

Coalescent Computing

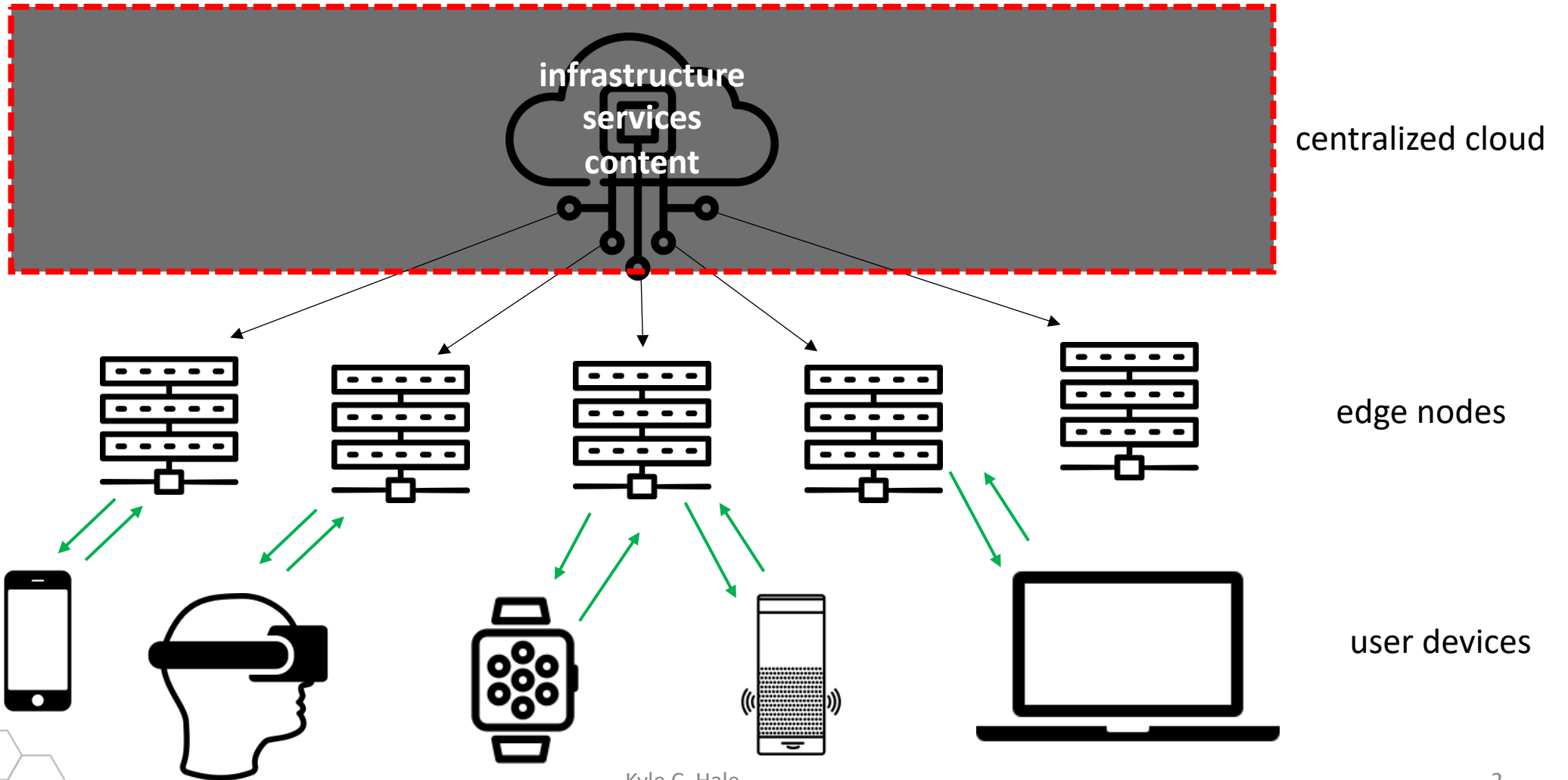
Kyle C. Hale

Laboratory for High-Performance Experimental Systems and Architecture (HEXSA)

