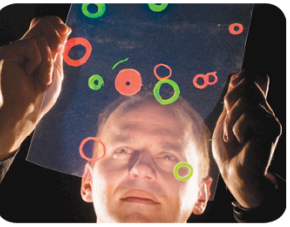
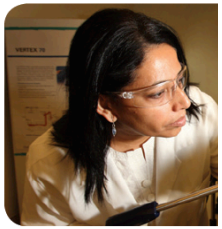
SAND2015-4780C





# "If you can dodge a wrench, you an dodge a ball"

**June 13, 2015**

**Dylan Stark**

**George Stelle**

Sandia National Laboratories

*Exceptional service in the national interest*

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

CCR Center for Computing Research

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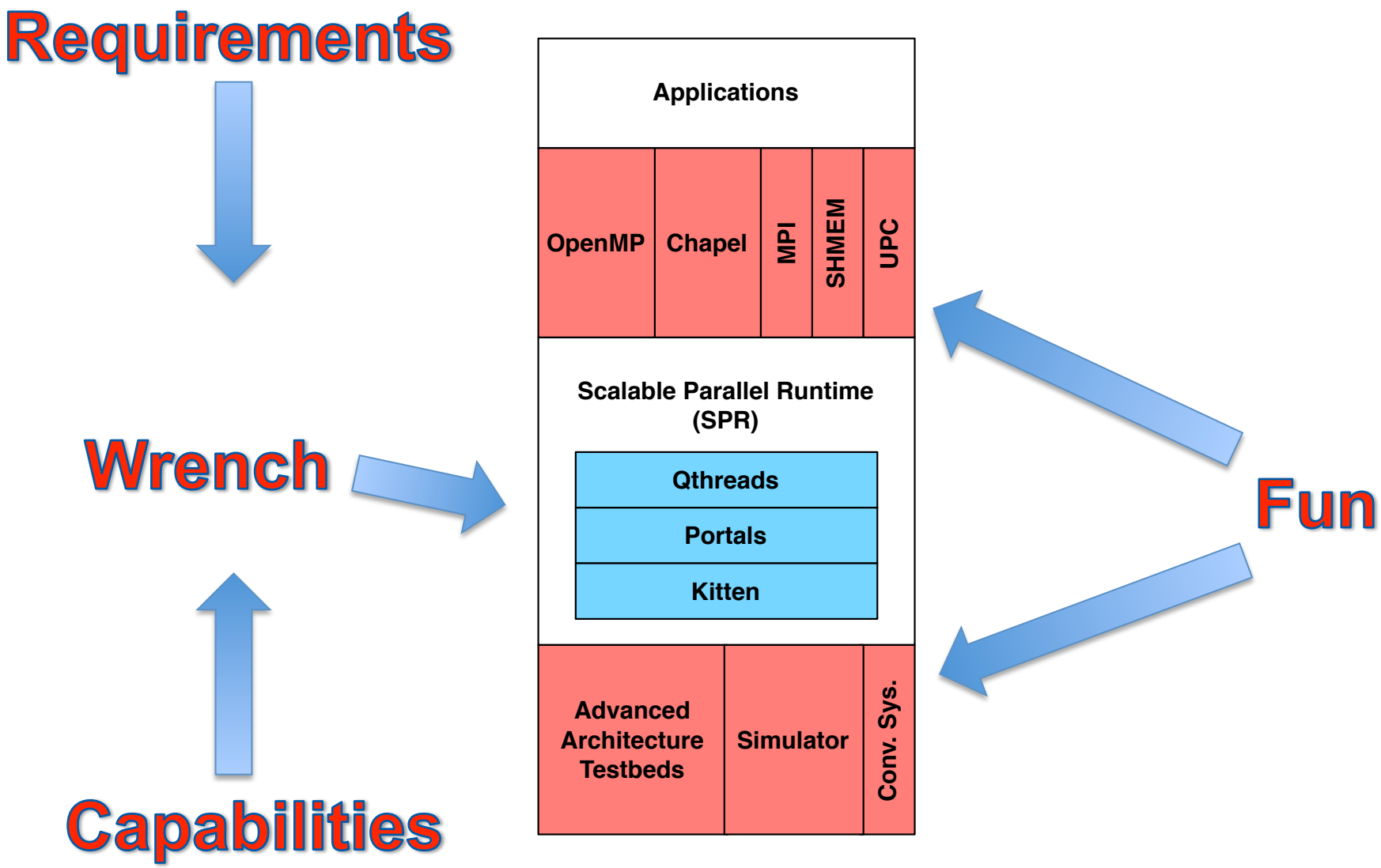
Requirements
Wrench
Capabilities
Fun
Applications
OpenMP
Chapel
MPI
SHMEM
UPC
Scalable Parallel Runtime (SPR)
Qthreads
Portals
Kitten
Advanced Architecture Testbeds
Simulator
Conv. Sys.

**“It is important to understand what you CAN DO before you learn to measure how well you seem to have DONE IT.”**

–John Tukey

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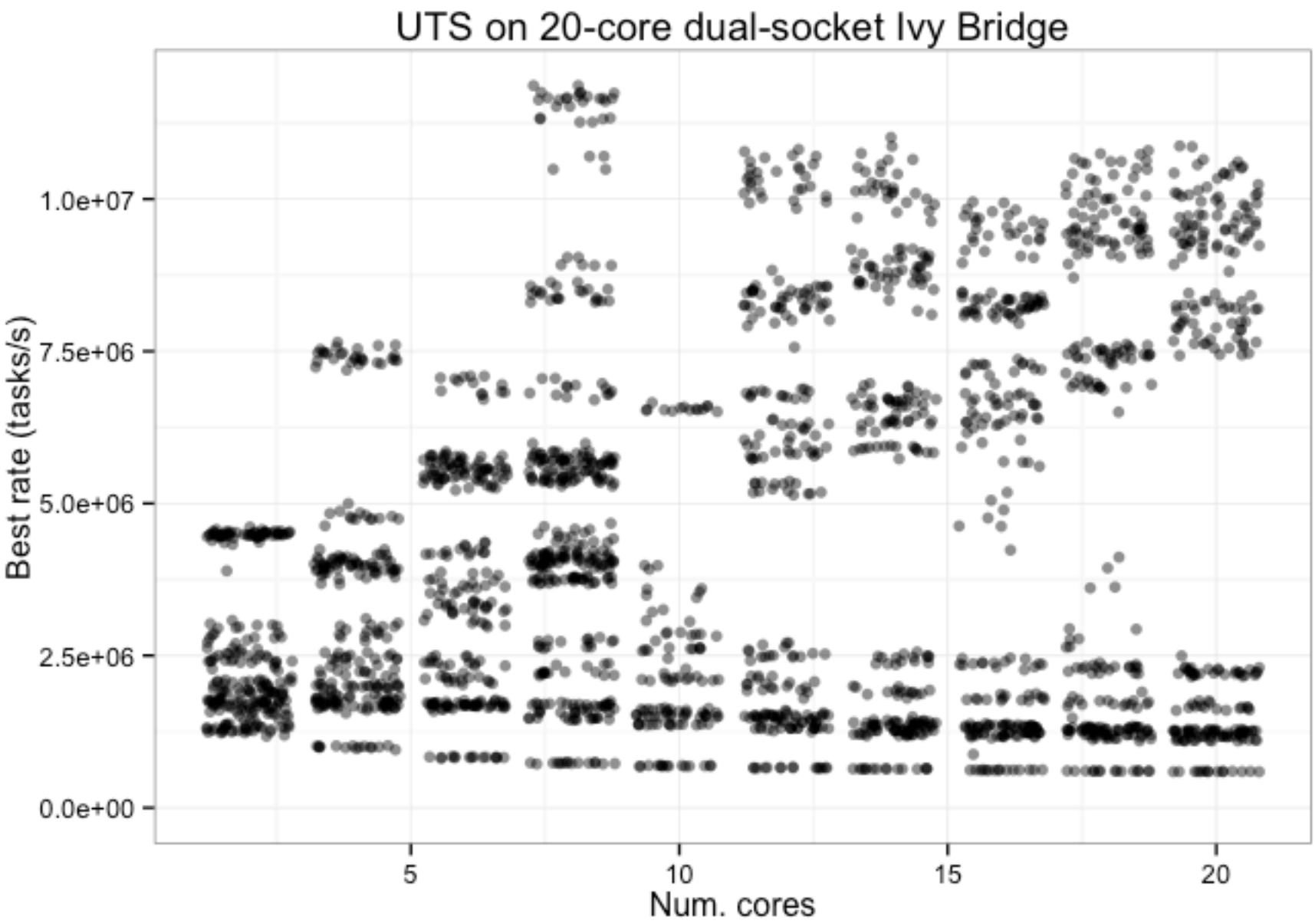
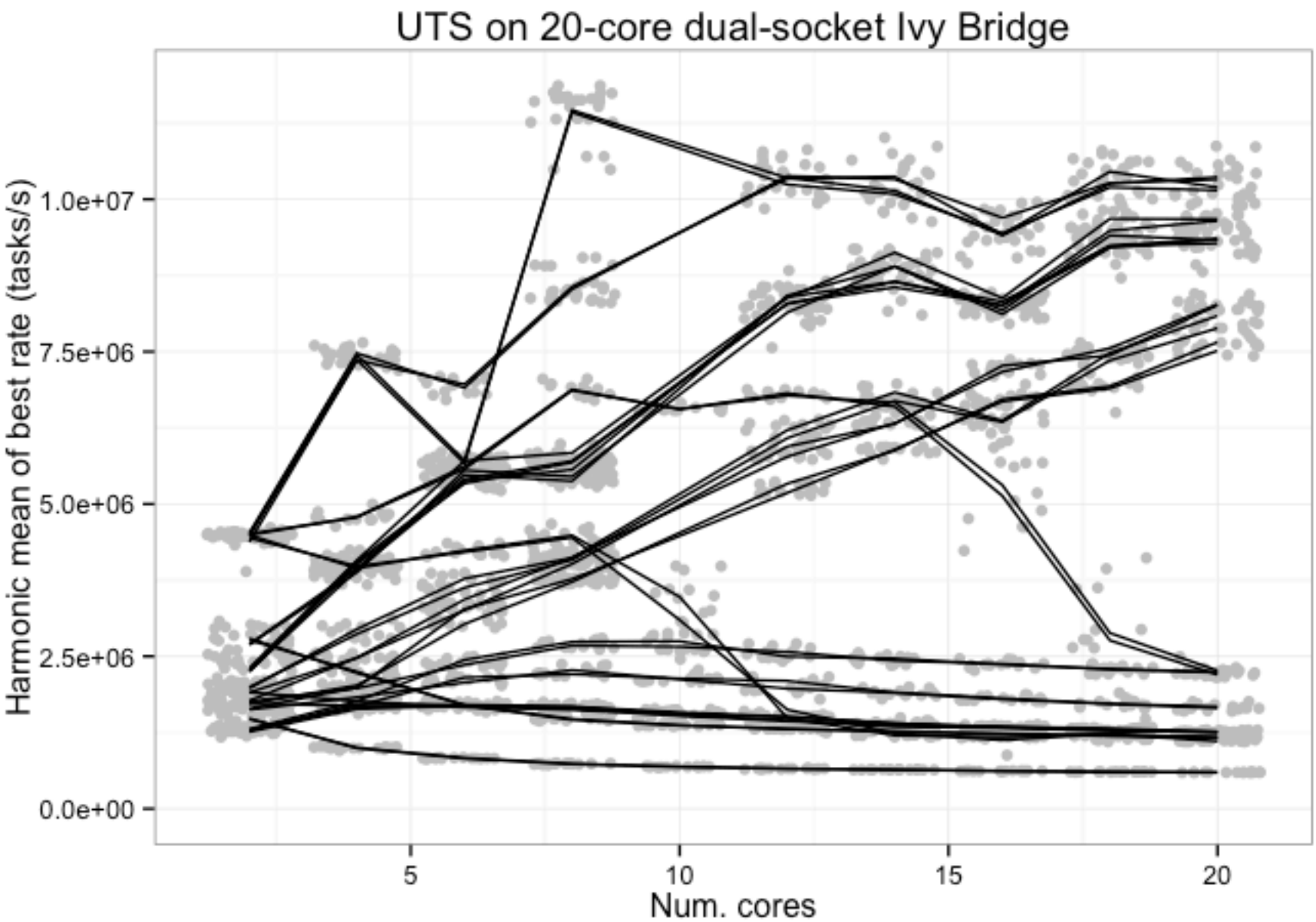
–John Tukey

