The CASE of FEMU: Cheap, Accurate, Scalable and Extensible Flash Emulator

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Parallel/\ *

CNEXLABS +

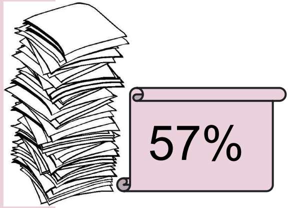
What SSD platforms are used?

Simulator

DiskSim+SSD

SSDSim | FlashSim

- Simple
- Time-saving
- Trace driven
- Internal-research only



Emulator

Hardware Platform

≠

Trends

- Software-Defined Flash
- Split-Level Architecture

Simulator

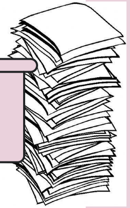
DiskSim+SSD

SSDSim | FlashSim

- ✓ Simple
- ✓ Time-saving
- ✗ Trace driven
- ✗ Internal-research only

Emulator

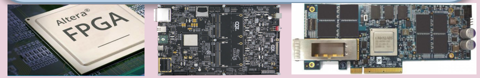
20%



19% Single SSD

1% Distributed SSDs

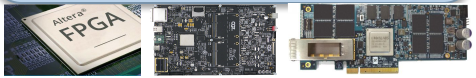
Hardware Platform



OpenSSD OpenChannel-SSD

- ✓ Full-stack Research
- ✓ Accurate
- ✗ Expensive
- ✗ Complex to use
- ✗ Wear-out

Simulator	Emulator	Hardware Platform
DiskSim+SSD; SSDSim; FlashSim	Guest OS; LightNVM's QEMU; VSSIM; FlashEm	OpenSSD; OpenChannel-SSD
✓ Simple	✓ Fullstack Research	✓ Full-stack Research
✓ Time-saving	✓ Cheap	✓ Accurate
✗ Trace driven	✗ Poor Scalability	✗ Expensive
✗ Internal-research only	✗ Poor Accuracy	✗ Complex to use
		✗ Wear-out



