Azure for Research

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University of Cambridge and Microsoft Research

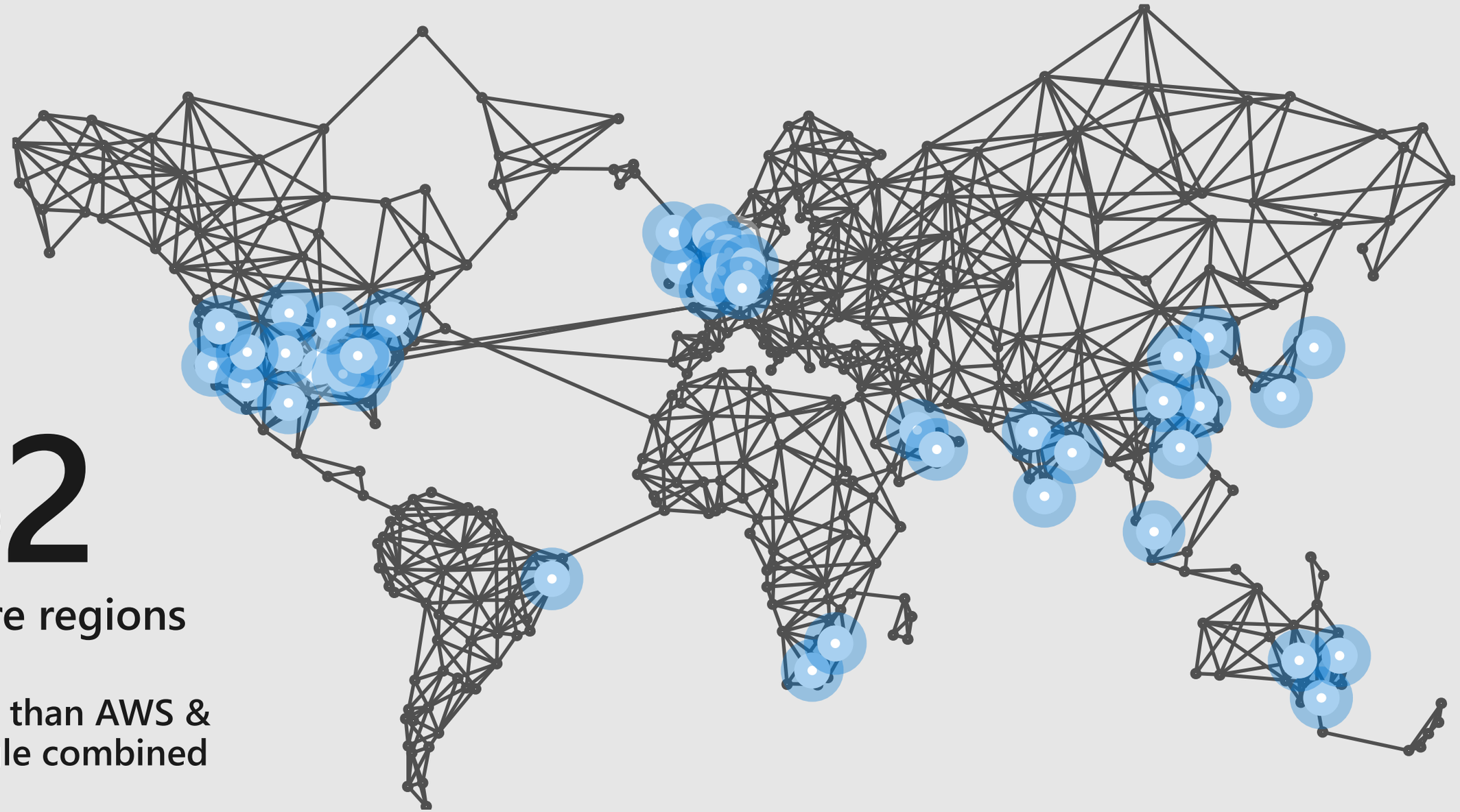
Deep engagements across computer science, engineering, health and life sciences

Funded **70 PhD students at the University of Cambridge (since 2004)** and hosted **45 PhD interns (since 2016).**
Many MSR researchers are alumni of the University, and Fellows of Colleges.

Health Data Research UK Team of the Year 2020 – with Cambridge University and Microsoft - HDR UK's Team of the Year award 2020 - HDR UK

Multi-million pound Microsoft-Cambridge Machine Learning Initiative EPSRC Prosperity Partnership kicked off with Engineering Department - UK government backs University of Cambridge and Microsoft mission to build better AI | Department of Engineering

Project InnerEye AI for Cancer treatment with University of Cambrige and Addenbrookes being deployed on Azure for patients – just won £0.5M NHSX AI Award - Cambridge award winners in AI innovation | CUH