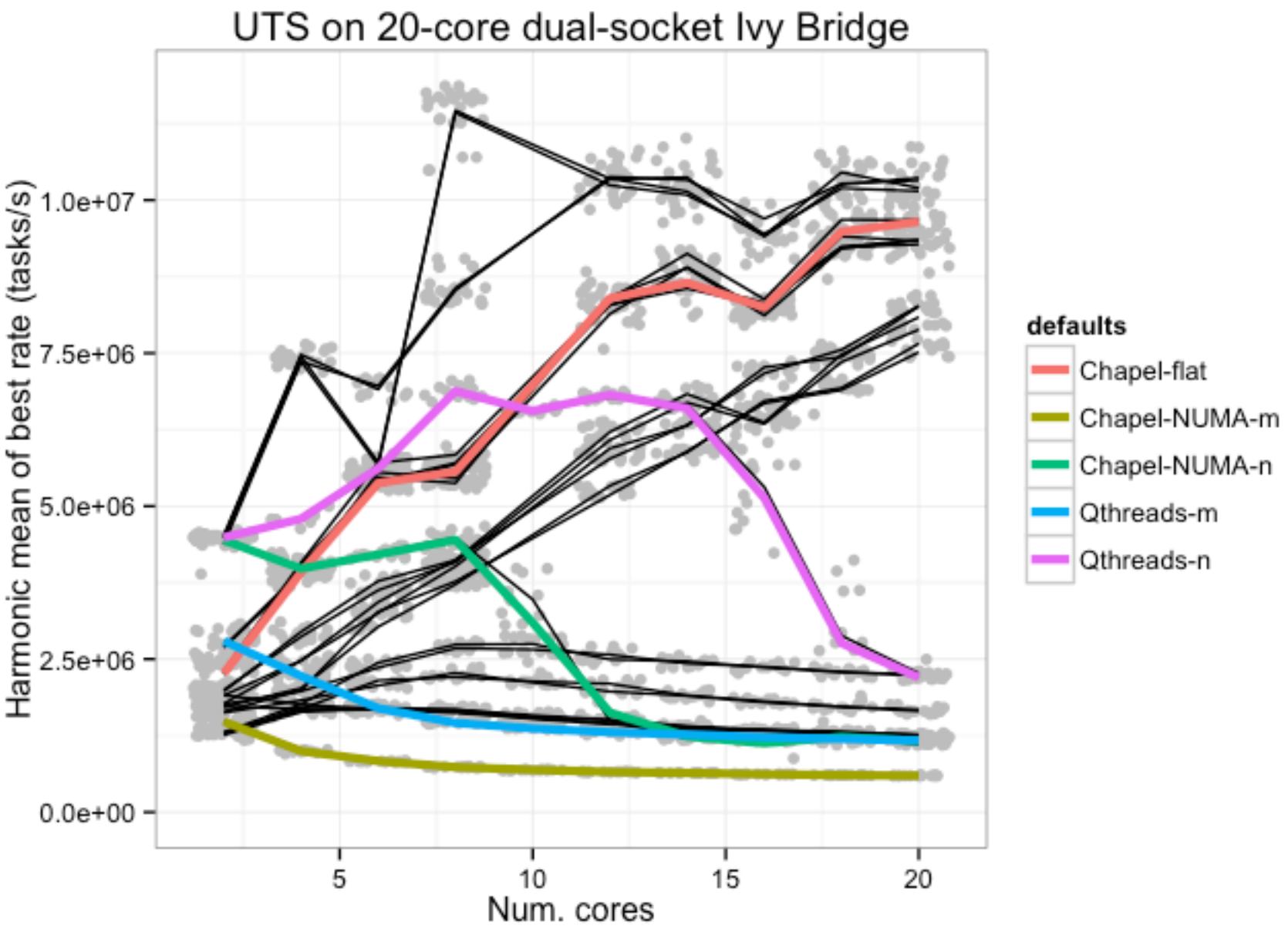
***START WITH THE BASICS:***

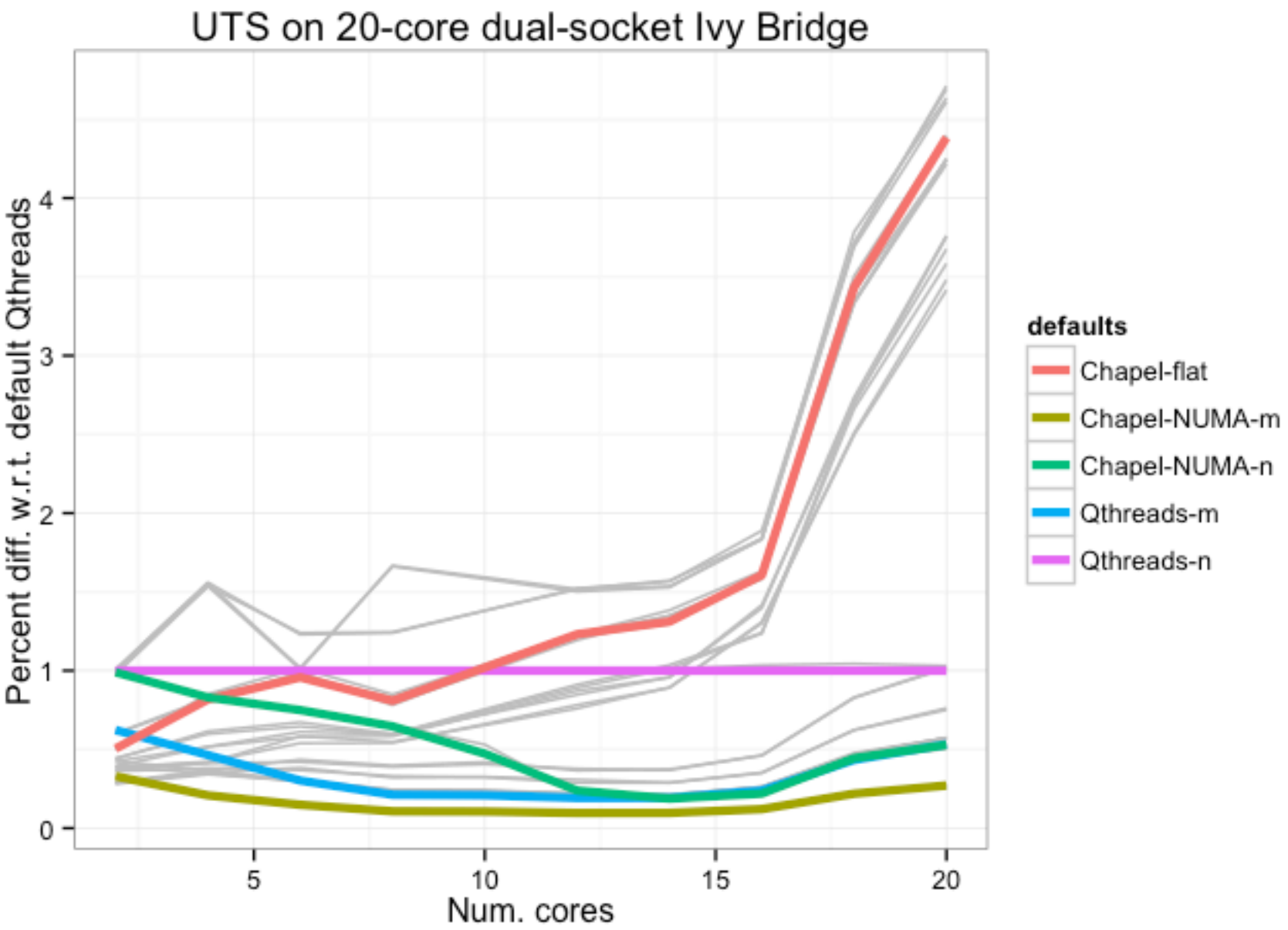
UNBALANCED TREE SEARCH (UTS)

INTEL XEON IVY BRIDGE (20-core dual-socket)


UTS on 20-core dual-socket Ivy Bridge
Best rate (tasks/s)
1.0e+07
7.5e+06
5.0e+06
2.5e+06
0.0e+00
5
10
15
20
Num. cores


UTS on 20-core dual-socket Ivy Bridge
Harmonic mean of best rate (tasks/s)
1.0e+07
7.5e+06
5.0e+06
2.5e+06
0.0e+00
5
10
15
20
Num. cores


UTS on 20-core dual-socket Ivy Bridge