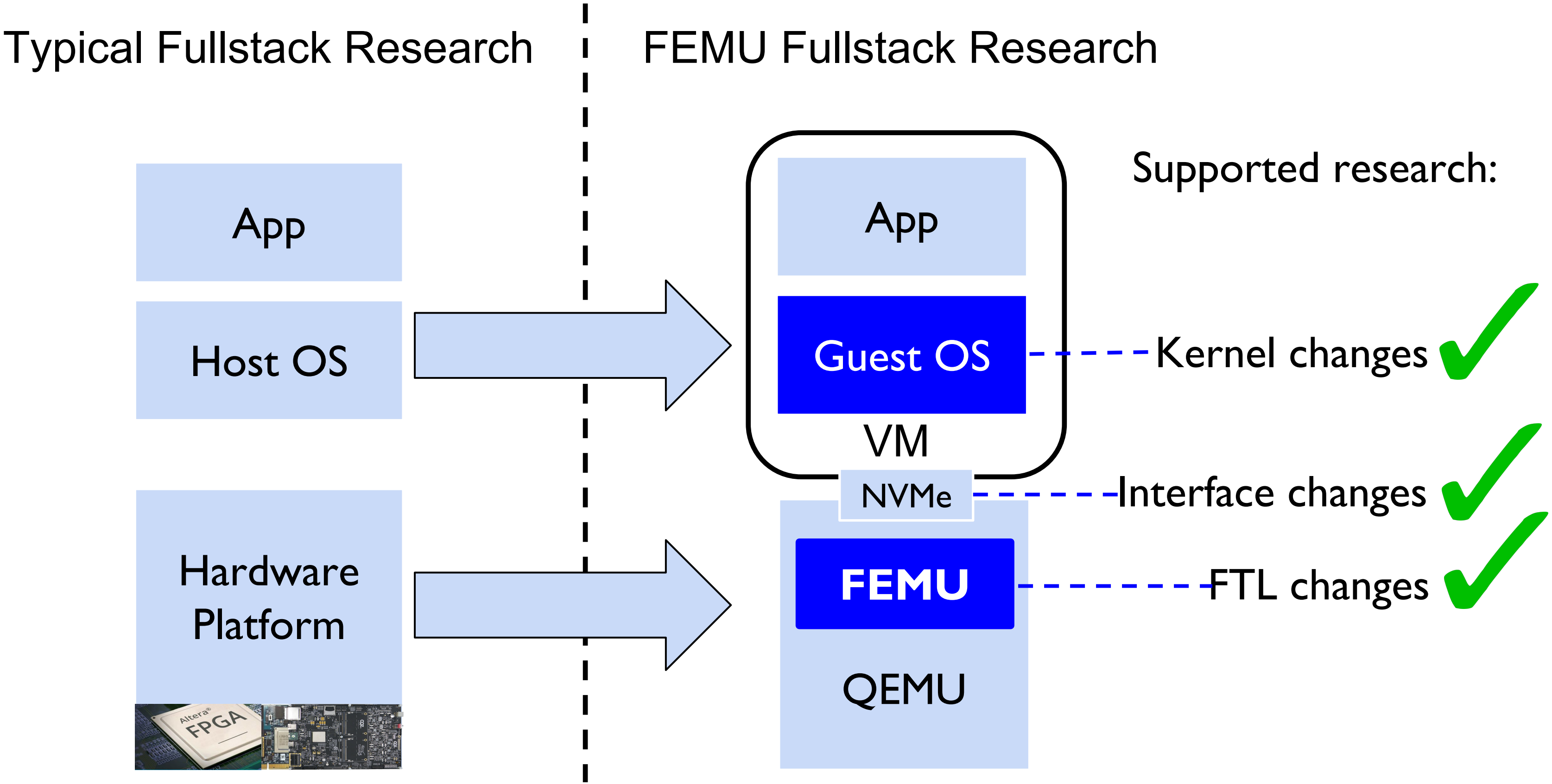
OpenSSD OpenChannel-SSD

The "CASE" of FEMU

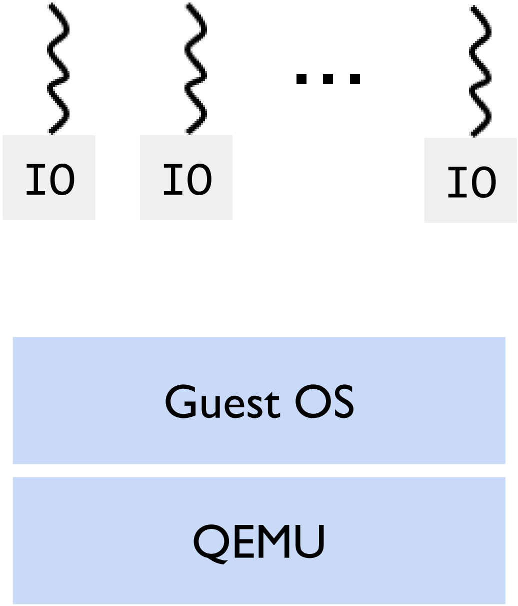
FEMU: QEMU/Software based Flash Emulator

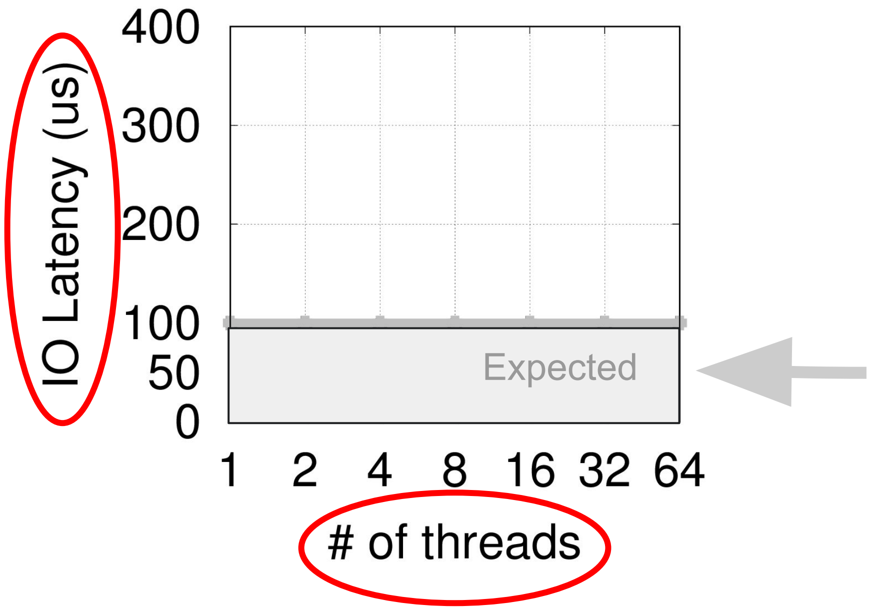
- **C**heap: $0, https://github.com/ucare-uchicago/femu
- **A**ccurate: 0.5-38% error rate in latency
  - 11% average at microsecond level
- **S**calable: support 32 channels/chips
- **E**xtensible
  - modifiable interface
  - modifiable FTL

What is FEMU?