62

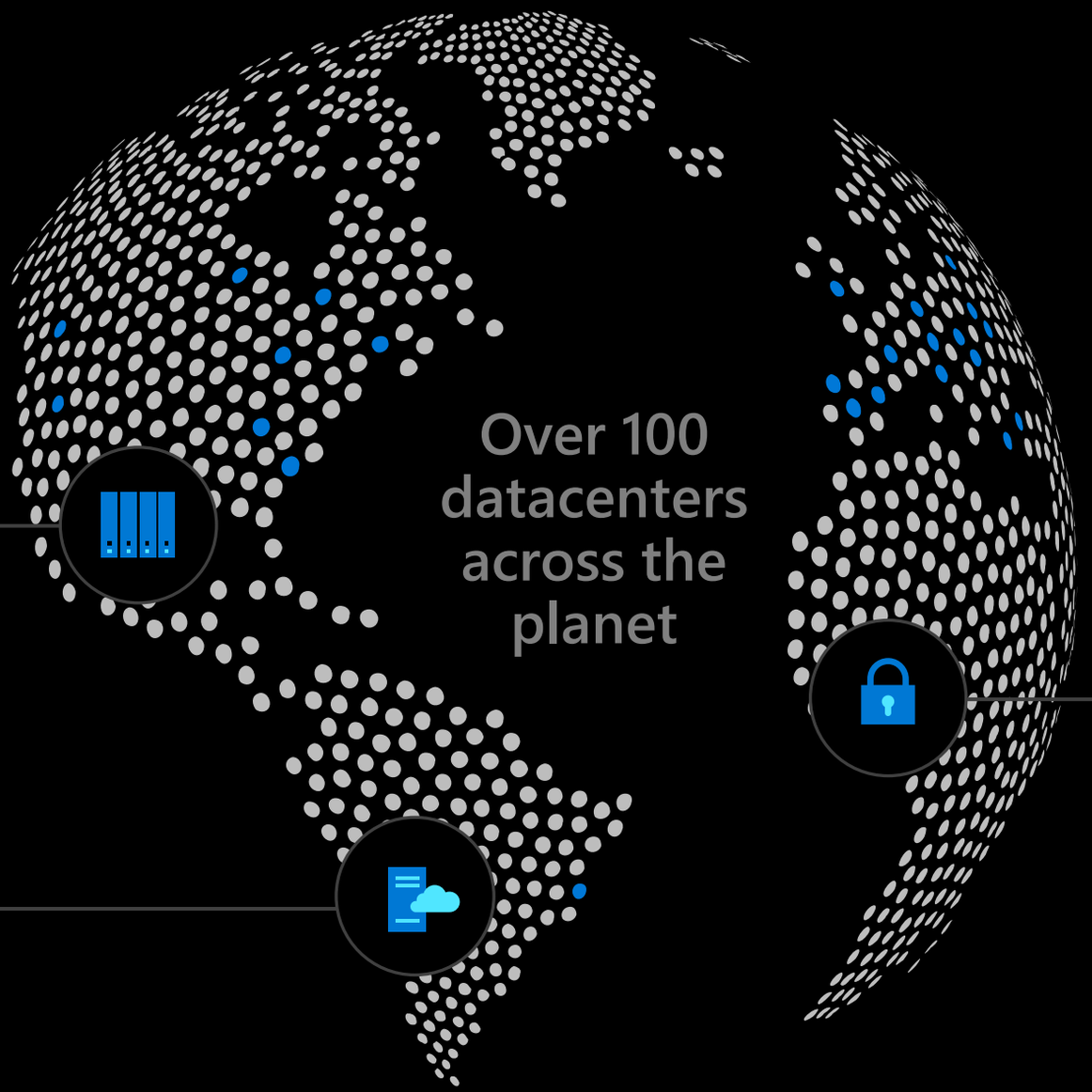
Azure regions

More than AWS &
Google combined

A secure foundation at global scale

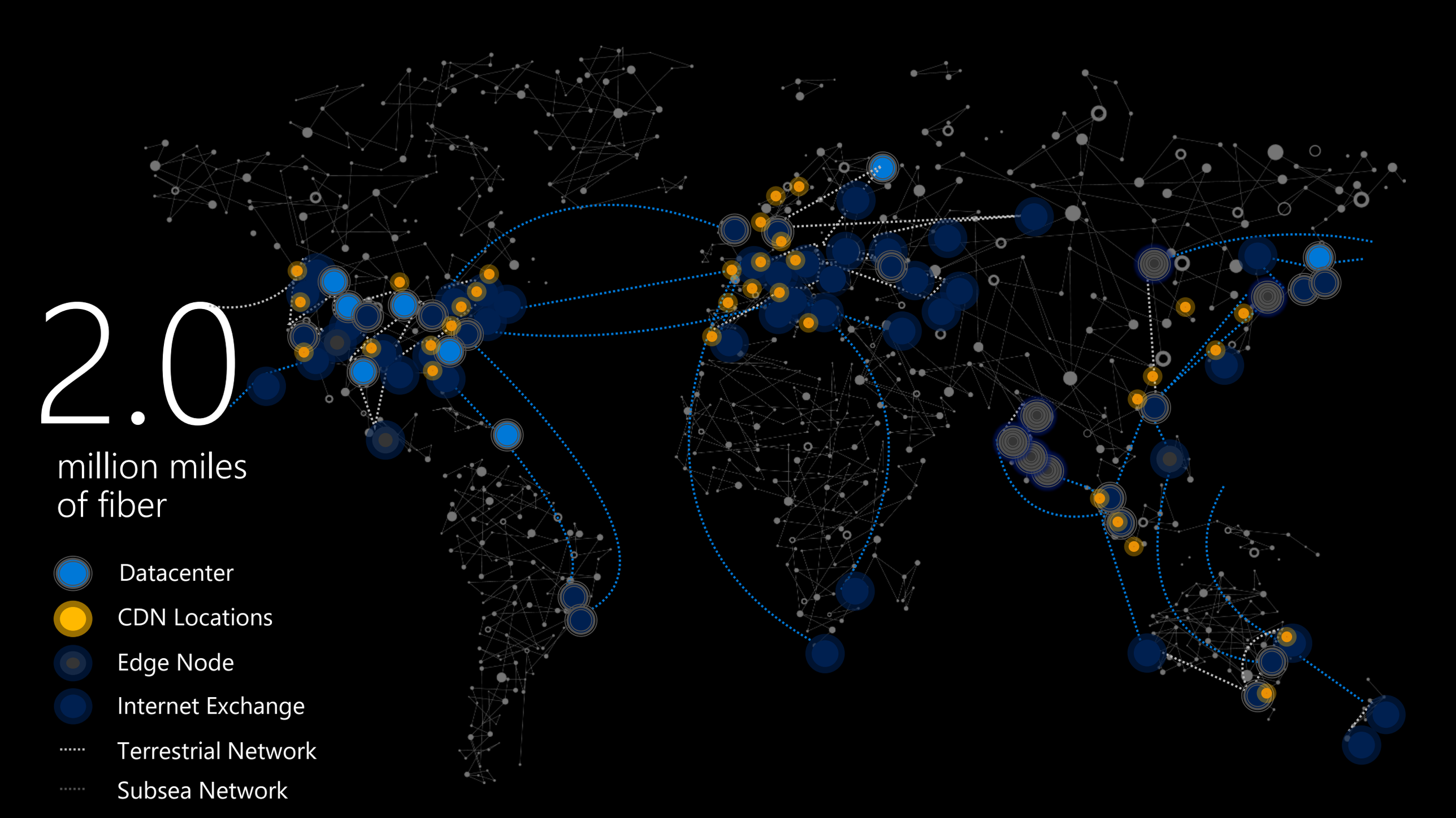
Each **physical datacenter** protected with world-class, multi-layered protection

Global cloud infrastructure with custom hardware and network protection



Secured with cutting-edge **operational security**

- Restricted access
- 24x7 monitoring
- Global security experts


2.0
million miles
of fiber
Datacenter
CDN Locations
Edge Node
Internet Exchange
Terrestrial Network
Subsea Network

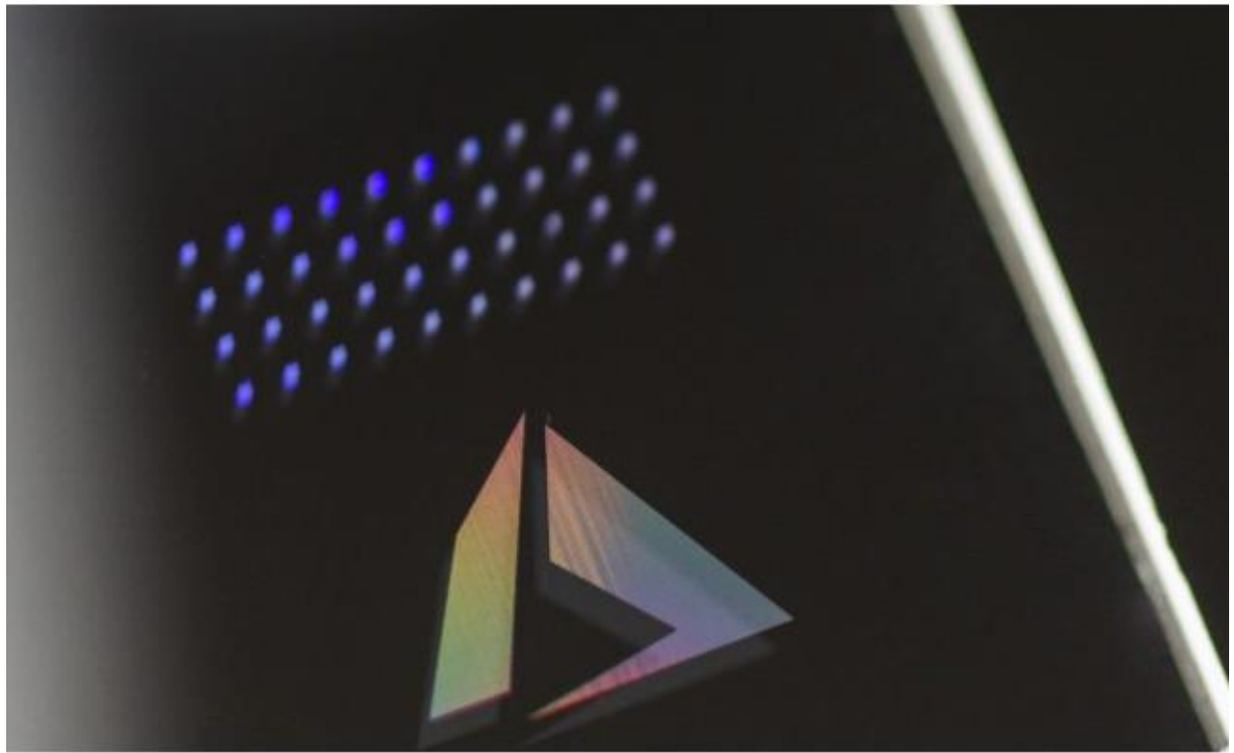
Microsoft Data Center
Boydton, VA

Addressing IT for Research challenges

Customer Challenges	Solution	Business Benefits
Less than 50% of IT budget is spent through Central IT Services	Centralise IT Budget spend for Research	Reduce costs (economies of scale) Increase efficiency Less time on procurement
Requests from Academics and Research can take 3-6 months+ to procure and deploy	On demand & Self Service environment with virtually unlimited capacity	Central IT able to service Research requirements immediately
Research and Academic IT departmental environments typically lack governance	Centrally managed environment with Governance framework included	Central IT able to fully support Research environments Compliant Research
Researchers and Academics spend too much time procuring and building IT environments	Central on demand services provide almost immediate access to required environment	More time for actual research Agile Research environment Faster publication
Researchers often need short term access to expensive Research environments	Agile environment that provides required services for the time needed. No CAPEX, Only charged for actual usage	No CAPEX requirement Only charged for actual use Research Funding for IT can be held until required.

