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CSE 291: Operating Systems in Datacenters

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Agenda for Today

- Research Tips: Benchmarking
- FPGAs overview
- Coyote discussion

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Research Tips: Benchmarking

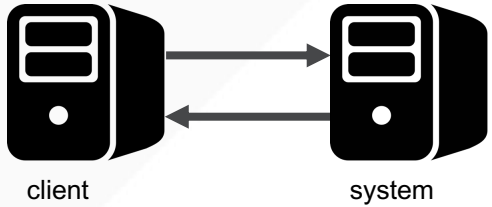
Research Tips: Benchmarking

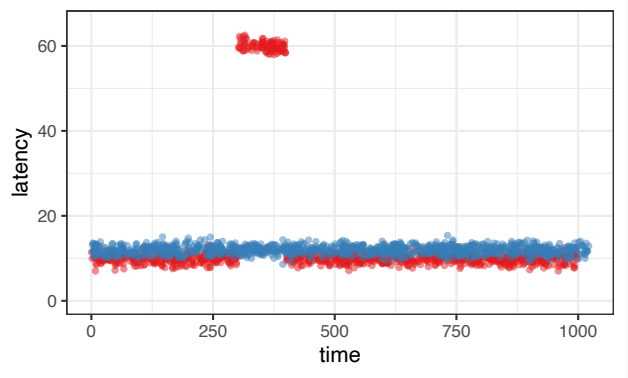
- Strategies for effectively measuring systems performance
- Why is this important?
  - Reading papers:
    - Do the experiments measure/show what they intend to?
    - Do the results make sense?
  - Benchmarking in your own research projects:
    - Conduct accurate and meaningful measurements

Benchmarking (Fake) Example

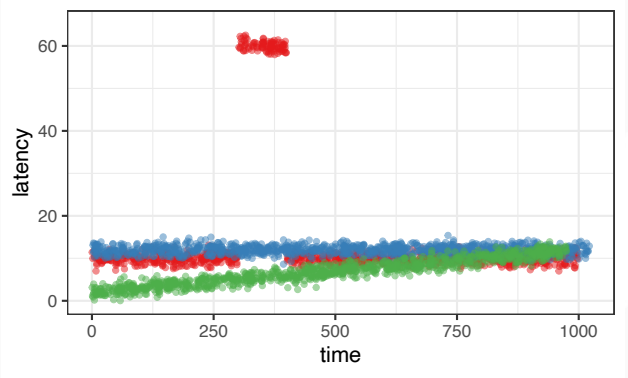
- Comparing the latency of different systems, A and B
  - Which system has better latency?
- Suppose we measure them and find:

System	A	B	C	D
Average latency	14.7	12.0	6.9	31.0

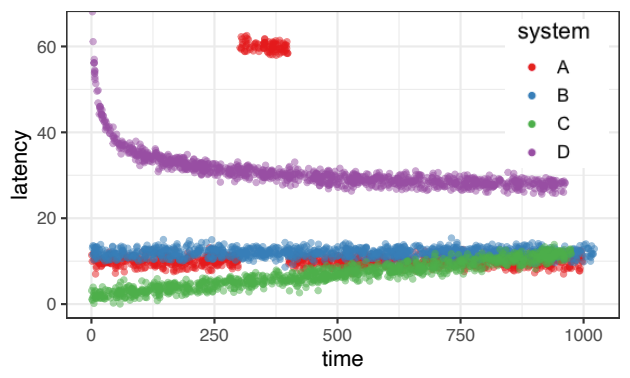




latency spike – maybe a bug? another app?



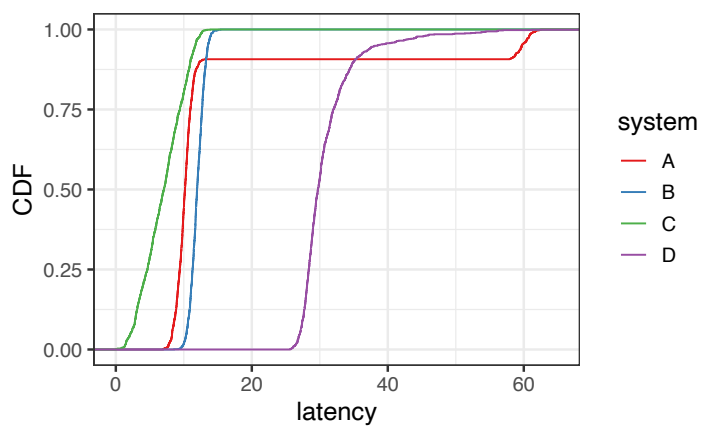
increasing latency – queue building up?