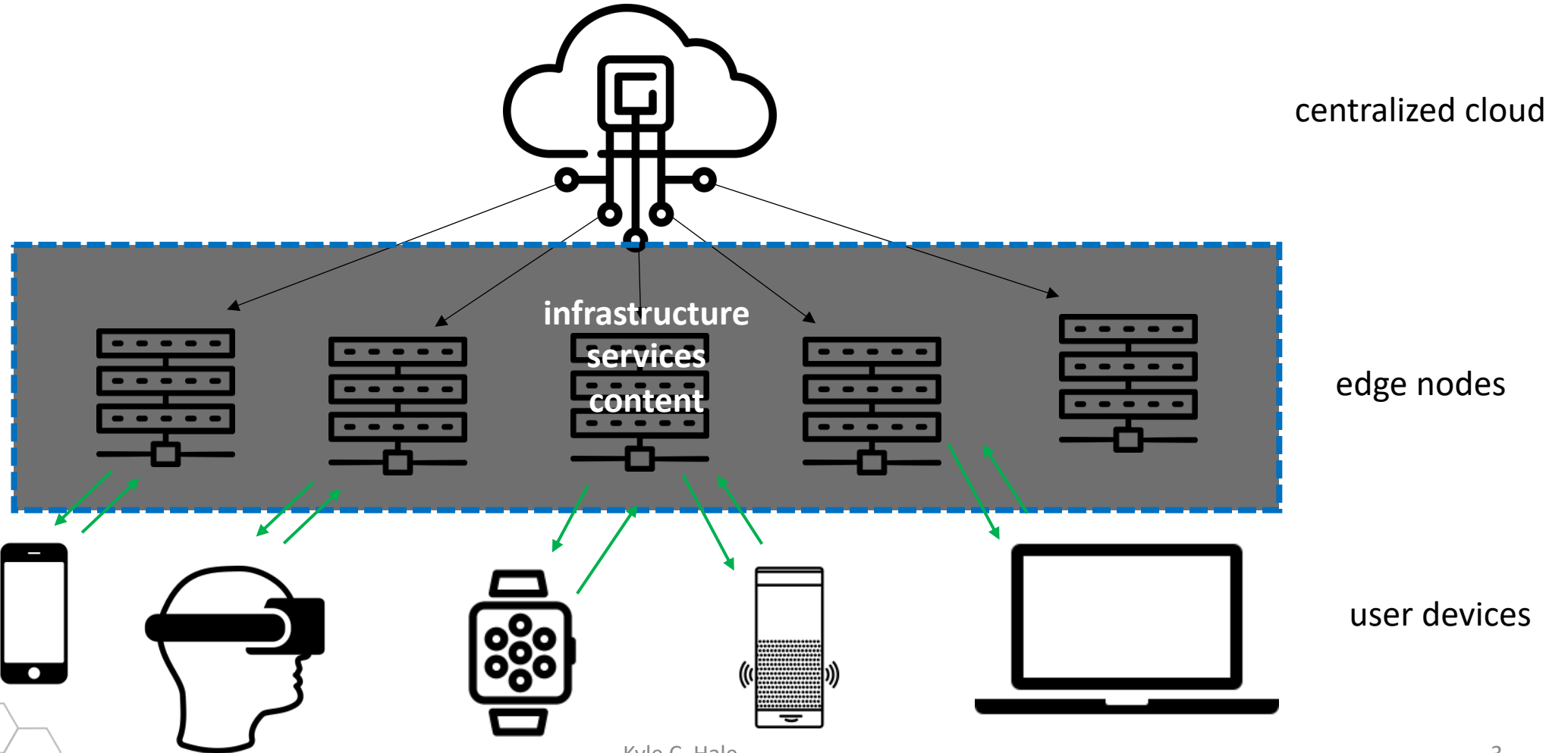
APSys 2021



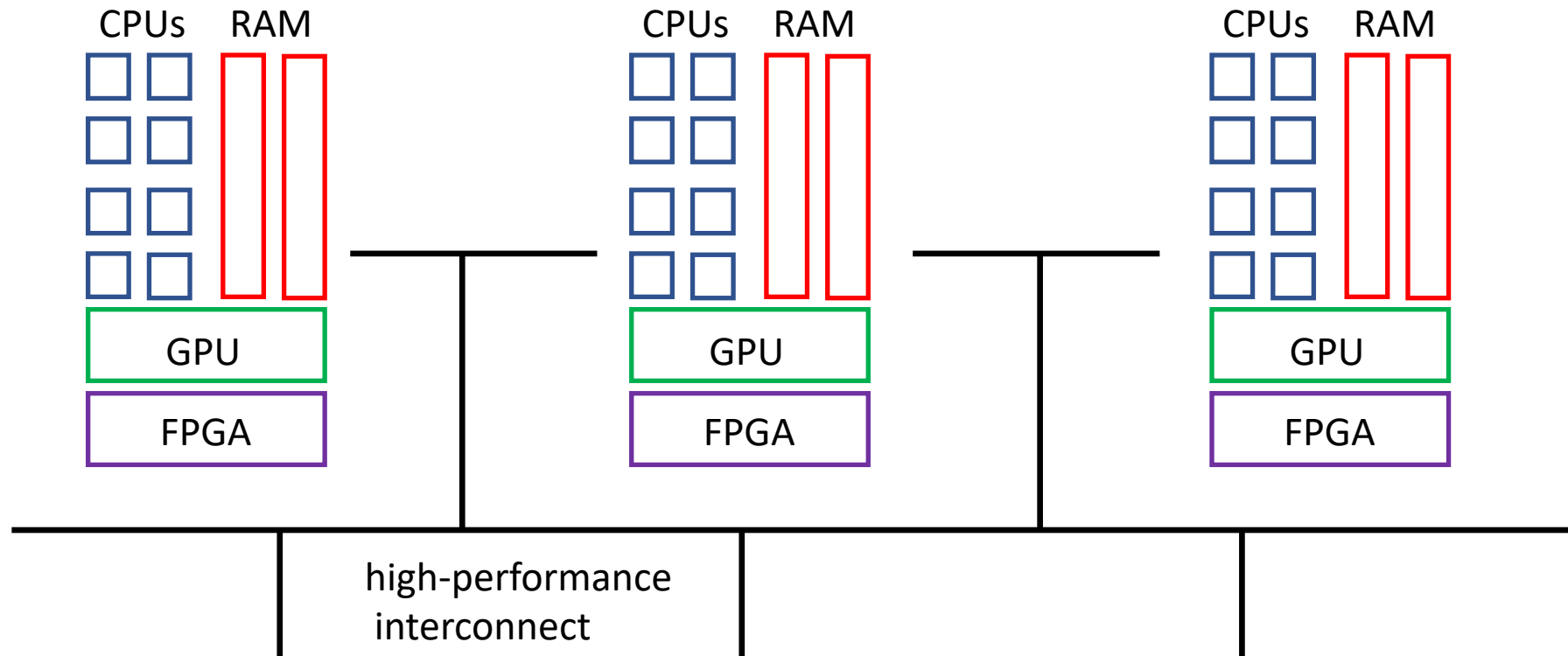
The Cloud is Decentralizing: Services and Infrastructure at the Edge



