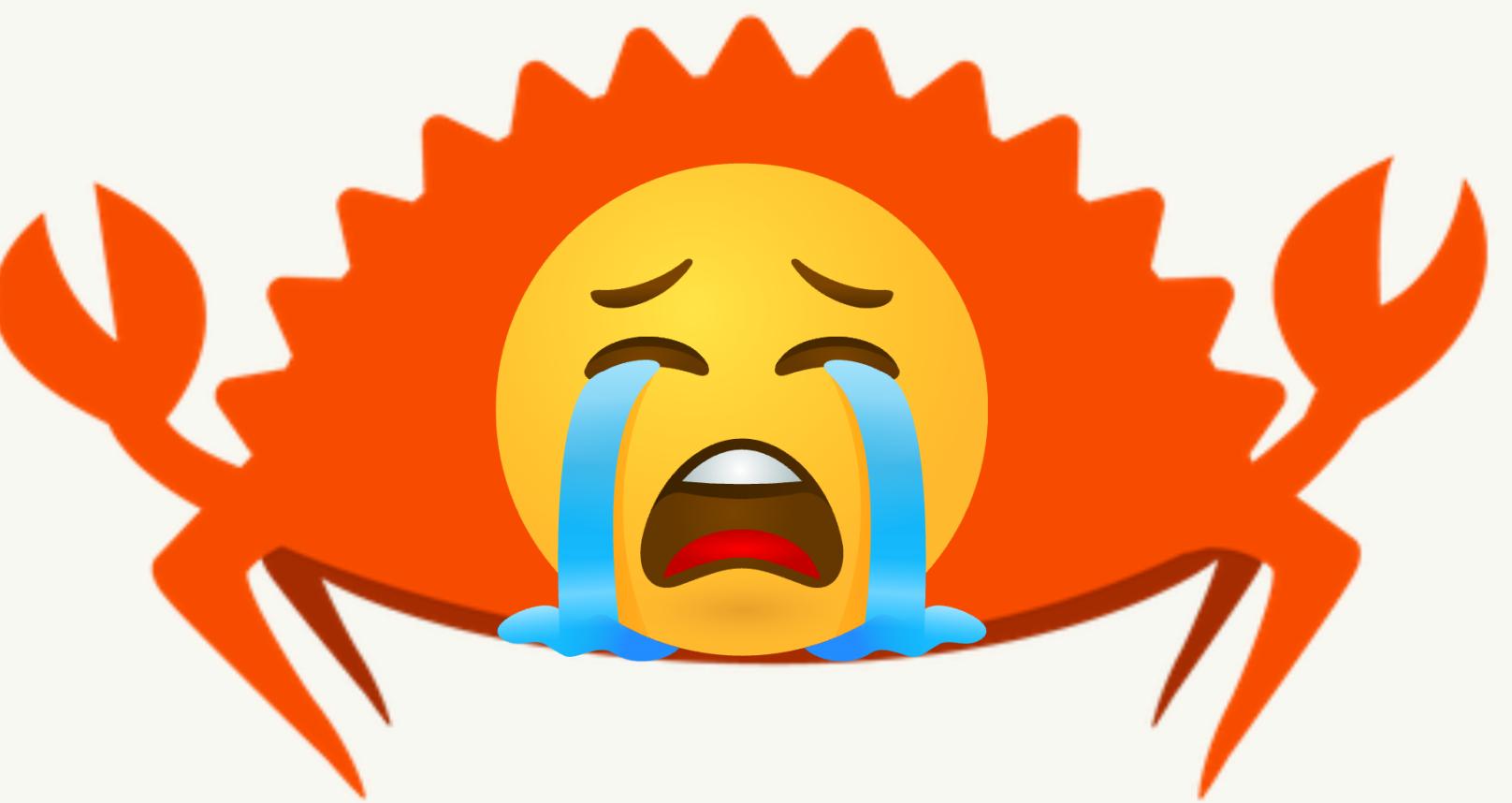