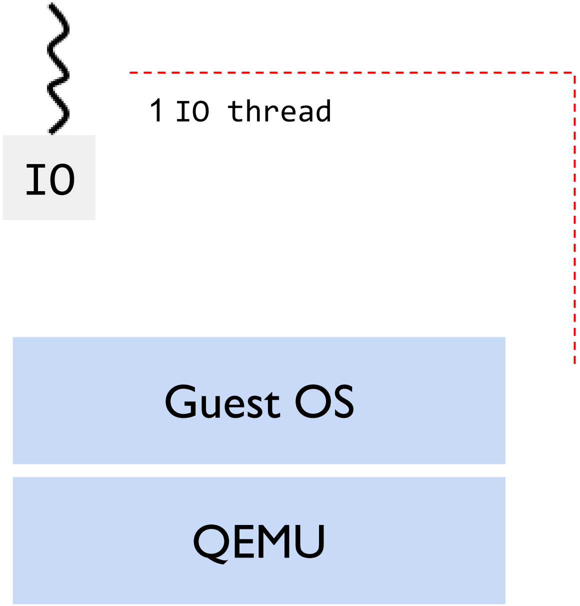

Typical Fullstack Research
FEMU Fullstack Research
App
Host OS
Hardware Platform
Altera FPGA
App
Guest OS
VM
NVMe
FEMU
QEMU
Supported research:
Kernel changes
Interface changes
FTL changes