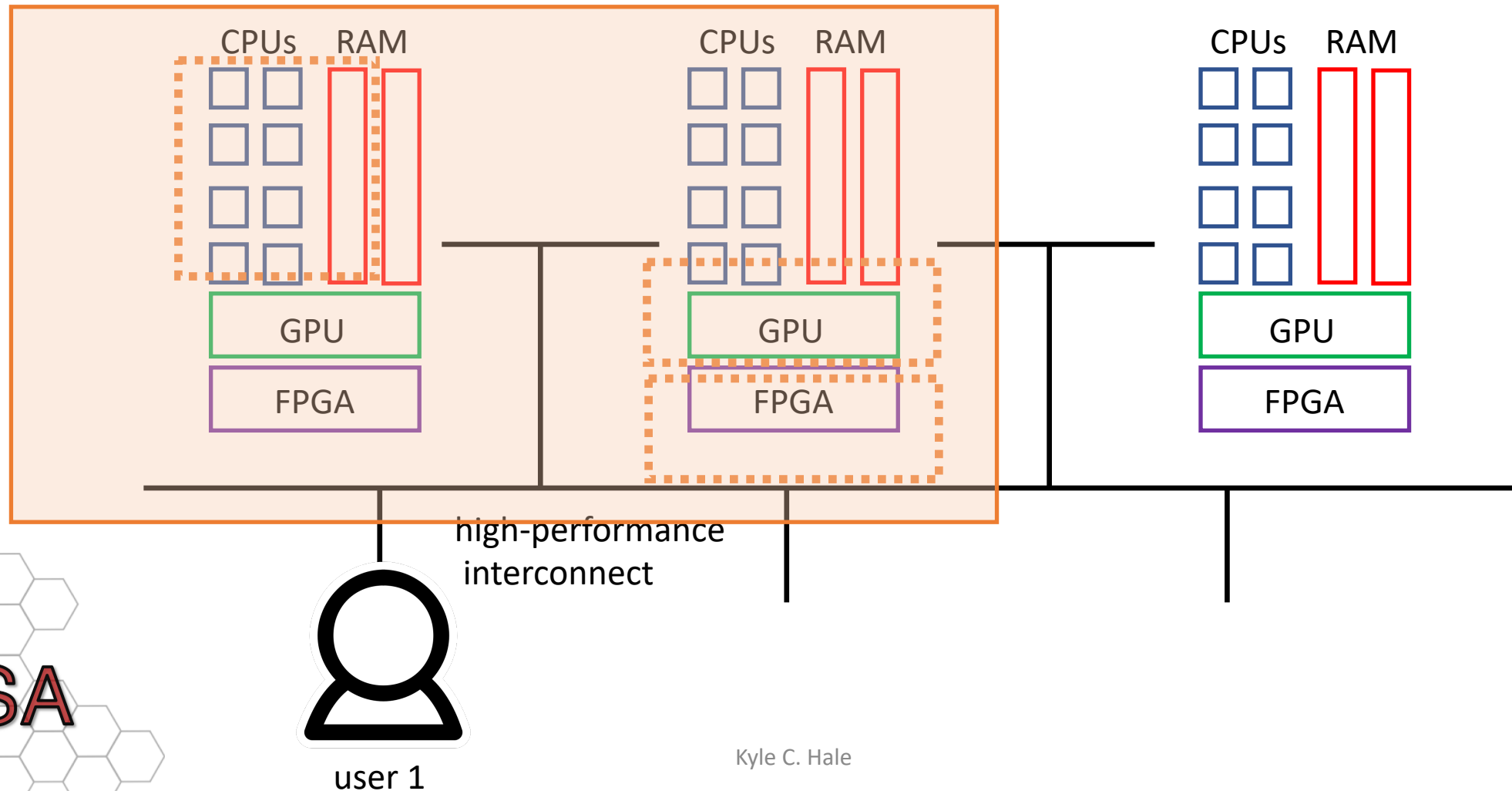
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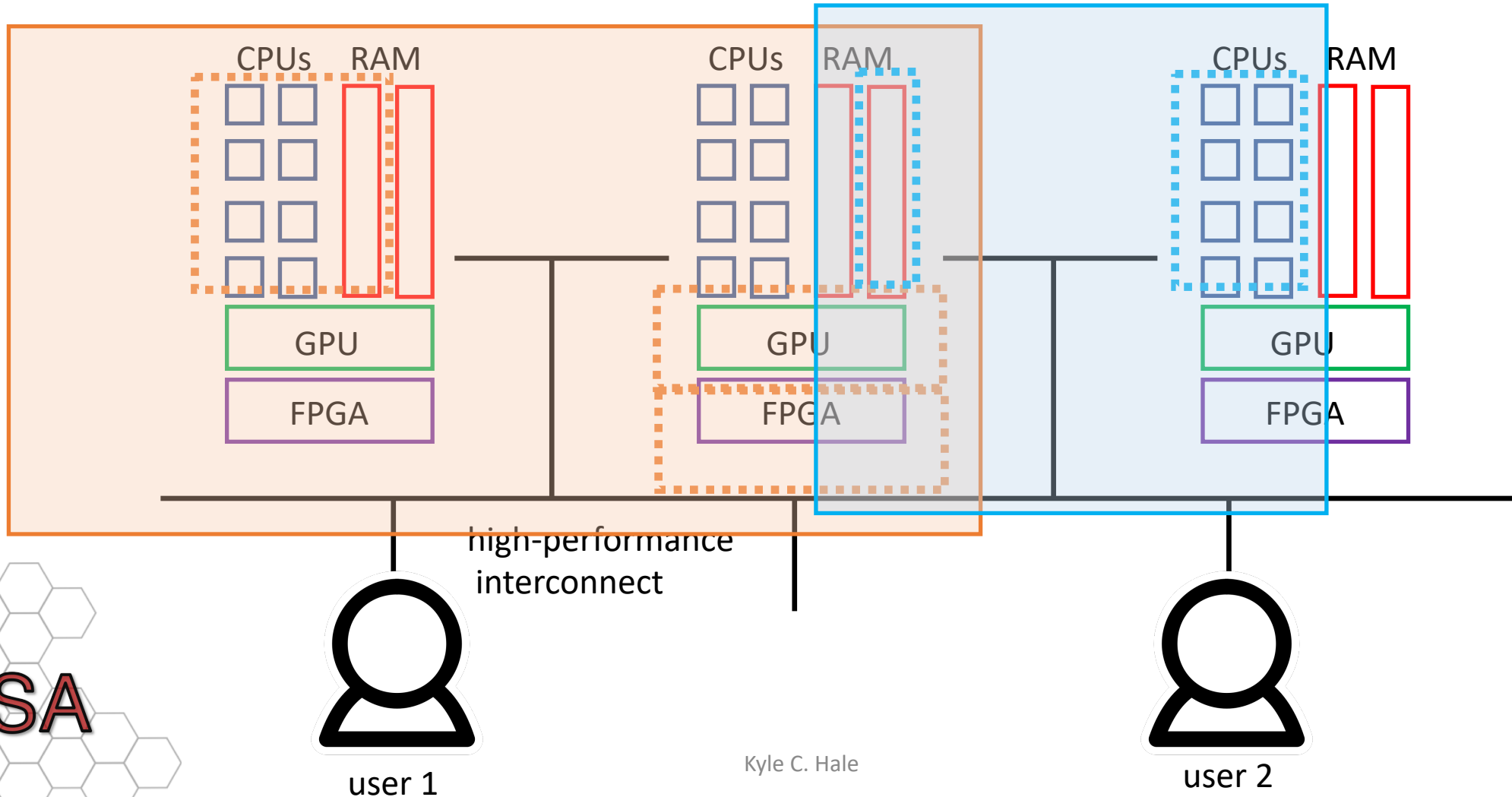
Resources are becoming *disaggregated* in the datacenter



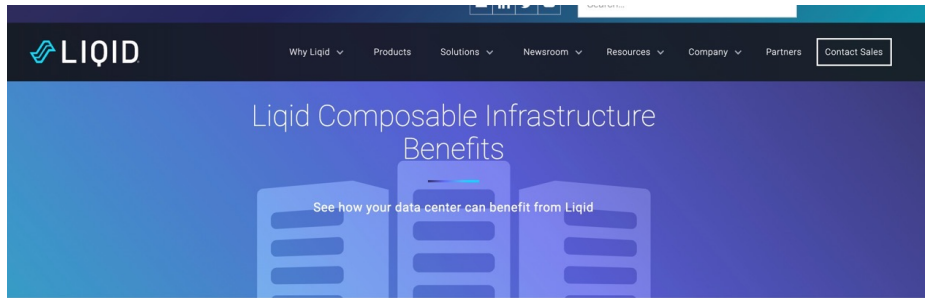
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Resources are becoming *disaggregated* in the datacenter



