CompSci 401: Cloud Computing

Cloud End-to-end Traffic

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DUKE KUNSHAN UNIVERSITY

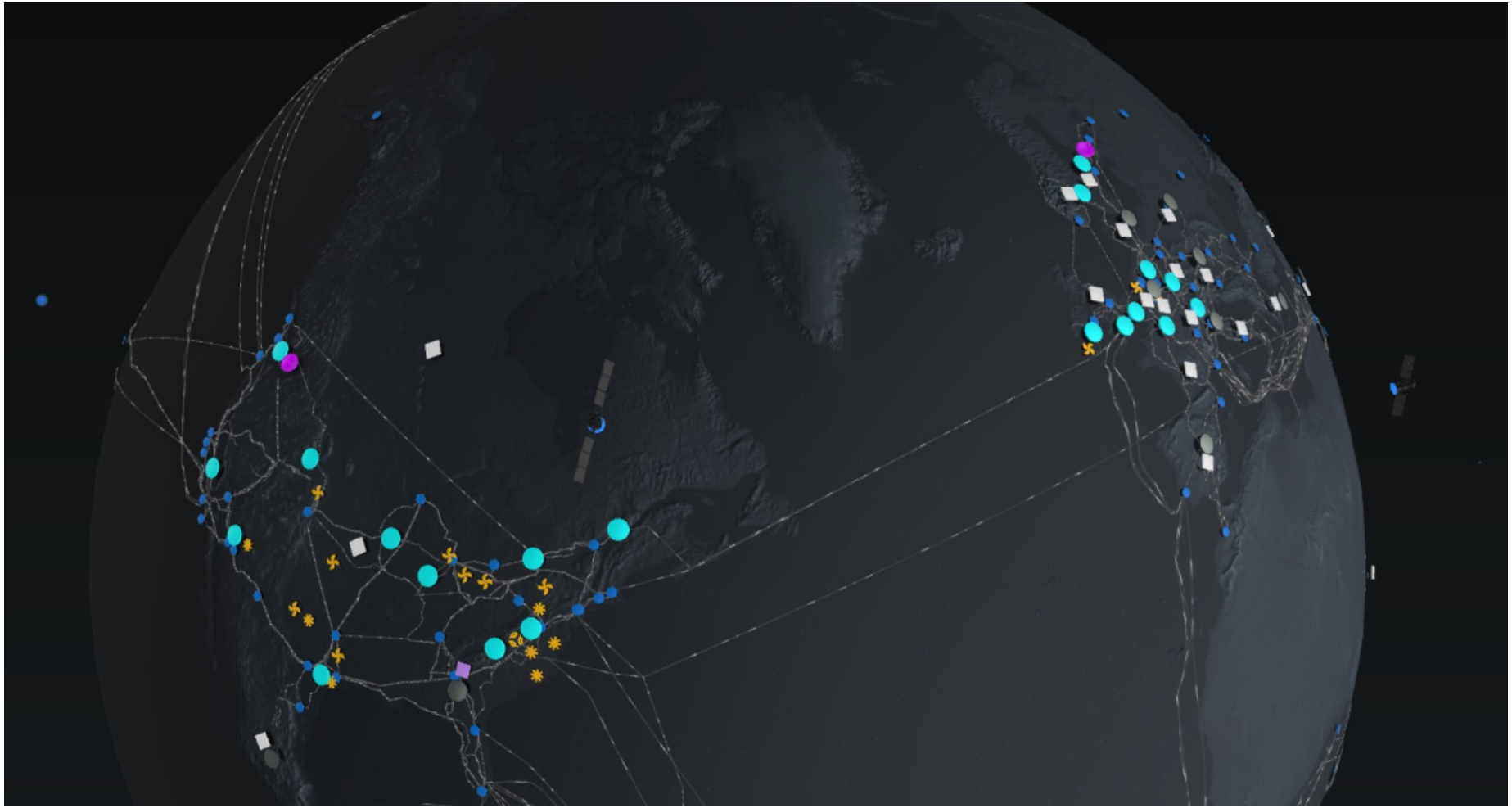
Cloud computing and end-to-end latency

- User traffic must traverse the Internet to reach a datacenter
- Incurs additional latency
  - Many applications do not care about latency
    - Video streaming, most Web applications, basic downloads
  - Some applications do care about latency
    - Gaming, teleconferencing, self-driving vehicles, telesurgery

Distributed, global deployments

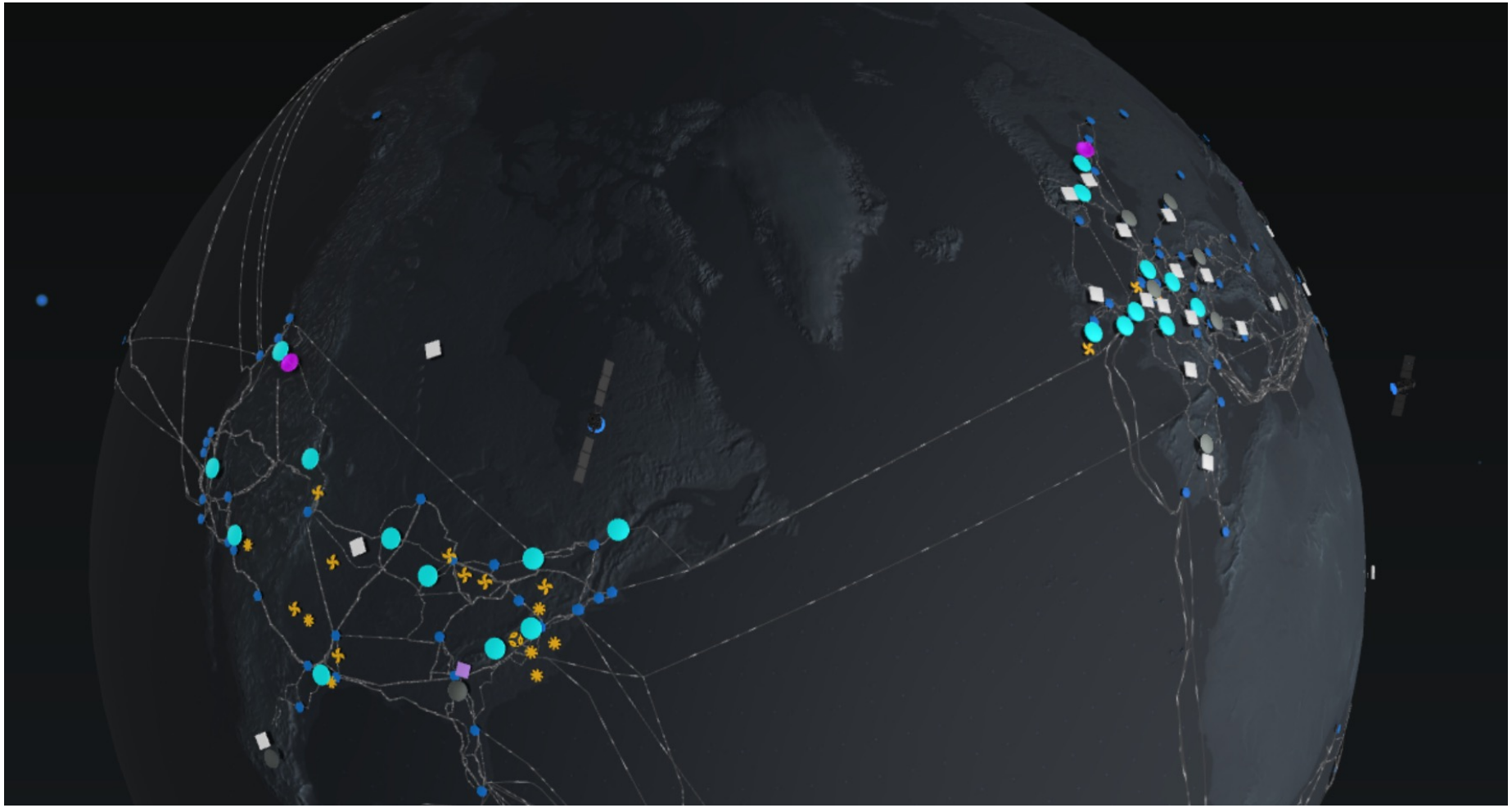
Google

Distributed, global deployments



https://infrastructuremap.microsoft.com/explore

Distributed, global deployments



Fast connectivity:
175K miles of fiber
140 countries

https://infrastructuremap.microsoft.com/explore

Cloud computing improved latency

- End-to-end latency improved significantly
  - 400ms latency between Brazil and the US back in 2000 → unplayable games
  - 120-200ms latency between Brazil and the US in 2020 → some playable games
  - 30-120ms latency within Brazil to São Paulo in 2020 → headshots

Cloud computing improved latency, but…

- End-to-end latency improved significantly
  - 400ms latency between Brazil and the US back in 2000 → unplayable games
  - 120-200ms latency between Brazil and the US in 2020 → some playable games
  - 30-120ms latency within Brazil to São Paulo in 2020 → headshots
- However, 100ms is unacceptable for some applications
  - Telesurgery
  - Collision avoidance for self-driving vehicles
  - Industrial, robot, home automation

Bandwidth constraints

- Datacenters have a lot of bandwidth, but traffic traverses the Internet
  - Incurs load and transit costs on intermediate networks
- But some applications require *a lot* of bandwidth
  - Netflix
  - Youtube

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  - “Net neutrality”

