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CSE 291: Operating Systems in Datacenters

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Agenda for Today

- Research Tips: Benchmarking
- Disaggregation overview
- LegoOS discussion

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Research Tips: Benchmarking

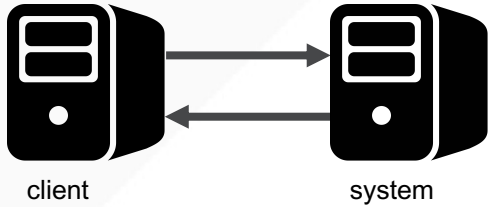
Research Tips: Benchmarking

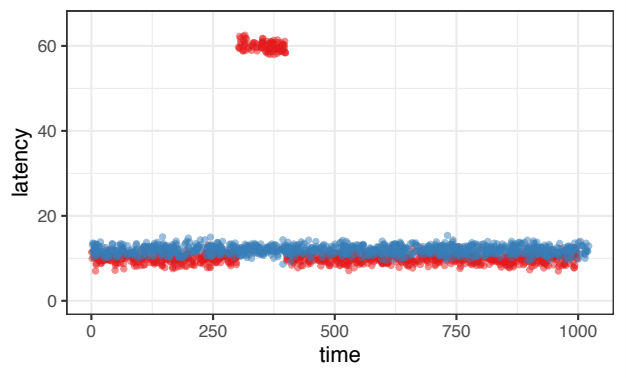
- Strategies for effectively measuring systems performance
- Why is this important?
  - Reading papers:
    - Do the experiments measure/show what they intend to?
    - Do the results make sense?
  - Benchmarking in your own research projects:
    - Conduct accurate and meaningful measurements

Benchmarking (Fake) Example

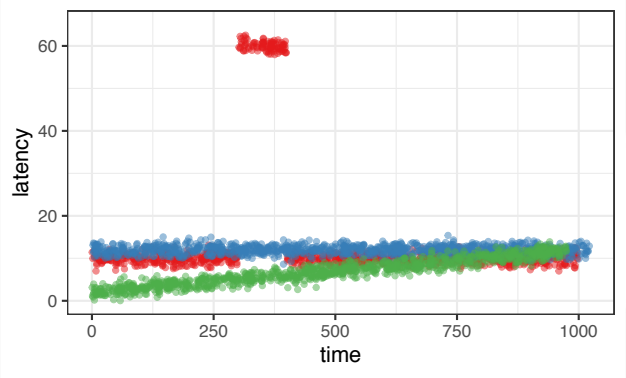
- Comparing the latency of different systems, A and B
  - Which system has better latency?
- Suppose we measure them and find:

System	A	B	C	D
Average latency	14.7	12.0	6.9	31.0

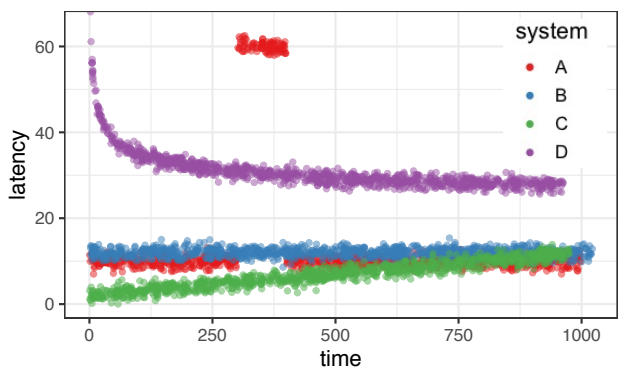




latency spike – maybe a bug?



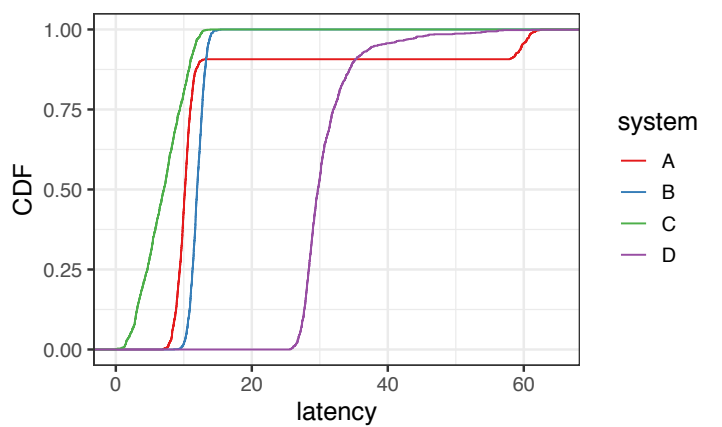
increasing latency – queue building up?