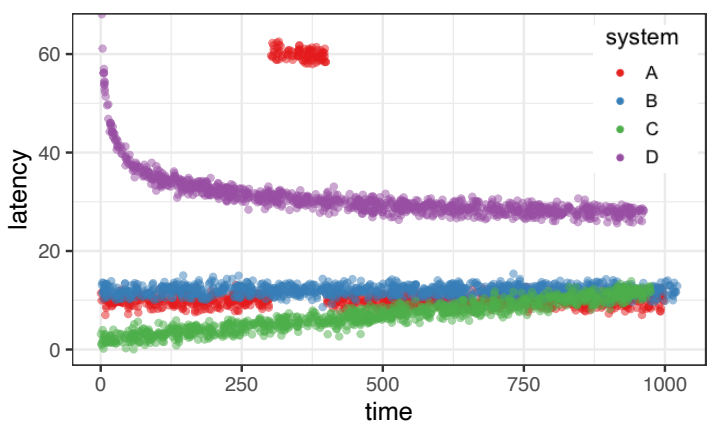


decreasing latency – warm-up period?

Always Start with the Raw Data

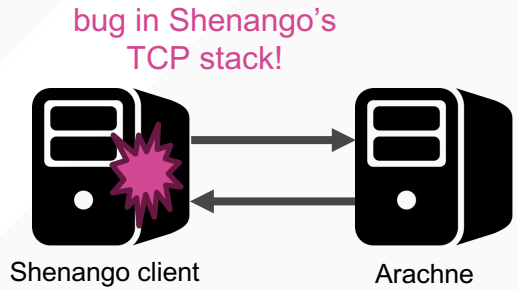
- Start by trying to understand the raw data
  - What is the distribution of it?
  - How does it change over time?
  - Does the data behave as you expected?
- Once you understand the raw data, then you can summarize it
  - Averages, medians, 99th percentile, etc.

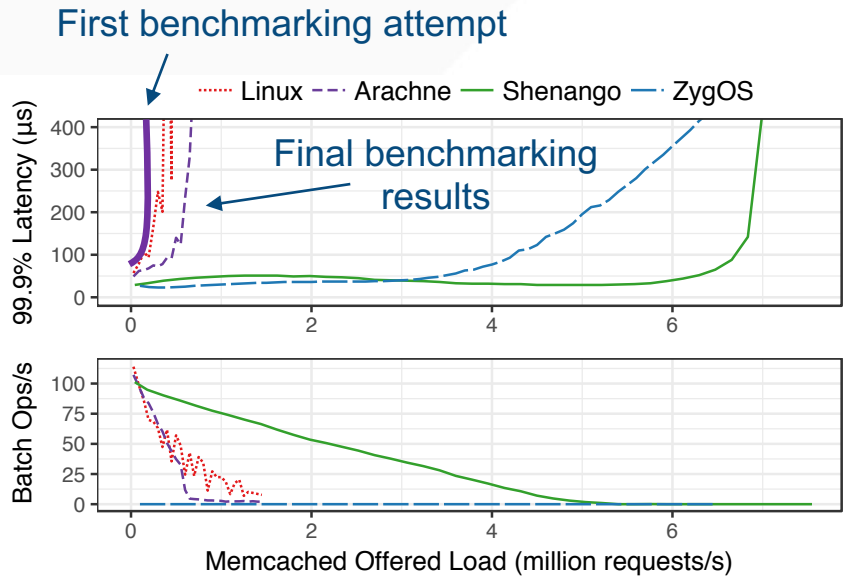




Benchmarking (Real) Example

- Comparing Shenango to Arachne
- Arachne performed poorly! All done?
- But… performance was worse than reported in their paper 🤔
- More measurements: Arachne had a lot more TCP retransmissions
- More measurements: bug in **Shenango's** TCP stack!





Measure One Level Deeper

- Application-level metrics
  - Job completion time, requests per second, etc.
- But measure lower-level statistics too!
  - Network: bandwidth, packets per second, latency
  - CPU: CPU utilization over time, per app, context switches
  - Transport protocol: retransmissions, timeouts, dropped packets
  - Statistics that are specific to your system
    - E.g., in Shenango: core reallocations, work stealing

Make Benchmarking Easy

- Design and experimentation are iterative processes
- Make it easy to iterate
  - Write scripts to run your experiments
    - Automated and reproducible
  - Run smaller experiments first
    - Debug/test in simpler or faster configurations
  - Parallelize your experiments

Benchmarking Tips

- Start with the raw data
- Always measure one level deeper
- Make it easy to run benchmarks
- Want more tips?
  - “Systems Benchmarking Crimes”
    - `https://gernot-heiser.org/benchmarking-crimes.html`
  - “Always Measure One Level Deeper” [CACM 2018]