Research Benefits

- Agile environment
- Rapid access to services
- Flexible – resources adapt to project
- Access to Cognitive Services
- Cash Flow
- Enhanced security and compliance
- Industry Accreditations (ISO, NHS etc)
- Increased research capacity
- Quicker to publication
- Sustainability
- Access to new innovations, sooner



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NEWCASTLE UNIVERSITY

Petascale Cloud Supercomputing for Terapixel Visualization of a Digital Twin

Nicolas S. Holliman, *Member IEEE Computer Society*, Manu Antony,
James Charlton, Stephen Dowsland, Philip James and Mark Turner

Abstract— Background—Photo-realistic terapixel visualization is computationally intensive and to date there have been no such visualizations of urban digital twins, the few terapixel visualizations that exist have looked towards space rather than earth. Objective—our aims are: creating a *scalable* cloud supercomputer software architecture for visualization; a *photo-realistic terapixel 3D visualization* of urban IoT data supporting daily updates; a *rigorous evaluation* of cloud supercomputing for our application. Method—We migrated the Blender Cycles path tracer to the public cloud within a new software framework designed to scale to petaFLOP performance. Results—we demonstrate we can compute a terapixel visualization in under one hour, the system scaling at 98% efficiency to use 1024 public cloud GPU nodes delivering 14 petaFLOPS. The resulting terapixel image supports interactive browsing of the city and its data at a wide range of sensing scales. Conclusion—The GPU compute resource available in the cloud is greater than anything available on our national supercomputers providing access to globally competitive resources. The direct financial cost of access, compared to procuring and running these systems, was low. The indirect cost, in overcoming teething issues with cloud software development, should reduce significantly over time.

Index Terms—Data Visualization, Internet of Things, Scalability, Supercomputers

https://arxiv.org/ftp/arxiv/papers/1902/1902.04820.pdf

Azure: Trusted

Global

- ISO 27001
- ISO 27018
- ISO 27017
- ISO 22301
- SOC 1 Type 2
- SOC 2 Type 2
- SOC 3
- CSA STAR Self-Assessment
- CSA STAR Certification
- CSA STAR Attestation

Regional

- Argentina PDPA
- EU Model Clauses
- UK G-Cloud
- China DJCP
- China GB 18030
- China TRUCS
- Singapore MTCS
- Australia IRAP/CCSL
- New Zealand GCIO
- Japan My Number Act
- ENISA IAF
- Japan CS Mark Gold
- Spain ENS
- Spain DPA
- India MeitY
- Canada Privacy Laws
- Privacy Shield
- Germany IT Grundschutz workbook

Industry

- PCI DSS Level 1
- CDSA
- MPAA
- FACT UK
- Shared Assessments
- FISC Japan
- HIPAA/ HITECH Act
- HITRUST
- GxP 21 CFR Part 11
- MARS-E
- IG Toolkit UK
- FERPA
- GLBA
- FFIEC

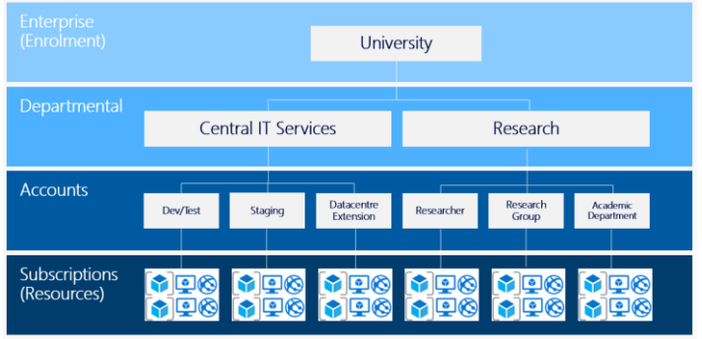
Us Gov

- Moderate JAB P-ATO
- High JAB P-ATO
- DoD DISA SRG Level 2
- DoD DISA SRG Level 4
- DoD DISA SRG Level 5
- SP 800-171
- FIPS 140-2
- Section 508 VPAT
- ITAR
- CJIS
- IRS 1075

Using Compliance to broaden Research capability

Azure is an open cloud

Governed service for Research

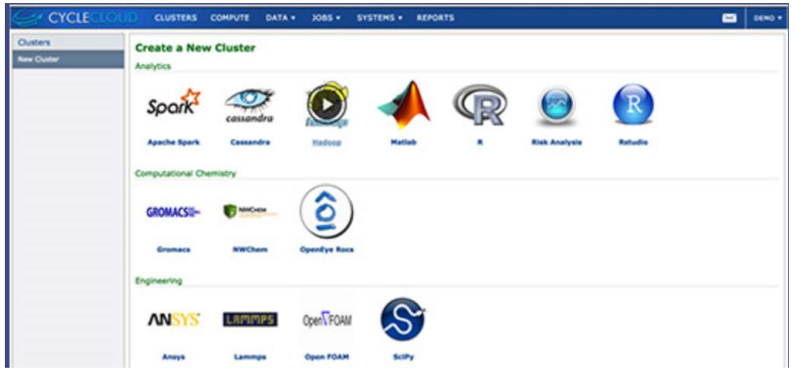


Central Research Management

Research structure, billing, account and delegation management. Central Governance of Research services is a key aim of most Universities.

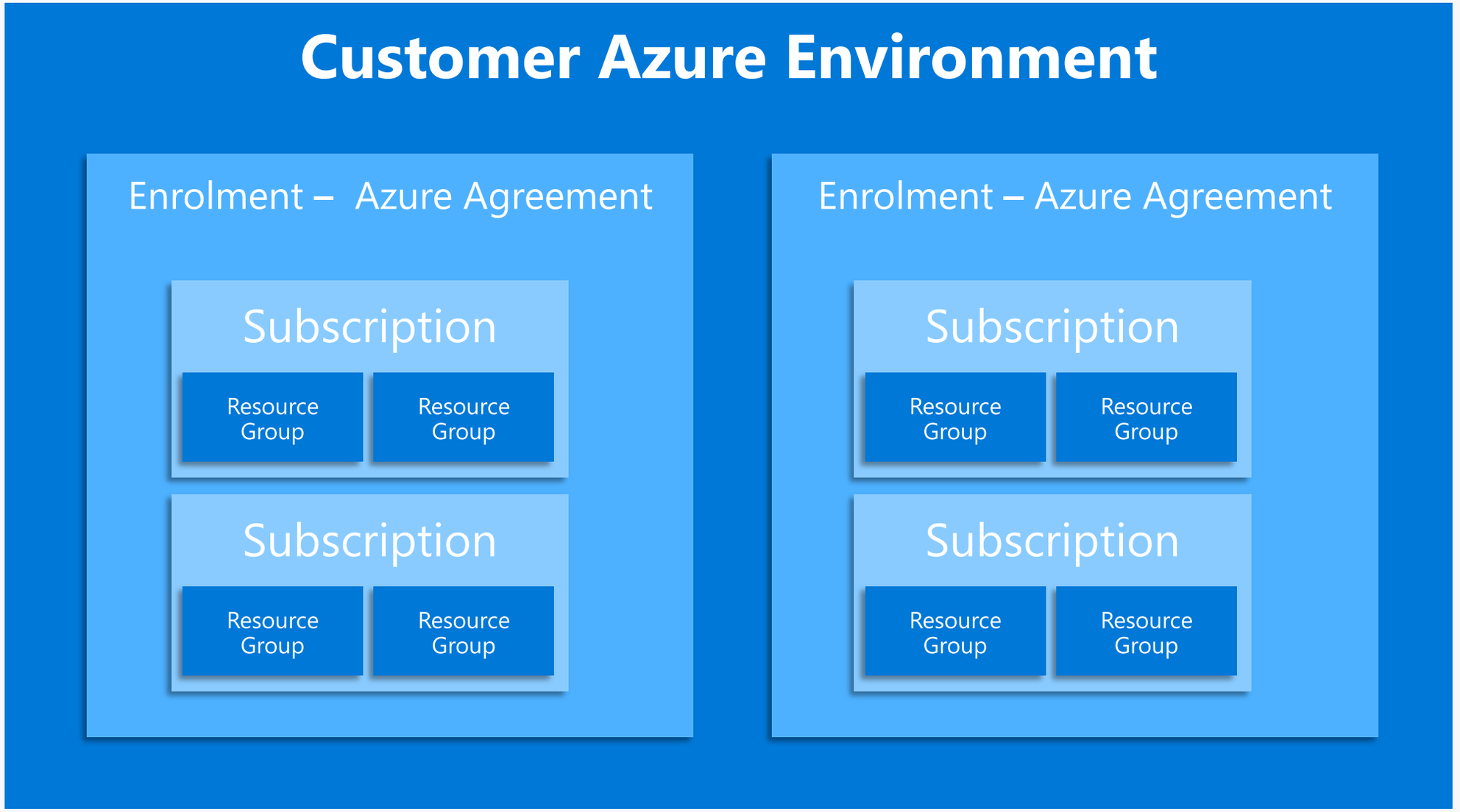
Automation for Research

Immediate access to resources. No procurement process or pre-build saves time that can be directed to actual research