CompSci 401: Cloud Computing

Edge Computing

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Edge Computing

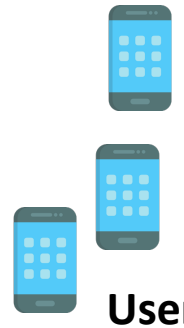
Datacenter

Internet

Local Infrastructure

User's Home

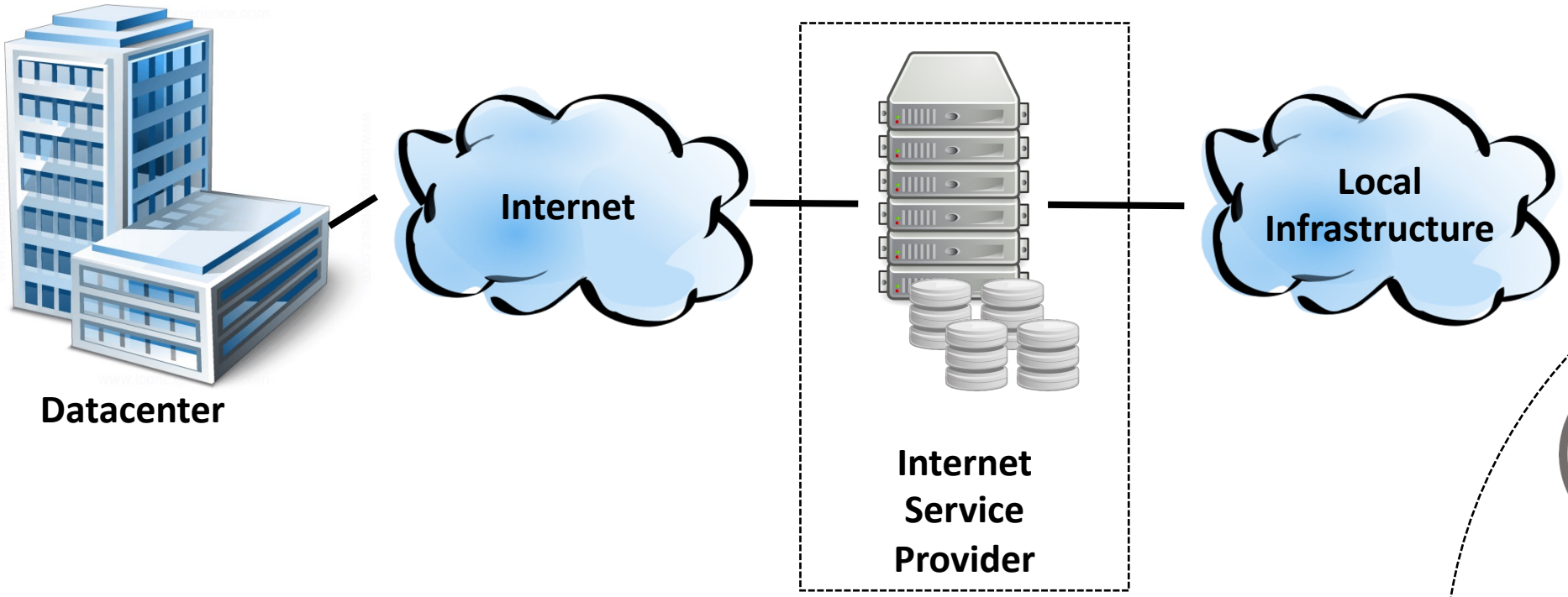
User



4G/5G Cell

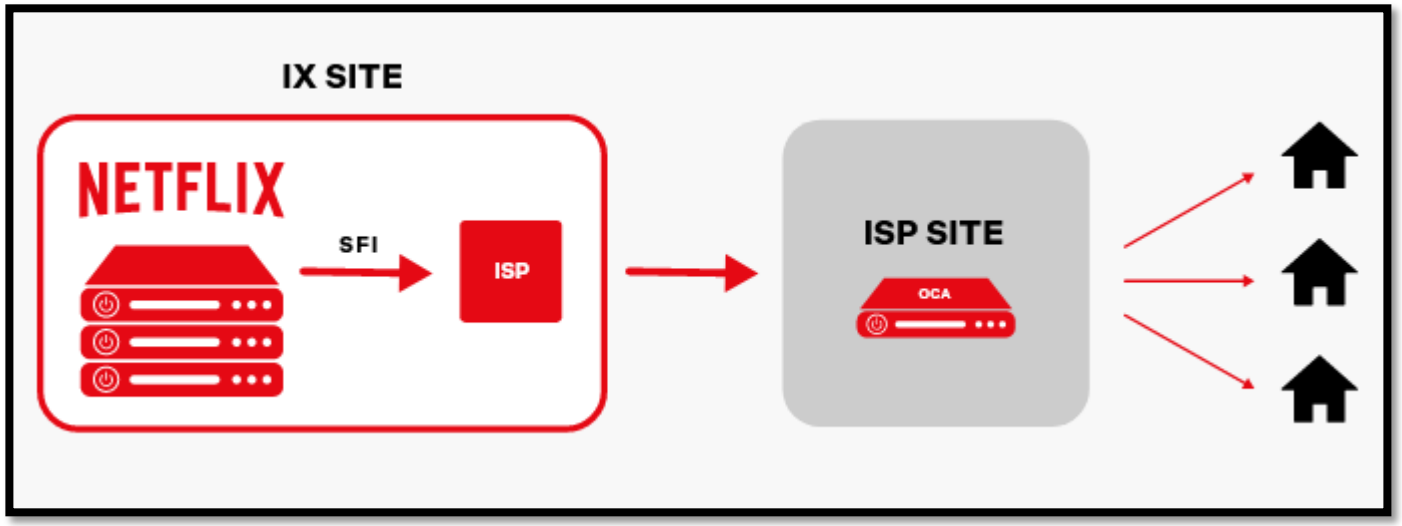
Users

Edge Computing

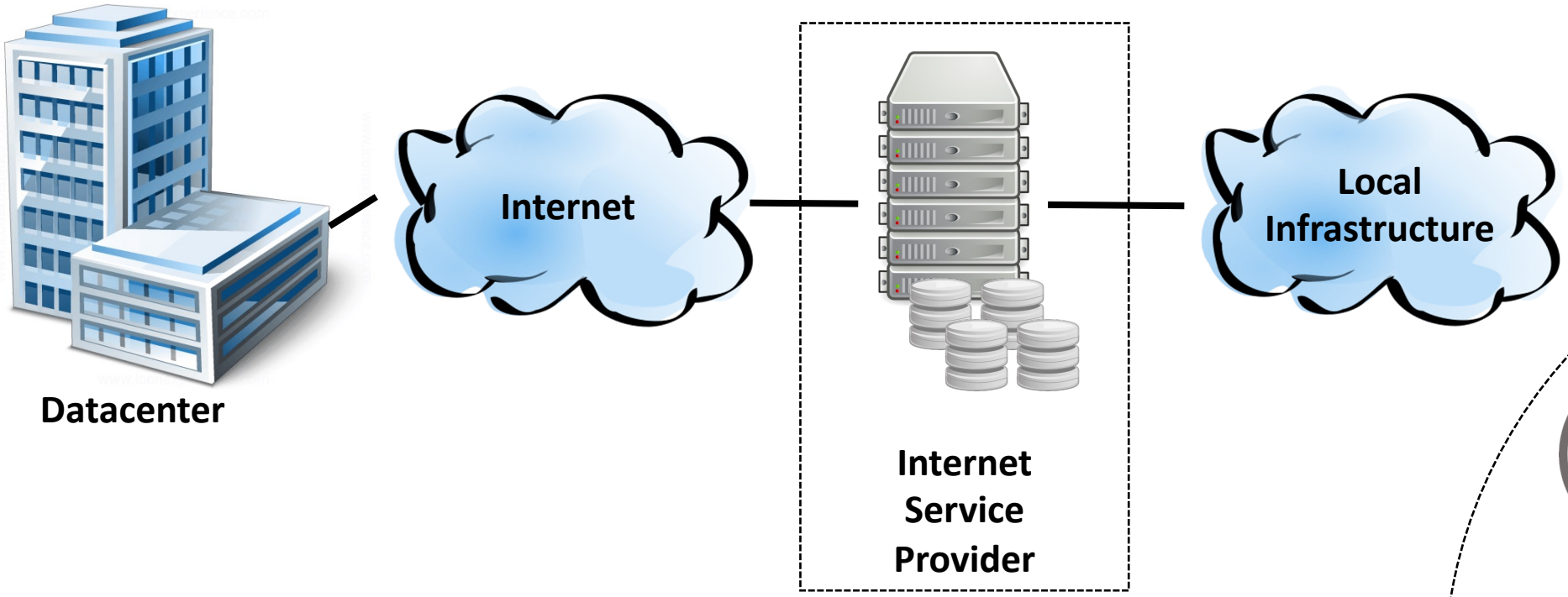


In-ISP caching

- Reduce latency and localize traffic
  - Facebook FNAs
  - Netflix OpenConnect
  - Akamai Accelerated Network
  - Google Global Cache
  - …



Edge Computing



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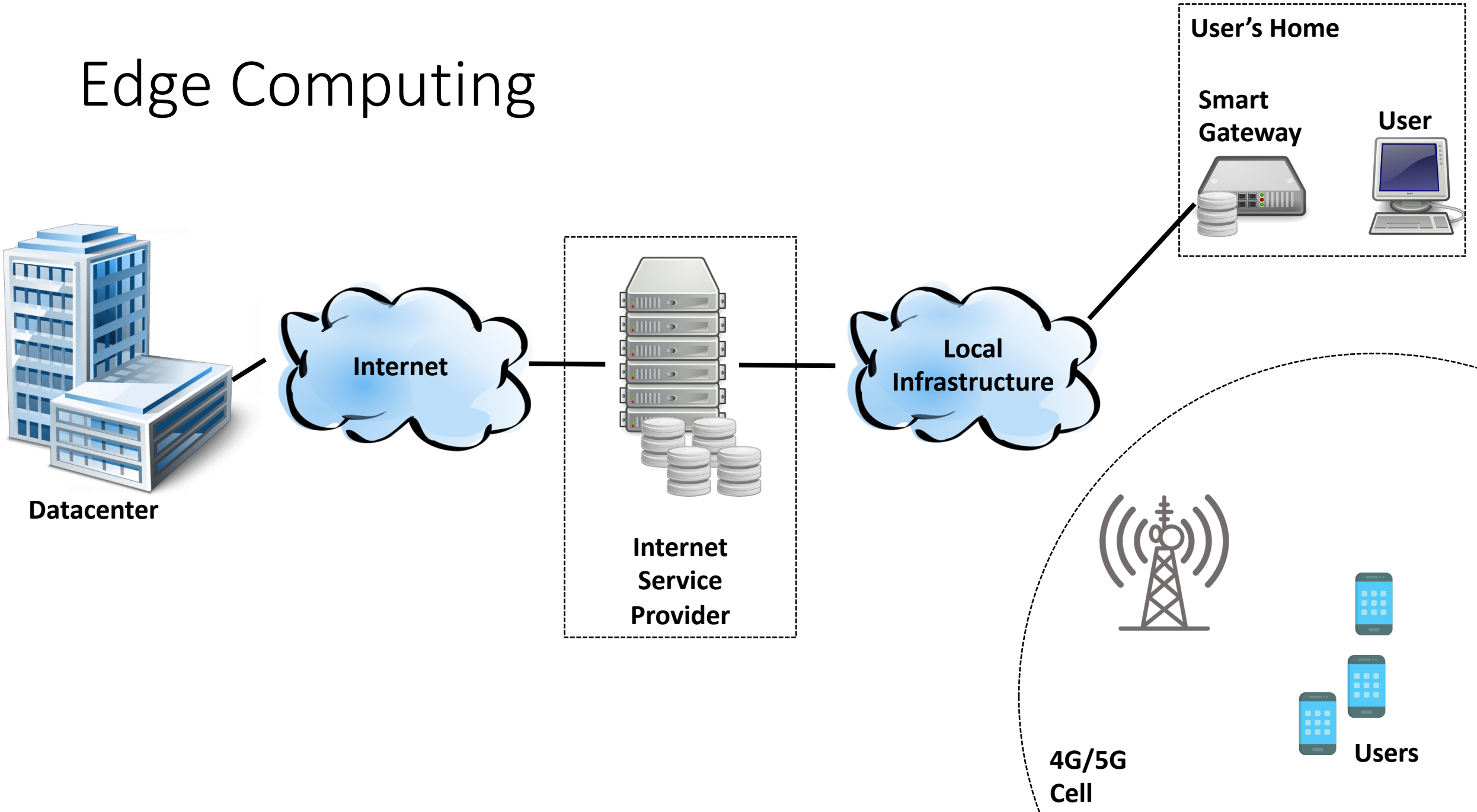

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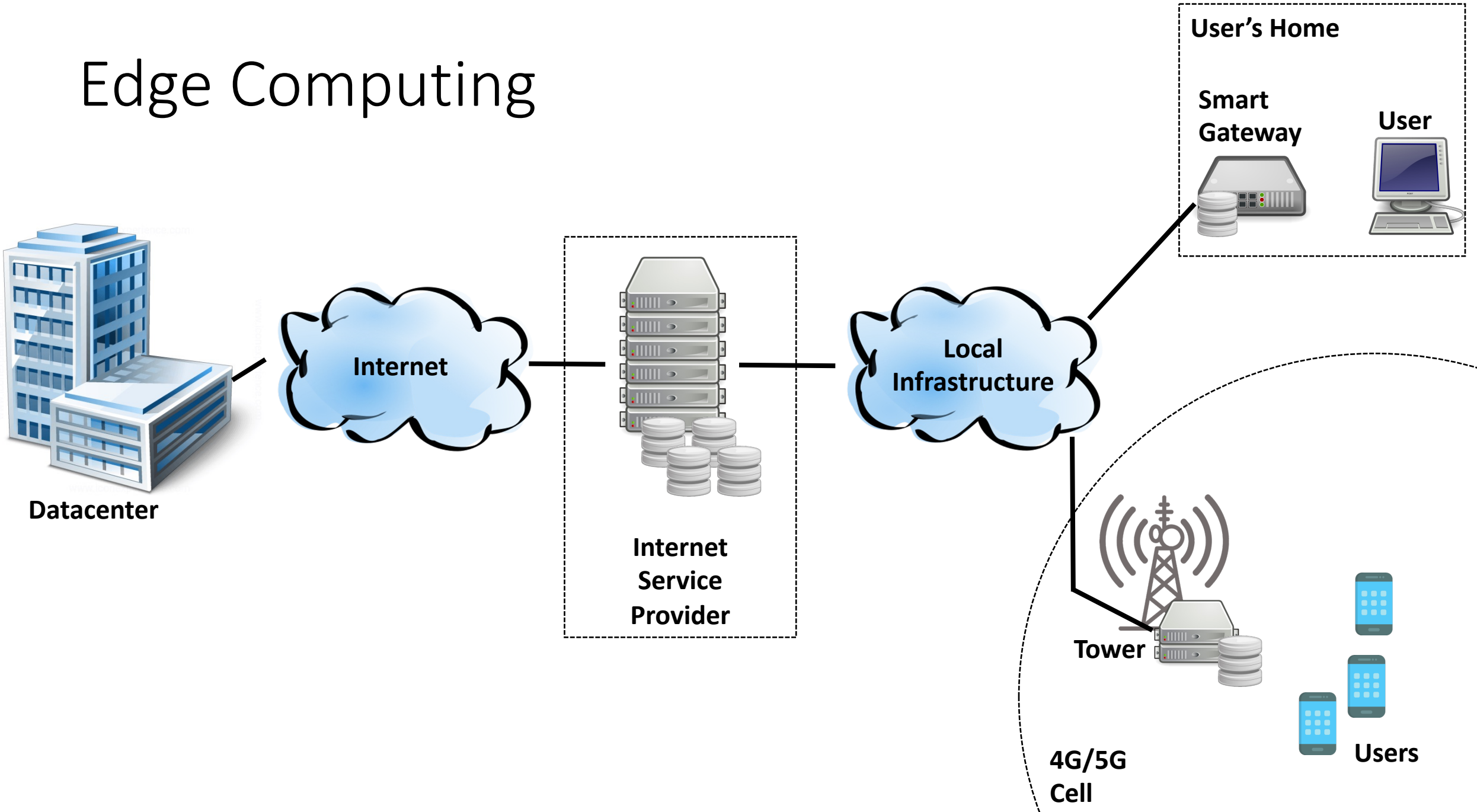
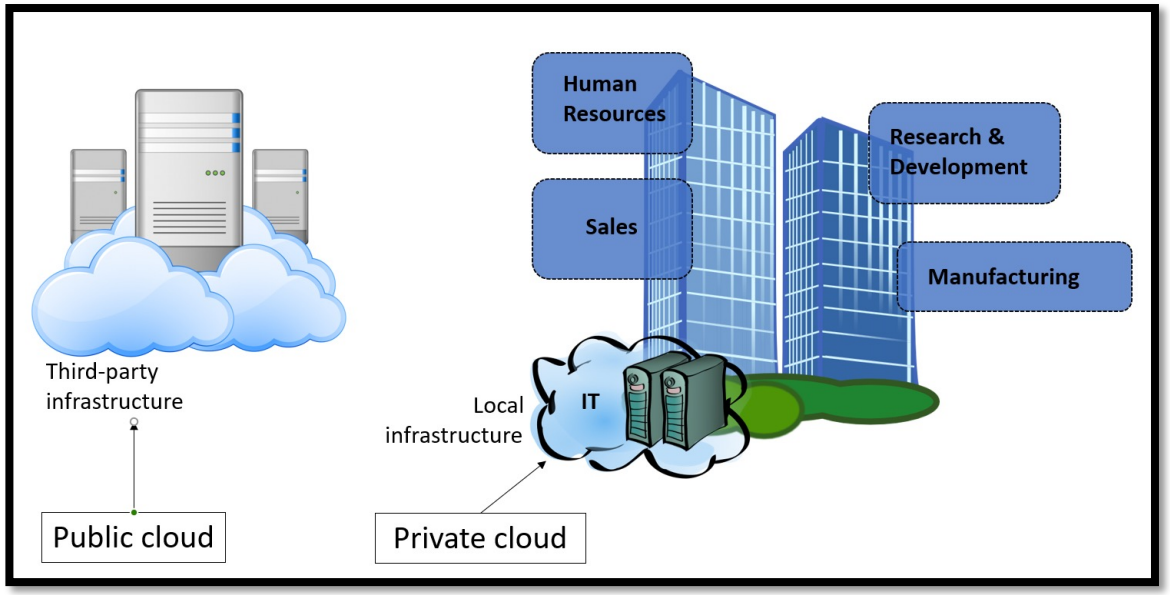