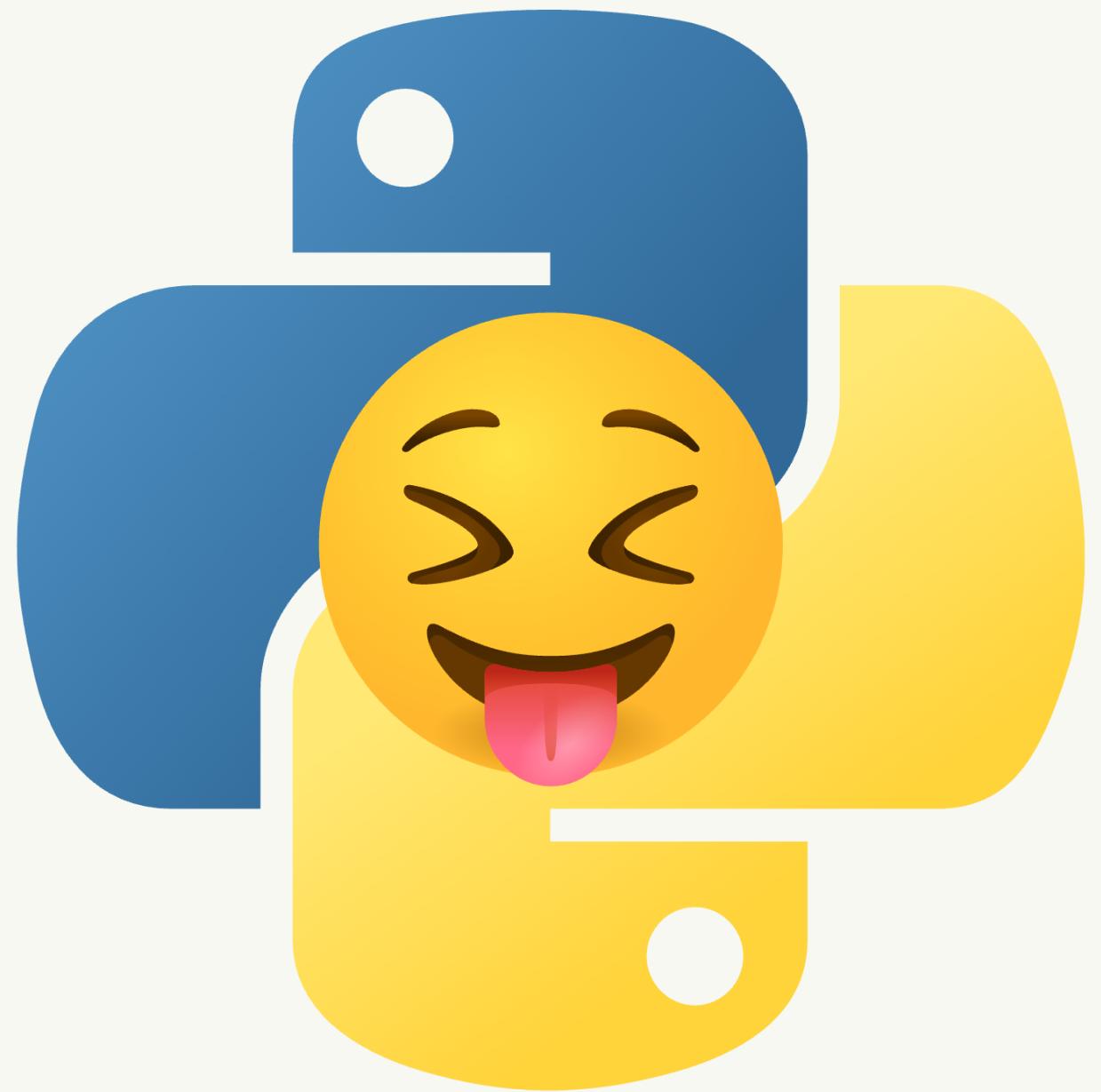
853,054,792,520,188,672