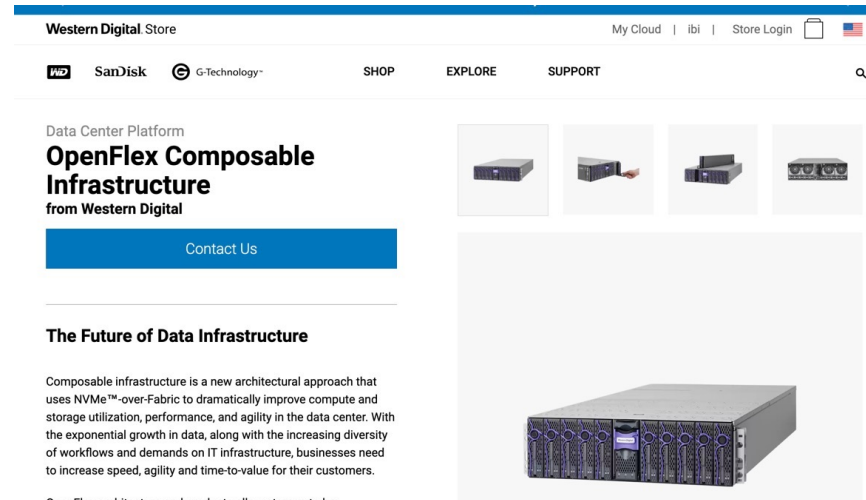
Composable Infrastructure



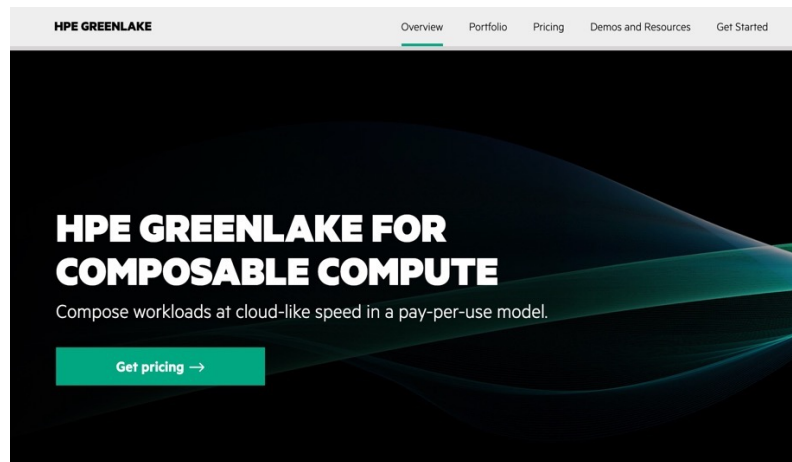
Accelerate Time-to-Value
Meet Exacting IT Demands in Real-time

- Dynamically configure servers in seconds
- Meet rigid workload requirements

source: <https://www.liqid.com/why-liqid/benefits>



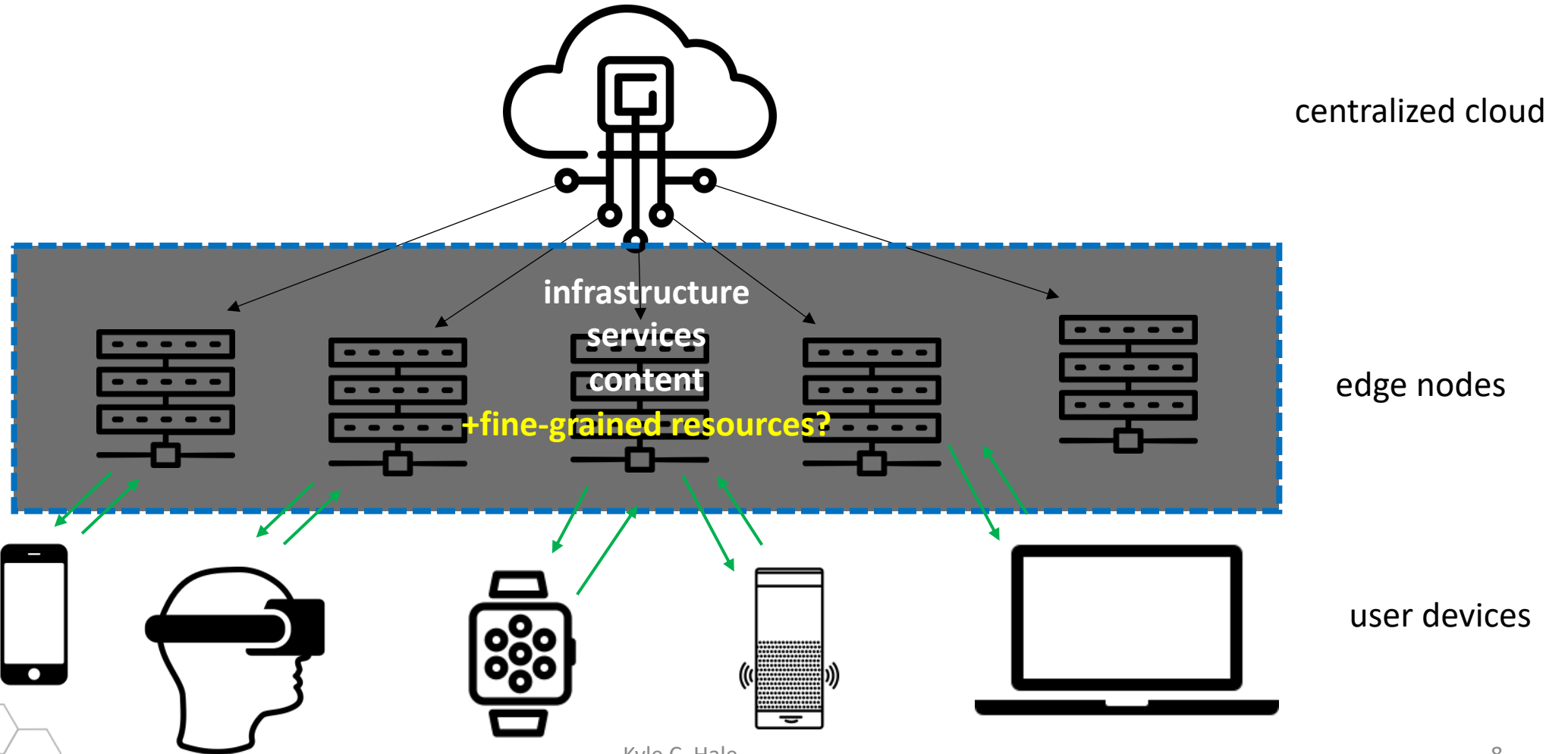
source: <https://www.westerndigital.com/products/data-center-platforms/openflex-composable-infrastructure>



<https://www.hpe.com/us/en/greenlake/composable-compute.html>



Disaggregation at the Edge



Cyber Foraging: are we ready?

- In Cyber Foraging, user devices would “live off the land” [1]
- Applications would be *partitioned* into disjoint components, offloaded, sometimes using VMs [2]
- Cloud offload, but with mobility

[1] R.K. Balan, J. Flinn, M. Satyanarayanan, S. Sinnamohideen, H. Yang, “The Case for Cyber Foraging,” EW ‘10, 2002
[2] M. Satyanarayanan, P. Bahl, R. Cáceres, N. Davies, “The Case for VM-Based Cloudlets in Mobile Computing,” IEEE Pervasive Computing 8(4), October 2009.



To date, there have been no compelling mass-market applications that require low latencies that cannot be achieved as a web service and that also are too computationally or energy intensive for modern smart phones to run locally. This might be a “chicken or the egg” problem: the lack of cyber foraging infrastructure could potentially be hindering the development of such applications. Later, we discuss one emerging class of applications that could prove to be the compelling application that cyber foraging needs.

R.K. Balan and J. Flinn, “Cyber Foraging Fifteen Years Later,” IEEE Pervasive Computing, 16(3), July 2017.