Centralization



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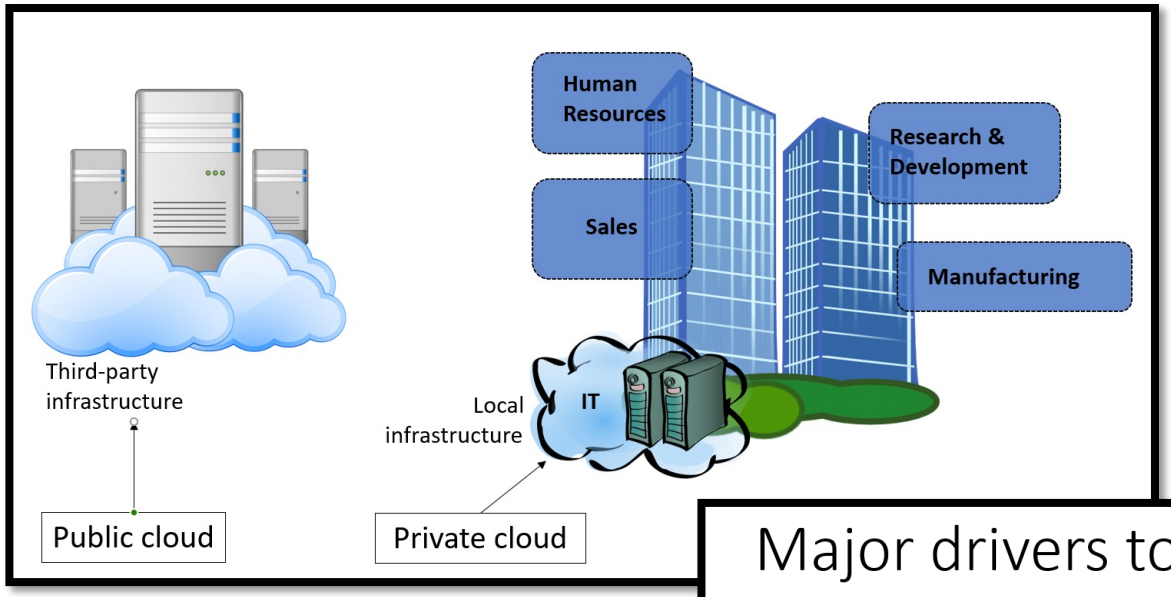
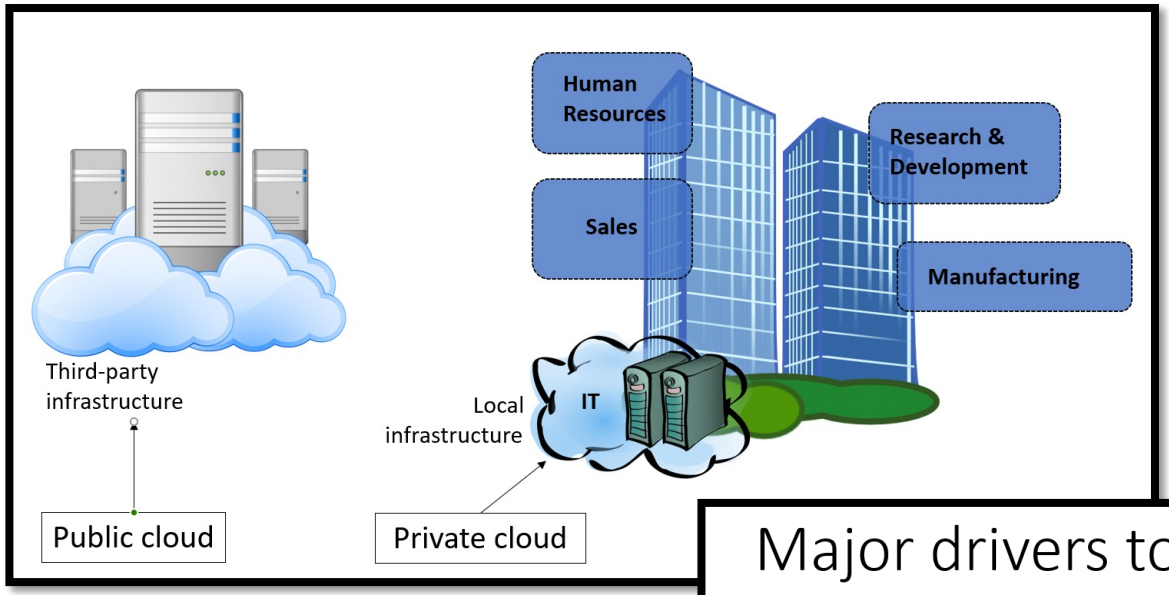


Major drivers to adoption

- Centralizing commodity servers in clusters
  - Better OPEX and CAPEX
  - Less human resources
  - Quantity discounts
  - Less heterogeneity
  - Easier automation

Centralization



Cloud providers potentialize these advantages

- Cloud providers host multiple tenants
- Build multiple large data centers to handle computing for customers
  - Buy thousands of each component, significant quantity discounts
  - Thorough automation
  - Standardized processes (e.g., for deploying new servers or replacing parts)
- Isolating tenants is key
  - Performance for a tenant must not depend on other tenants
  - Each tenant's data and code must be kept safe
    - An organization may even want to isolate departments from one another

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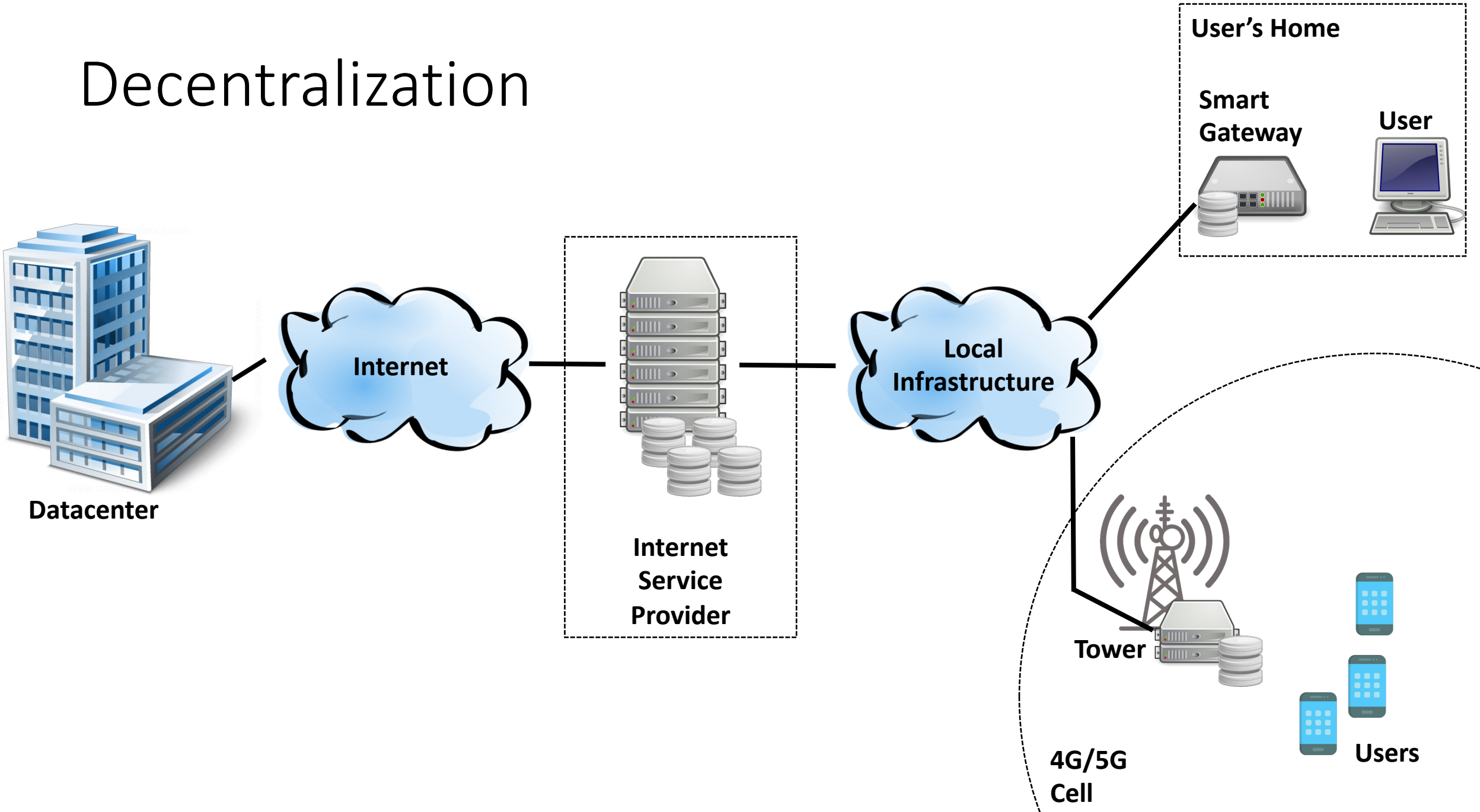
Decentralization