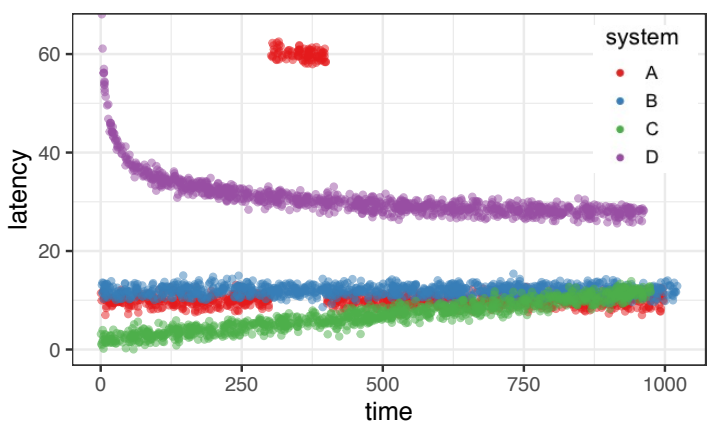


decreasing latency – warm-up period?

Always Start with the Raw Data

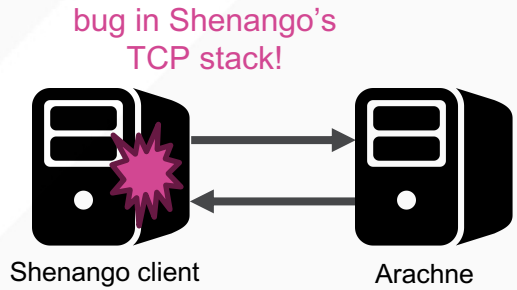
- Start by trying to understand the raw data
  - What is the distribution of it?
  - How does it change over time?
  - Does the data behave as you expected?
- Once you understand the raw data, then you can summarize it
  - Averages, medians, 99th percentile, etc.

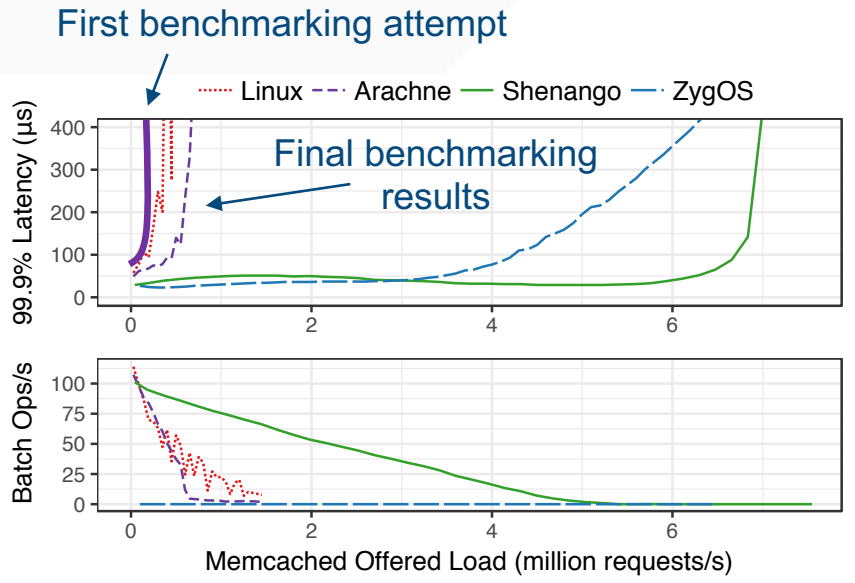




Benchmarking (Real) Example

- 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
  - 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

