Is the Problem-Based Benchmark Suite Fearless with Rust?

Javad Abdi, Guowei Zhang, Mark C. Jeffrey

SPAA 2023

UNIVERSITY OF TORONTO

Rust is gaining popularity because of its safety guarantees

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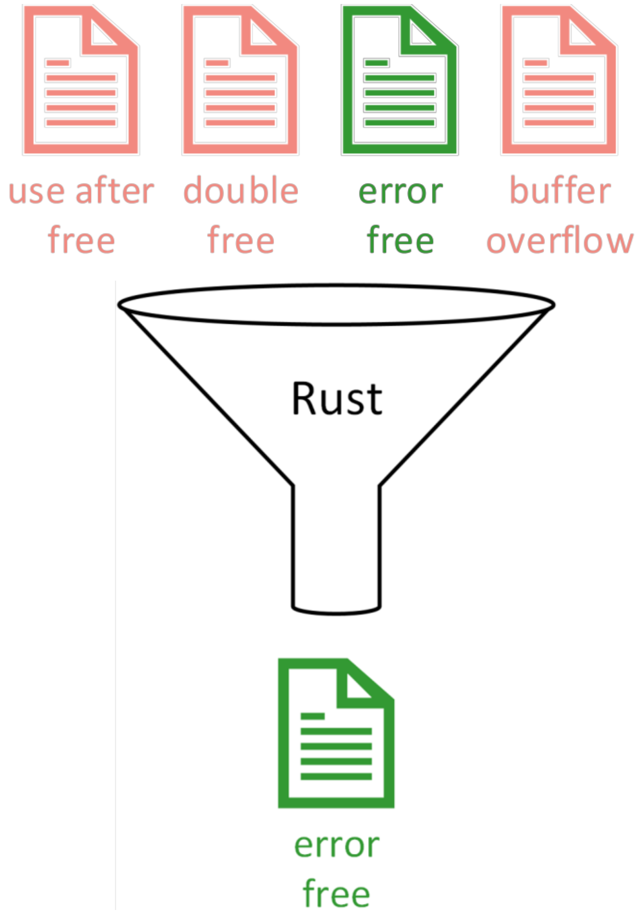
2022 Developer Survey

Rust is on its seventh year as the most loved language …



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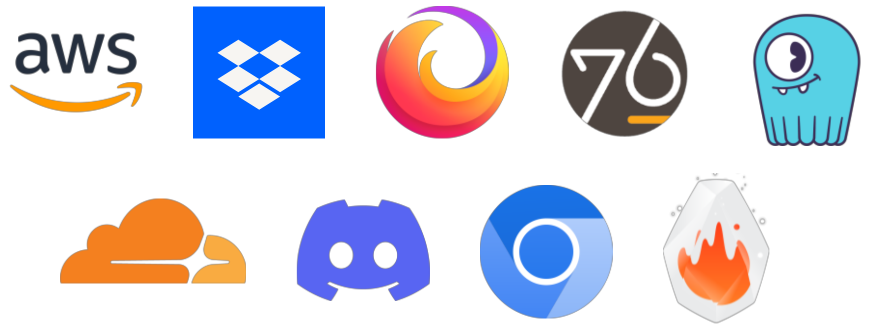

