“A Wait-free Queue as Fast as Fetch-and-Add”

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17 mars 2017

Progress guarantee

Blocking queue → unexpected delays from the Operating System can block every threads.

Progress Guarantee

	An operation is guaranteed to end in a finite number of steps for...
• *Obstruction-free*	*1 thread only (in isolation)*
• *Lock-free*	*at least 2 threads*
• *Wait-free*	*any number of threads*

Implementation - Atomic primitives

Fetch-and-Add

$FAA(x, v)$ returns the value of x and increments it by v

Compare-and-Swap

$CAS(x, t, v)$ replaces x by v if x equals t

Problematic

Can an **obstruction-free/lock-free** queue using **fetch-and-add** can be transformed to a **wait-free** queue using the **fast-path-slow-path** methodology ?

Obstruction-free queue

An obstruction-free queue using an infinite array.

```
⊤: invalid cell
⊥: empty cell
enqueue(x: var) {
  do t := FAA(&Tail, 1);
  while (!CAS(&Queue[t], ⊥,
       x));
}
```

```
dequeue(x: var) {
  do h := FAA(&Head, 1);
  while (CAS(&Queue[h], ⊥, ⊤) and
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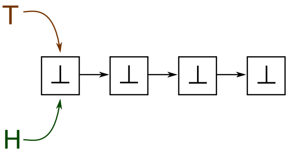

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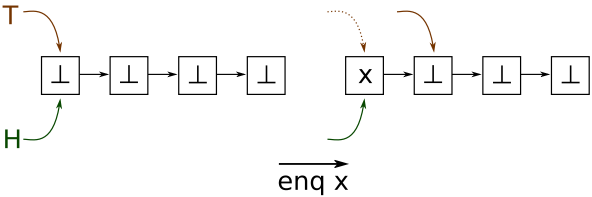

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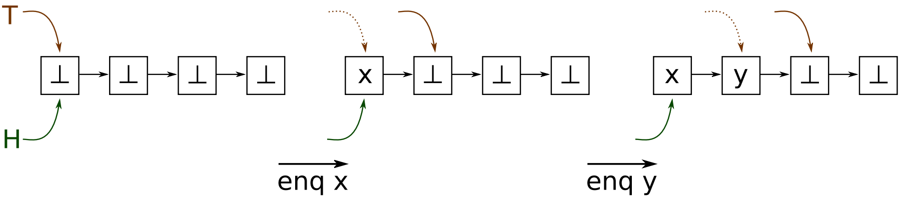

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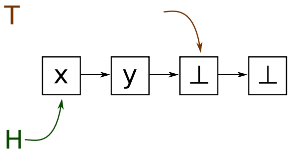

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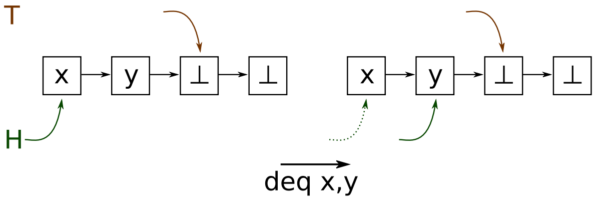

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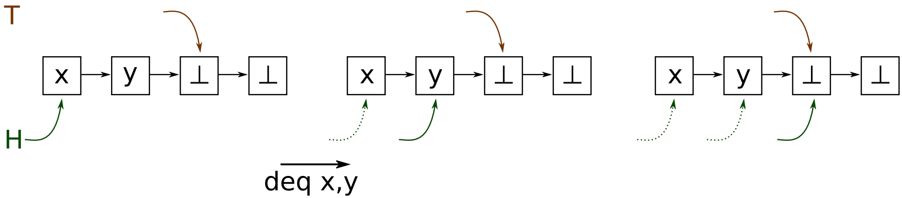

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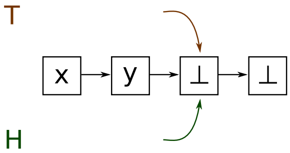

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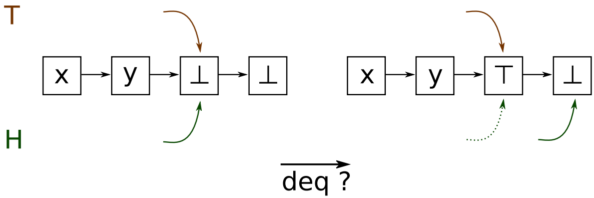
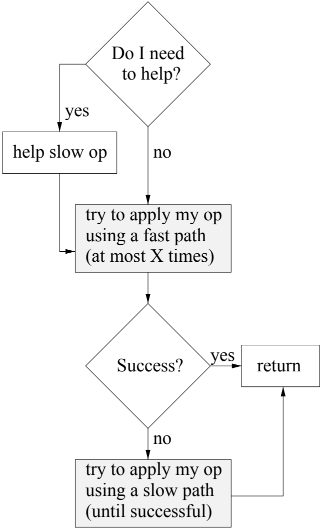
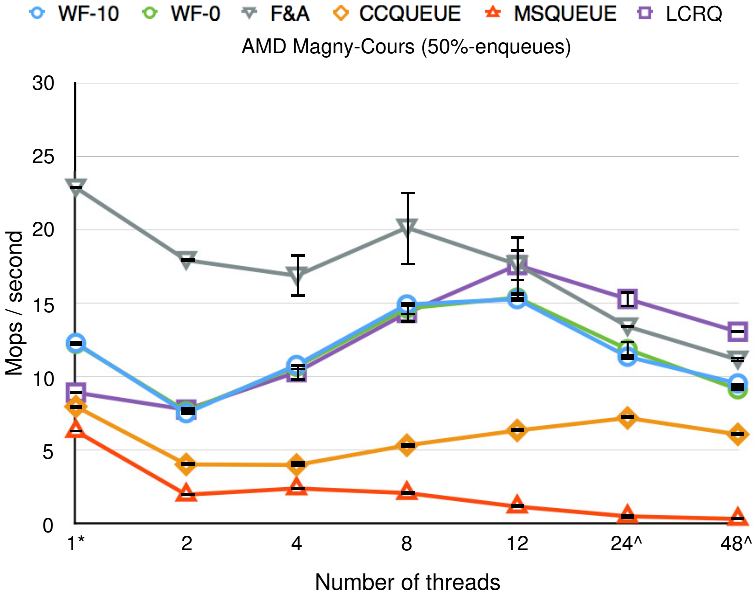


Fast-path-slow-path methodology

Transform lock-free/obstruction-free queue into wait-free queue


Do I need to help?
yes
no
help slow op
try to apply my op using a fast path (at most X times)
Success?
yes
return
no
try to apply my op using a slow path (until successful)

Results



WF-10
WF-0
F&A
CCQUEUE
MSQUEUE
LCRQ
AMD Magny-Cours (50%-enqueues)
Mops / second
30
25
20
15
10
5
0
1*
2
4
8
12
24^
48^
Number of threads

Discussions

Some lock-free/blocking objects are *practically* wait-free.

- 99.97% enqueue done in one try on fast-path
- 95.95% dequeue done in one try on fast-path

Low probability of the worst-case scenario (slow-path)

Conclusion

- First wait-free queue with performance as good as Lock-free queue

- Design complexity increased for wait-free queue

Thanks for your attention !

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