Harmonic mean of best rate (tasks/s)
1.0e+07
7.5e+06
5.0e+06
2.5e+06
0.0e+00
5
10
15
20
Num. cores
defaults
Chapel-flat
Chapel-NUMA-m
Chapel-NUMA-n
Qthreads-m
Qthreads-n


UTS on 20-core dual-socket Ivy Bridge
Percent diff. w.r.t. default Qthreads
0
1
2
3
4
5
10
15
20
Num. cores
defaults
Chapel-flat
Chapel-NUMA-m
Chapel-NUMA-n
Qthreads-m
Qthreads-n

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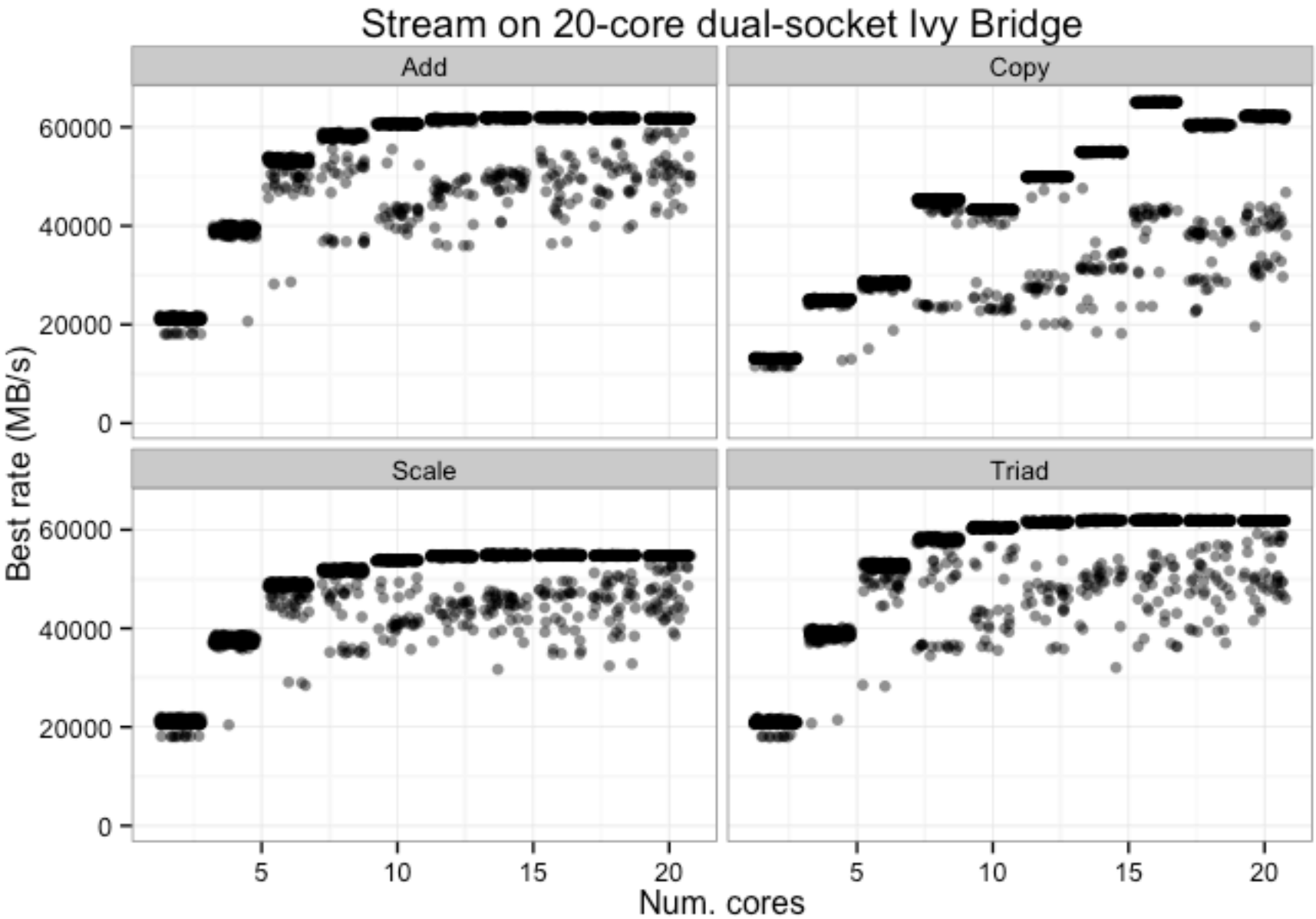
–John Tukey