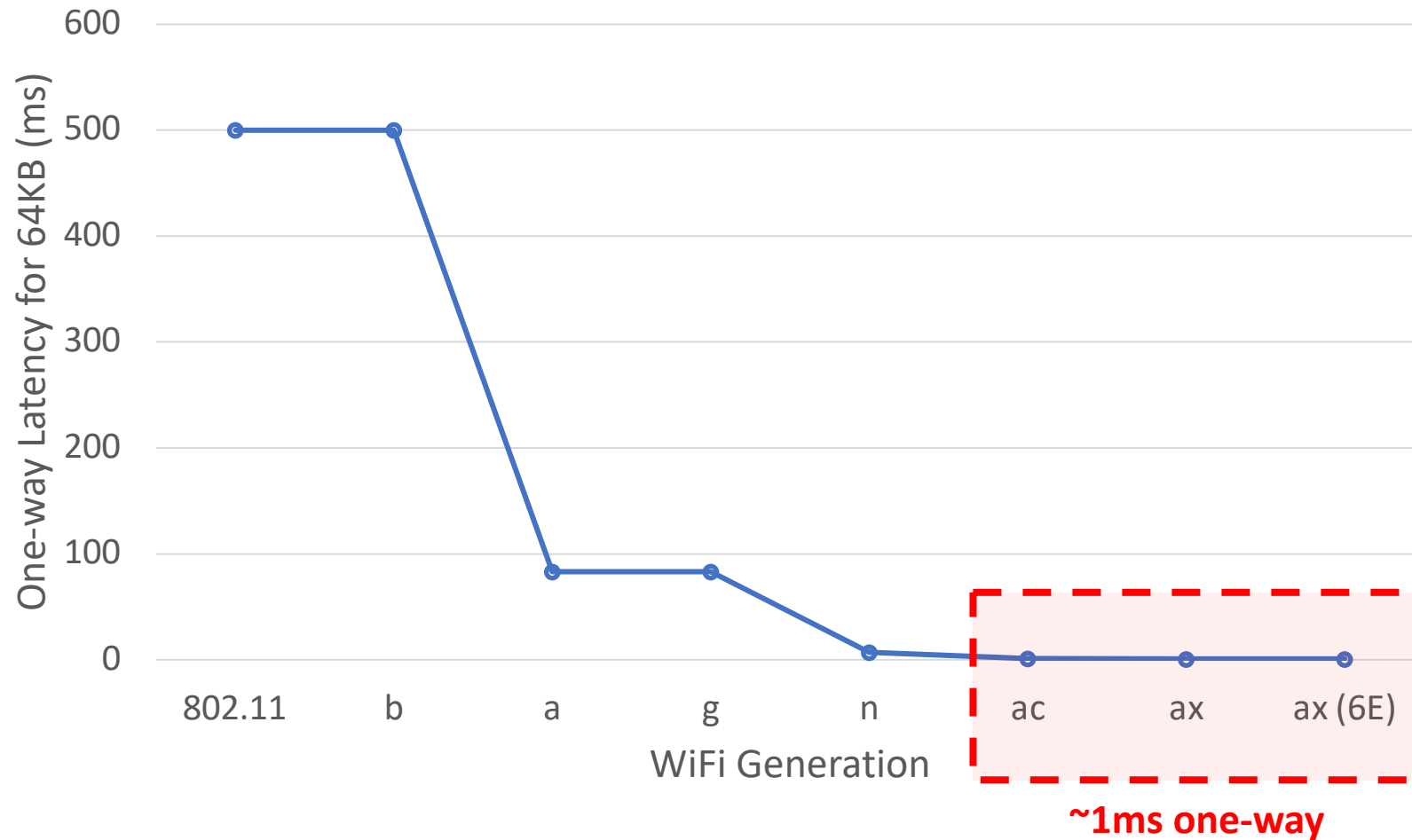


What's Changed?

- Virtualization technology has improved significantly
- Infrastructure provisioning has become more sophisticated (NB serverless research)
- Composable infrastructure
- Hardware design more democratic
- AR/VR/XR is here

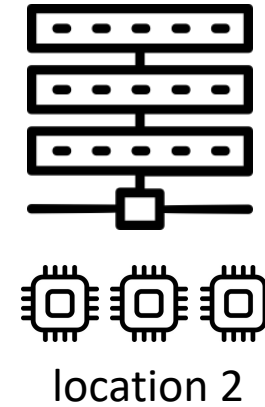
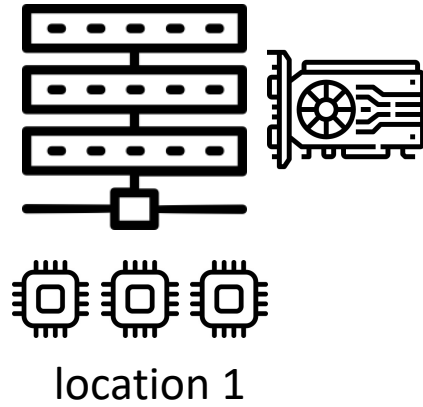
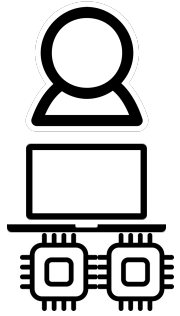


...also, wireless latency continues to drop



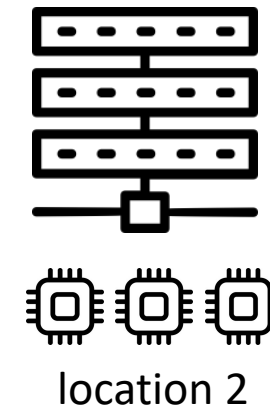
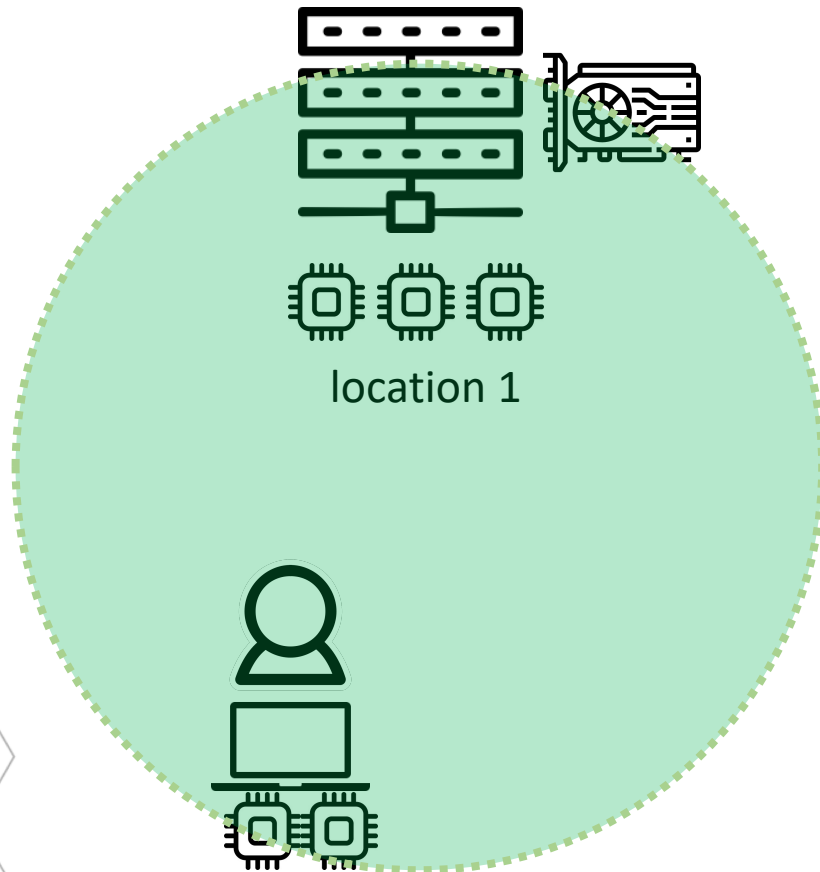
Coalescent Computing