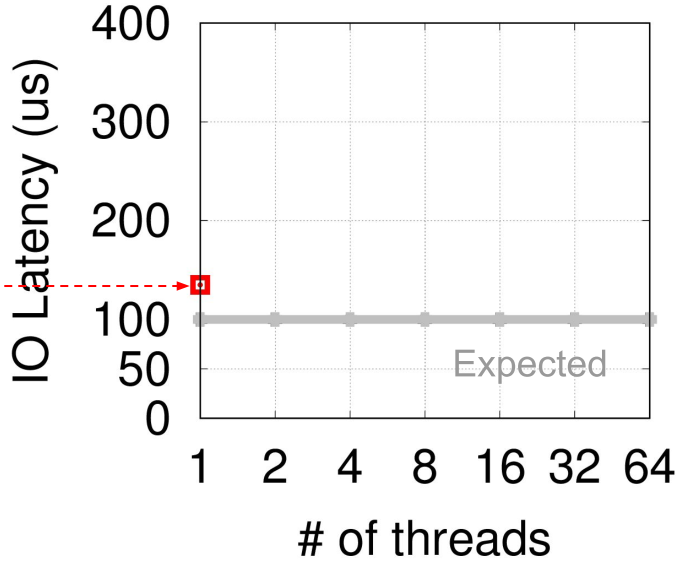
QEMU Scalability

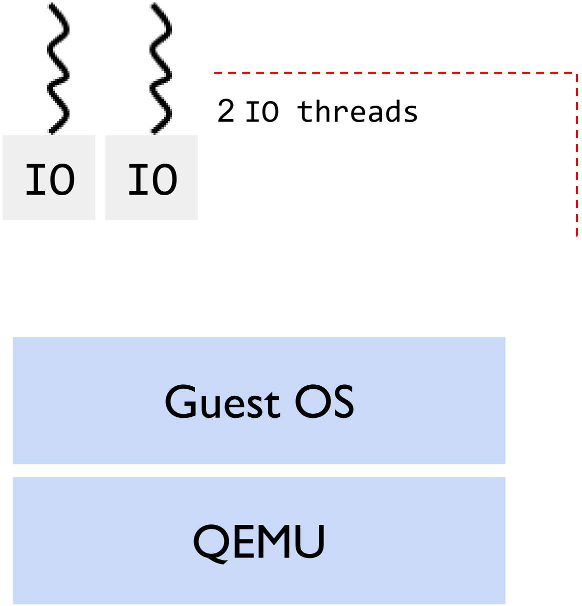


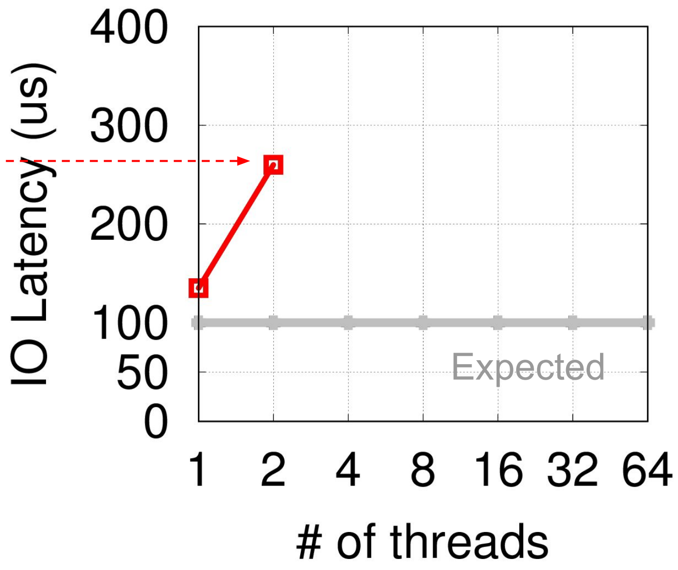


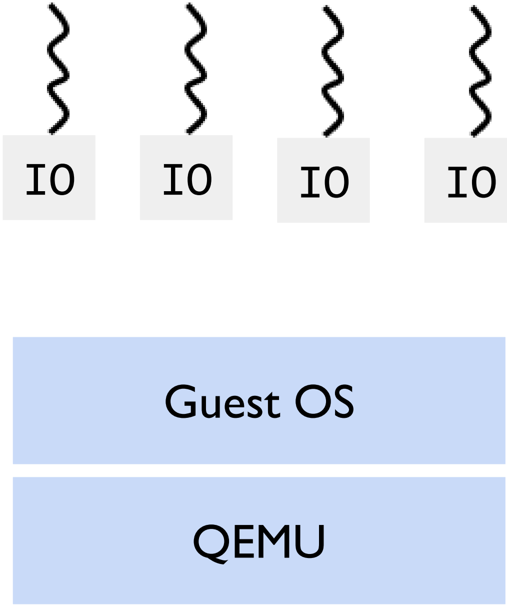
QEMU IDE Scalability

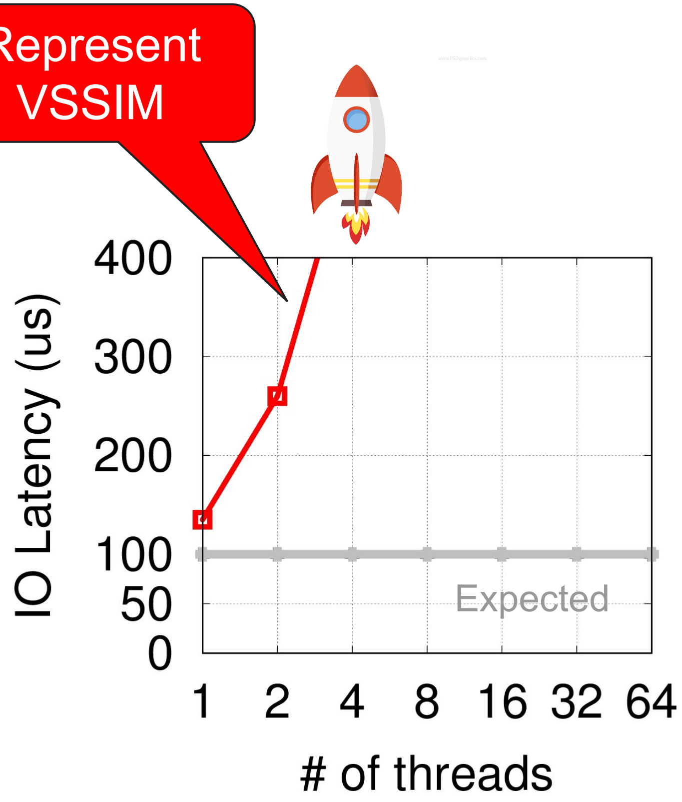




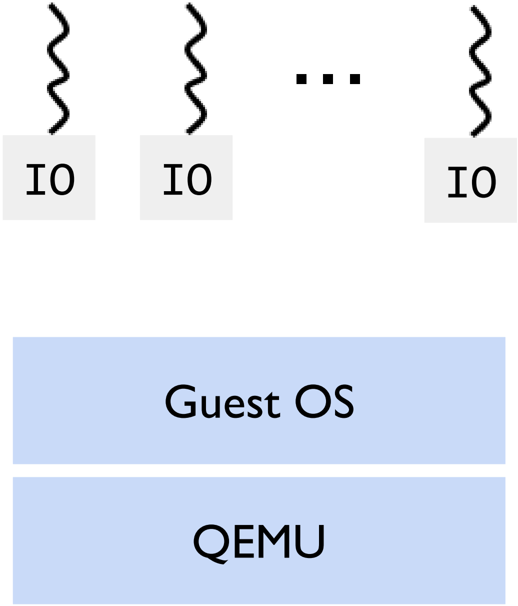