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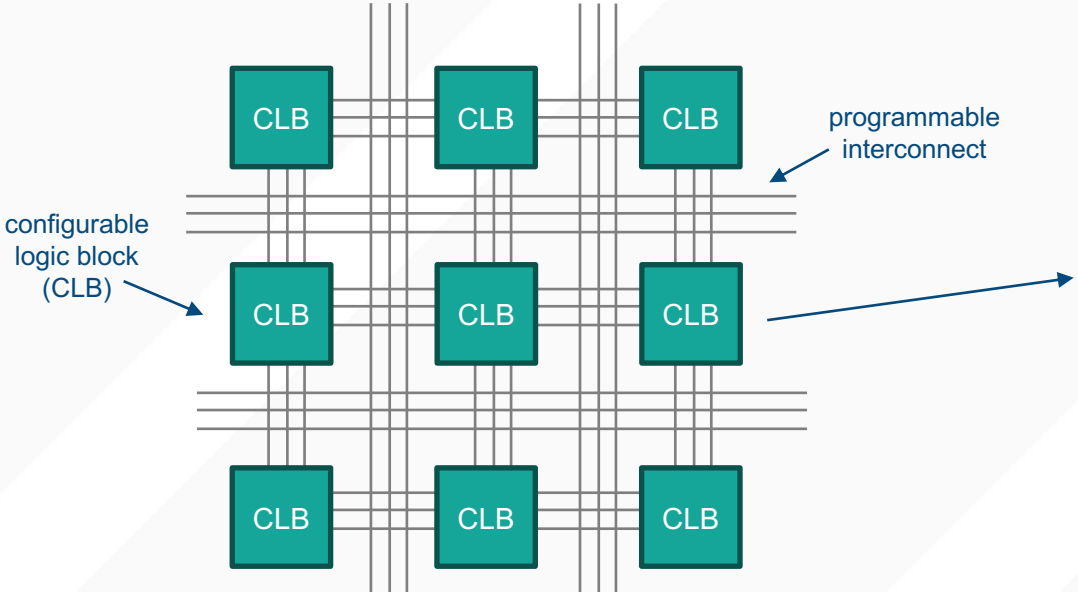
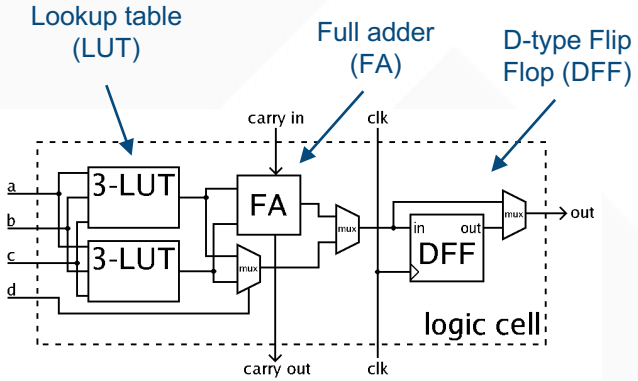
FPGAs

What is an FPGA?

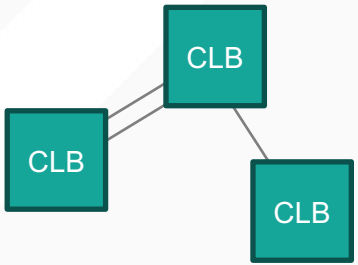
- FPGA: Field Programmable Gate Array
  - Grid of configurable logic blocks (CLBs)
  - Connected by a programmable interconnect
  - RAM, I/O, etc.

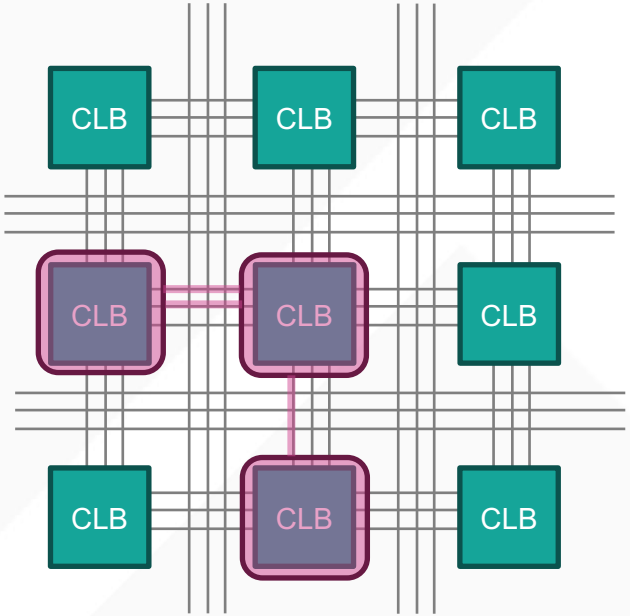




simple logic block

How do you program an FPGA?





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Coyote Discussion