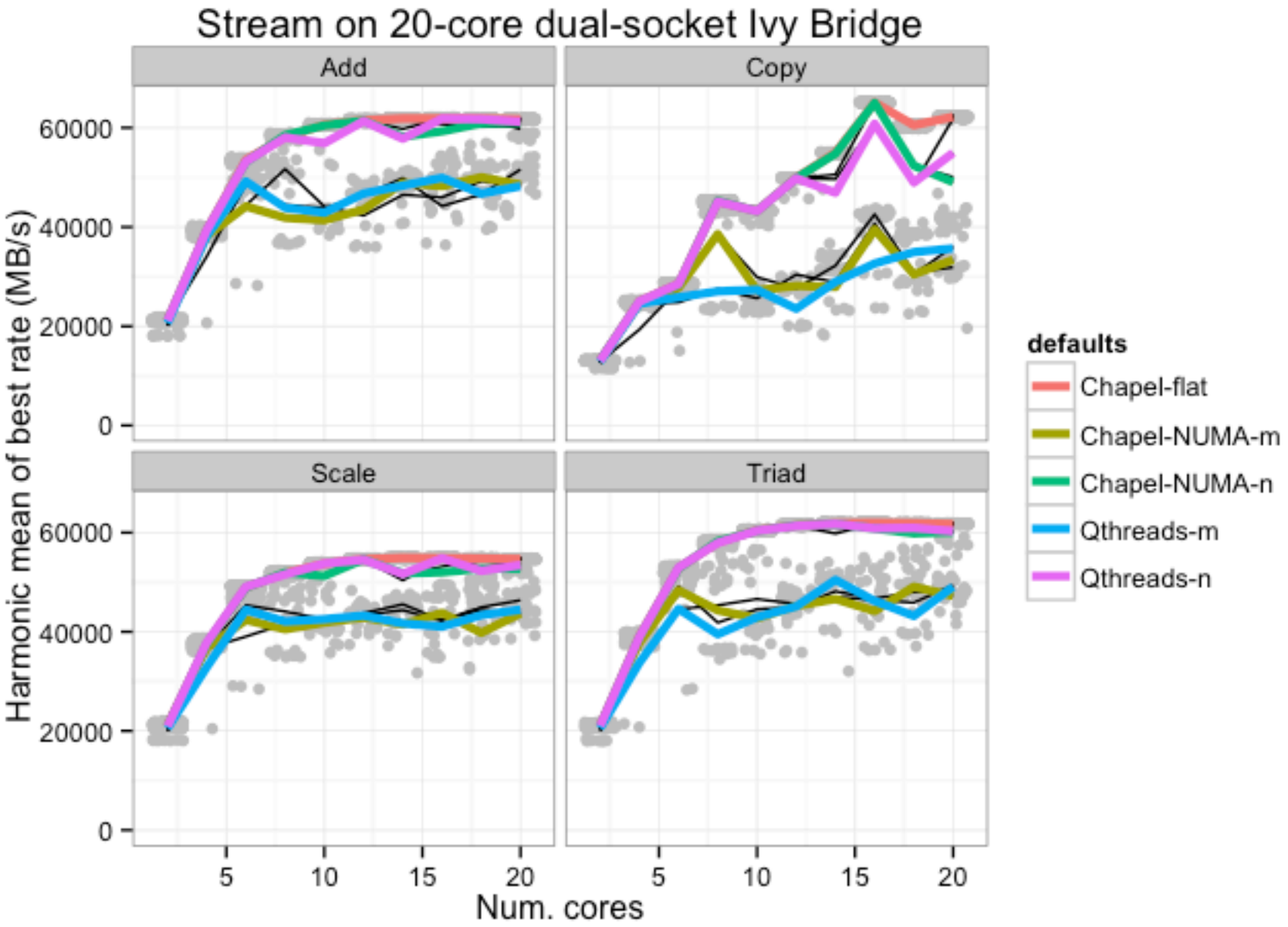
***CHANGE THE APPLICATION (REQUIREMENTS):***

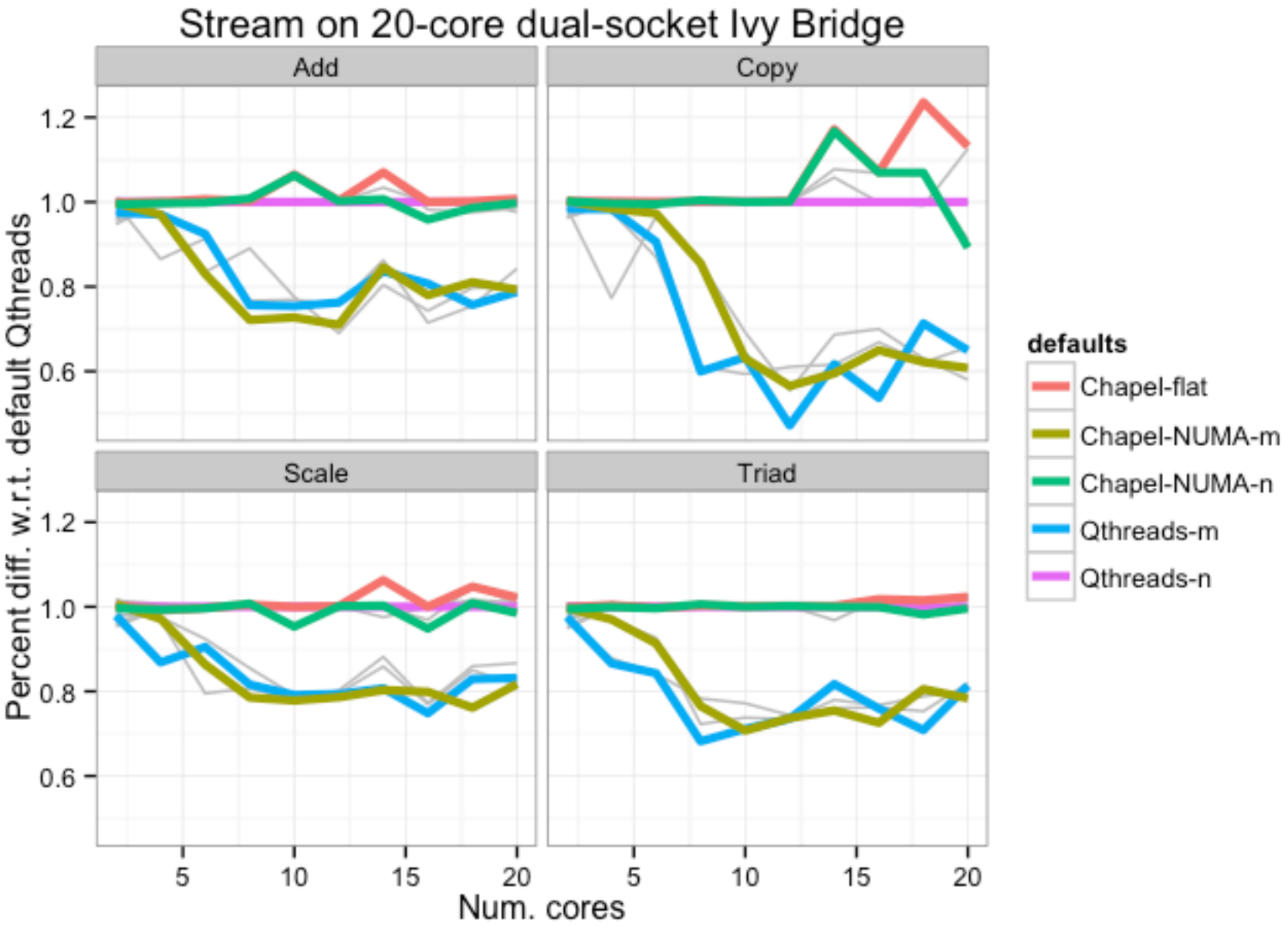
STREAM

INTEL XEON IVY BRIDGE (20-core dual-socket)


Stream on 20-core dual-socket Ivy Bridge
Add
Copy
Scale
Triad
Best rate (MB/s)
60000
40000
20000
0
5
10
15
20
Num. cores

Stream on 20-core dual-socket Ivy Bridge
Add
Copy
Scale
Triad
Harmonic mean of best rate (MB/s)
60000
40000
20000
0
5
10
15
20
Num. cores


Stream on 20-core dual-socket Ivy Bridge
Add
Copy
Scale
Triad
Harmonic mean of best rate (MB/s)
60000
40000
20000
0
5
10
15
20
Num. cores
defaults
Chapel-flat
Chapel-NUMA-m
Chapel-NUMA-n
Qthreads-m
Qthreads-n


Stream on 20-core dual-socket Ivy Bridge
Add
Copy
Scale
Triad
Percent diff. w.r.t. default Qthreads
1.2
1.0
0.8
0.6
5
10
15
20
Num. cores
defaults
Chapel-flat
Chapel-NUMA-m
Chapel-NUMA-n
Qthreads-m
Qthreads-n