2 IO threads
IO
IO
Guest OS
QEMU

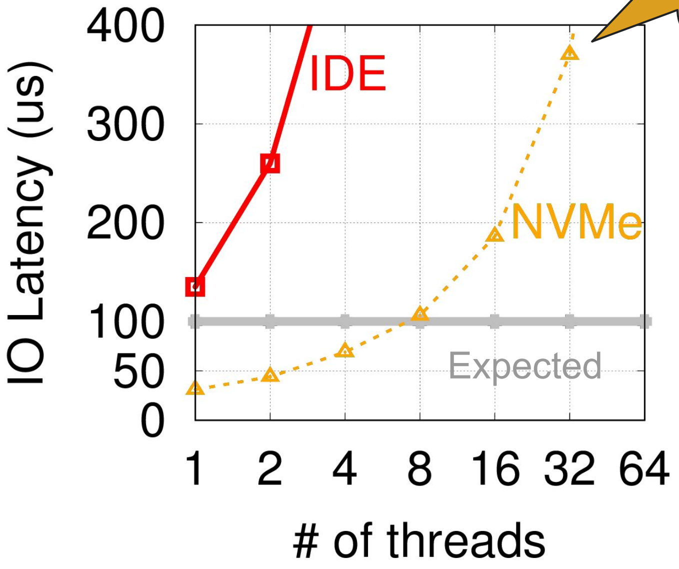

IO Latency (us)
400
300
200
100
50
0
Expected
1
2
4
8
16
32
64
# of threads


IO
IO
IO
IO
Guest OS
QEMU


Represent VSSIM
IO Latency (us)
400
300
200
100
50
0
1
2
4
8
16
32
64
# of threads
Expected