27 years

Automatons

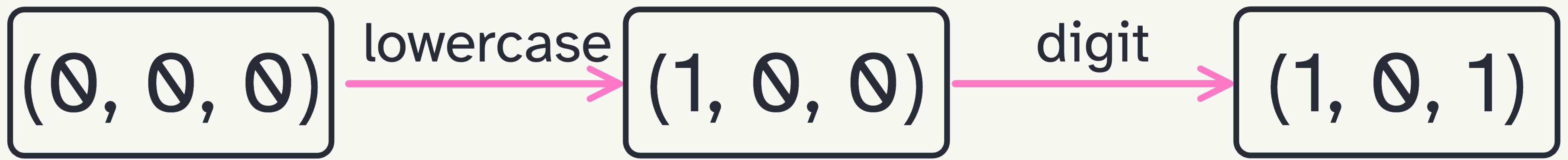


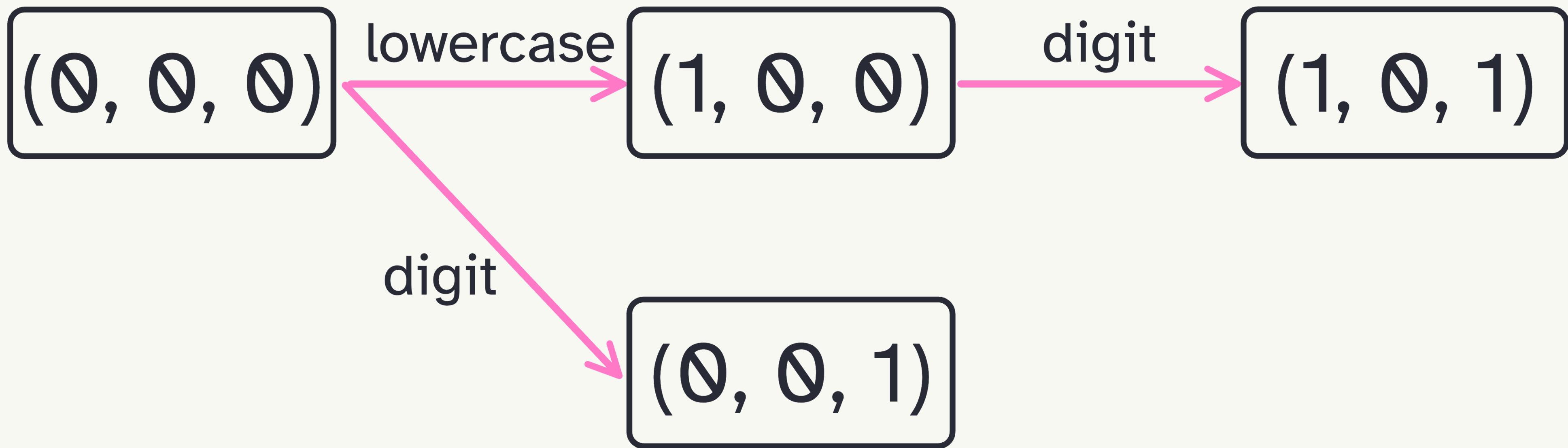


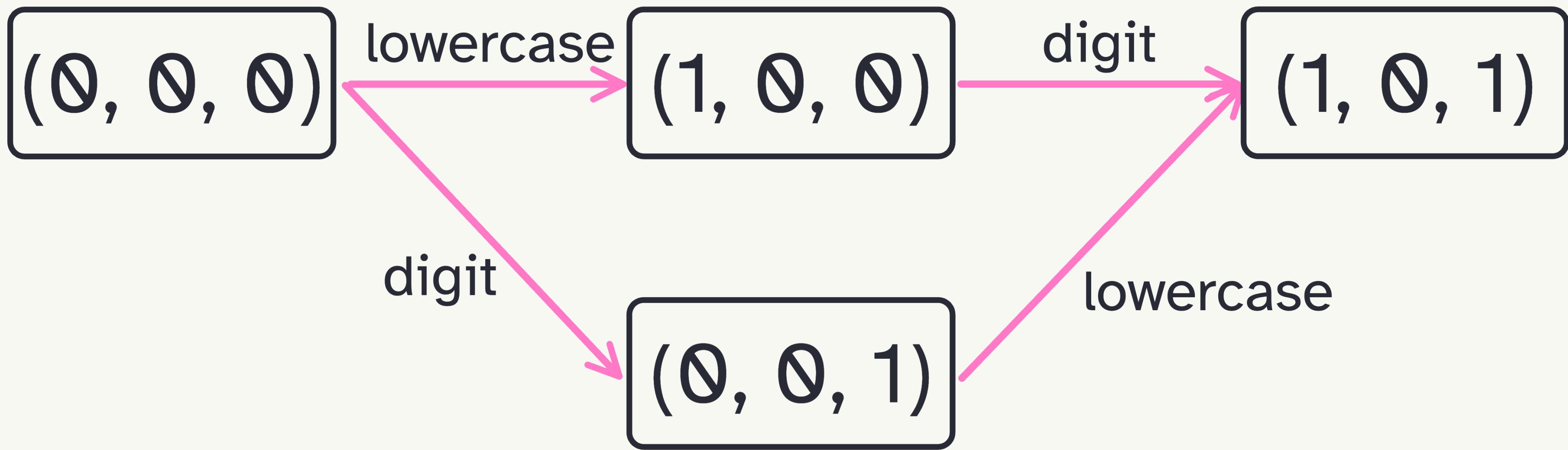