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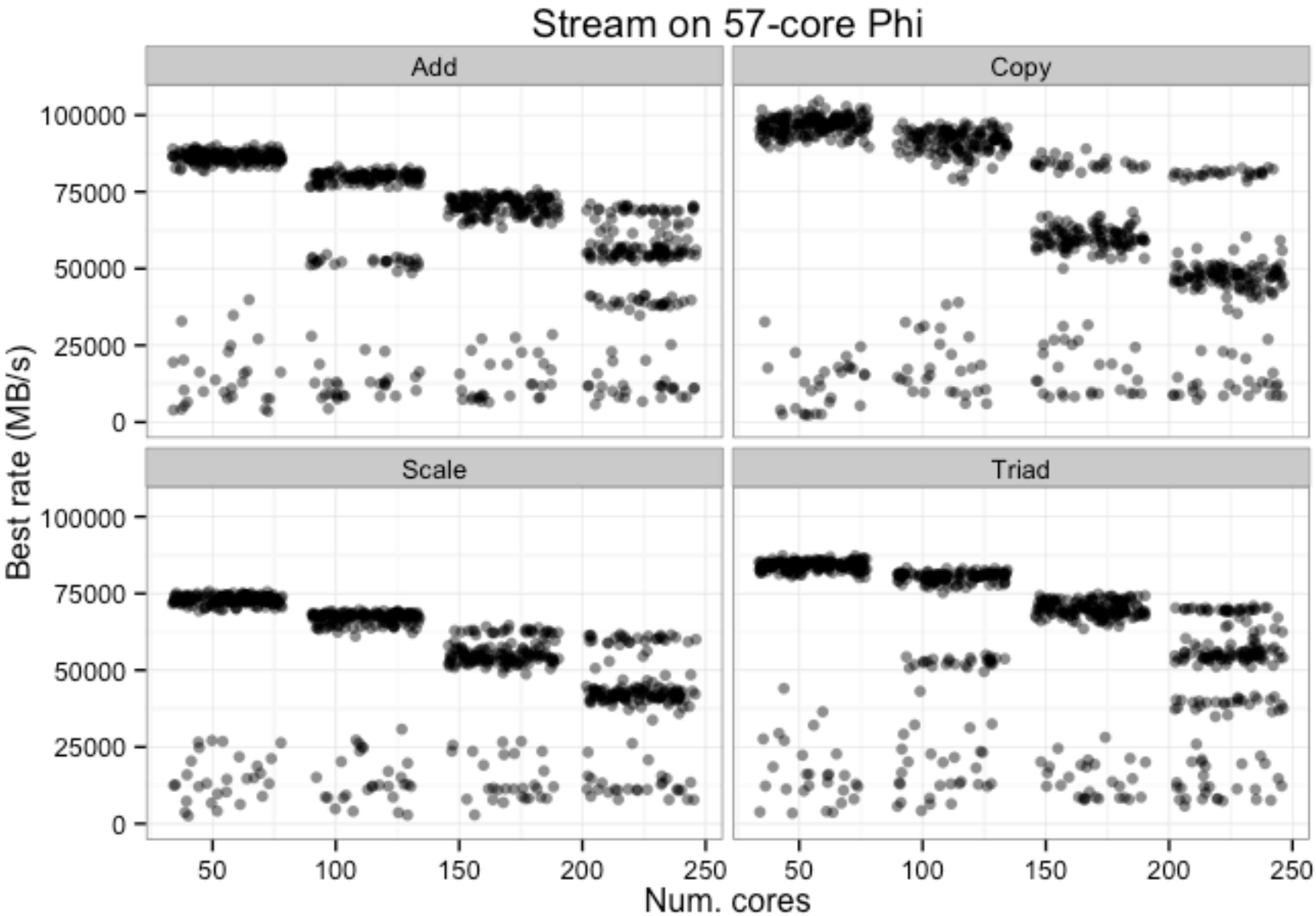
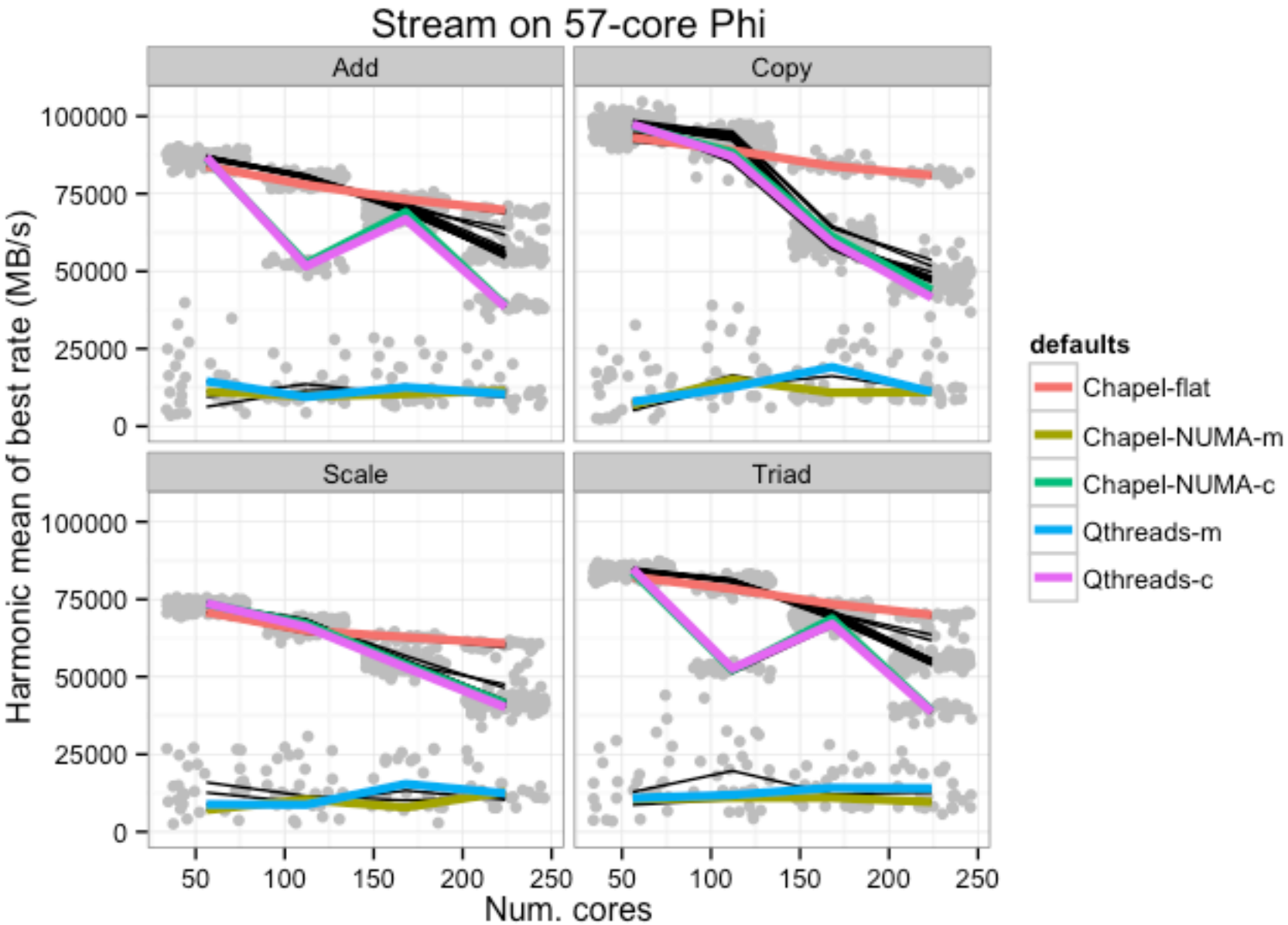
–John Tukey

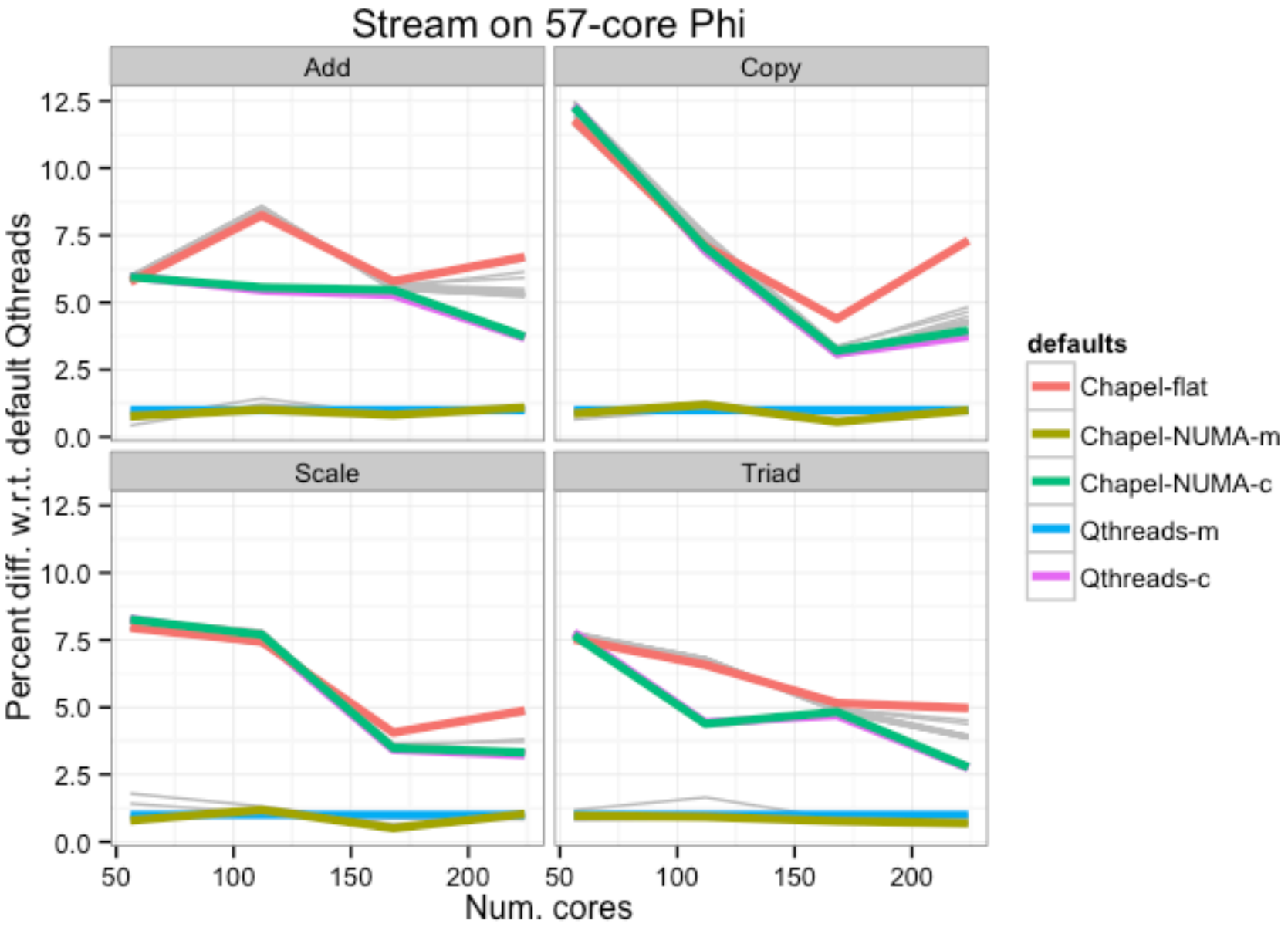
***CHANGE THE ARCHITECTURE (CAPABILITIES):***