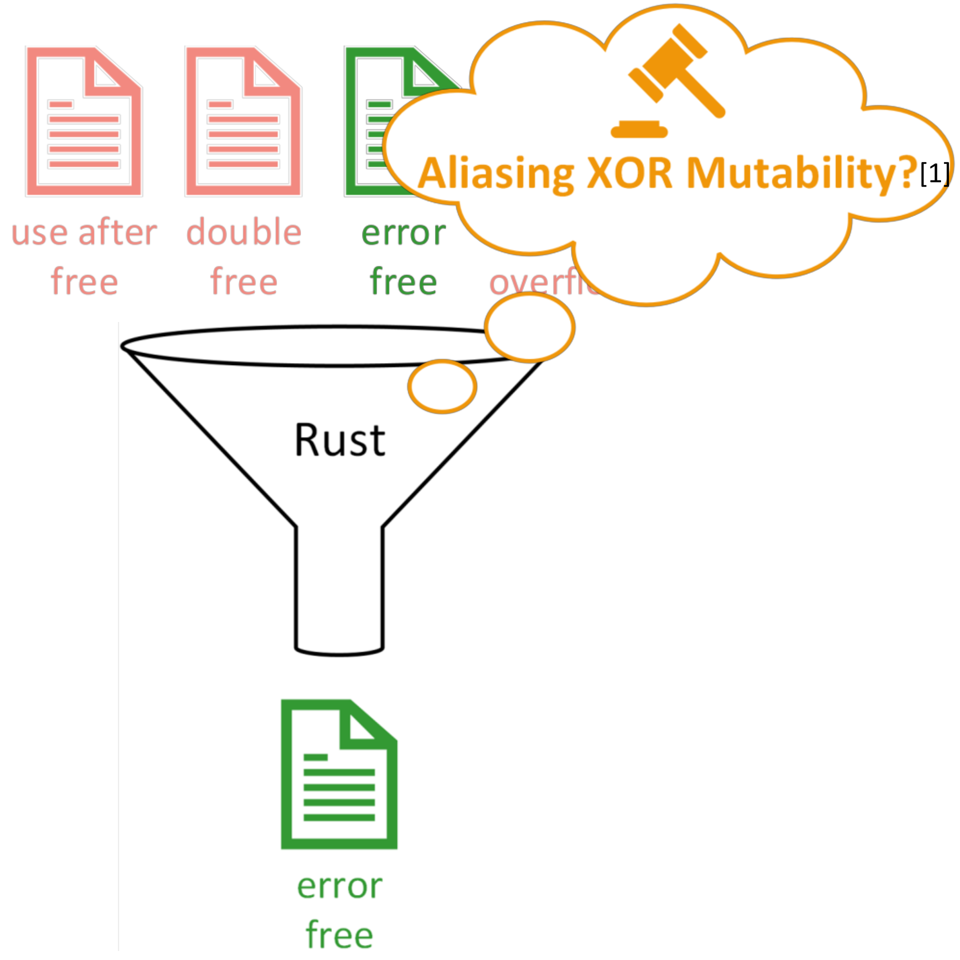

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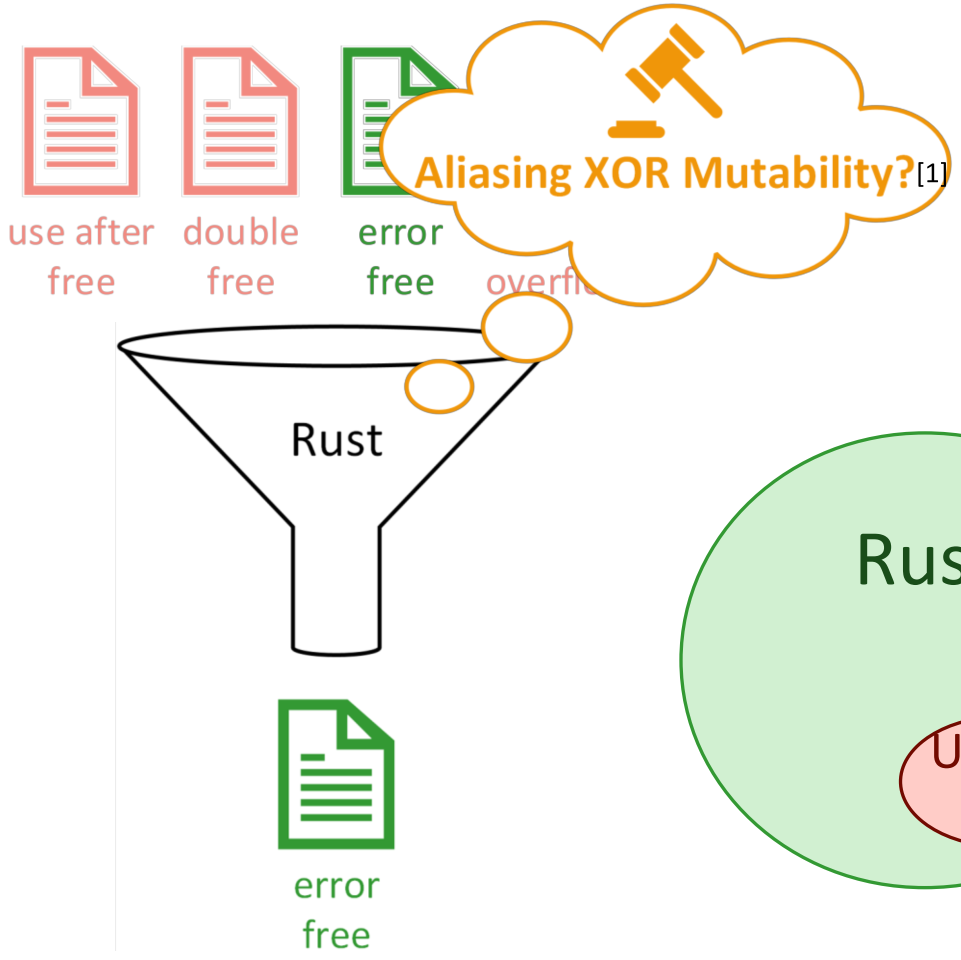

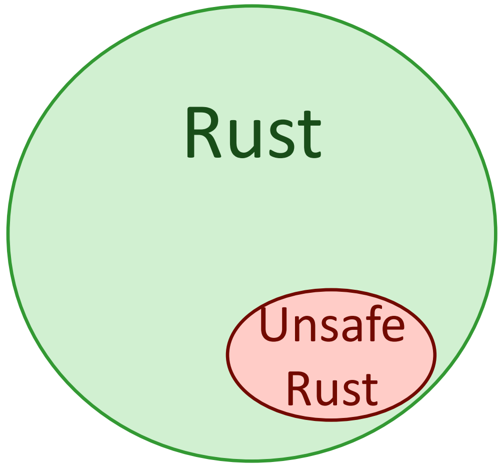

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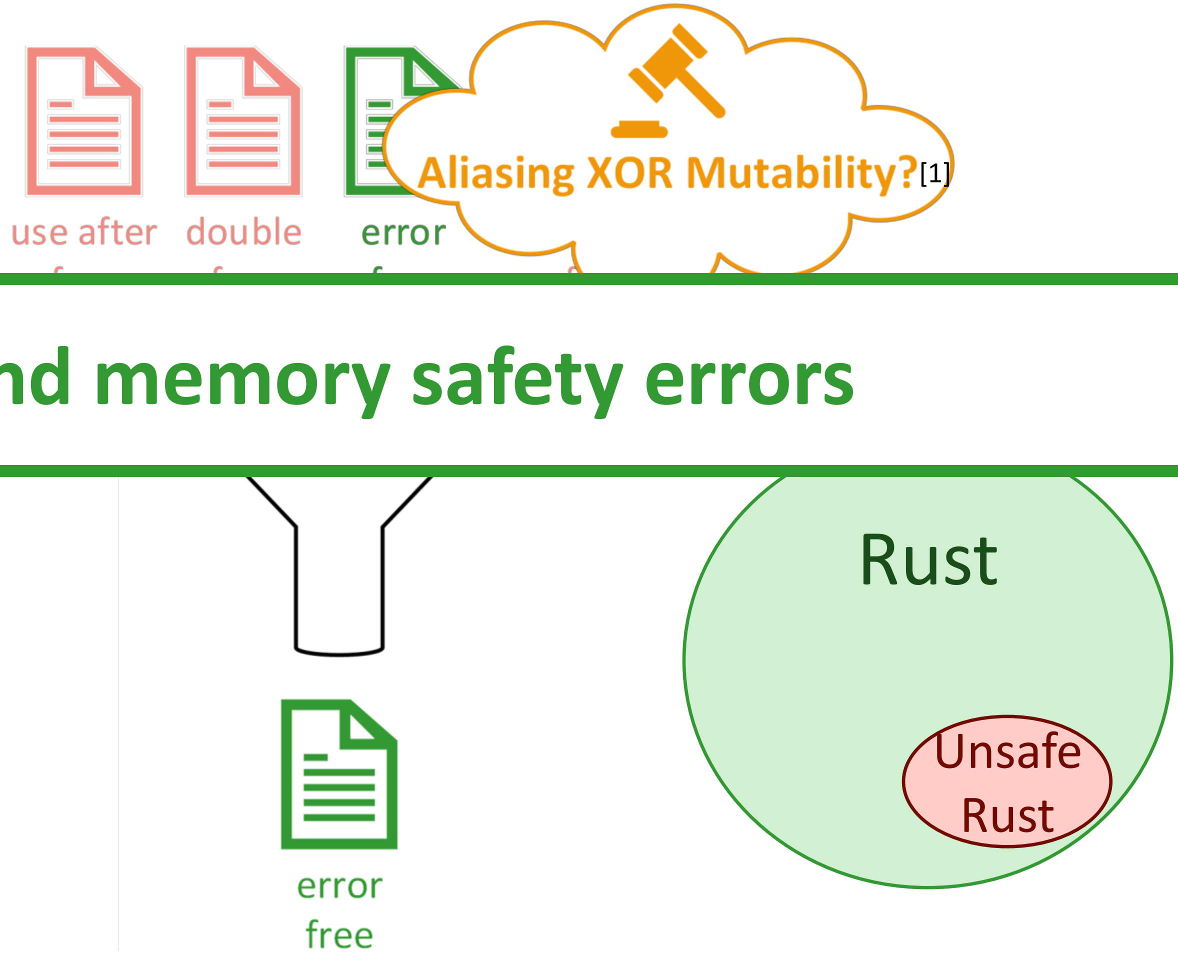