Benchmarking Tips

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

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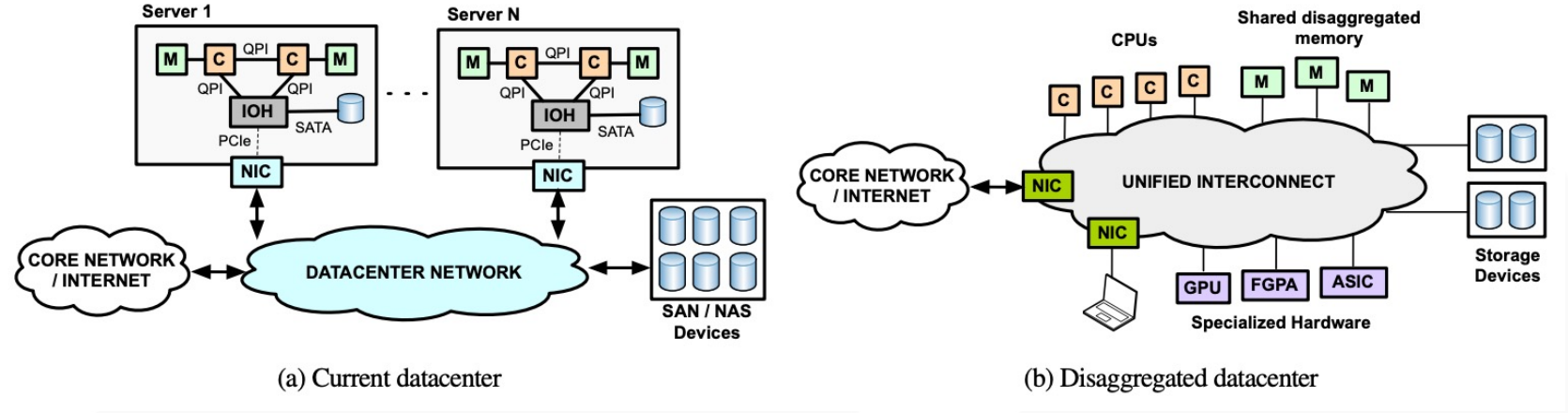
Disaggregation

What is disaggregation?

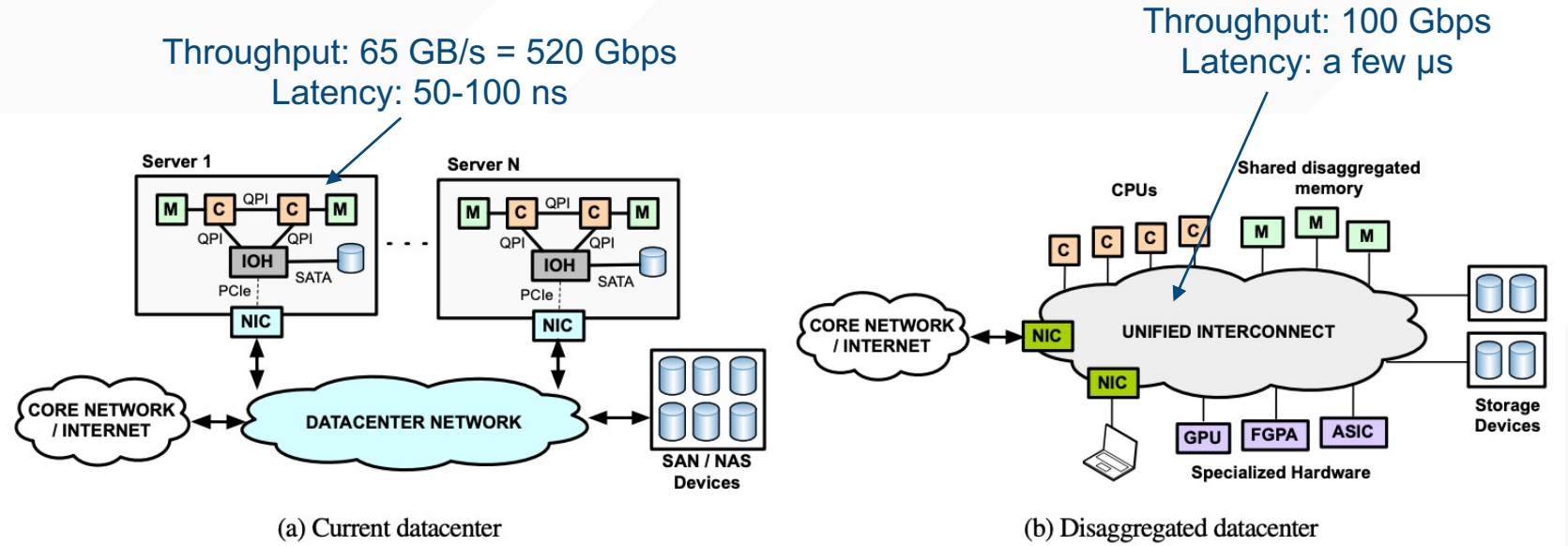
- Disaggregated datacenter
  - Resources directly connect to the network in “resource blades”
  - No notion of a “server” anymore