Ephemeral Single-System Image at the Edge



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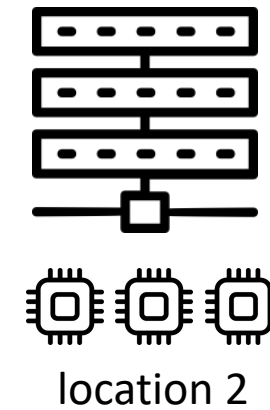
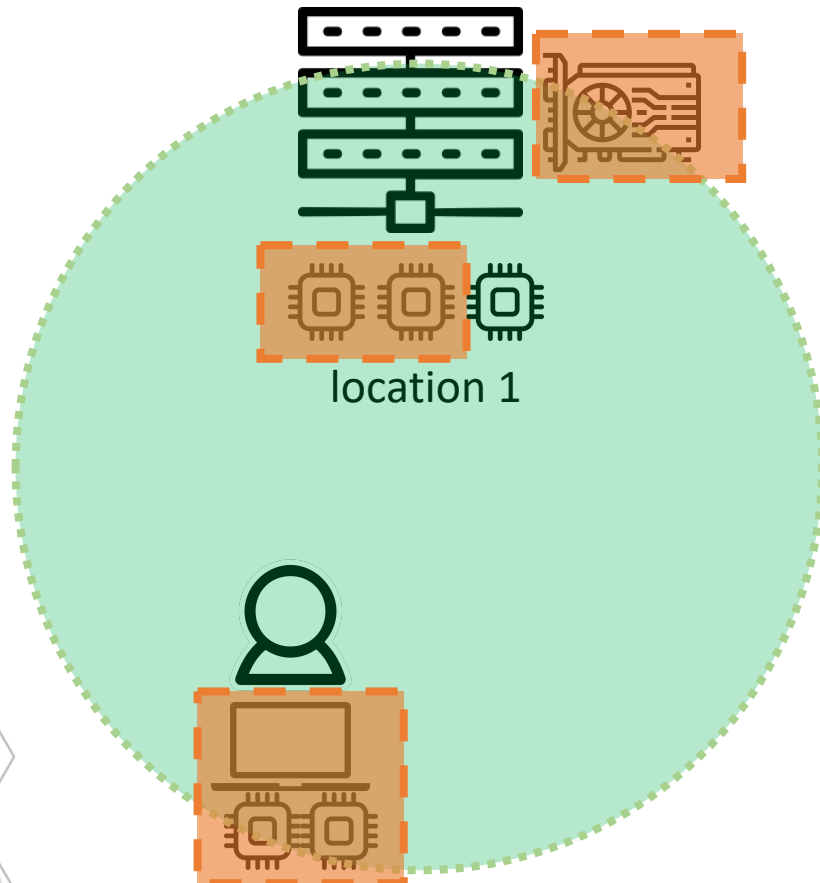


User nears physical proximity of edge system

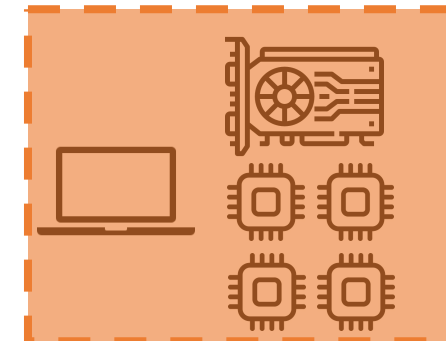


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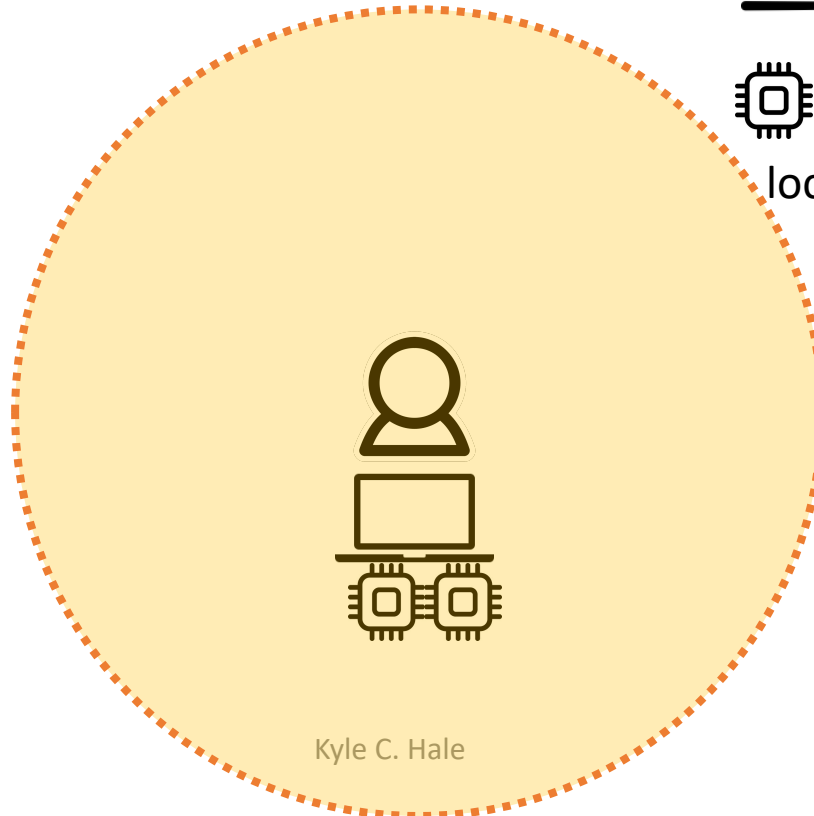
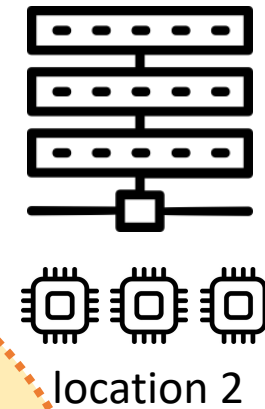
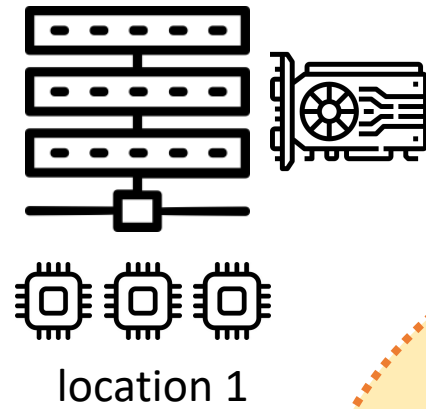