STREAM

INTEL XEON PHI (57-core)


Stream on 57-core Phi
Add
Copy
Scale
Triad
Best rate (MB/s)
100000
75000
50000
25000
0
50
100
150
200
250
Num. cores


Stream on 57-core Phi
Add
Copy
Scale
Triad
Harmonic mean of best rate (MB/s)
100000
75000
50000
25000
0
50
100
150
200
250
Num. cores
defaults
Chapel-flat
Chapel-NUMA-m
Chapel-NUMA-c
Qthreads-m
Qthreads-c


Stream on 57-core Phi
Add
Copy
Scale
Triad
Percent diff. w.r.t. default Qthreads
12.5
10.0
7.5
5.0
2.5
0.0
50
100
150
200
Num. cores
defaults
Chapel-flat
Chapel-NUMA-m
Chapel-NUMA-c
Qthreads-m
Qthreads-c

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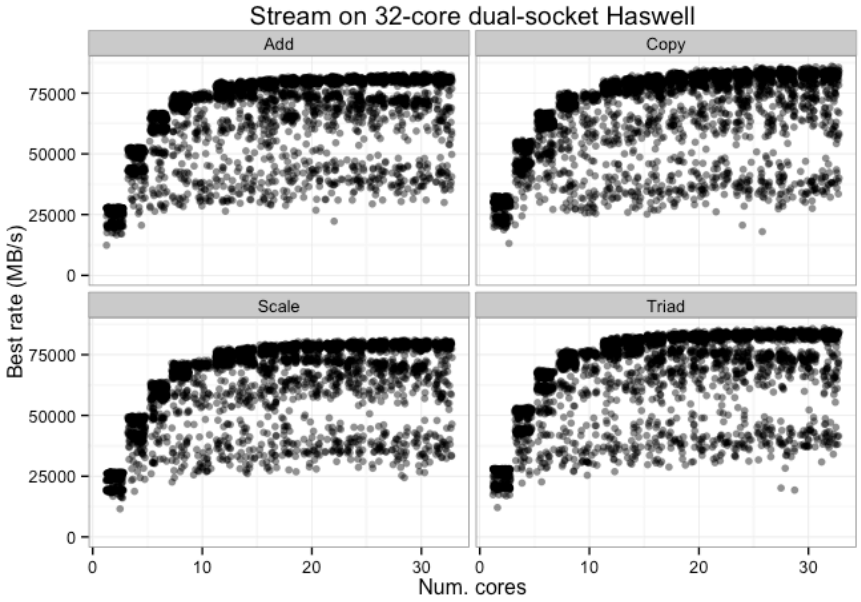
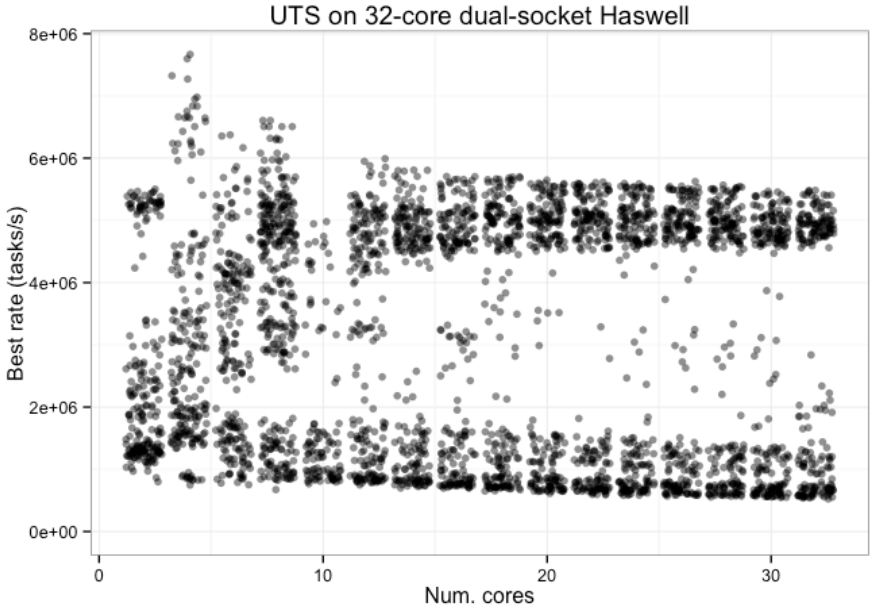
–John Tukey

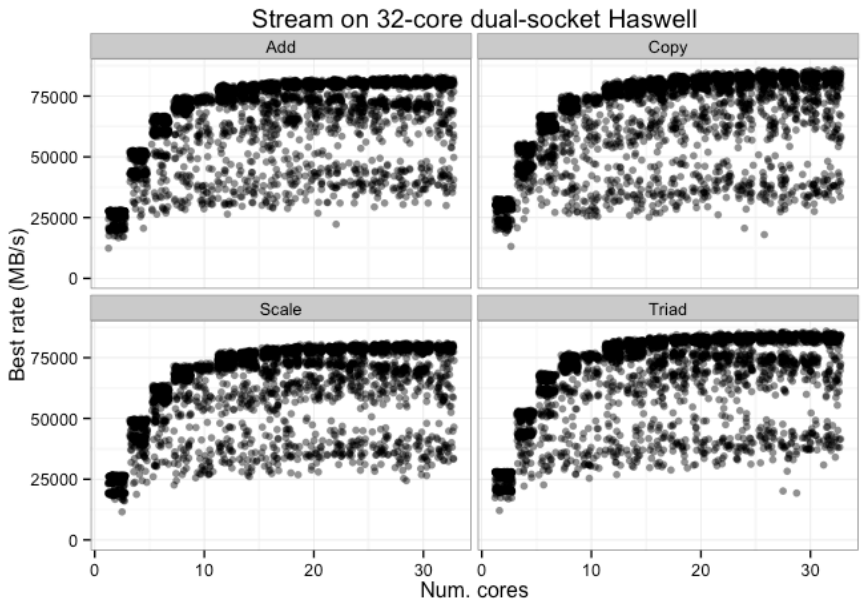
***RINSE AND REPEAT:***

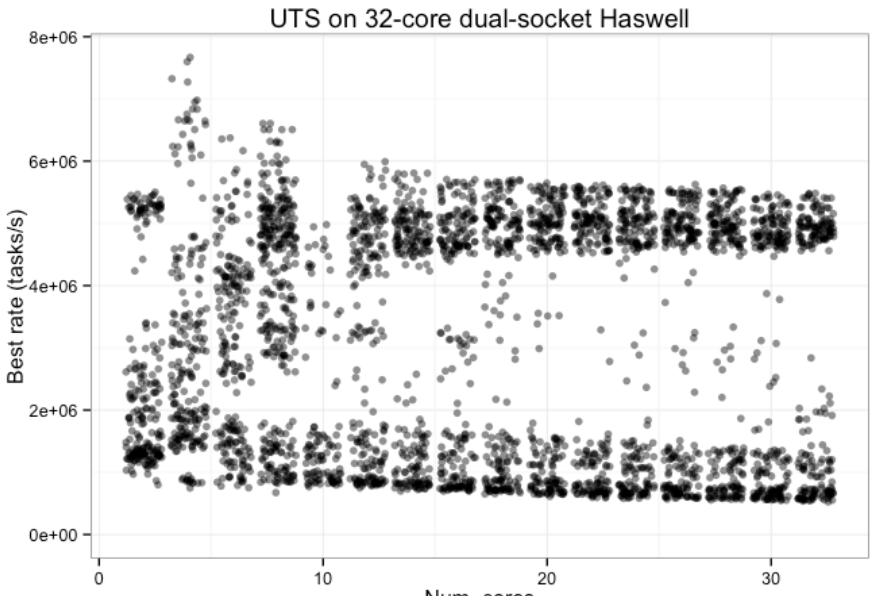
STREAM & UNBALANCED TREE SEARCH (UTS)