QEMU NVMe Scalability



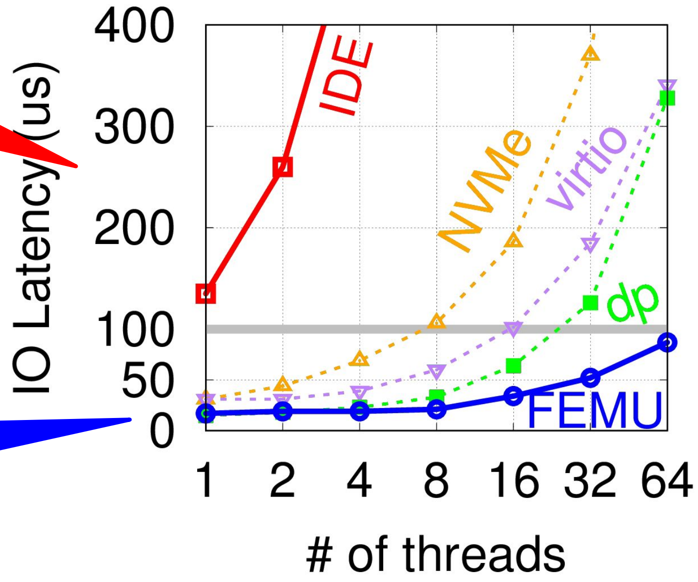


Represent LightNVM's QEMU

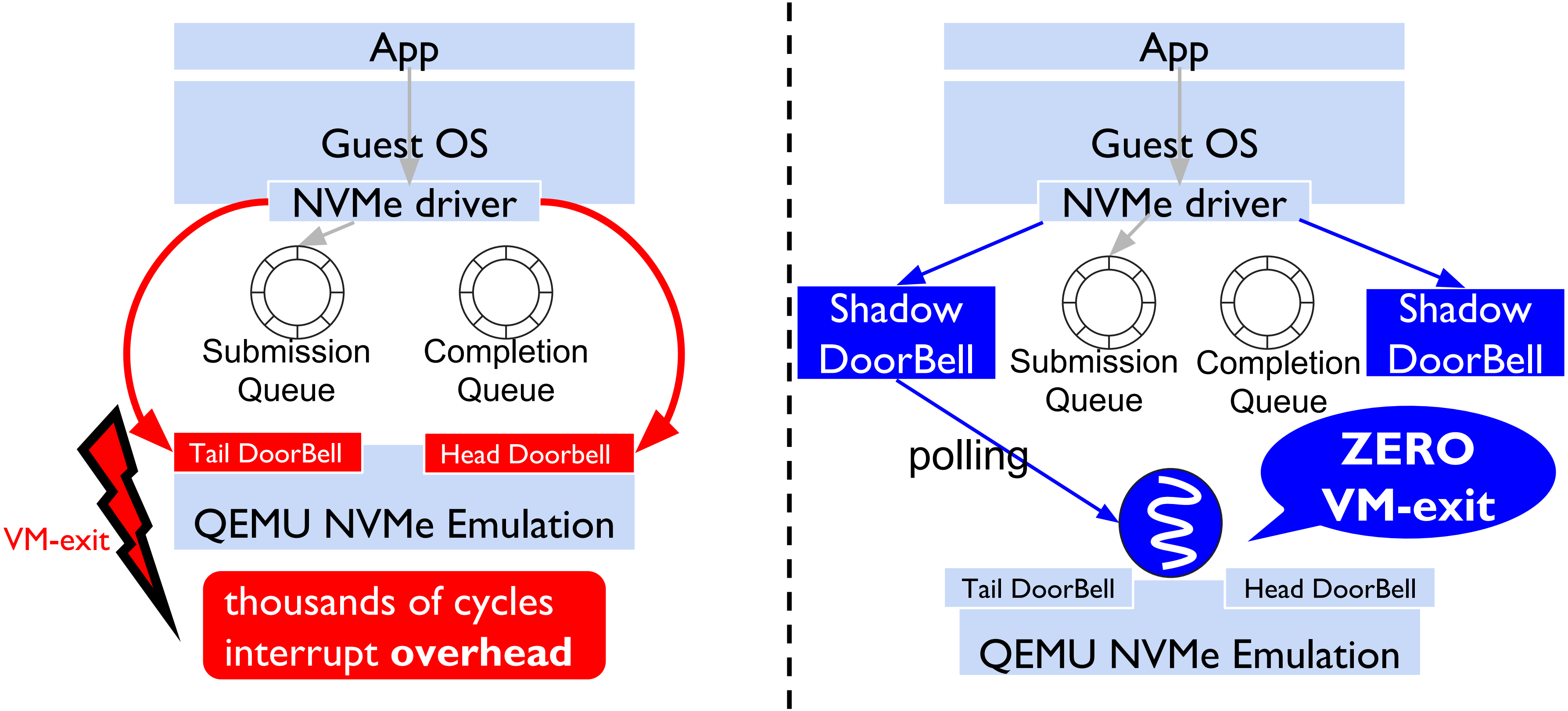
QEMU Scalability

QEMU and existing emulators are NOT Scalable !

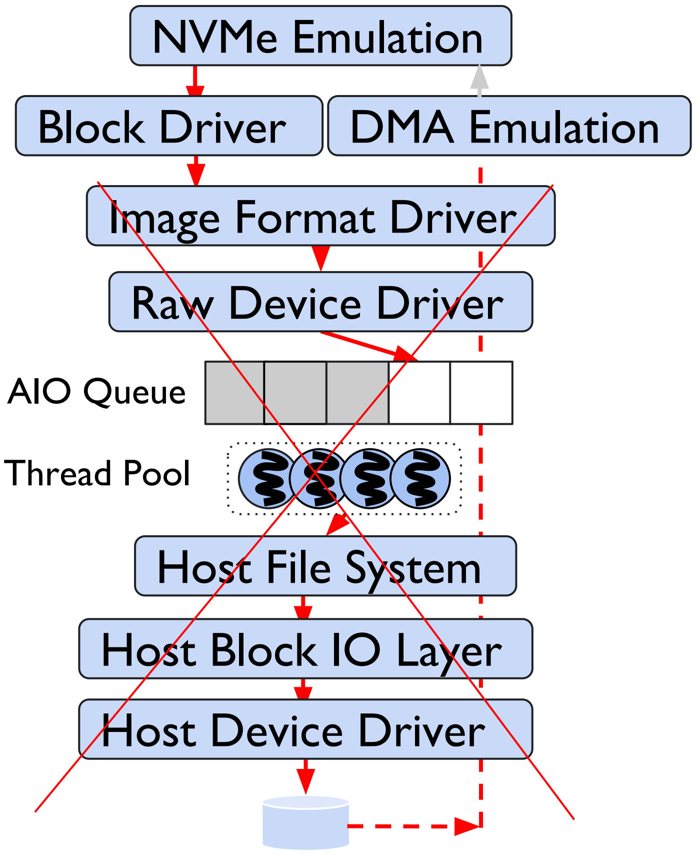
FEMU is Scalable !