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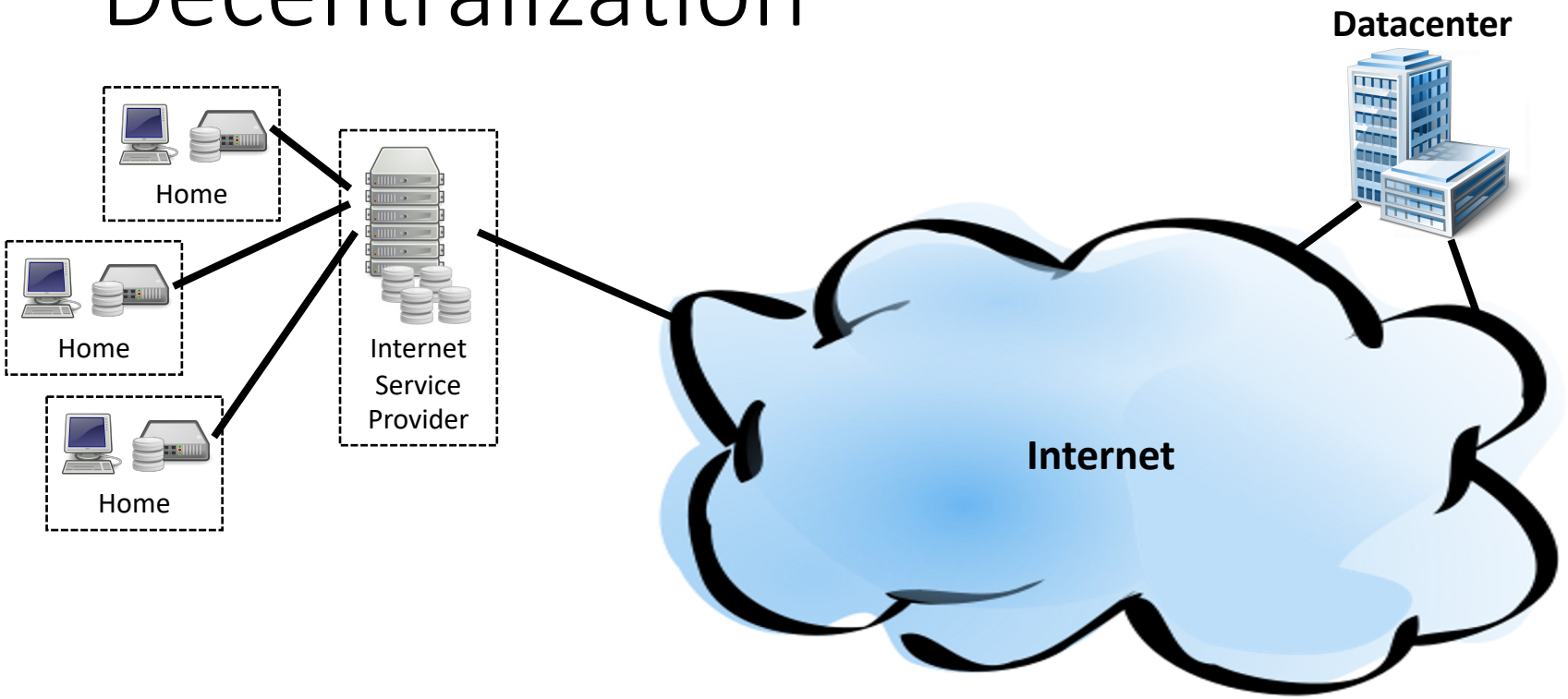

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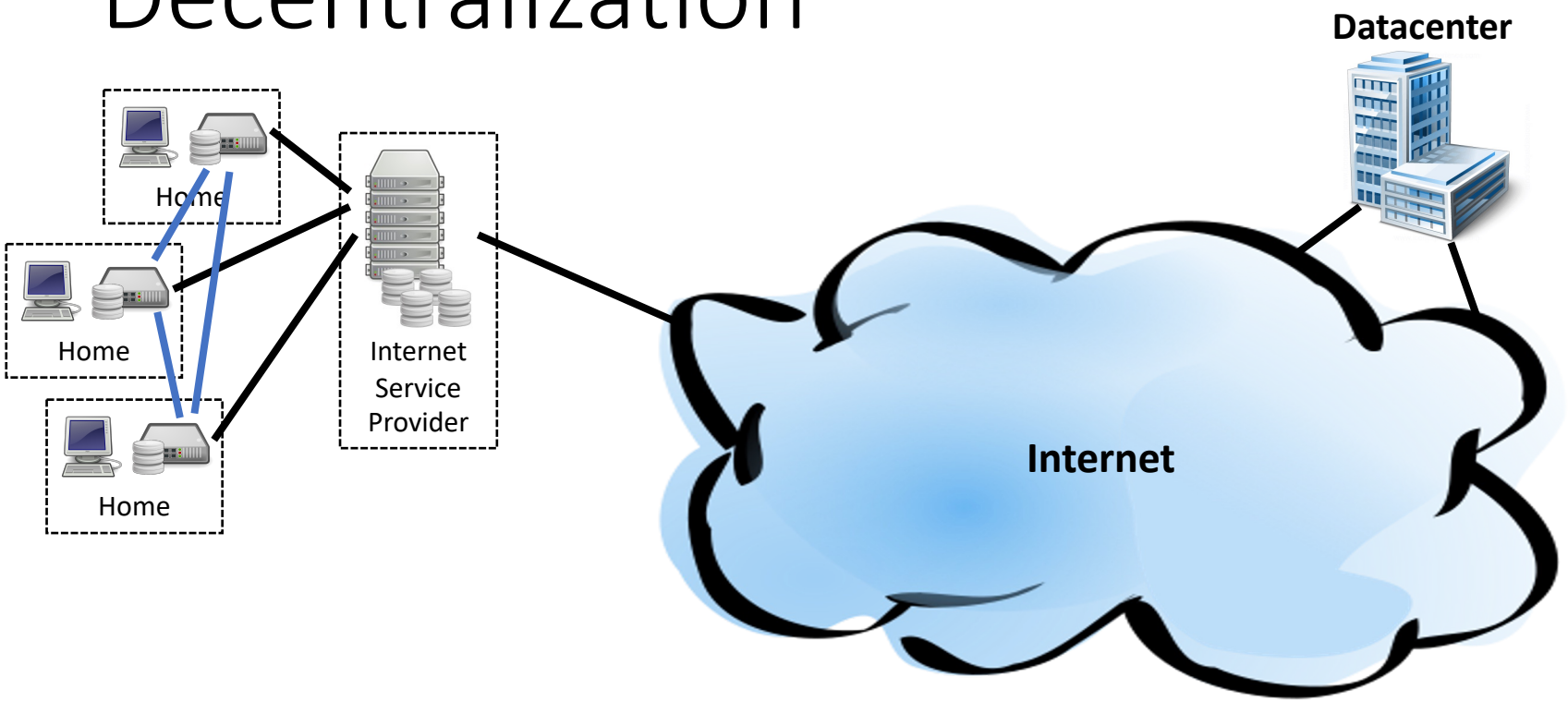

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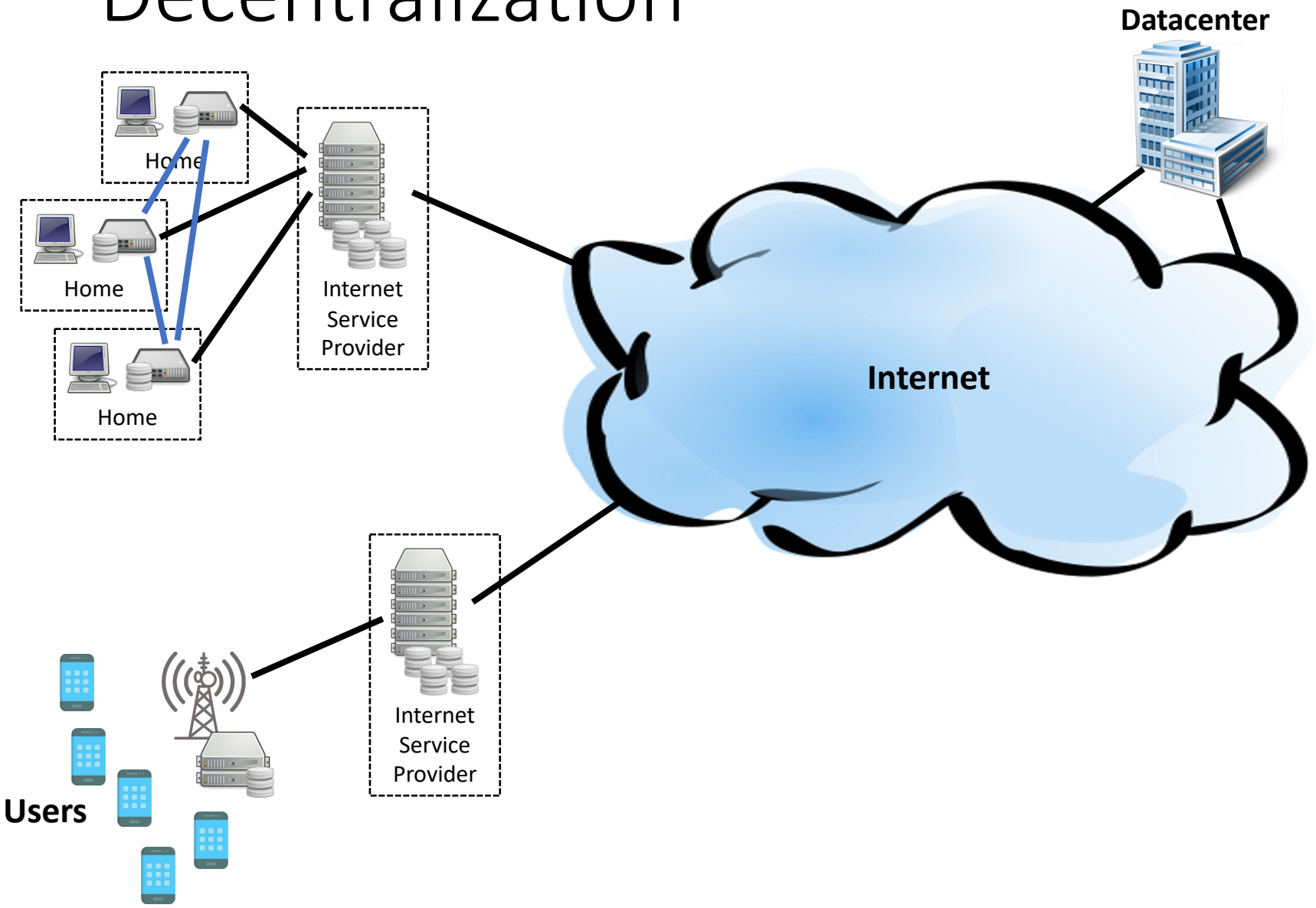

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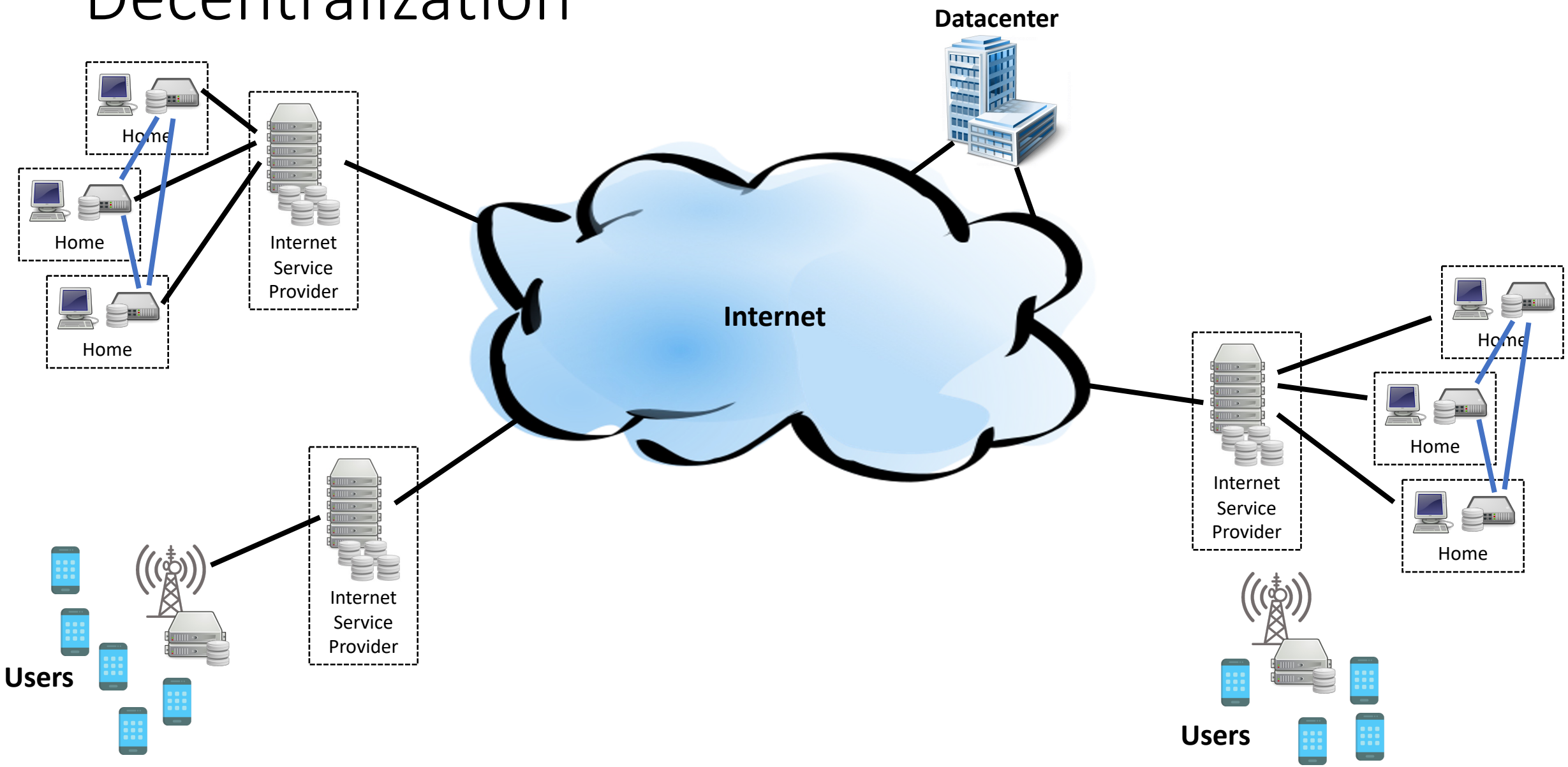