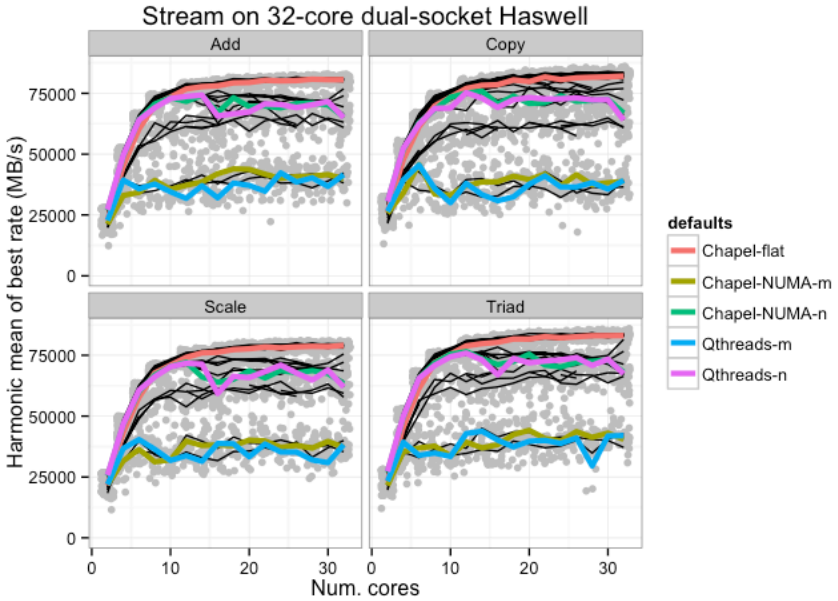
INTEL XEON HASWELL (32-core)

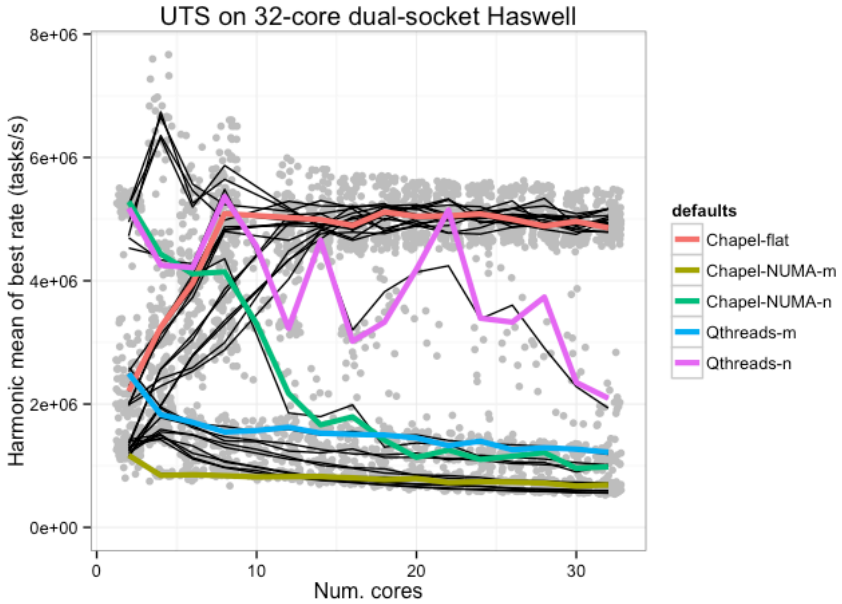

Stream on 32-core dual-socket Haswell
Add
Copy
Scale
Triad
Best rate (MB/s)
75000
50000
25000
0
0
10
20
30
Num. cores

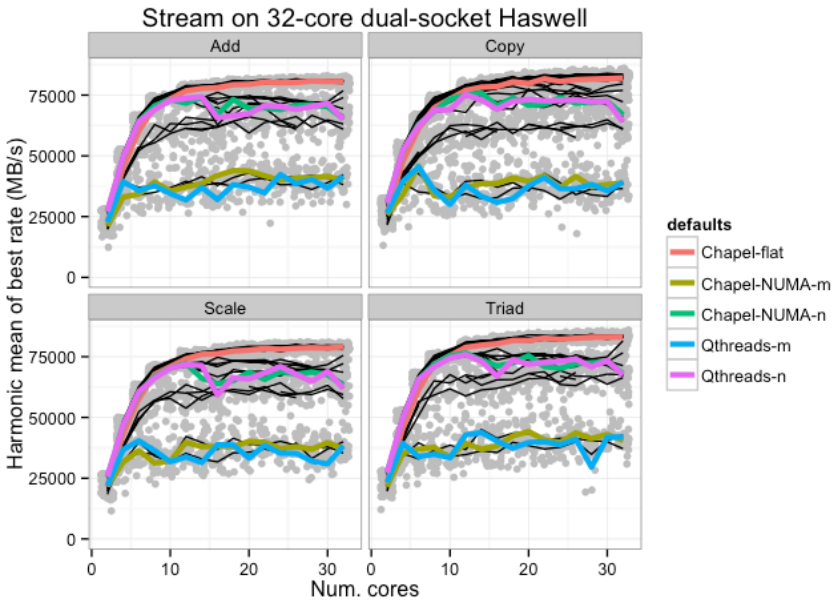

UTS on 32-core dual-socket Haswell
Best rate (tasks/s)
8e+06
6e+06
4e+06
2e+06
0e+00
0
10
20
30
Num. cores

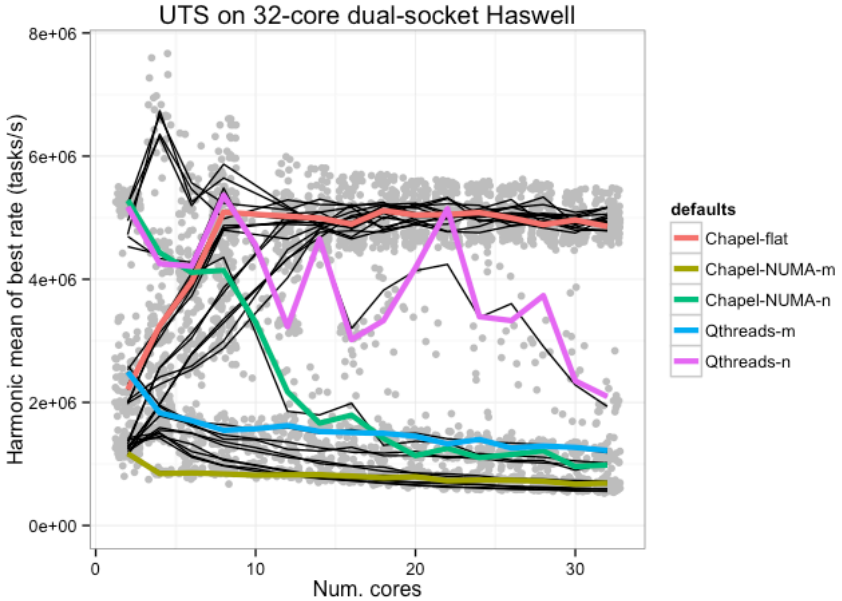

Stream on 32-core dual-socket Haswell
Add
Copy
Scale
Triad
Best rate (MB/s)
75000
50000
25000
0
0
10
20
30
Num. cores

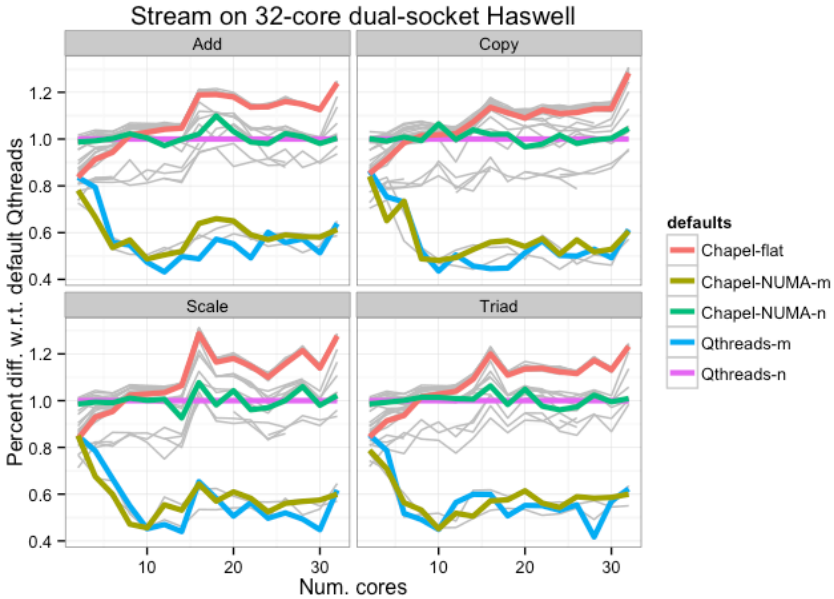

UTS on 32-core dual-socket Haswell
Best rate (tasks/s)
8e+06
6e+06
4e+06
2e+06
0e+00
0
10
20
30