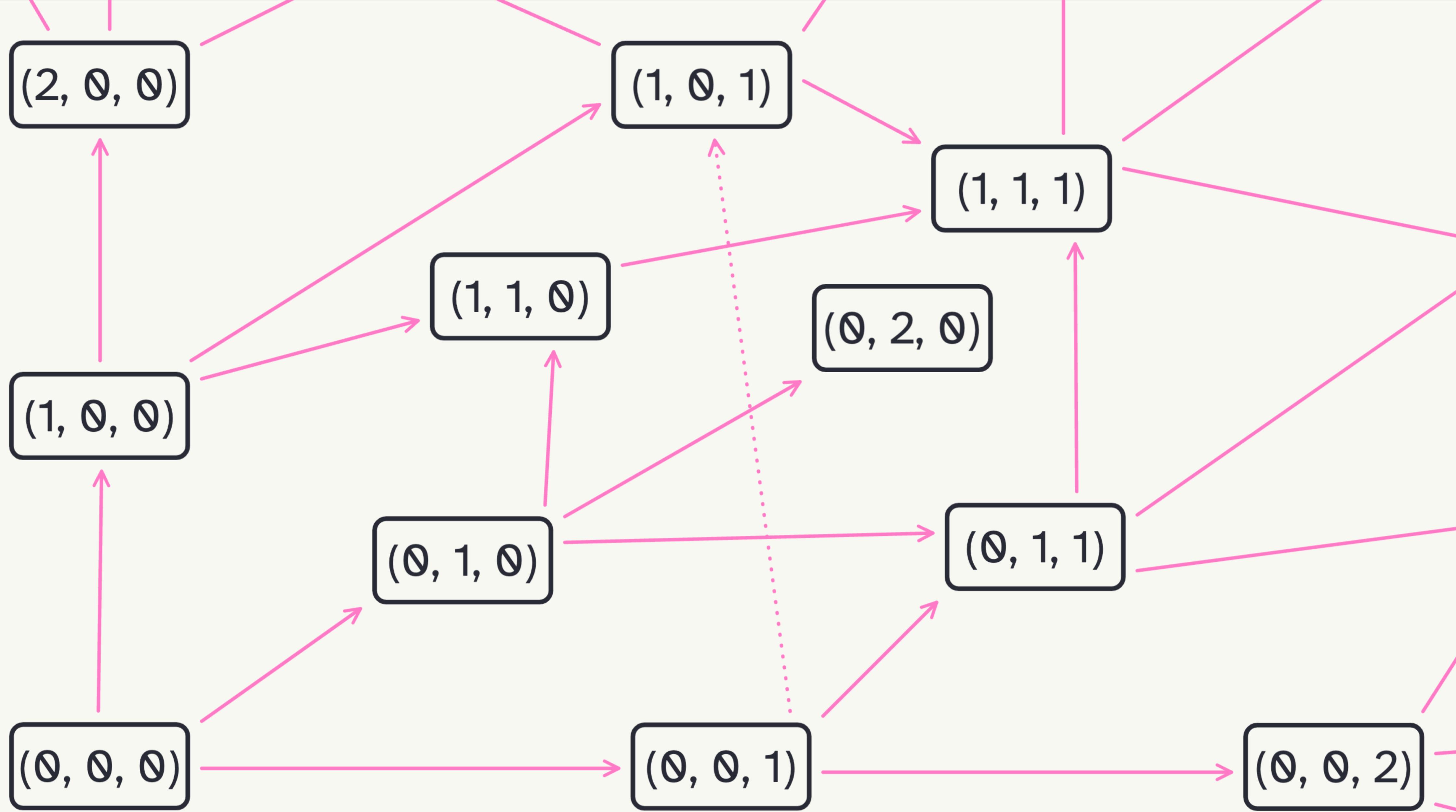
$$(0, 0, 0)$$











Counting to 698,438,863,898,480,640 in <1ms



Rodrigo 🐍 🚀

rodrigo@mathspp.com