Resources coalesced into one logical system



Coalescent Computing

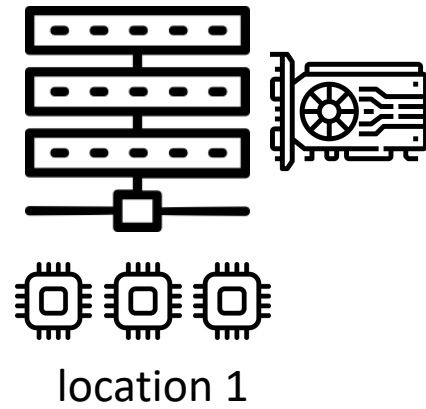
Ephemeral Single-System Image at the Edge



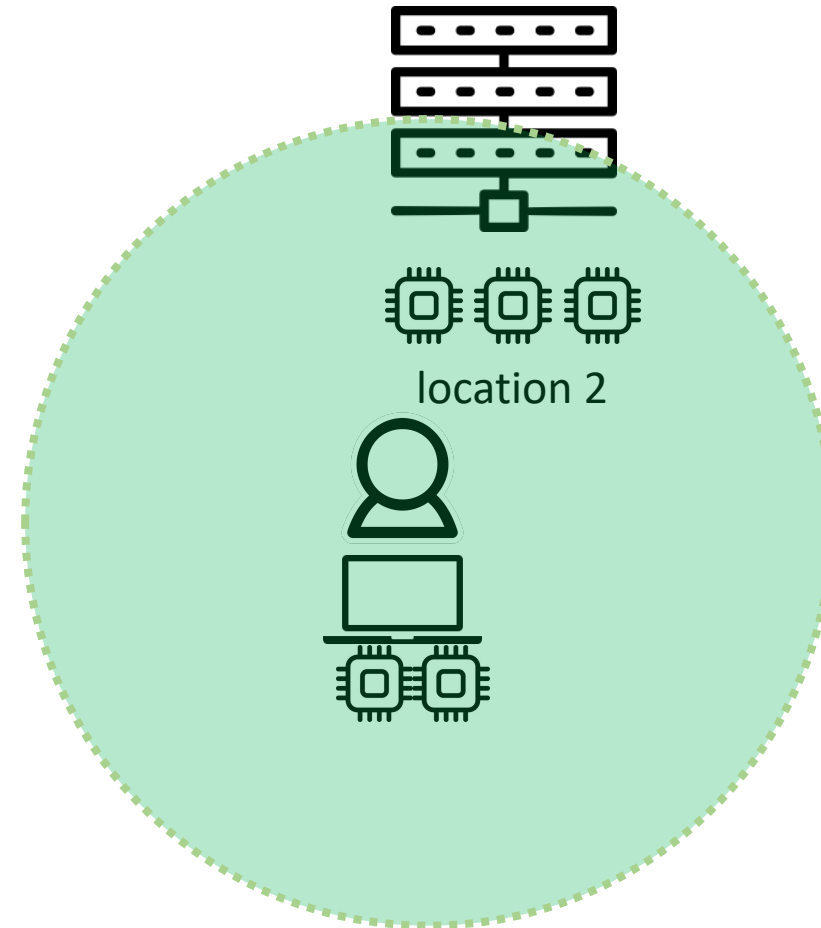
**User leaves environment,
resources relinquished**

Coalescent Computing

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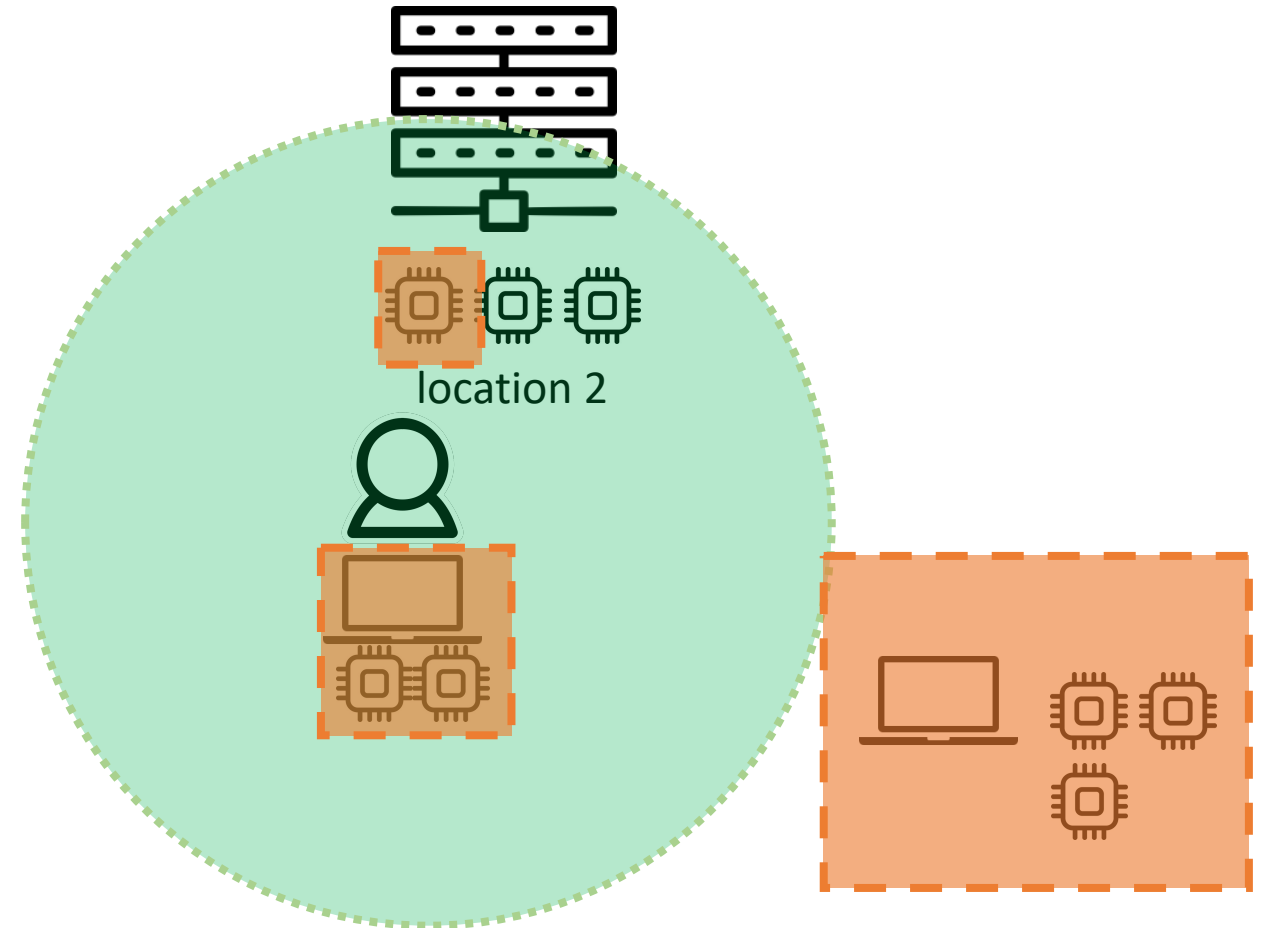
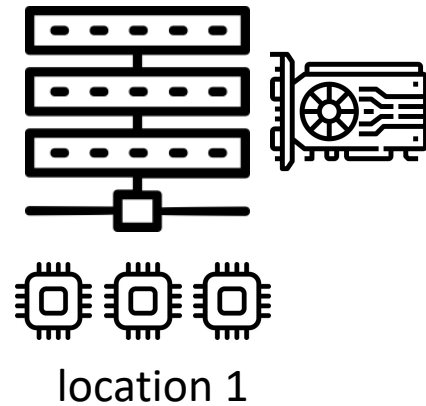