Rust catches all type and memory safety errors

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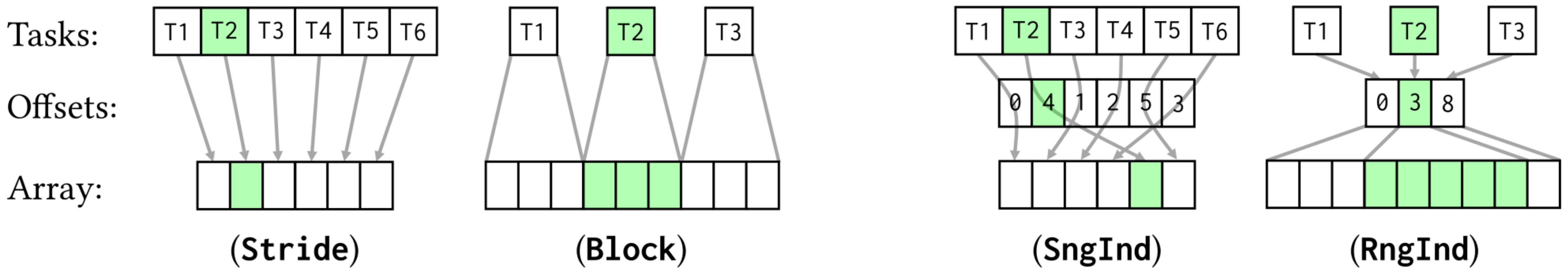
Rust claims to provide "fearless concurrency"

Fear : Anticipation of concurrency errors that manifest at run time.

Our RQ : How does fearless concurrency translate to parallelism?



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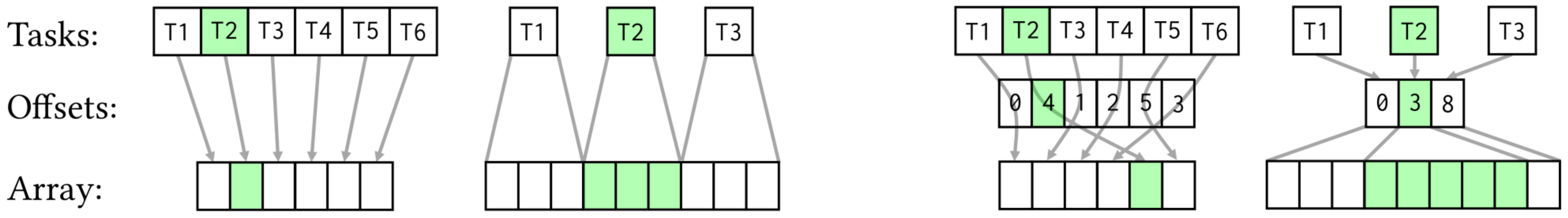
Are all parallel patterns fearless in Rust?



(**Stride**) (**Block**) (**SngInd**) (**RngInd**)

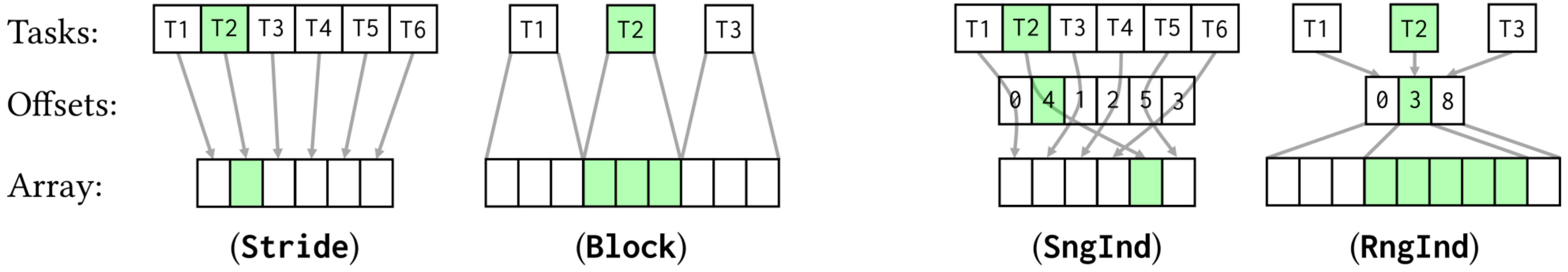
Contribution: Interrogate fearless concurrency by expressing (ir)regular parallelism

Rusty-PBBS:

- A port of PBBS[Anderson et al.,PPoPP'22] in Rust with both regular and irregular patterns.

Our Case Study:

- Classification of parallel expression patterns in Rusty-PBBS.
- Evaluating Rust support and fearlessness for each pattern.