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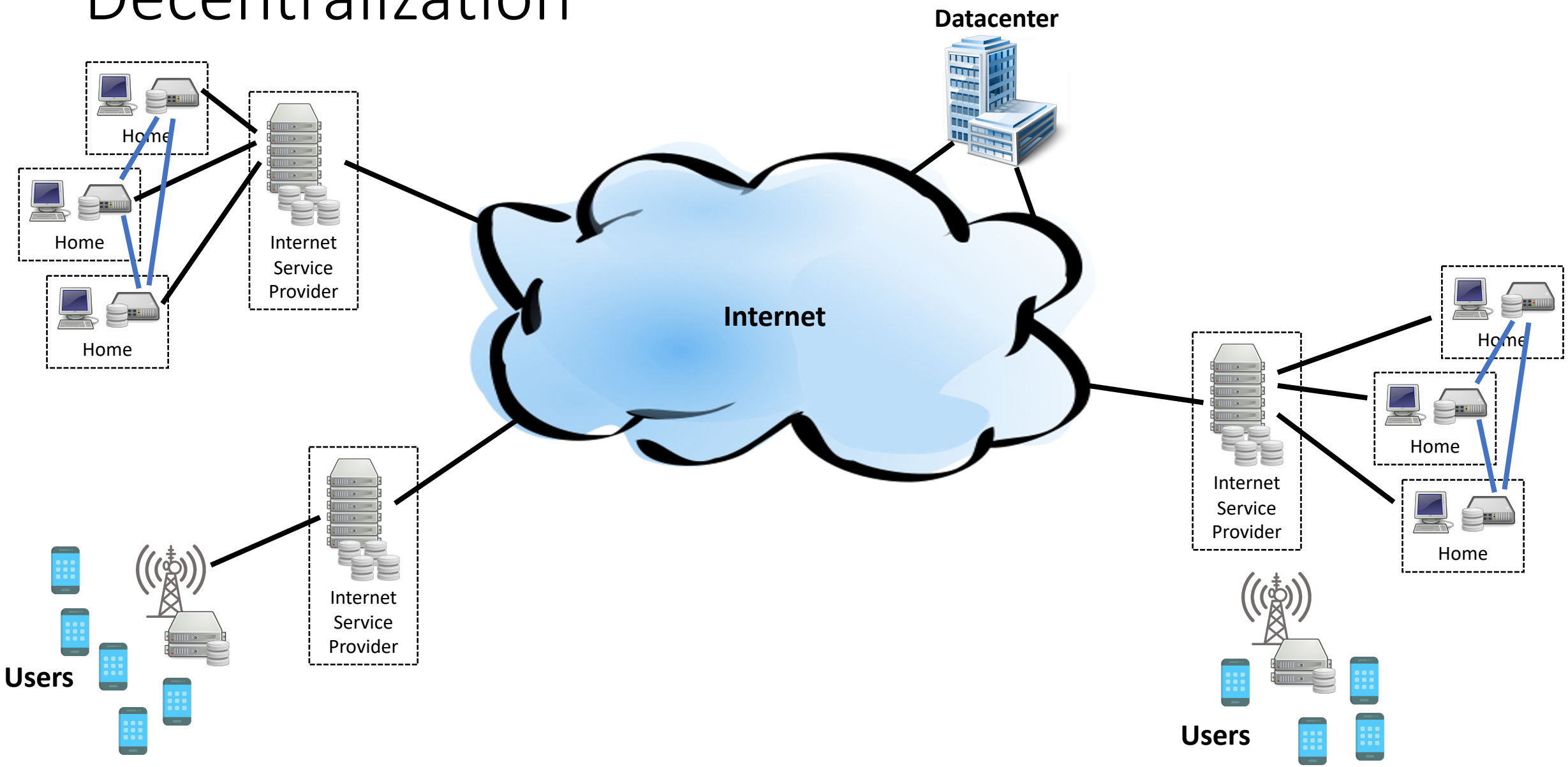
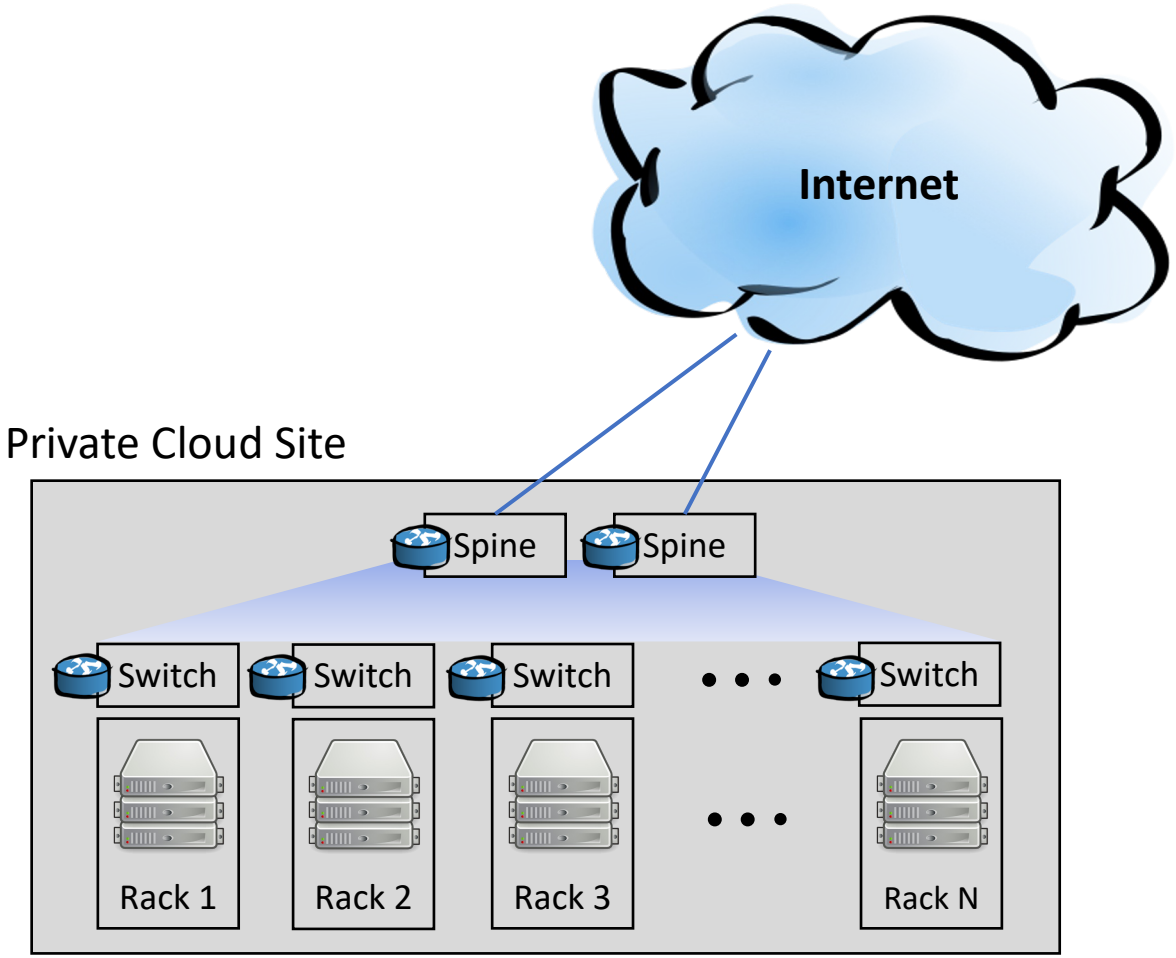


Provisioning Private Clouds

Prof. Ítalo Cunha

Control and Management



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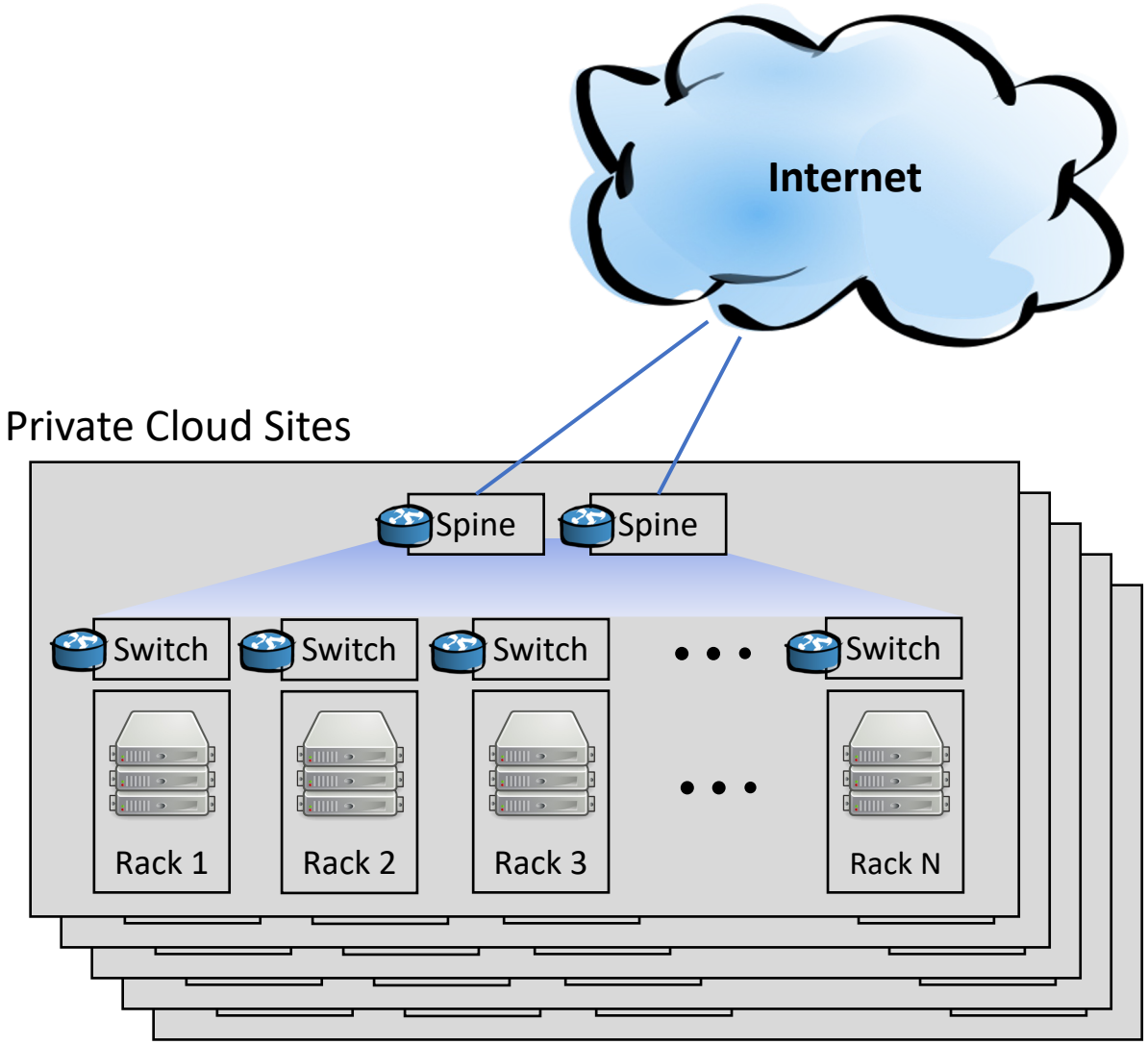