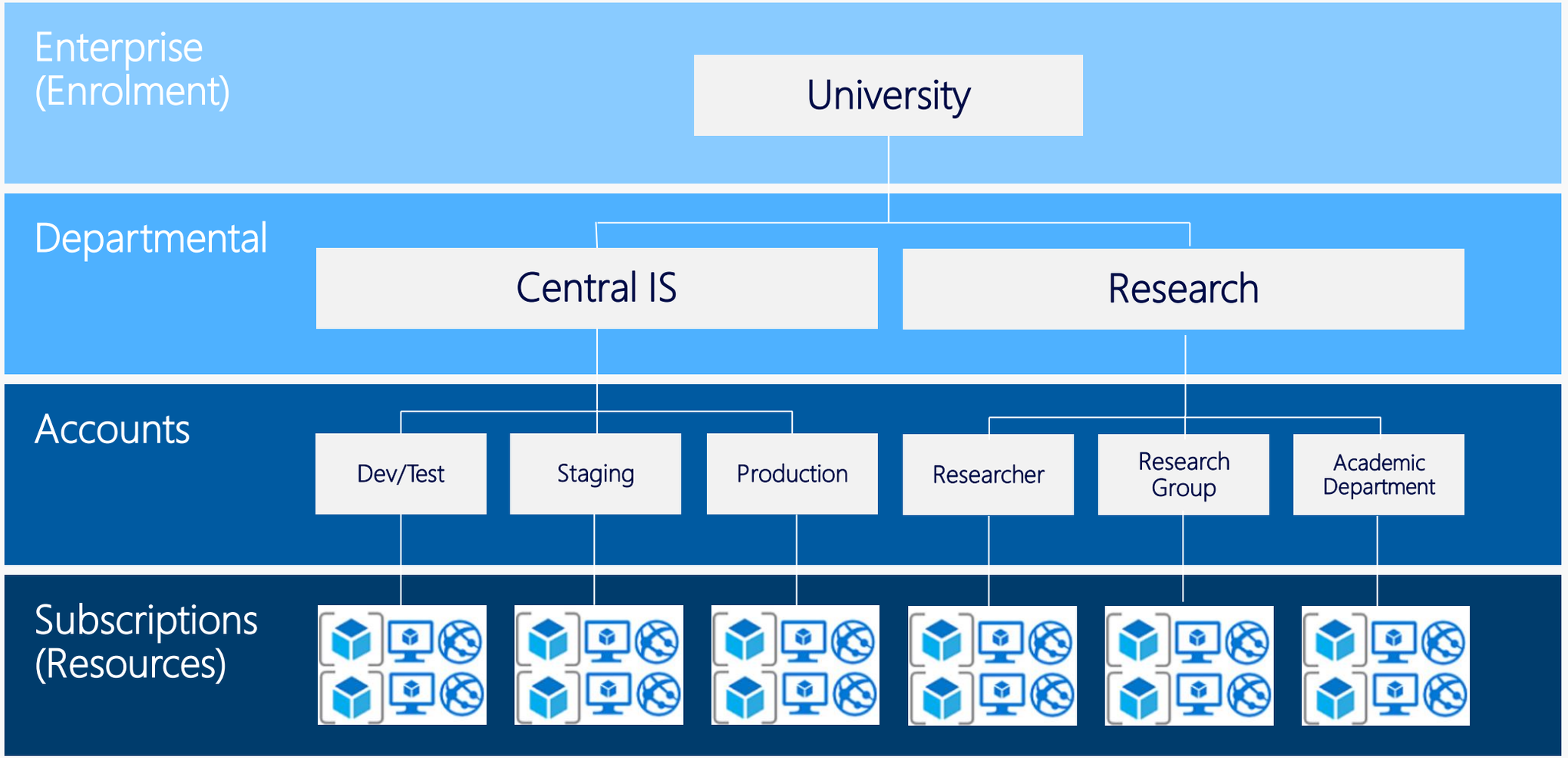


On demand Research services

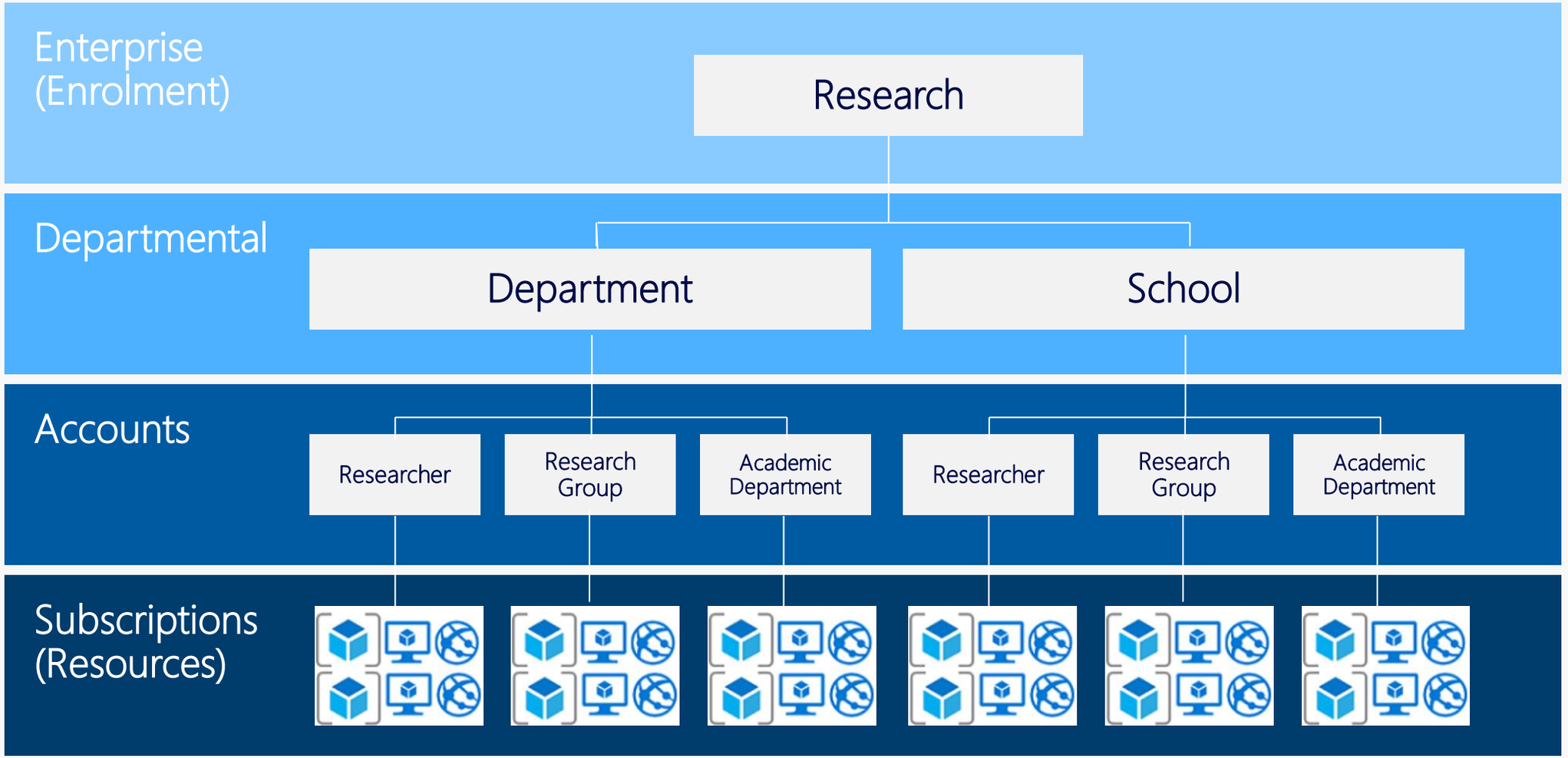
Researchers able to select their own resources without having to learn Azure or connect with Central IT