Contribution: Interrogate fearless concurrency by expressing (ir)regular parallelism

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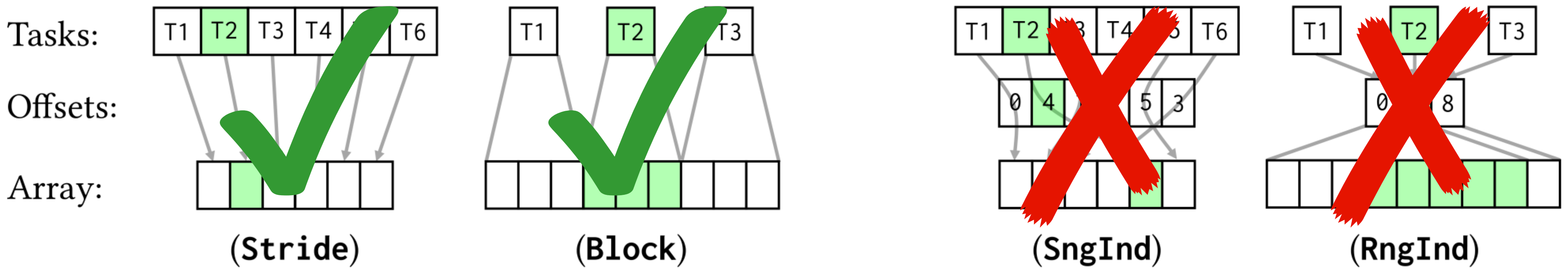
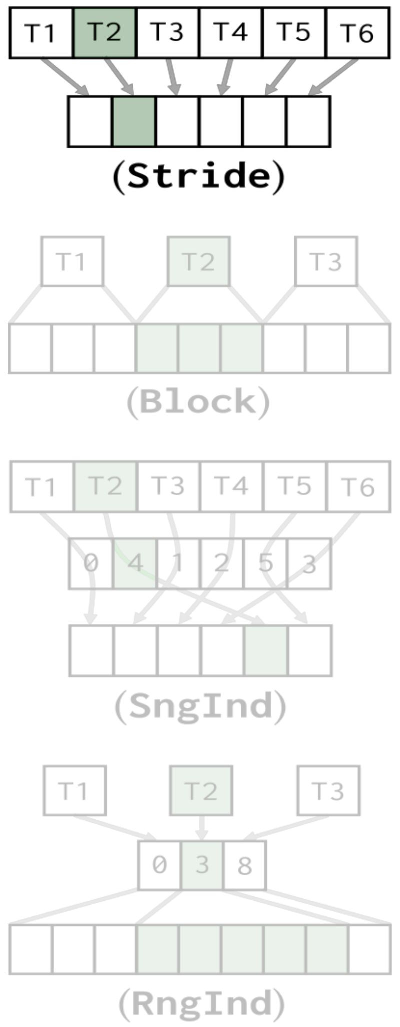


Fearless regular parallelism with Rust(+Rayon)

Regular parallelism:

- Known set of tasks
- Known dependences



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```
fn par_increment(v: &mut [u32])
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  v.par_iter_mut()
   .for_each(|vi|  *vi+=1);
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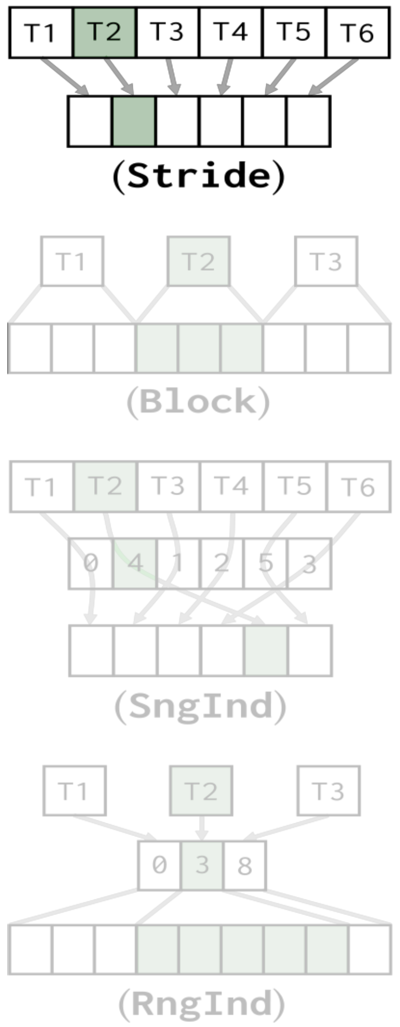
```

stride pattern on **v**



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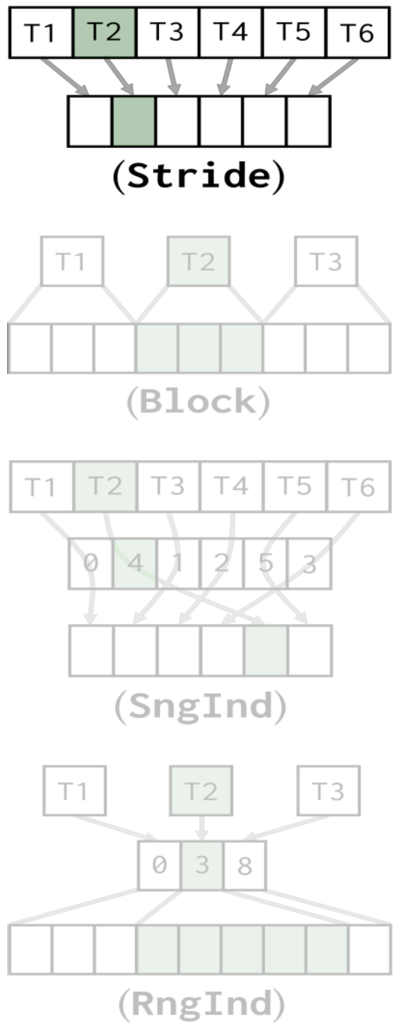
task



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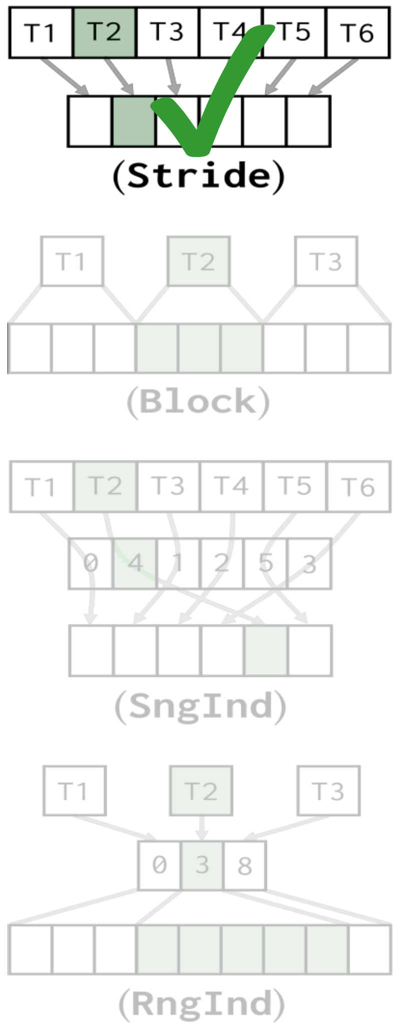
task : Cannot access v ⇒ **No data races**



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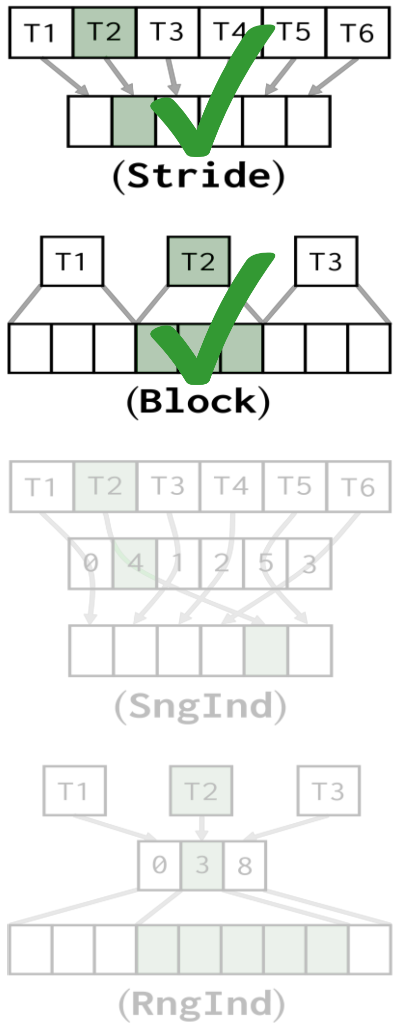

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Regular parallelism:

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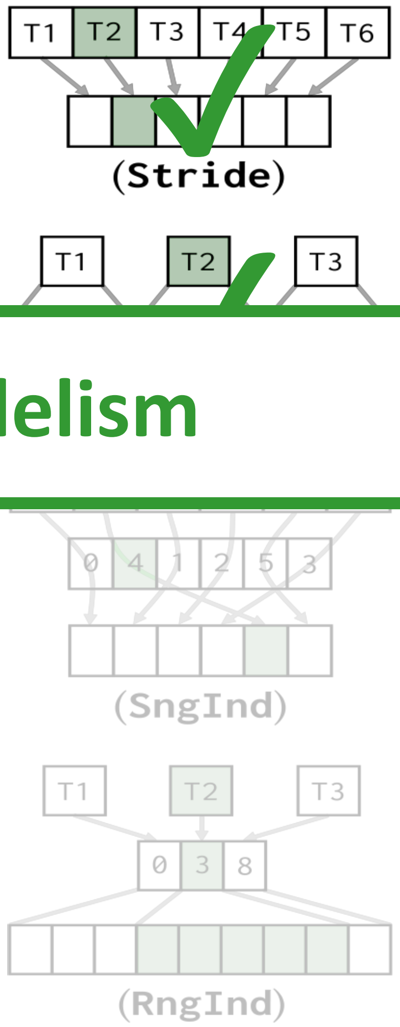

Rust statically rules out data races for regular parallelism

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stride pattern on **v**

task : Cannot access v ⇒ **No data races**

Irregular parallelism remains scary

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fn indirect_increment(v: &mut [u32], offsets: &[usize])
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  (0..v.len()).into_par_iter()