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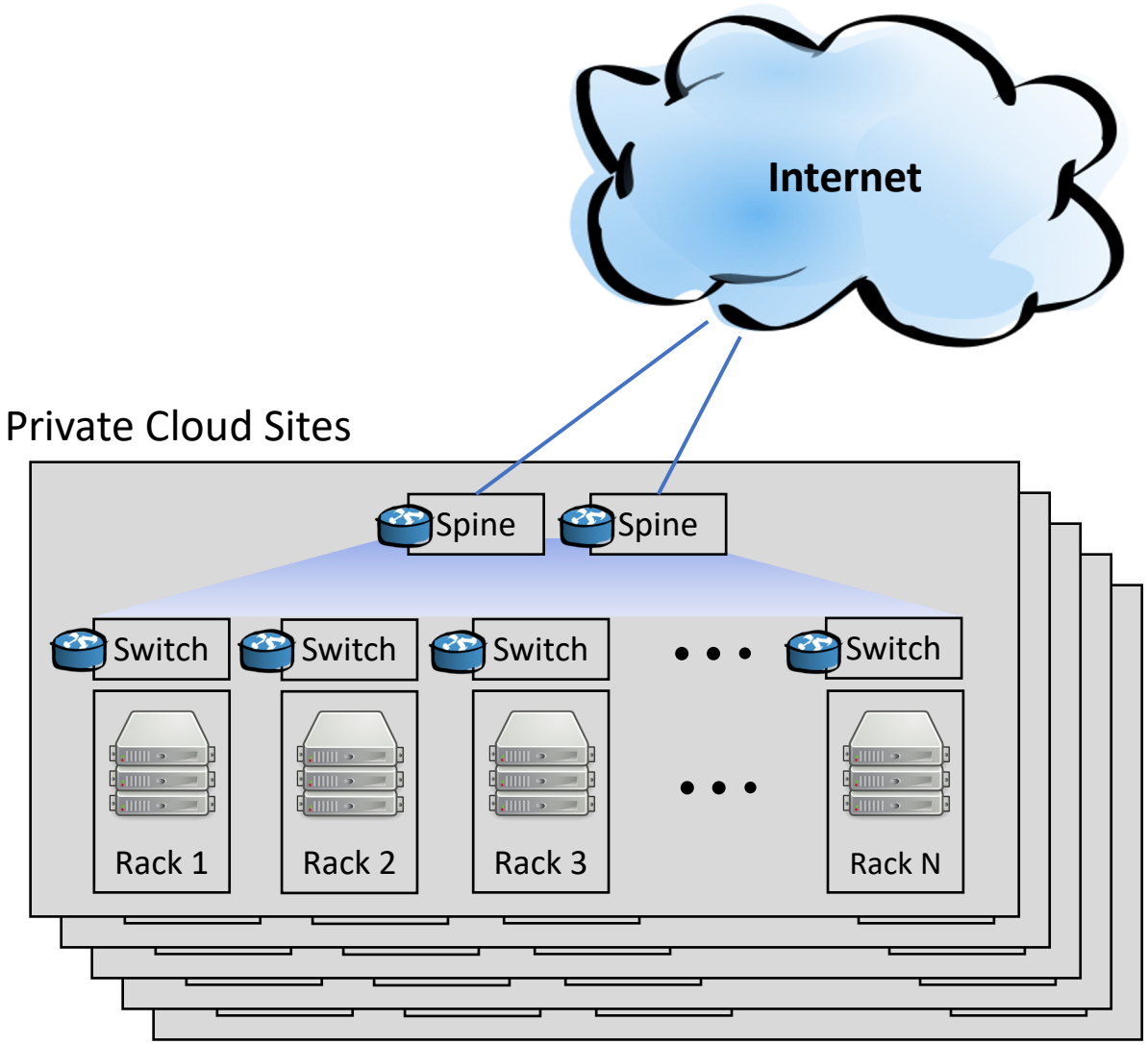
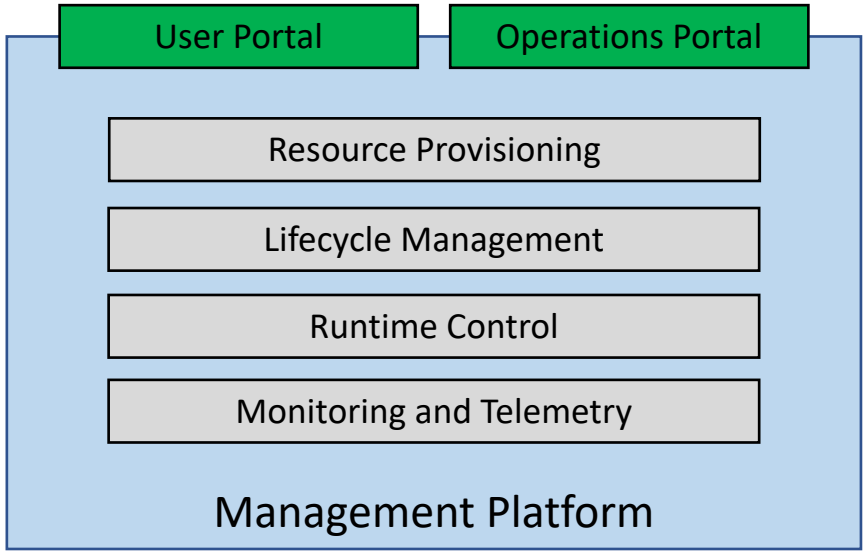
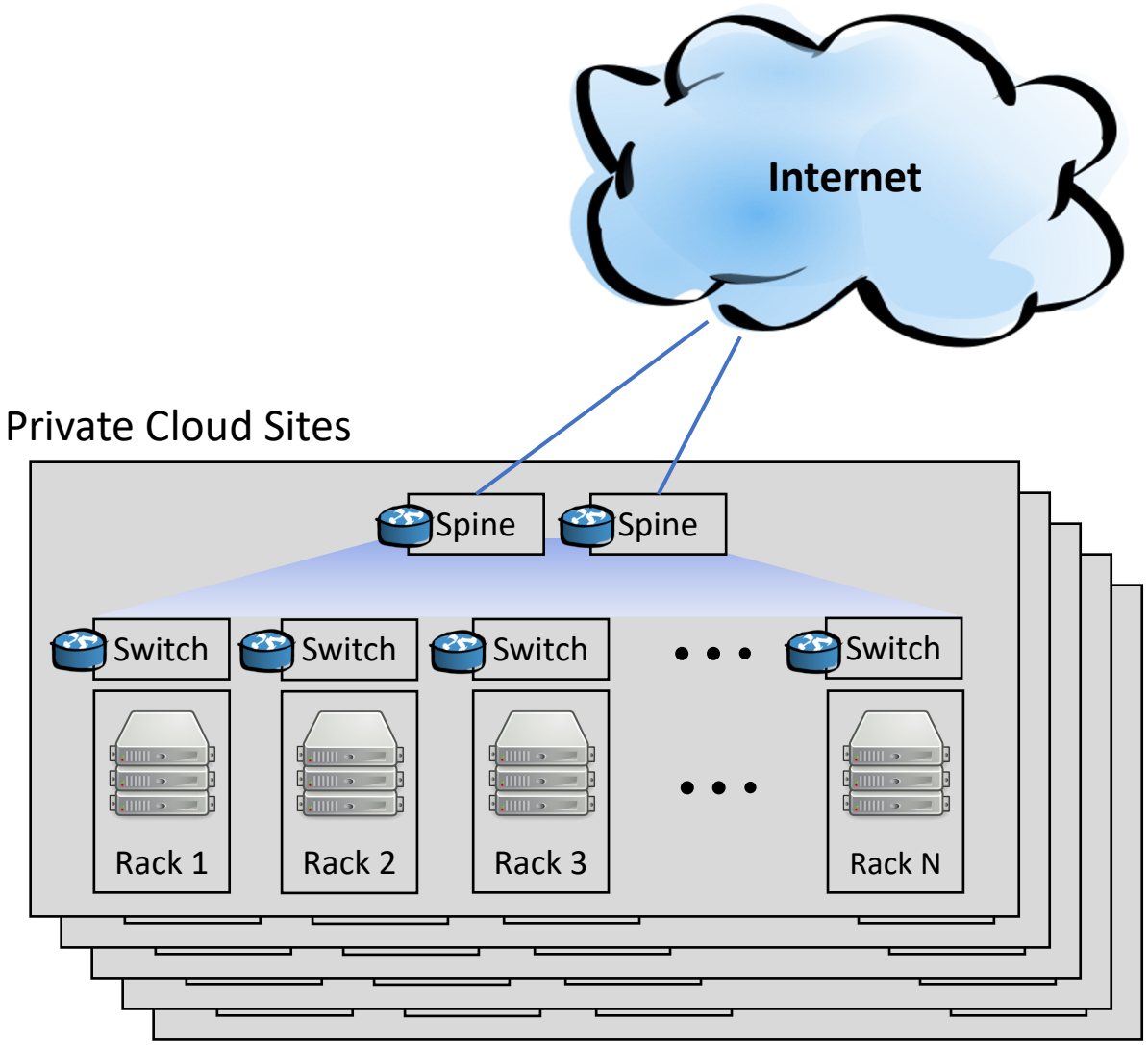
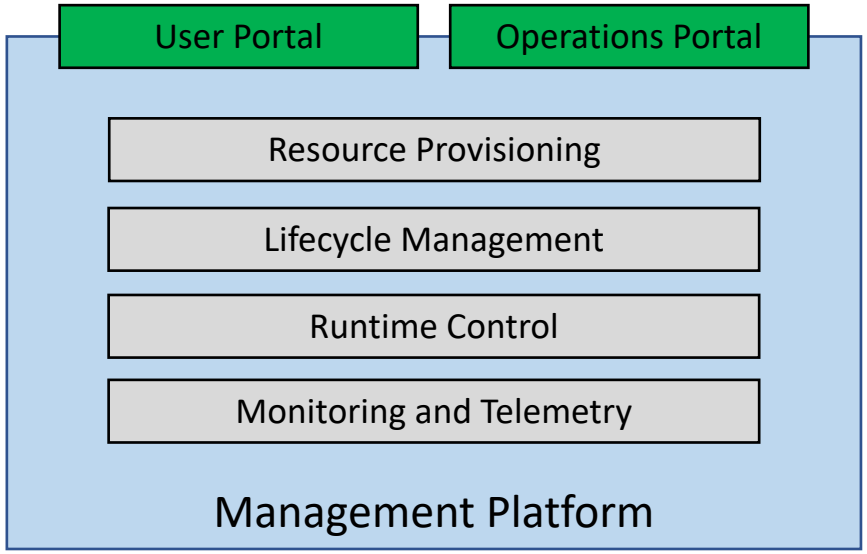




Control and Management

Stakeholders:
- Users
- Operators
- Service providers





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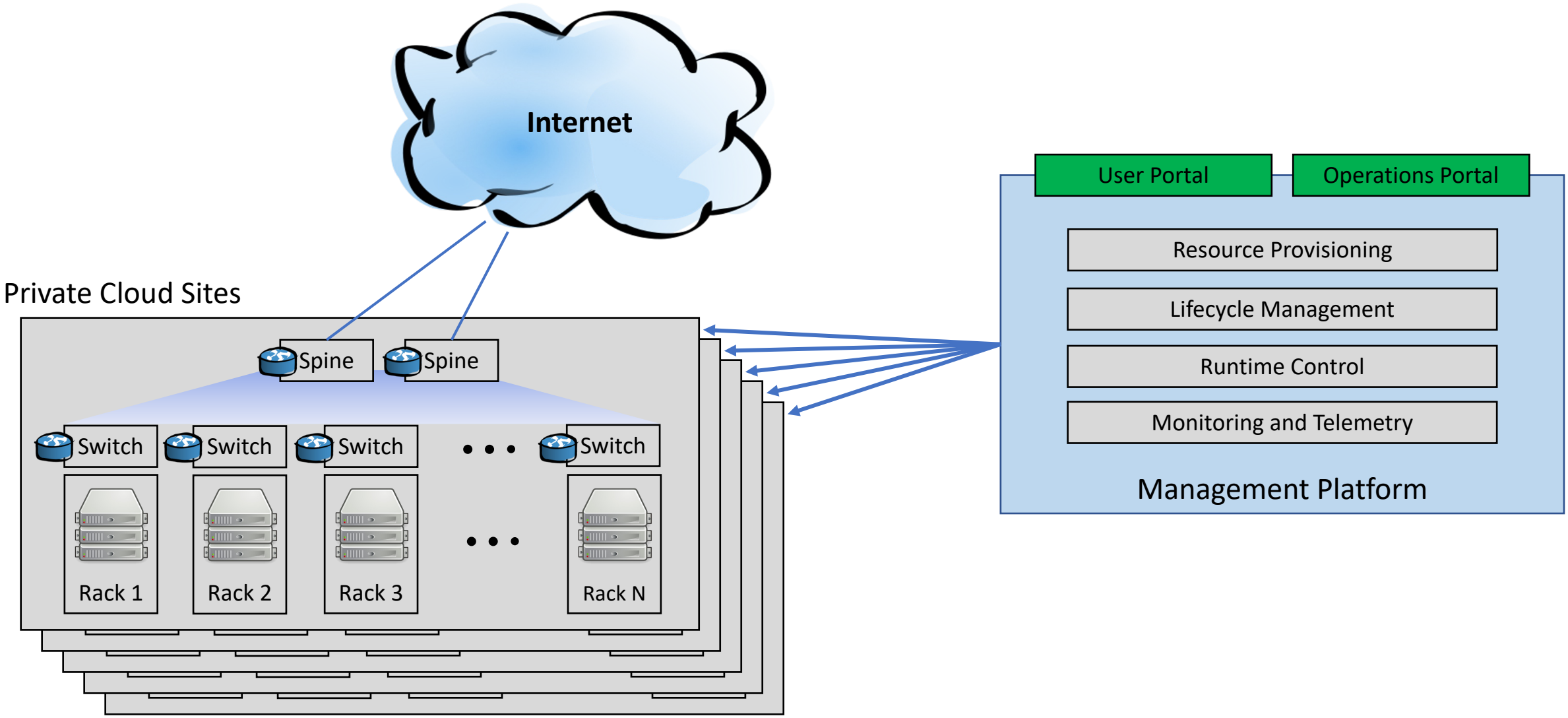