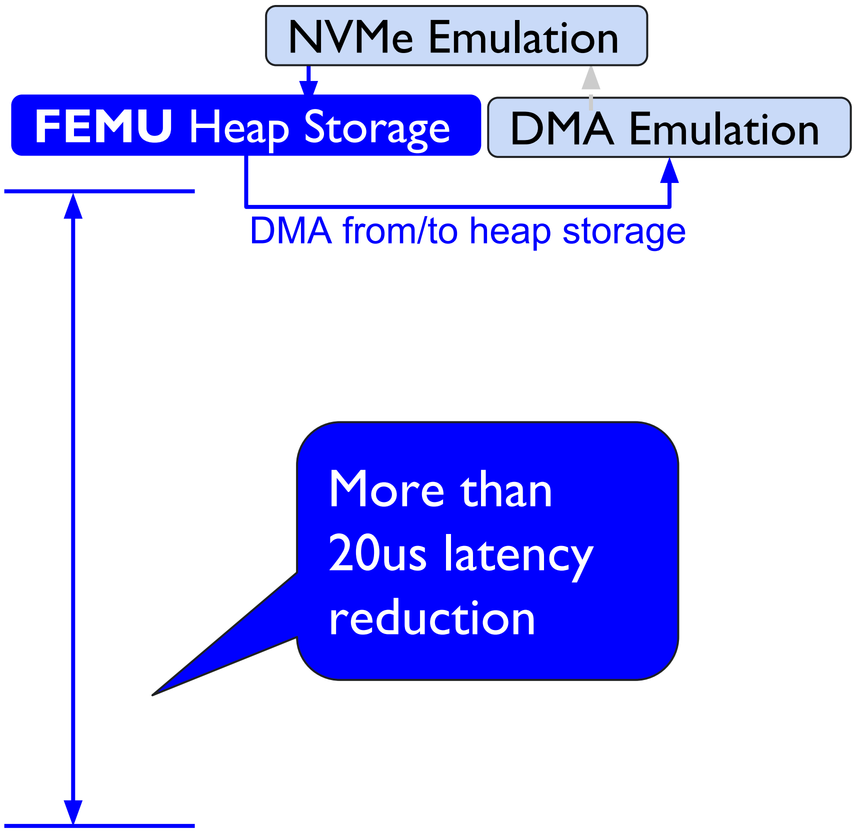


Scalability Root Causes & Solutions (1)



Scalability Root Causes & Solutions (2)