“Network Requirements for Resource Disaggregation” [OSDI ‘16]

What makes disaggregation challenging?

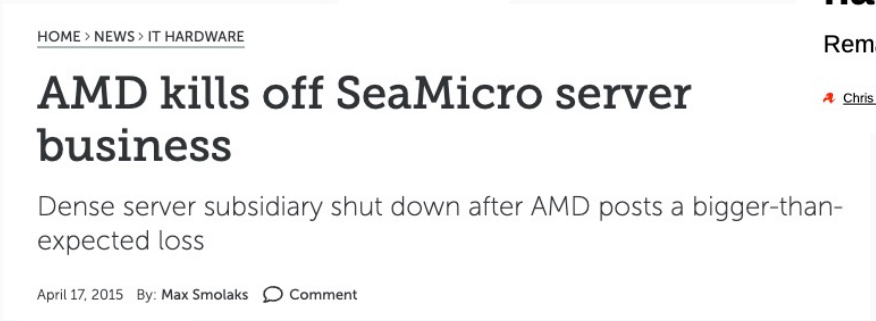
- Traditional datacenter networks have much lower throughput and higher latency than server interconnects



"Network Requirements for Resource Disaggregation" [OSDI '16]

Hardware for Disaggregation

- Many announcements of disaggregated hardware:
  - SeaMicro
  - Intel Rack Scale Architecture, 2013
  - HP The Machine, announced in 2014
  - UC Berkeley Firebox, 2014



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AMD kills off SeaMicro server business

Dense server subsidiary shut down after AMD posts a bigger-than-expected loss

April 17, 2015 By: Max Smolaks Comment

RIP HPE's The Machine product, 2014-2016: We hardly knew ye

Remains of lab experiment, including ReRAM, will be scattered into future gear

Chris Mellor Tue 29 Nov 2016 // 07:28 UTC

But… no widespread adoption yet

https://www.datacenterdynamics.com/en/news/amd-kills-off-seamicro-server-business/
https://www.theregister.com/2016/11/29/hp_labs_delivered_machine_proof_of_concept_prototype_but_machine_product_is_no_more/

Disaggregation-Related Research Questions

- What kind of network is required?
  - “Network Requirements for Resource Disaggregation” [OSDI ‘16]
  - “Pond: CXL-Based Memory Pooling Systems for Cloud Platforms” [ASPLOS ‘23]
- Transparent or not?
  - “AIFM: High-Performance, Application-Integrated Far Memory” [OSDI ‘20]
- How to share disaggregated resources?
  - “MIND: In-Network Memory Management for Disaggregated Data Centers” [SOSP ‘21]

Want to learn more about disaggregation?

- WORDS 2022
  - Workshop on Resource Disaggregation and Serverless Computing
  - November 17th, 2022
  - UCSD and virtual
  - Registration is free
  - https://www.wordsworkshop.org/

Keynote and Invited Industry Talk 9:30-11:00 PT (session chair - Ryan Kosta)

- **Keynote: Marcos Aguilera, VMware** – "Memory disaggregation: Why it will happen now and bring a surprise impact"

Abstract: Disaggregation refers to moving hardware resources outside the box. Looking at history, we learn that disaggregation succeeds based two key factors: burning issue and technical feasibility. We also learn that, once successful, disaggregation brings an impact that is much broader than originally envisioned. We look at memory disaggregation from this perspective; we make the case why memory disaggregation will finally happen now and discuss some of its potential surprise impact: fluid memory, instantaneous VM migration, and cheap Byzantine Fault Tolerance. The wildly different nature of these applications suggest that memory disaggregation will be a research topic of wide interest in the years to come.

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LegoOS Discussion