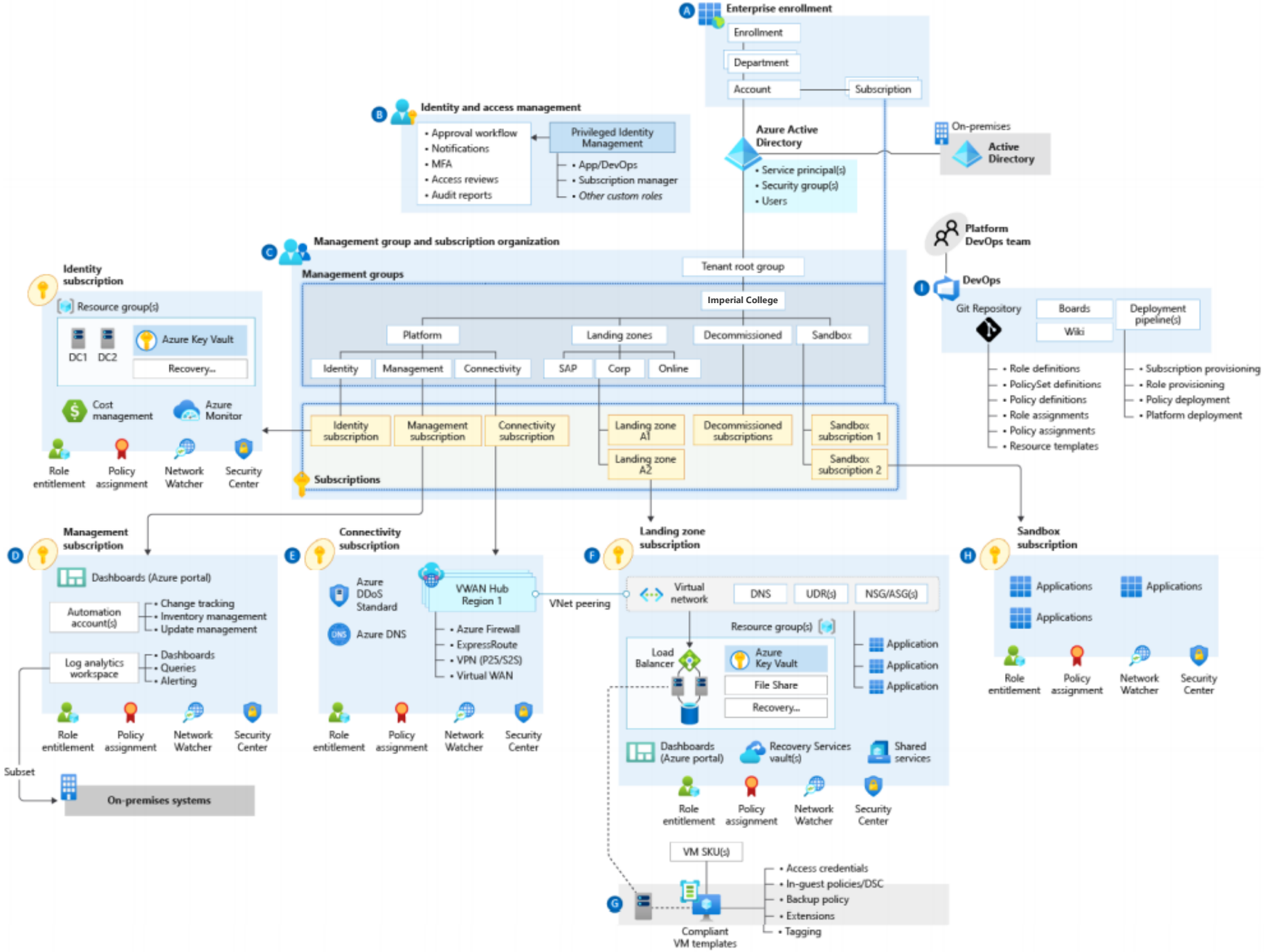

Customer Azure Environment
Enrolment – Azure Agreement
Subscription
Resource Group
Resource Group
Subscription
Resource Group
Resource Group
Enrolment – Azure Agreement
Subscription
Resource Group
Resource Group
Subscription
Resource Group
Resource Group

Azure Management Structure

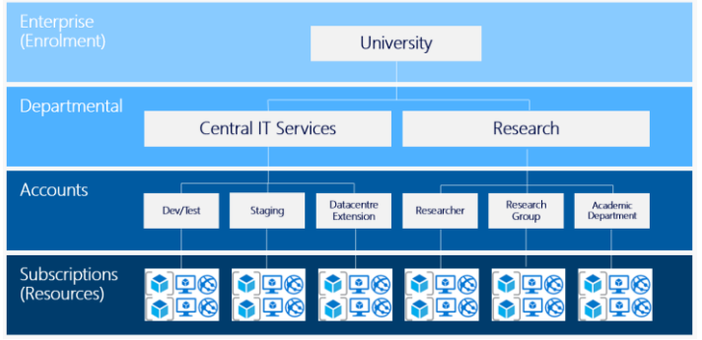


Azure Management Structure




A
Enterprise enrollment
Enrollment
Department
Account
Subscription
B
Identity and access management
• Approval workflow
• Notifications
• MFA
• Access reviews
• Audit reports
Privileged Identity Management
• App/DevOps
• Subscription manager
• Other custom roles
Azure Active Directory
• Service principal(s)
• Security group(s)
• Users
On-premises
Active Directory
Platform DevOps team
C
Management group and subscription organization
Management groups
Tenant root group
Imperial College
Platform
Landing zones
Decommissioned
Sandbox
Identity
Management
Connectivity
SAP
Corp
Online
I
DevOps
Git Repository
Boards
Wiki
Deployment pipeline(s)
• Role definitions
• PolicySet definitions
• Policy definitions
• Role assignments
• Policy assignments
• Resource templates
• Subscription provisioning
• Role provisioning
• Policy deployment
• Platform deployment
Identity subscription
Resource group(s)
DC1
DC2
Azure Key Vault
Recovery...
Cost management
Azure Monitor
Role entitlement
Policy assignment
Network Watcher
Security Center
Identity subscription
Management subscription
Connectivity subscription
Landing zone A1
Landing zone A2
Decommissioned subscriptions
Sandbox subscription 1
Sandbox subscription 2
Subscriptions
D
Management subscription
Dashboards (Azure portal)
Automation account(s)
• Change tracking
• Inventory management
• Update management
Log analytics workspace
• Dashboards
• Queries
• Alerting
Role entitlement
Policy assignment
Network Watcher
Security Center
E
Connectivity subscription
Azure DDoS Standard
Azure DNS
VWAN Hub Region 1
• Azure Firewall
• ExpressRoute
• VPN (P2S/S2S)
• Virtual WAN
Role entitlement
Policy assignment
Network Watcher
Security Center
VNet peering
F
Landing zone subscription
Virtual network
DNS
UDR(s)
NSG/ASG(s)
Resource group(s)
Load Balancer
Azure Key Vault
File Share
Recovery...
Application
Application
Application
Dashboards (Azure portal)
Recovery Services vault(s)
Shared services
Role entitlement
Policy assignment
Network Watcher
Security Center
H
Sandbox subscription
Applications
Applications
Applications
Role entitlement
Policy assignment
Network Watcher
Security Center
Subset
On-premises systems
G
VM SKU(s)
• Access credentials
• In-guest policies/DSC
• Backup policy
• Extensions
• Tagging
Compliant VM templates

Centrally managed Azure for Research



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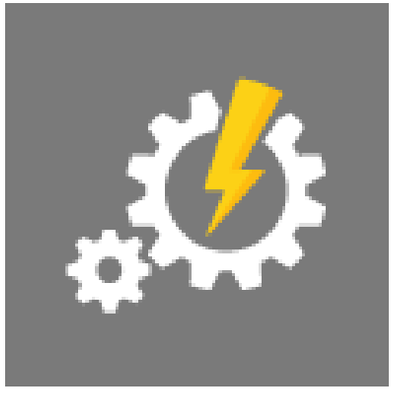