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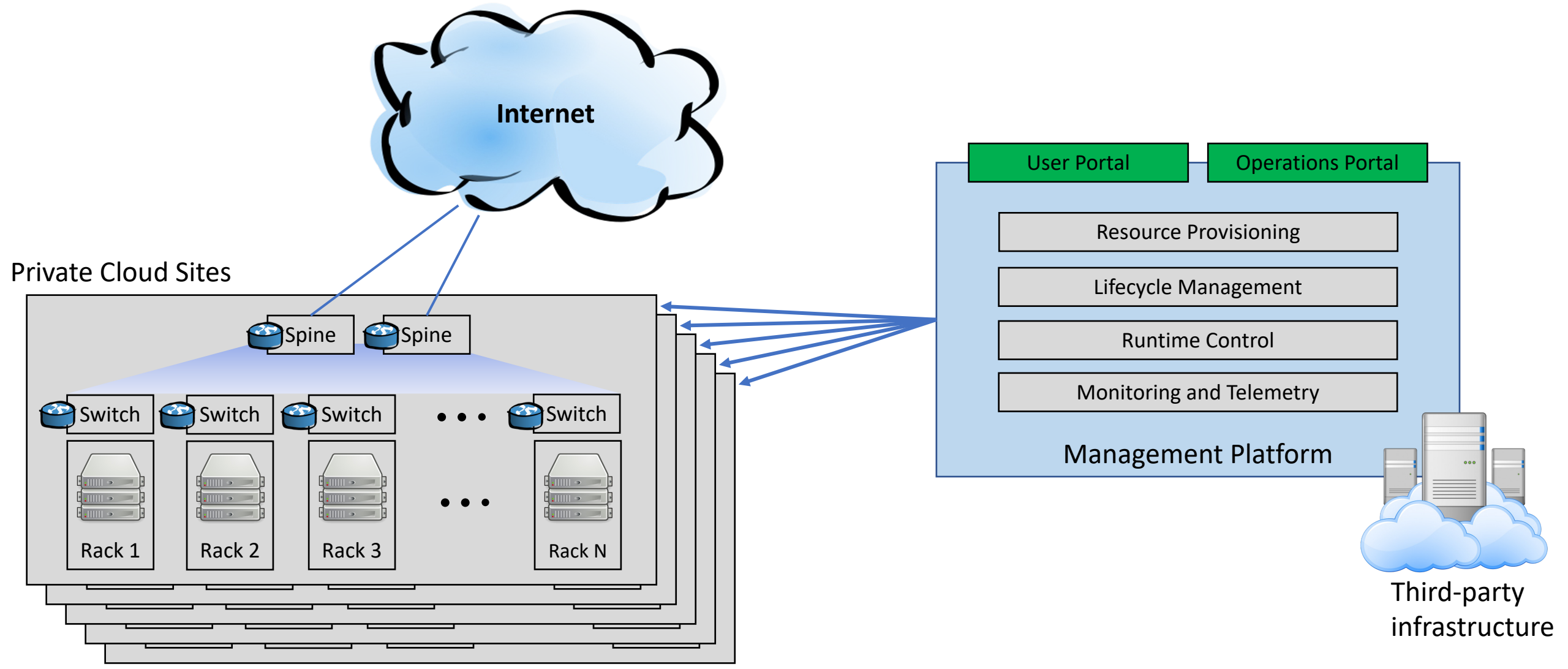

Resource Provisioning

Prof. Ítalo Cunha

Resource provisioning

- Bringing virtual and physical resources online
  - Hands-on deployment for physical resources
    - “Racking” and connecting power and network cables
  - Bootstrapping
    - Getting resources into a “ready” state (e.g., reachable over the network)

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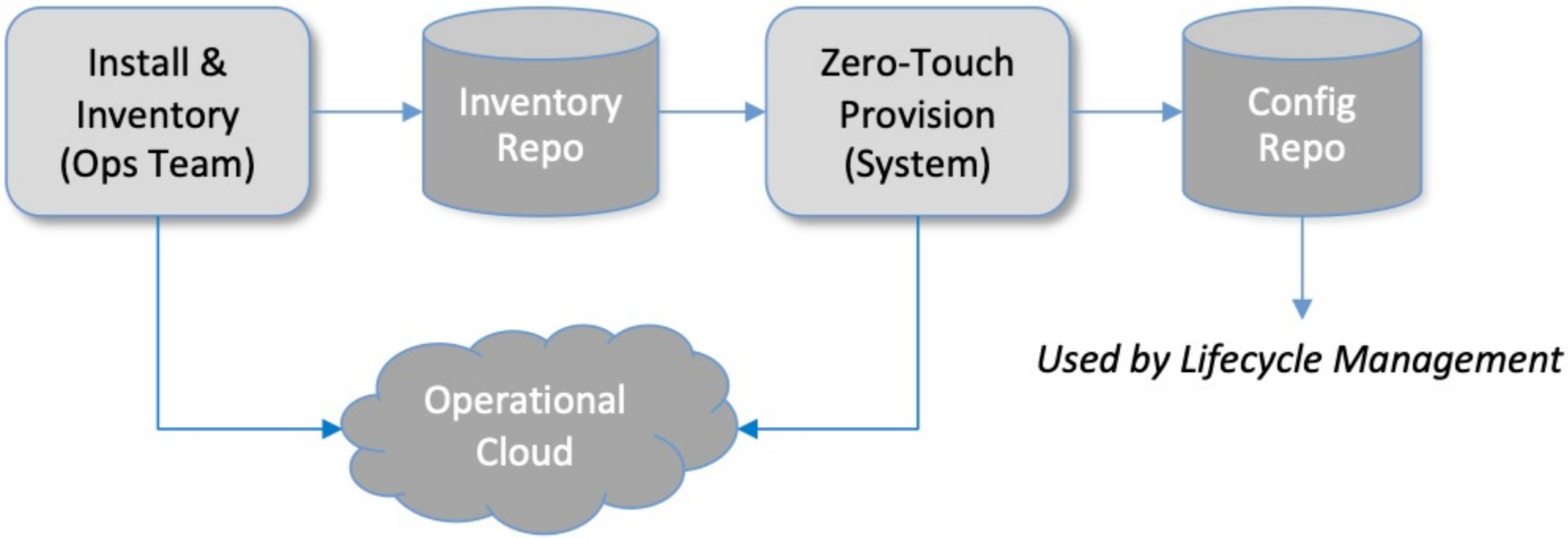
- Resource provisioning also happens incrementally over time
  - Upgrades, removal of obsolete resources, deployment of new resources

Overview of resource provisioning



“Day 0 operations”

Installation and inventory

- Cannot be entirely zero-touch for physical infrastructures
  - Assume we are dealing with commodity general-purpose resources
  - For virtual infrastructures, cloud provider APIs are used to provision resources
    - “Infrastructure as Code”
  - For plug-and-play appliances, configuration may be preinstalled

Installation and inventory

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  - For virtual infrastructures, cloud provider APIs are used to provision resources
    - “Infrastructure as Code”
  - For plug-and-play appliances, configuration may be preinstalled
- Goal is to minimize the amount of manual handling
  - Focus on getting the device connected and reachable
  - Zero-touch provisioning tools take it from there

Documenting the infrastructure

- Managing infrastructure requires ground truth about it
  - Organizations
  - Sites
  - Racks
    - Switches
    - Servers
    - Storage
    - Other equipment
  - Deployment
  - Power and networking

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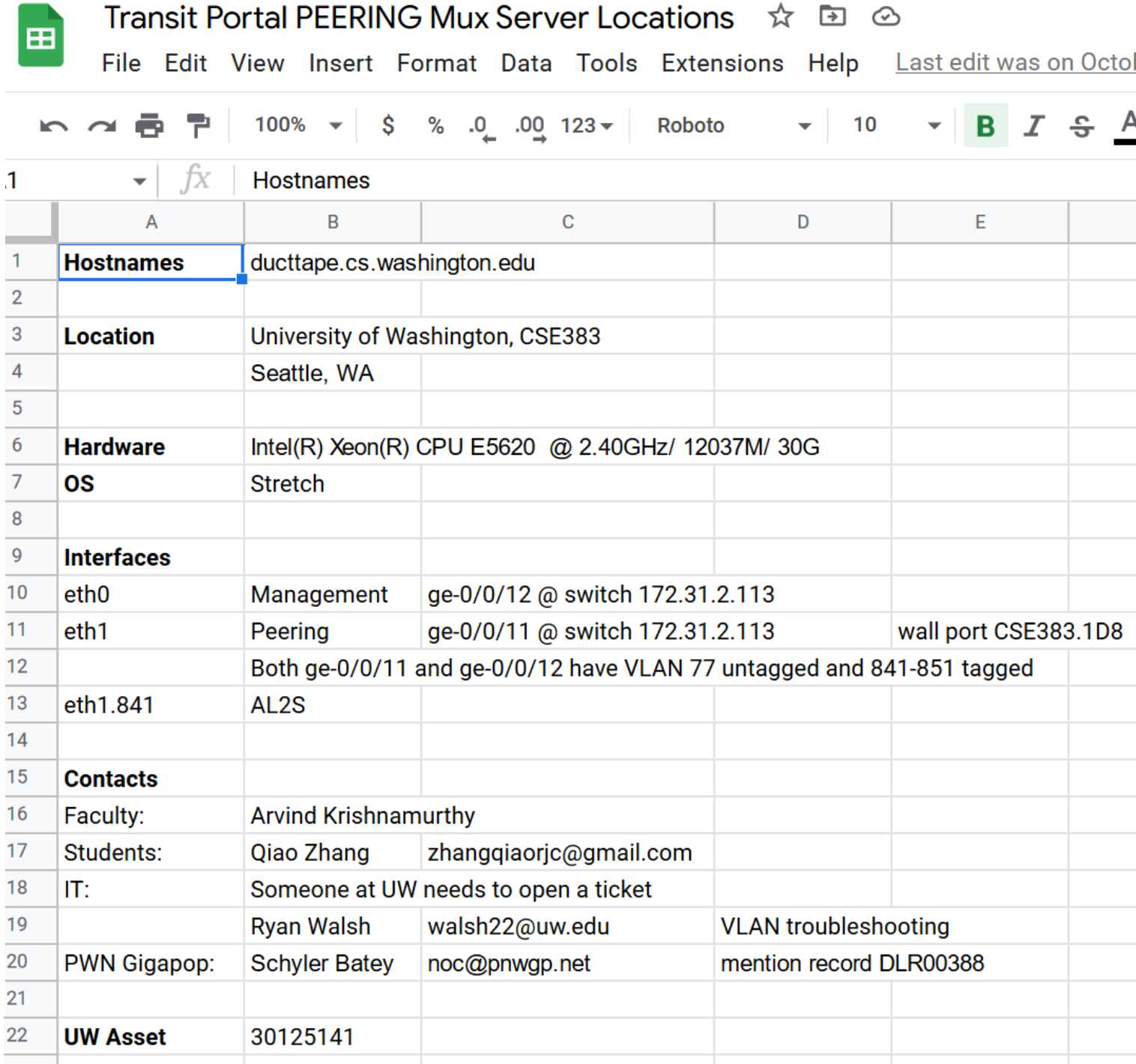
Device:
- Rack and rack position
- Manufacturer
- Model
- Serial number
- Device type
- MAC addresses
- Power outlet
- Switch ports and VLANs