User approaches another edge system

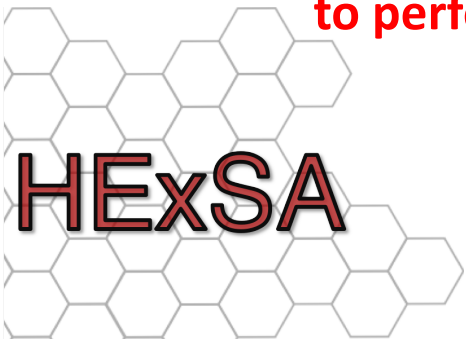


Coalescent Computing

Ephemeral Single-System Image at the Edge



Resources coalesced again, subject to performance, policy constraints

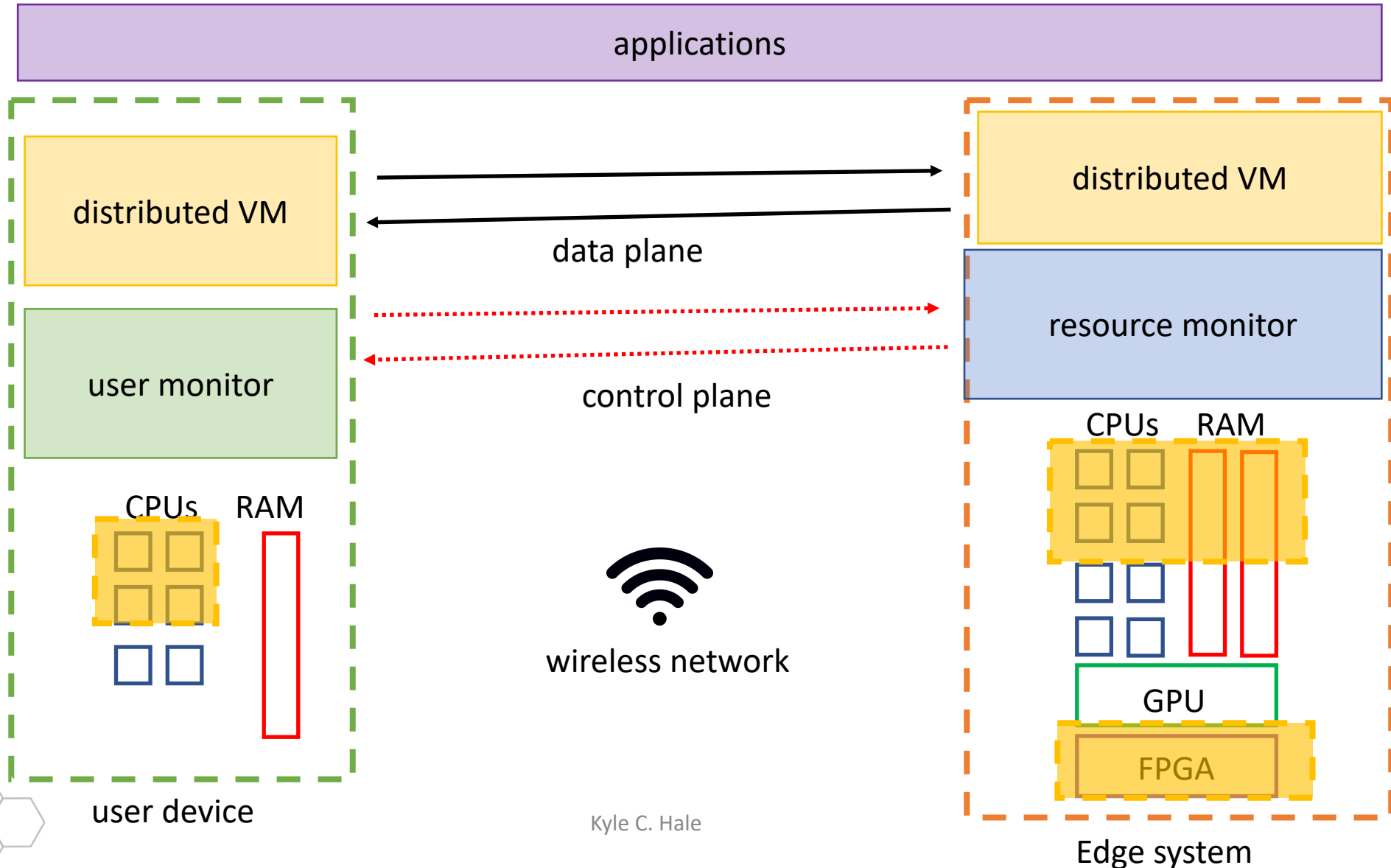


Coalescence Principle

Users' devices experience a ***coalescence*** of resources proportional to proximity as users move through the physical environment



A Coalescent Operating System



Characteristics of a Coalescent OS

- **Transparency**: user need not be aware of coalescence (other than extra resources)
- **Performance**: offload should only occur so as to improve
- **Resilience**: due to mobility, nodes come and go *often*
- **Customizability**: which types of resources, when, at what cost...
- **Privacy and Security**: same problems with IaaS, but isolation mechanisms may need to be lighter-weight, enforcement challenging



Thanks!

Me: khale@cs.iit.edu

HExSA Lab: <https://hexsa.halek.co>

Students

- Brian Tauro (PhD)
- Conghao Liu (PhD)
- MD Ali (PhD)
- Akhil Kodumuri (ugrad)
- Alexandra Suarez (ugrad)
- Isabel Raymundo (ugrad)