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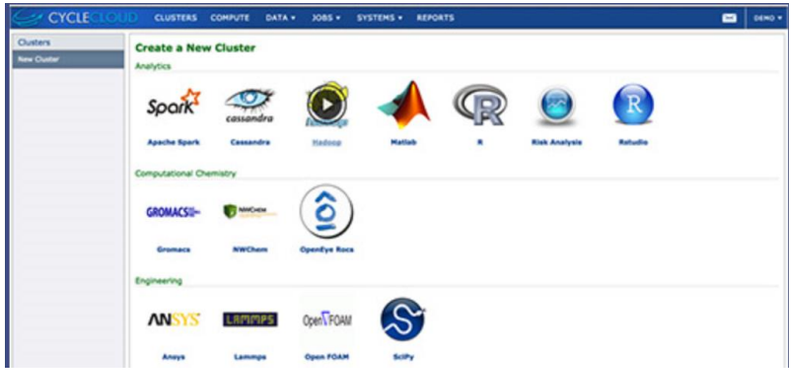
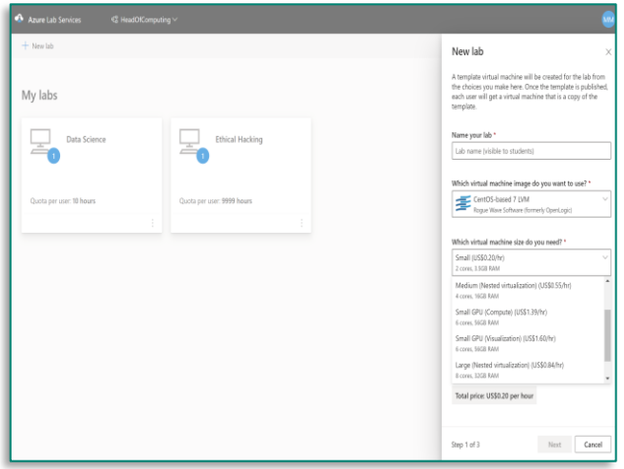


On demand Research services

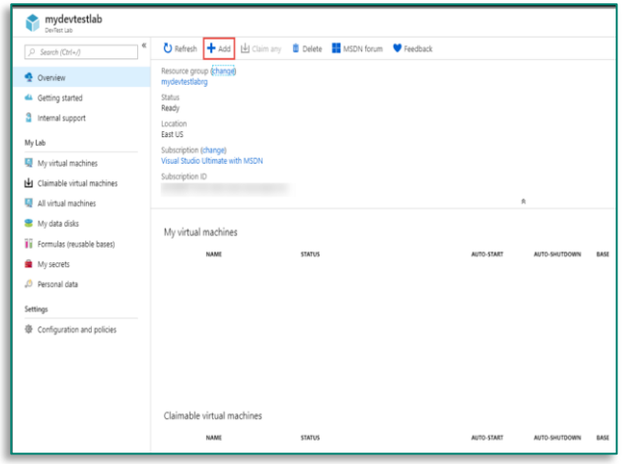
Researchers able to select their own resources without having to learn Azure or connect with Central IT with Azure Labs and CycleCloud

Azure resource management portals



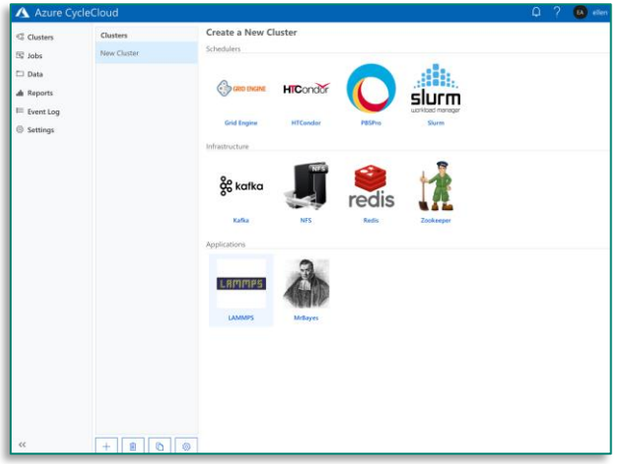
Azure Labs

- Curriculum use
- Lecturer manages
- Schedule sessions



Azure Dev/Test Labs

- Research development
- Central control



Cycle Cloud

- Manage clusters, HPC, HTC
- Scripted build
- Utilisation management
- Cost Management

HPC Resource Stack on Azure

Transformative Services

Azure Machine Learning | Azure Data Lake | Azure ML Compute

Workload Orchestration

VM Scale Sets | Azure Batch | Azure CycleCloud

Fast, Secure Networking

ExpressRoute | InfiniBand

High Performing Storage

Azure HPC Cache | Azure NetApp Files | Clusterstore

Optimized Compute

H-Series | N-Series | Cray

Machine Learning on Azure

Domain-specific pretrained models

Vision | Speech | Language | Search

Familiar data science tools

Visual Studio Code | Azure Notebooks | Jupyter | Command Line

Popular frameworks

PyTorch | TensorFlow | Scikit-Learn | ONNX

Productive services

Azure DataBricks | Azure Machine Learning | ML VMs

Powerful infrastructure

CPU | GPU | FPGA

HPC Resources on Azure

HPC VMs on Azure

No-compromise CPU and GPU based resources

- Up to 16 cores, 3.2 GHz E5-2667 V3 Haswell processor
- Up to 224 GB DDR4 memory, 14GB per core
- FDR InfiniBand @ 56 Gbps, 2.6 microsecond latency
- 2 TB of local SSD

- Up to 44 cores, Intel Xeon Platinum processor
- Up to 352 GB DDR4 memory, 8GB per core
- EDR InfiniBand @ 100 Gbps
- 700 GB NVMe

- Up to 60 cores, AMD EPYC processor
- Up to 240 GB DDR4 memory, 4GB per core
- EDR InfiniBand @ 100 Gbps
- 700 GB NVMe

H-Series:

Most powerful CPU virtual machines with optional RDMA

N-Series:

GPU virtual machines specialized for graphic-intensive workloads

- Up to 4 NVIDIA Tesla K80 GPUs
- Up to 24 cores
- Up to 224 GiB memory
- Up to 1440 GiB of local SSD
- FDR InfiniBand

- Up to 4 NVIDIA Pascal P100 GPUs
- Up to 24 cores
- Up to 448 GiB memory
- Up to 3 TB of local SSD
- FDR InfiniBand

- Up to 4 NVIDIA Volta V100 GPUs
- Up to 24 cores
- Up to 448 GiB memory
- Up to 3 TB of local SSD
- FDR InfiniBand

- Up to 4 NVIDIA Pascal P40 GPUs
- Up to 24 cores
- Up to 448 GiB memory
- Up to 3 TB of local SSD
- FDR InfiniBand

- Up to 4 NVIDIA Tesla M60 GPUs
- Up to 24 cores
- Up to 224 GiB memory
- Up to 1440 GiB of local SSD

- Up to 4 NVIDIA Tesla M60 GPUs
- Up to 24 cores
- Up to 448 GiB memory
- Up to 2,948 GiB of local SSD

Cray in Azure

A dedicated supercomputer on your virtual network

- Innovate faster to solve your toughest challenges
- Access to advanced cloud solutions and AI
- Bring your simulation data and services closer together
- Simplify the management of your infrastructure

Azure Batch Capabilities

Job scheduling

- Supports both embarrassingly parallel and tightly-coupled MPI jobs
- Run > 1 task in parallel per node
- Detect and retry failed tasks
- Can set max execution time for jobs and tasks
- Task dependencies
- Job prep and cleanup tasks

Rich app management

- Get apps from blobs, Batch app packages, package managers, custom VM images
- Docker container images

Choice of VMs

- Windows or Linux
- Standard or custom images
- Windows pool can use AHUB
- Use low-priority VMs

Monitoring

- VM monitoring and auto-recover
- Metrics and logs available via Portal and API

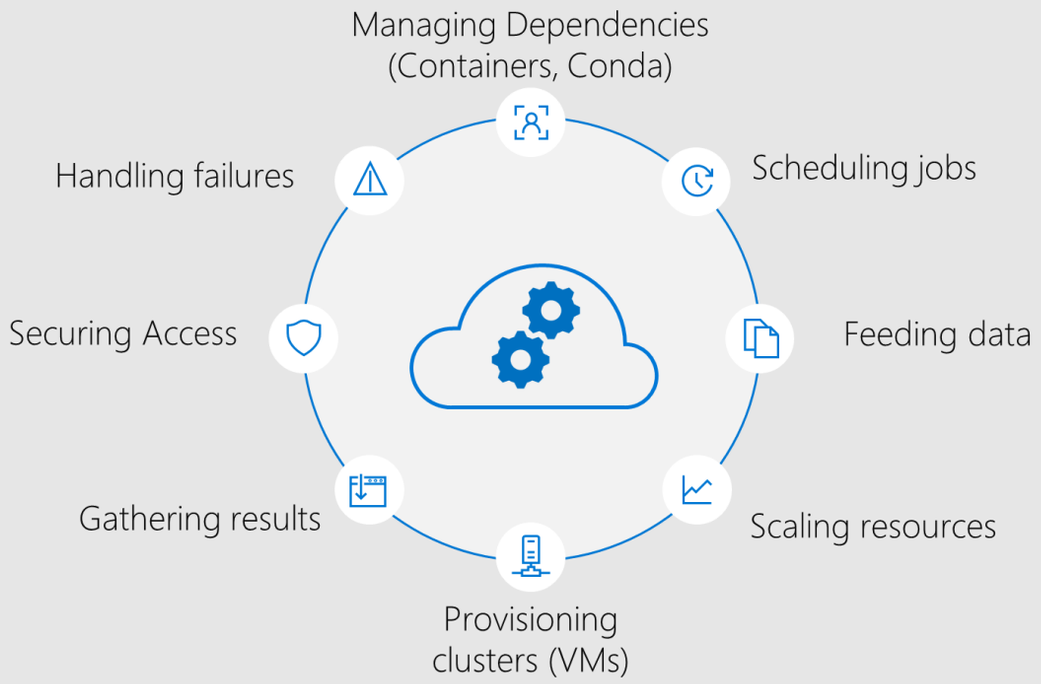
Access via APIs, CLIs, and UIs

- .NET, Java, Node.js, Python, REST
- PowerShell, x-plat Azure CLI
- Azure Portal, Batch Labs x-plat client UI

What is Azure ML Compute?