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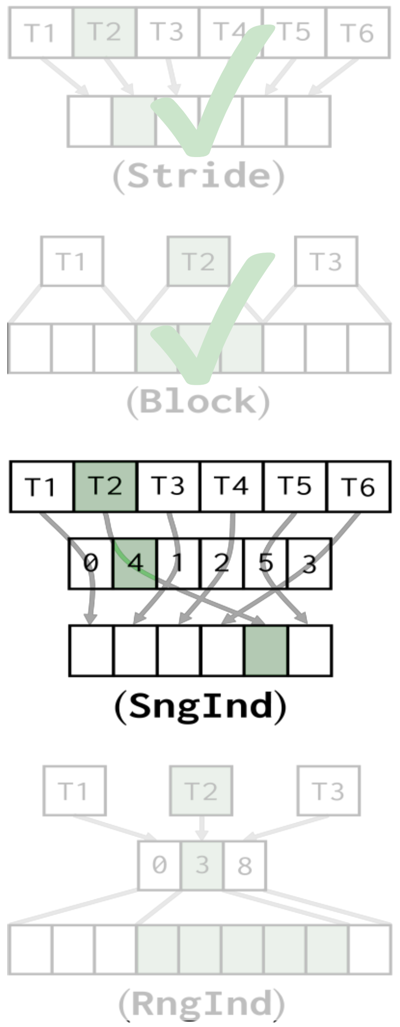
parallel loop



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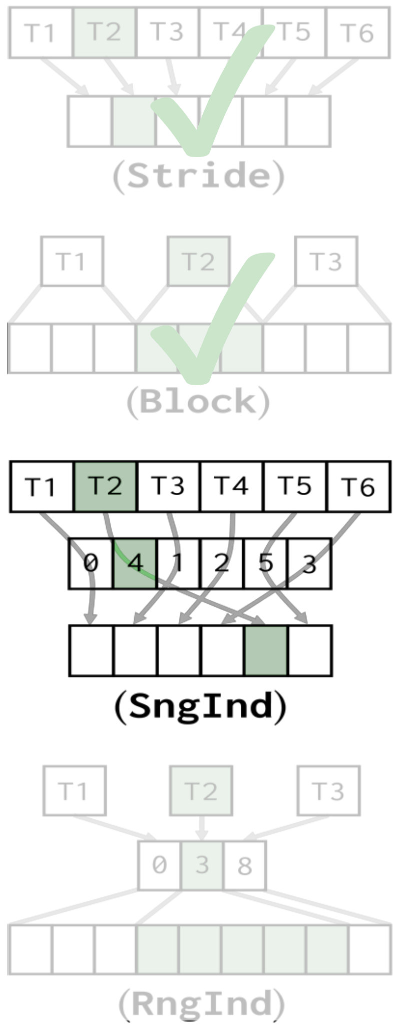

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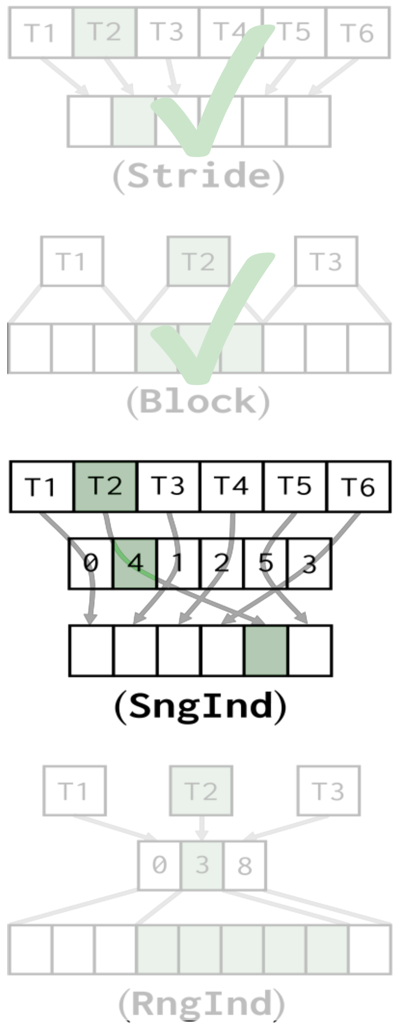
Compile error



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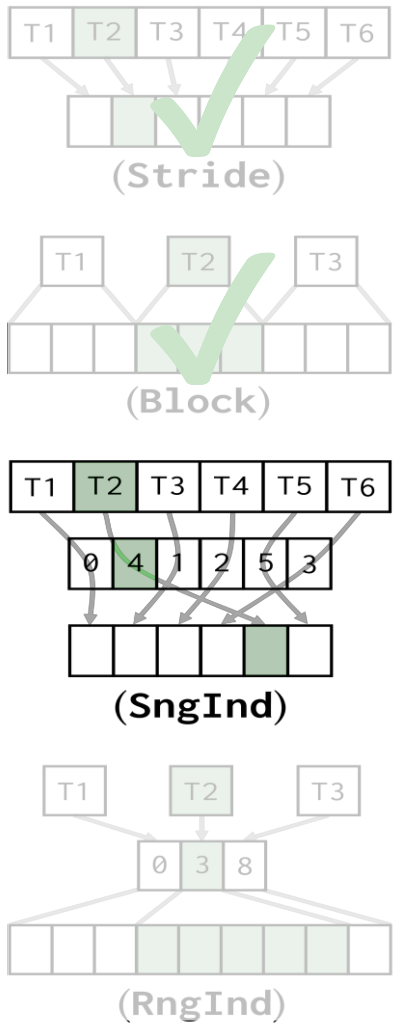
Duplicates: Synchronization 😱



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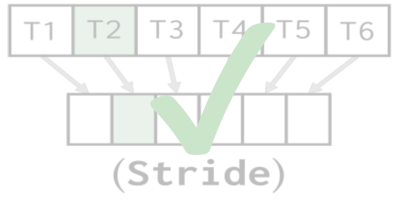

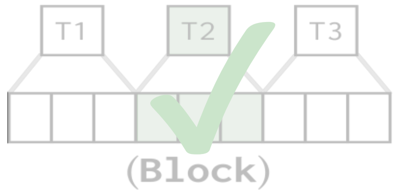

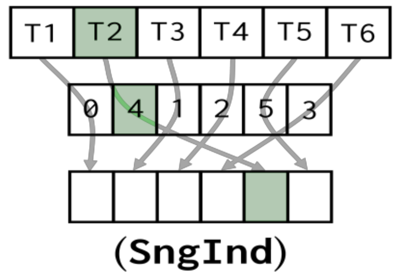

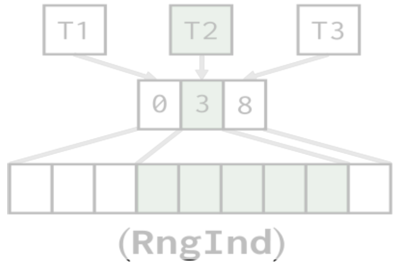

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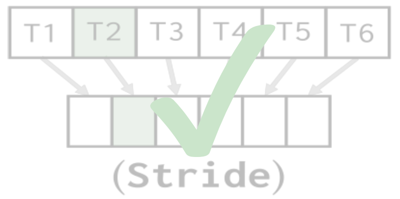

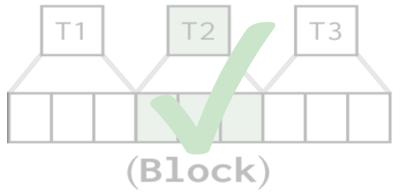

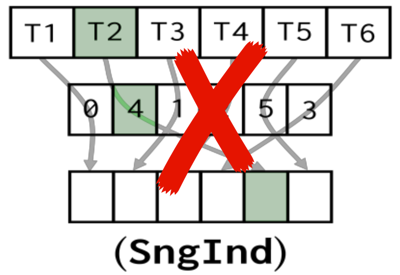

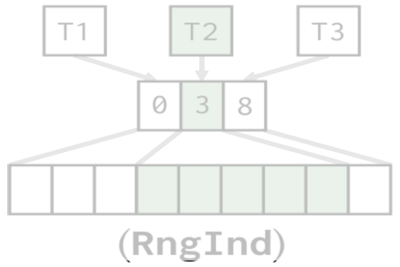

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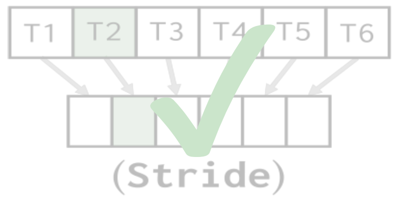

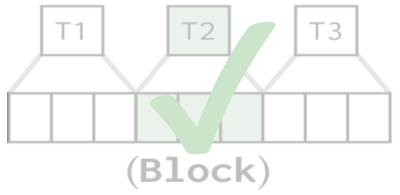

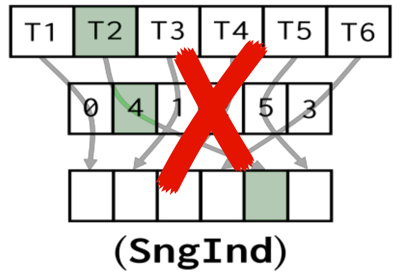

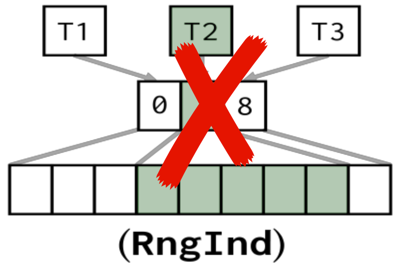

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fn indirect_increment(v: &mut [u32], offsets: &[usize])
{
  (0..v.len()).into_par_iter() ← parallel loop
     .for_each(|i|
}
```