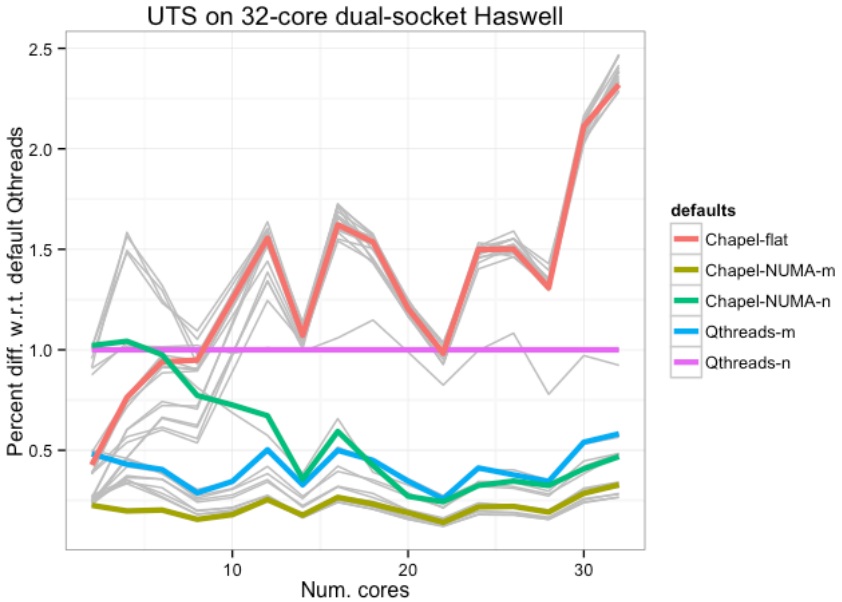

Stream on 32-core dual-socket Haswell
Add
Copy
Scale
Triad
Harmonic mean of best rate (MB/s)
75000
50000
25000
0
0
10
20
30
Num. cores
defaults
Chapel-flat
Chapel-NUMA-m
Chapel-NUMA-n
Qthreads-m
Qthreads-n


UTS on 32-core dual-socket Haswell
Harmonic mean of best rate (tasks/s)
8e+06
6e+06
4e+06
2e+06
0e+00
0
10
20
30
Num. cores
defaults
Chapel-flat
Chapel-NUMA-m
Chapel-NUMA-n
Qthreads-m
Qthreads-n


Stream on 32-core dual-socket Haswell
Add
Copy
Scale
Triad
Harmonic mean of best rate (MB/s)
75000
50000
25000
0
0
10
20
30
Num. cores
defaults
Chapel-flat
Chapel-NUMA-m
Chapel-NUMA-n
Qthreads-m
Qthreads-n


UTS on 32-core dual-socket Haswell
Harmonic mean of best rate (tasks/s)
8e+06
6e+06
4e+06
2e+06
0e+00
0
10
20
30
Num. cores
defaults
Chapel-flat
Chapel-NUMA-m
Chapel-NUMA-n
Qthreads-m
Qthreads-n


Stream on 32-core dual-socket Haswell
Add
Copy
Scale
Triad
Percent diff. w.r.t. default Qthreads
1.2
1.0
0.8
0.6
0.4
10
20
30
Num. cores
defaults
Chapel-flat
Chapel-NUMA-m
Chapel-NUMA-n
Qthreads-m
Qthreads-n


UTS on 32-core dual-socket Haswell
Percent diff. w.r.t. default Qthreads
2.5
2.0
1.5
1.0
0.5
10
20
30
Num. cores
defaults
Chapel-flat
Chapel-NUMA-m
Chapel-NUMA-n
Qthreads-m
Qthreads-n

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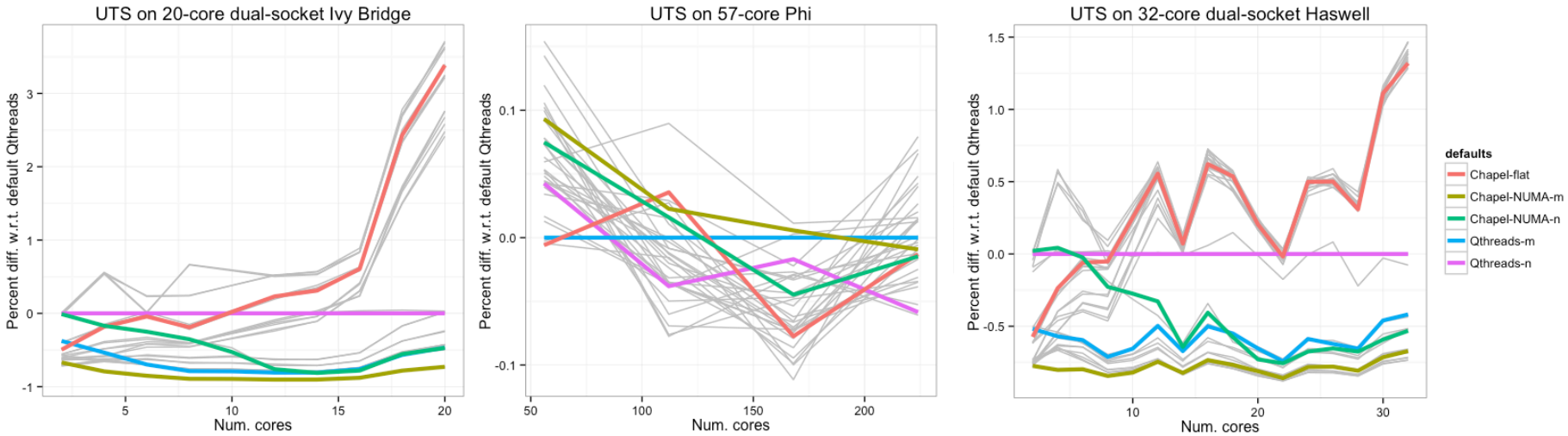
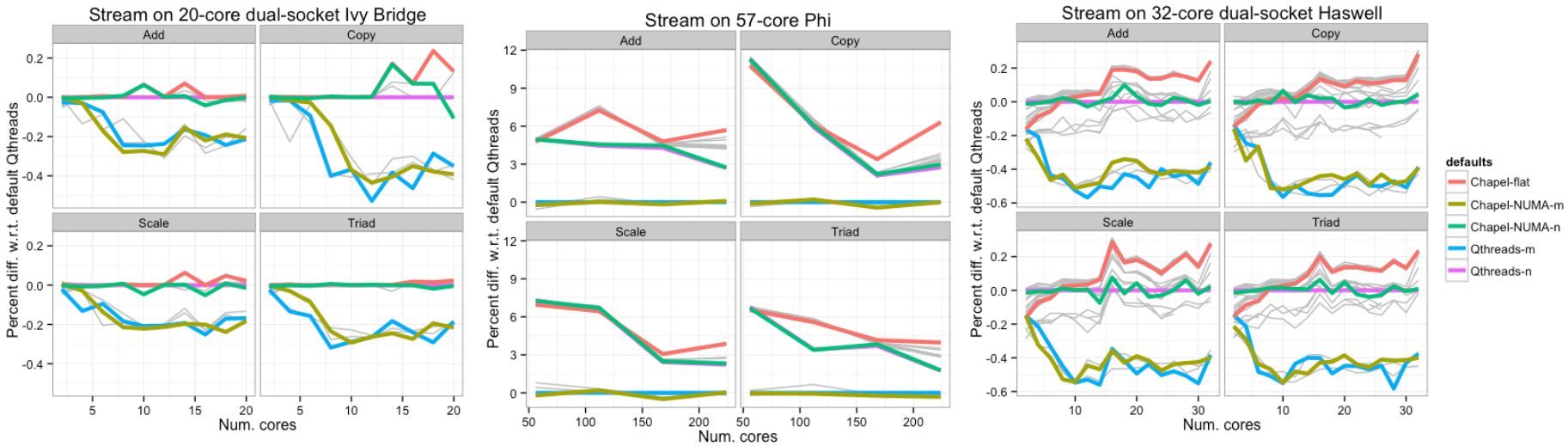
–John Tukey

**Beware what you don't know you don't know about what the runtimes are doing (there lie extraneous variables, and confounders!)**

**But keep exploring with more applications and architectures**




# Any questions?