Addresses the challenges of training Machine Learning models

Challenges with ML Training . . .



. . . addressed by Azure ML Compute

- Integrates Batch AI to provide managed compute clusters and job scheduling
- Work with clusters of GPU or CPU to run experiments in parallel and at scale to reduce training time
- Enables data scientists to easily train, test, and score Deep Learning and other AI/ML models without managing infrastructure
- Use with Azure Machine Learning service and integrate with your data science tools and pipeline

© Microsoft Corporation

Azure ML Compute Value

Dependencies and Containers

Leverage system-managed AML compute with pre-configured containers

Schedule jobs

Queue and prioritize jobs, start MPI, monitor and diagnose failures

Provision clusters

Use the latest NDv2 series VMs with the NVIDIA V100 GPUs. Install drivers and software, interact through SSH

Distribute data

Manage and scale access to training data, track logs & models in a secure & compliant manner

Scale resources

Autoscale resources to only pay while running a job. Share reserved instances, and use Low Priority VMs

© Microsoft Corporation

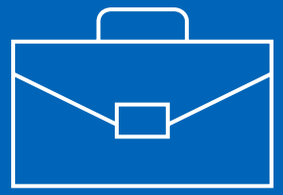
What is Azure CycleCloud?

User Empowerment

- Cloud-enable existing workflows
- Enable instant access to resources
- Provide auto-scaling, error handling

IT Management

- Link workflows for internal and external clouds
- Use Active Directory for authentication and authorization
- Provide secure and consistent access



Business Management

- Increase accountability by directly coupling service usage to expenditures
- Provides the tools to better manage and control costs

What is Avere vFXT?

A high performance file caching system that bridges your HPC environment with Azure

Avere vFXT Virtual Appliance

Cloud Burst

On-demand expansion of your HPC environment in Azure, which supports growing and unpredictable business demands

Lift & Shift

A complete shift of your computing environment into Azure primarily for file-based HPC applications

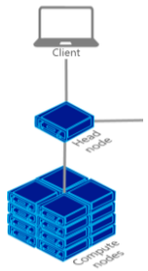
© Microsoft Corporation

Performance ⟷ Access ⟷ Flexibility

Big Compute Evolution – Where Are You?

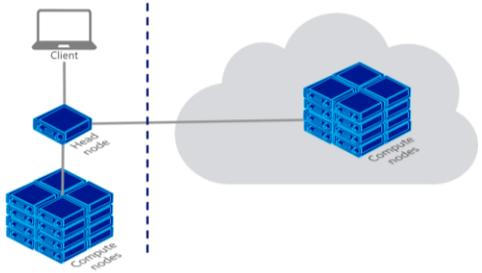
On-premises Clusters

- Easy scaling to reduce runtimes
- Job scheduling and management
- Compute node provisioning
- *Hardware is paid for*



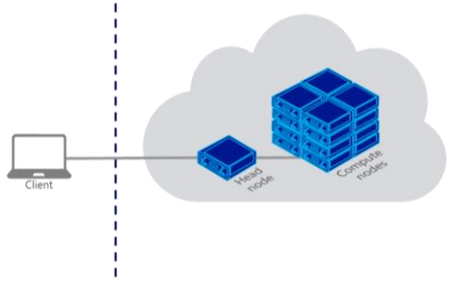
Hybrid Clusters

- Extend cluster to cloud to handle peak demand
- CycleCloud and Azure
- Manage like machines on your network with VPN or Express Route



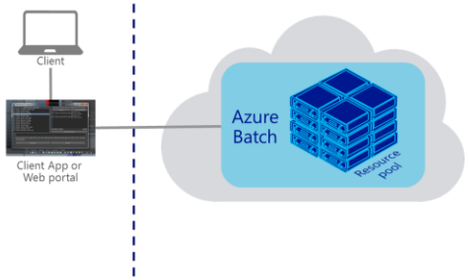
IaaS Clusters

- Deploy cluster all in cloud
- Move existing applications
- Support projects & testing
- Gallery images and templates to deploy
- Flexible VM configuration



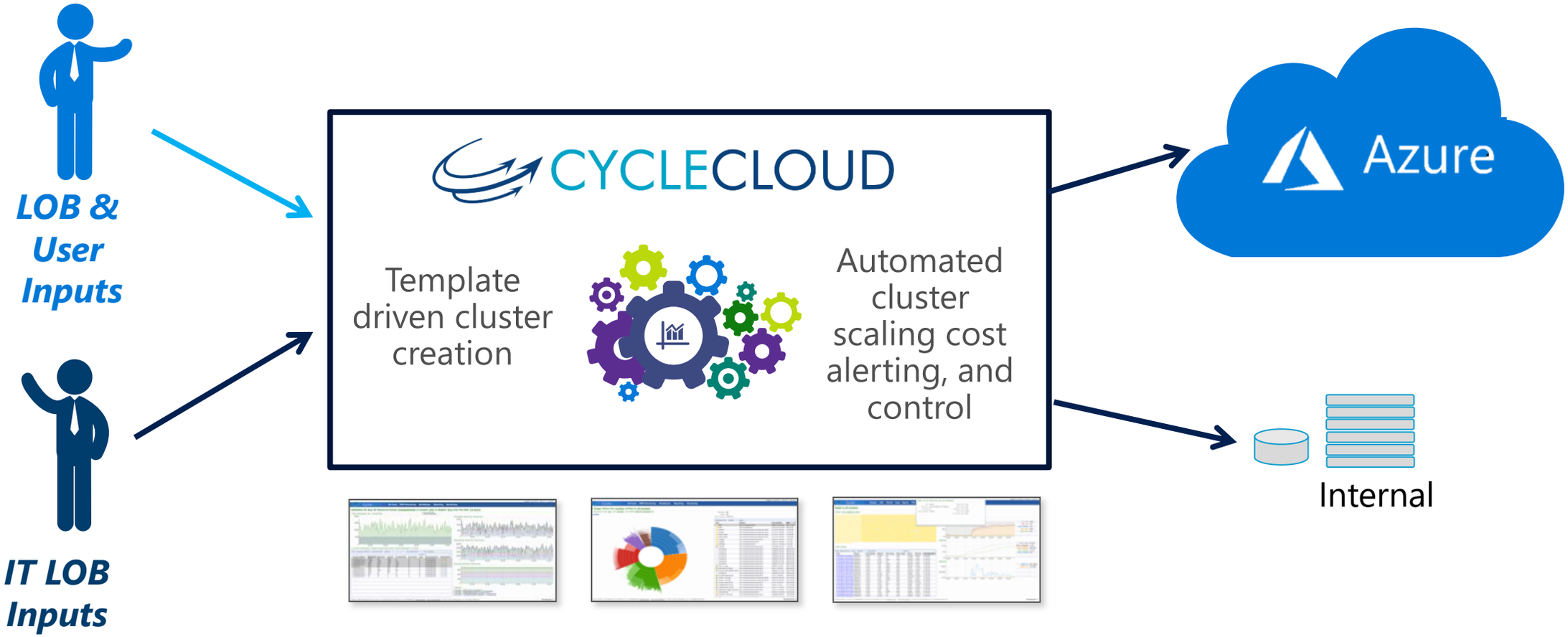
Cloud Native

- Azure Batch: Native cloud scheduler
- DevOps, not infrastructure management
- Elasticity with auto-scale
- Small to very large deployments
- Use within a service or to offer SaaS