Rust solutions for irregular parallelism are not fearless

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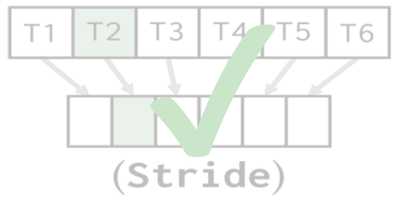
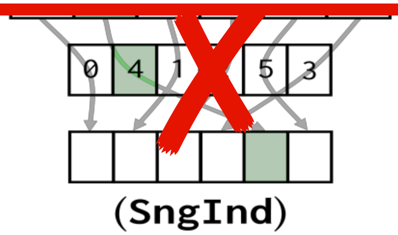
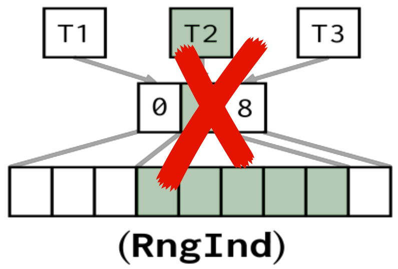


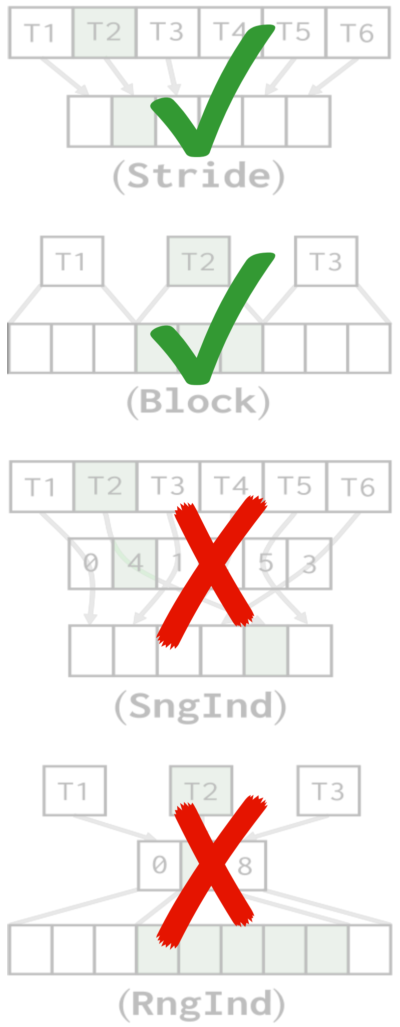




Does this matter?
Irregular parallelism is common in PBBS!