Transit Portal PEERING Mux Server Locations

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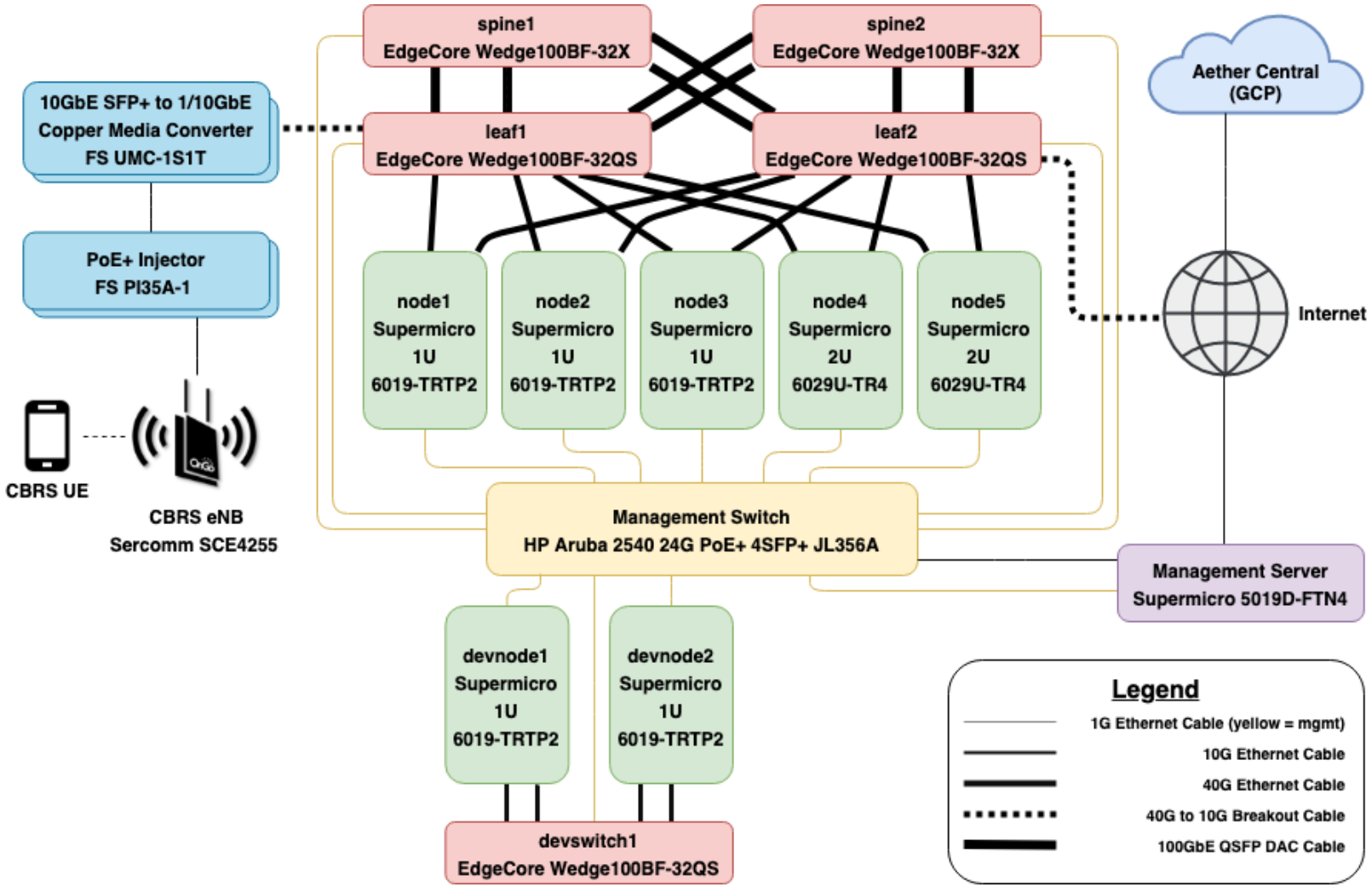
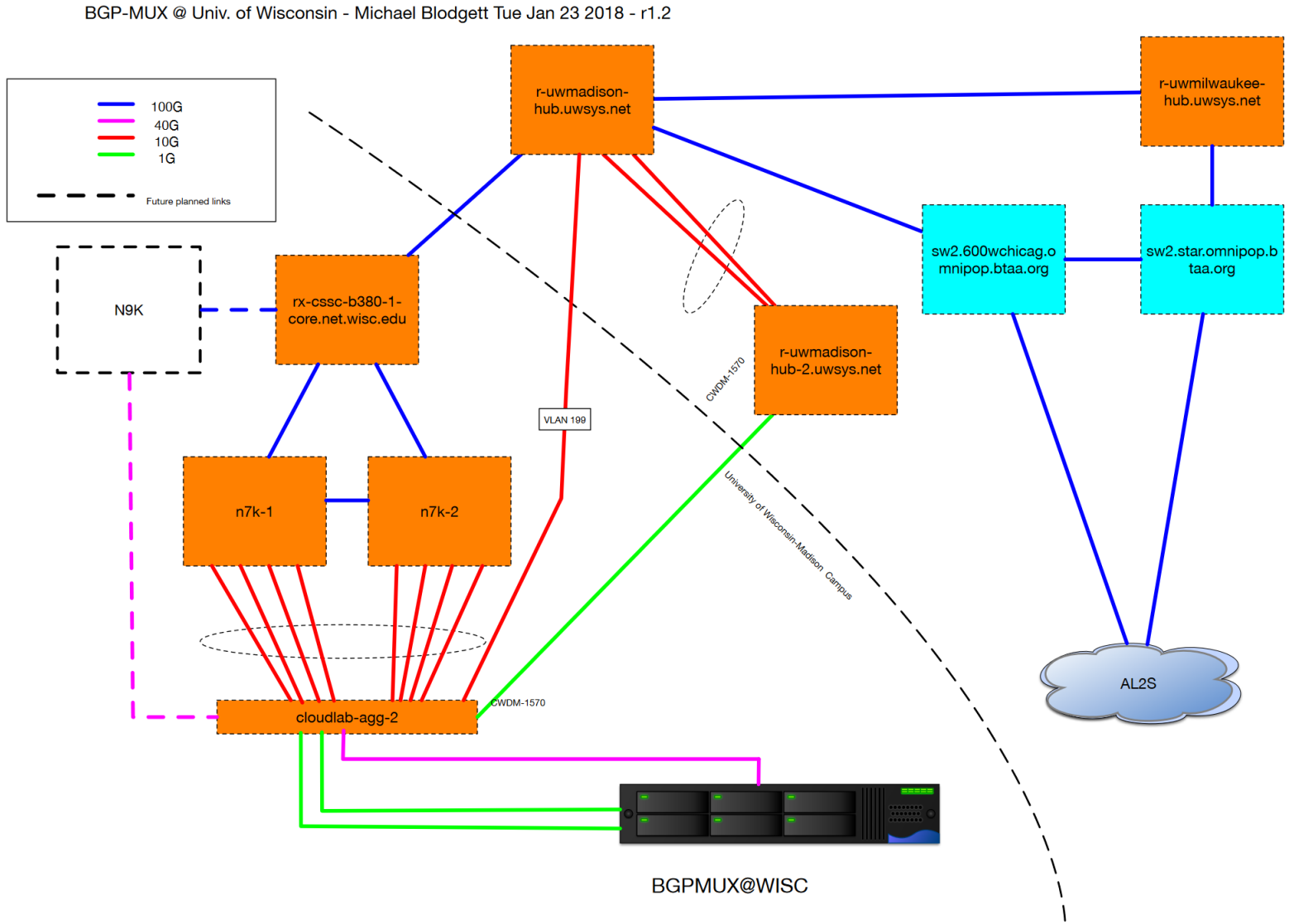
1 fx Hostnames

	A	B	C	D	E
1	**Hostnames**	ducttape.cs.washington.edu			
2					
3	**Location**	University of Washington, CSE383			
4		Seattle, WA			
5					
6	**Hardware**	Intel(R) Xeon(R) CPU E5620 @ 2.40GHz/ 12037M/ 30G			
7	**OS**	Stretch			
8					
9	**Interfaces**				
10	eth0	Management	ge-0/0/12 @ switch 172.31.2.113		
11	eth1	Peering	ge-0/0/11 @ switch 172.31.2.113		wall port CSE383.1D8
12		Both ge-0/0/11 and ge-0/0/12 have VLAN 77 untagged and 841-851 tagged			
13	eth1.841	AL2S			
14					
15	**Contacts**				
16	Faculty:	Arvind Krishnamurthy			
17	Students:	Qiao Zhang	zhangqiaorjc@gmail.com		
18	IT:	Someone at UW needs to open a ticket			
19		Ryan Walsh	walsh22@uw.edu	VLAN troubleshooting	
20	PWN Gigapop:	Schyler Batey	noc@pnwgp.net	mention record DLR00388	
21					
22	**UW Asset**	30125141			

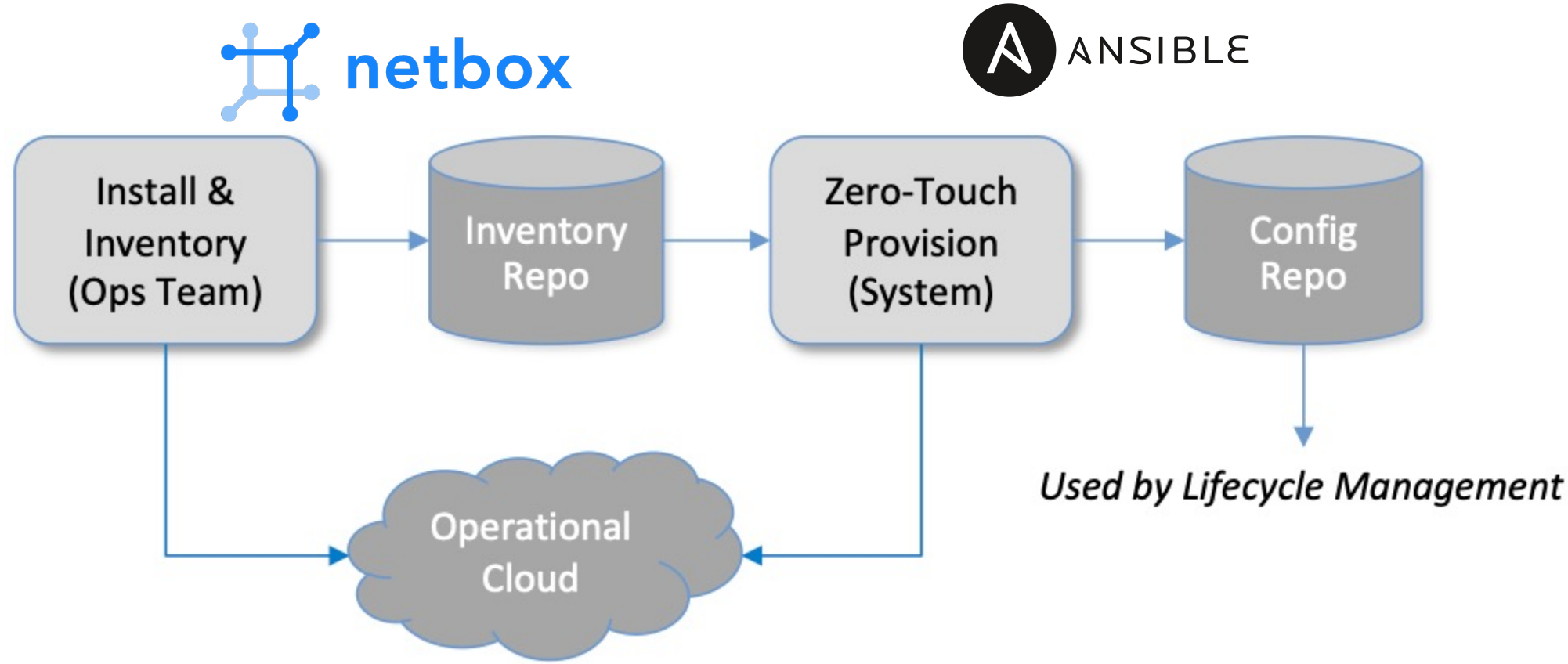
Infrastructure planning



Infrastructure documentation (after the fact)



Overview of resource provisioning



Example: Cabling in NetBox

Cables

ID	Label	Side A	Termination A	Side B	Termination B	Status	Type	Length	Color
165	—	mgmtswitch1.prod1.stanford1	gbe3	node1.prod1.stanford1	bmc	Connected	CAT6	2 Feet	
166	—	mgmtswitch1.prod1.stanford1	gbe4	node2.prod1.stanford1	bmc	Connected	CAT6	2 Feet	
167	—	mgmtswitch1.prod1.stanford1	gbe5	node3.prod1.stanford1	bmc	Connected	CAT6	2 Feet	
168	—	mgmtswitch1.prod1.stanford1	gbe6	node4.prod1.stanford1	bmc	Connected	CAT6	3 Feet	
169	—	mgmtswitch1.prod1.stanford1	gbe7	node5.prod1.stanford1	bmc	Connected	CAT6	3 Feet	
170	—	mgmtswitch1.prod1.stanford1	gbe11	spine1.prod1.stanford1	eth0	Connected	CAT6	5 Feet	
171	—	mgmtswitch1.prod1.stanford1	gbe12	spine2.prod1.stanford1	eth0	Connected	CAT6	5 Feet	
172	—	mgmtswitch1.prod1.stanford1	gbe13	leaf1.prod1.stanford1	eth0	Connected	CAT6	5 Feet	
173	—	mgmtswitch1.prod1.stanford1	gbe14	leaf2.prod1.stanford1	eth0	Connected	CAT6	5 Feet	
174	—	mgmtswitch1.prod1.stanford1	gbe15	node1.prod1.stanford1	gbe0	Connected	CAT6	2 Feet	
175	—	mgmtswitch1.prod1.stanford1	gbe16	node2.prod1.stanford1	gbe0	Connected	CAT6	2 Feet	
176	—	mgmtswitch1.prod1.stanford1	gbe17	node3.prod1.stanford1	gbe0	Connected	CAT6	2 Feet	
177	—	mgmtswitch1.prod1.stanford1	gbe18	node4.prod1.stanford1	gbe0	Connected	CAT6	3 Feet	
178	—	mgmtswitch1.prod1.stanford1	gbe19	node5.prod1.stanford1	gbe0	Connected	CAT6	3 Feet	