FEMU Accuracy

App

OpenChannel-SSD

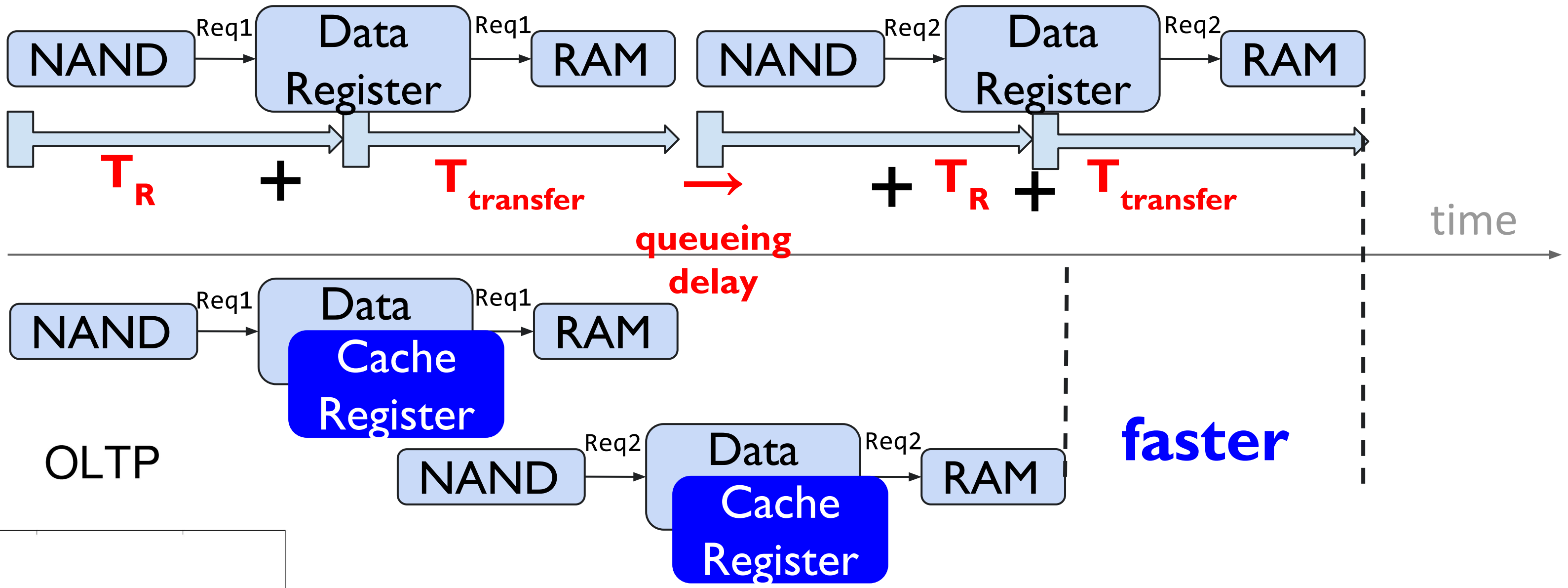
FEMU ?= 

L_{femu} L_{oc}

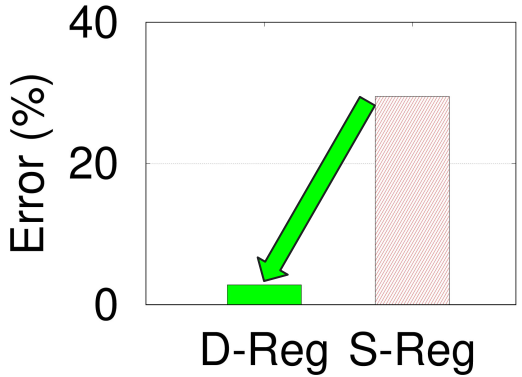
Error = $|L_{femu} - L_{oc}| / L_{oc}$

Single-Register model (**S-Reg**)

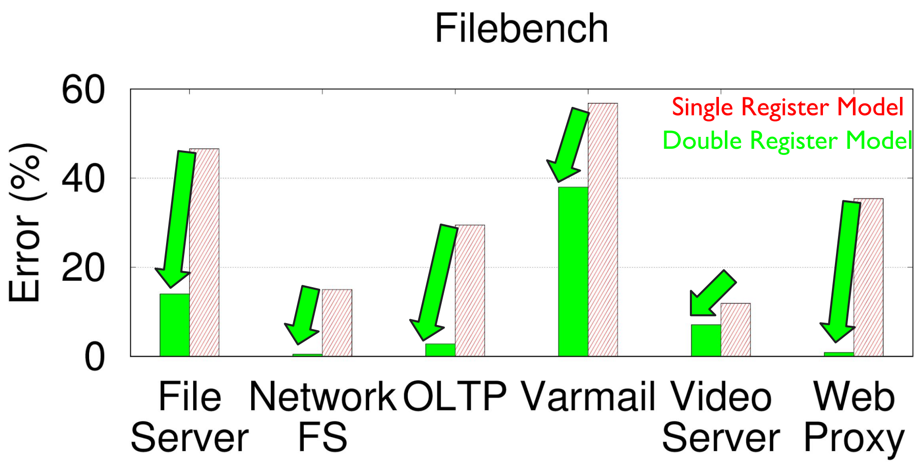
Double-Register model (**D-Reg**)



OLTP



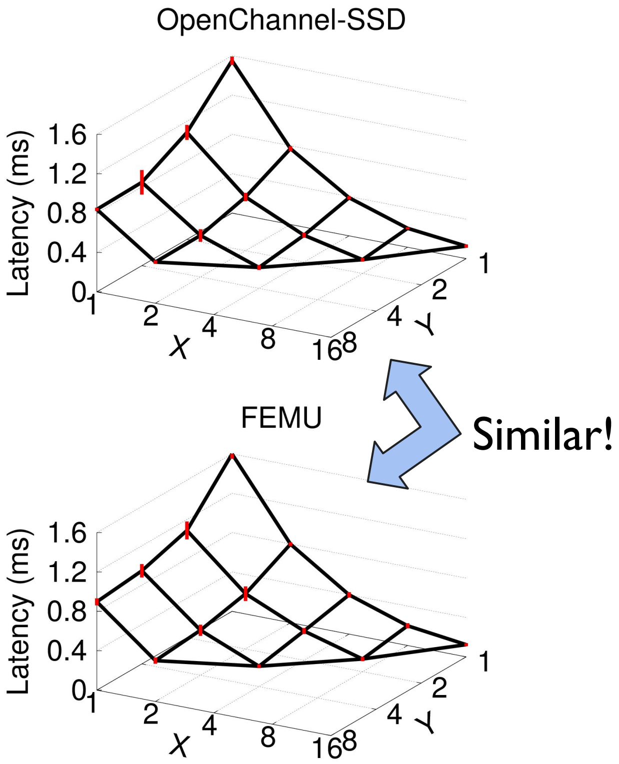
FEMU Accuracy



Latency Error: 11-57% ⇒ 0.5-38%

Single Register Model (**S-Reg**)

Double Register Model (**D-Reg**)



X: # of channels
Y: # of planes per channel

FEMU Limitations

- Further optimizations to support higher parallelism (more scalable)
- Accuracy can be improved
- Not able to emulate large-capacity SSD
- No persistence


• Cheap
• Accurate
• Scalable
• Extensible
FEMU
150mg
Installing, using and debugging FEMU can cause side effects including headache, nausea, agitation, and depression. If your research condition does not improve after using FEMU for a week, please talk to your advisor or us right away.
Order Now

Thank you!
Questions?

FEMU: https://github.com/ucare-uchicago/femu

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