Regular parallelism ✓

Irregular parallelism ✗



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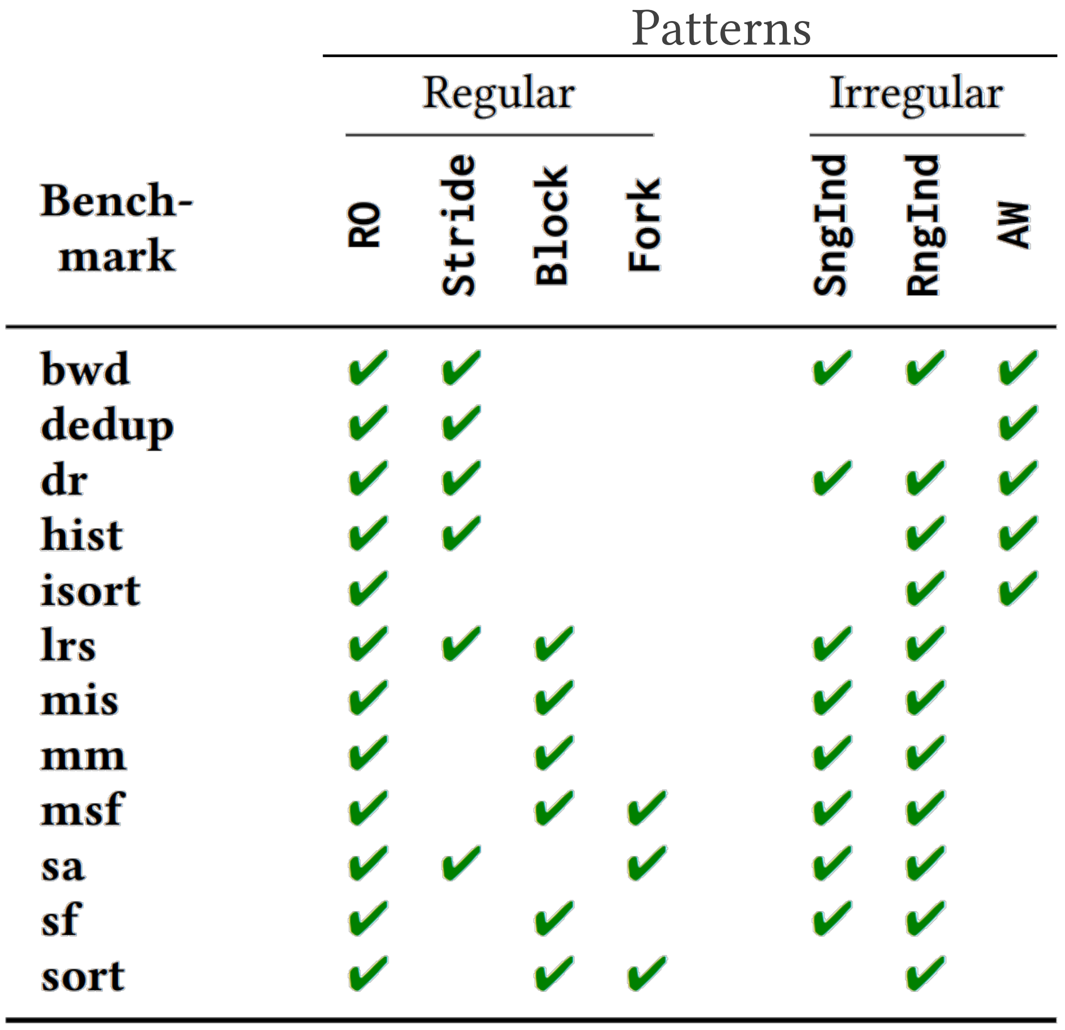
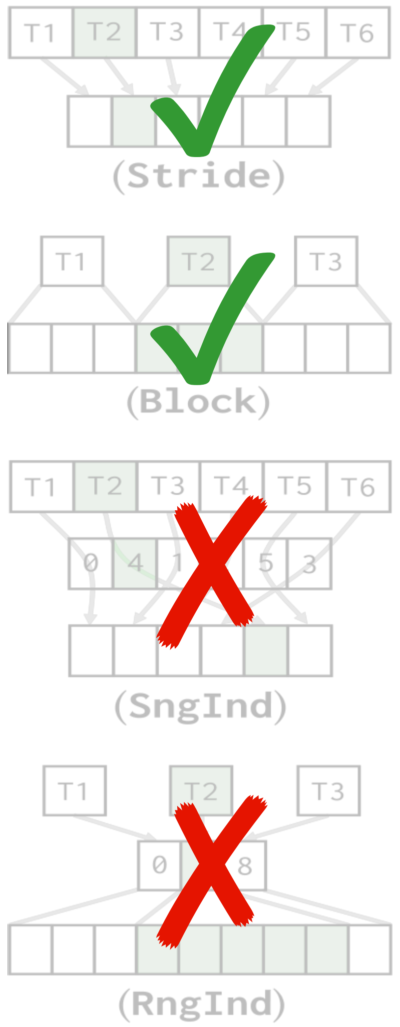


	Patterns						
	Regular				Irregular		
Bench-mark	RO	Stride	Block	Fork	SngInd	RngInd	AW
bwd	✓	✓			✓	✓	✓
dedup	✓	✓					✓
dr	✓	✓			✓	✓	✓
hist	✓	✓				✓	✓
isort	✓					✓	✓
lrs	✓	✓	✓		✓	✓	
mis	✓		✓		✓	✓	
mm	✓		✓		✓	✓	
msf	✓		✓	✓	✓	✓	
sa	✓	✓		✓	✓	✓	
sf	✓		✓		✓	✓	
sort	✓		✓	✓		✓	



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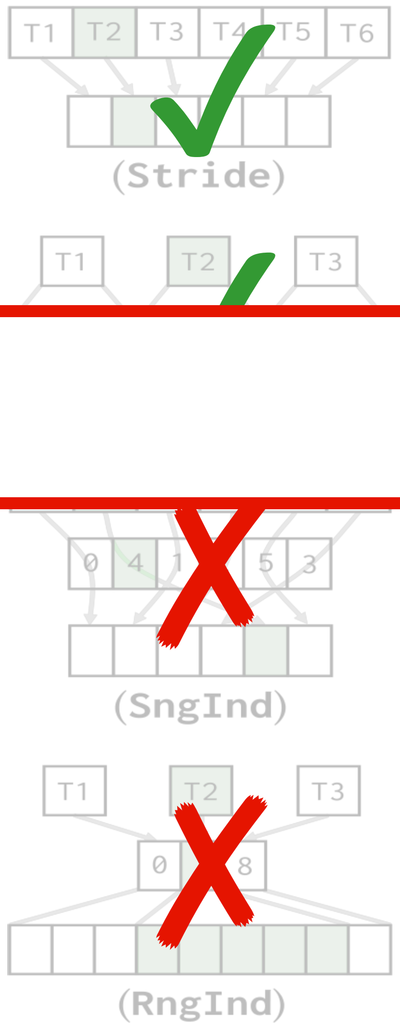
Expressing PBBS in Rust is not fearless

	Patterns						
	Regular				Irregular		
Bench-mark	RO	Stride	Block	Fork	SngInd	RngInd	AW
hist	✓	✓				✓	✓
isort	✓					✓	✓
lrs	✓	✓	✓		✓	✓	
mis	✓		✓		✓	✓	
mm	✓		✓		✓	✓	
msf	✓		✓	✓	✓	✓	
sa	✓	✓		✓	✓	✓	
sf	✓		✓		✓	✓	
sort	✓		✓	✓		✓	



Conclusions

Regular parallelism

Irregular parallelism

Easy parallelism is fearless!

Hard parallelism is still scary...

github.com/mcj-group/rusty-pbbs