Microsoft

Making Users and IT Successful



Hybrid/Clustered Big Compute Lifecycle

CYCLECLOUD

Provisioning

Cluster Configuration

Monitoring

Optimization

Microsoft

When to Use Azure Batch or CycleCloud

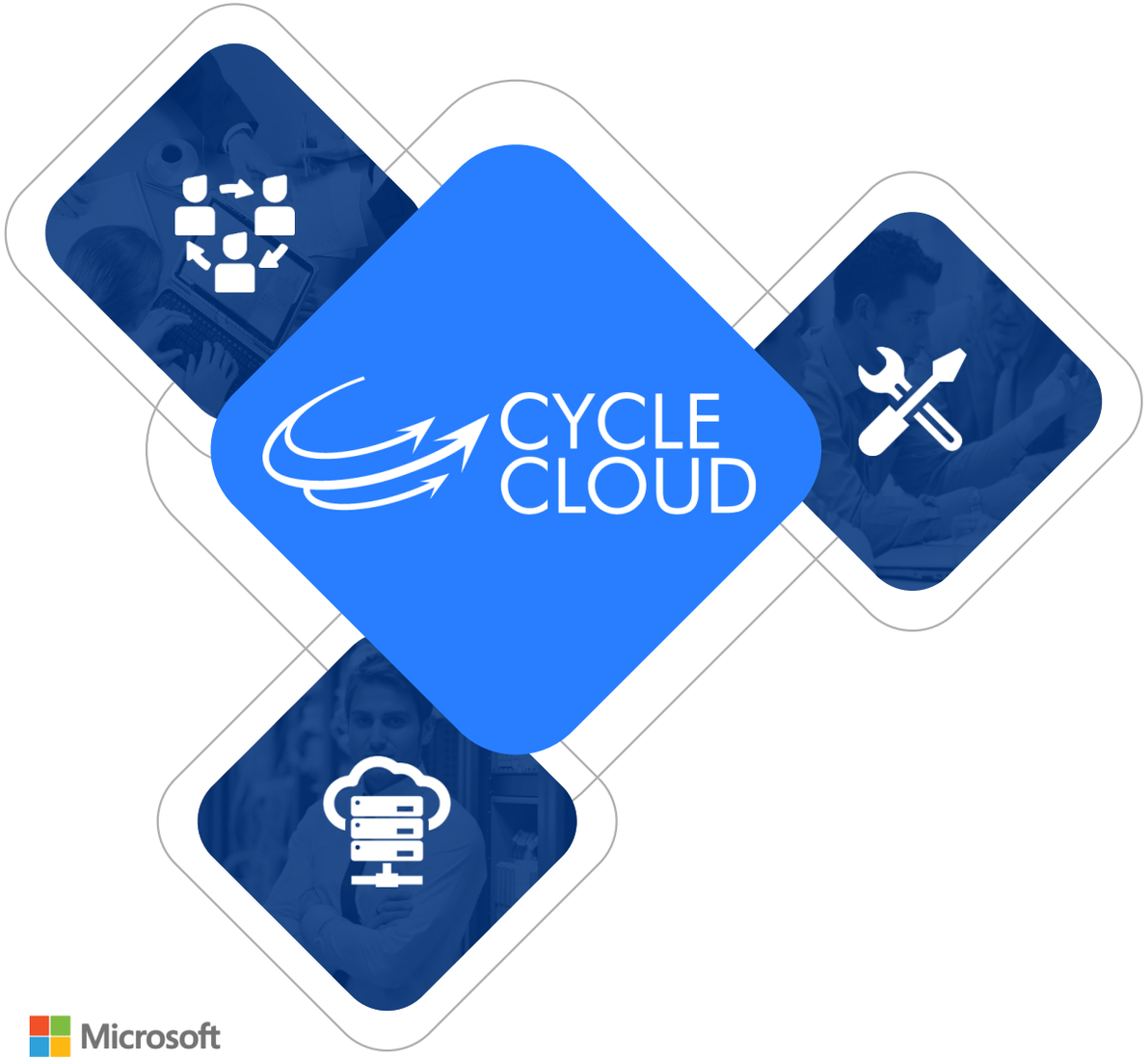
CycleCloud – Running clusters

- Targeted for IT/LOB Big Compute users running clusters
- Goal is to support hybrid workloads or clustered applications
- Clone existing clusters/workflows
- Support for HPC style clusters (PBSPro, Data Synapse, SLURM, GridEngine) and BigData/ML (Spark, TensorFlow)
- Azure-enable existing apps without rewriting

Azure Batch – Running jobs

- Targeted for developers writing applications that submit jobs
- Goal is to run jobs, with no cluster framework
- Accelerators for rendering, AI training, etc.
- No need for clusters/schedulers
- Enables creation of “SaaS” type services

Unleashing Big Compute Productivity



Users can cloud-enable existing workflows
Instant access to resources
Auto-scaling, error-handling

Reliable tools for IT
Workflows linking internal and external clouds
Tools to manage & control costs

Organizations providing secure, consistent access
Ability to link usage to spend
Leverage AD for authorization/governance

Complete Multi-Cloud Workflow Control

USER

Scope → Configure → Run on Cloud → Optimize

ADMIN

CYCLECLOUD

Provisioning
- Workload placement
- Optimal scale
- Cost optimization
- Data scheduling

Internal

amazon web services

Google Cloud Platform

Windows Azure

Monitoring
- Auto-scaling
- Usage tracking
- Error handling
- Reporting

Cluster Configuration
- Multi-cloud, without changes
- Pre-set or User-defined "types"
- Abstraction for all cluster data. attributes (roles, OS, etc.)

Optimization
- Benchmark instances
- Make Workflow UI
- Human Workflow

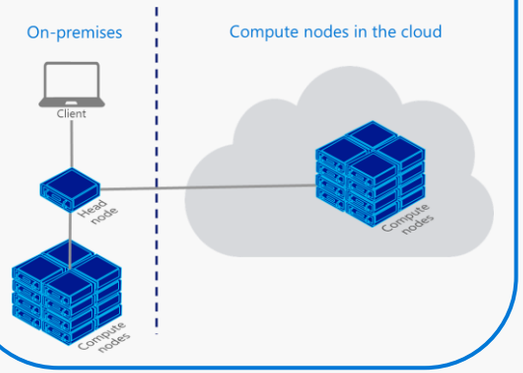
File: Declarative Cluster Definition

Packages, Installers Containers, Data

Azure HPC Solutions

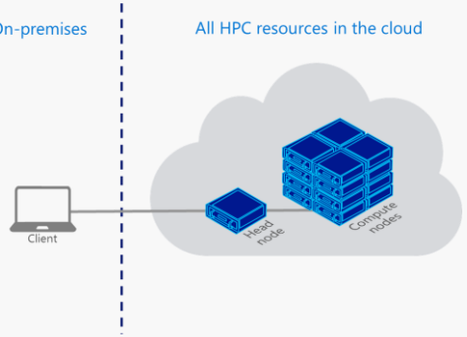
Hybrid cluster

Add cloud resources to your existing cluster, on demand



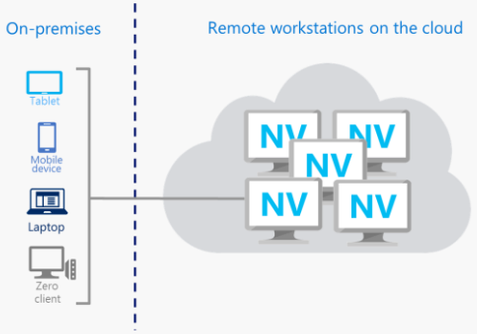
Cluster on the cloud

Provision one (or more) new clusters in minutes



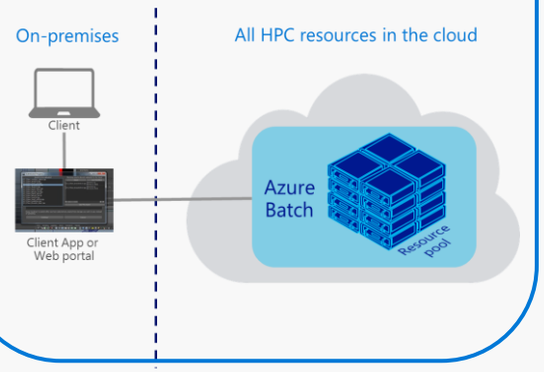
Scientific workstations

Deploy powerful remote workstations for researchers



App burst with Batch

Run at scale directly from your application

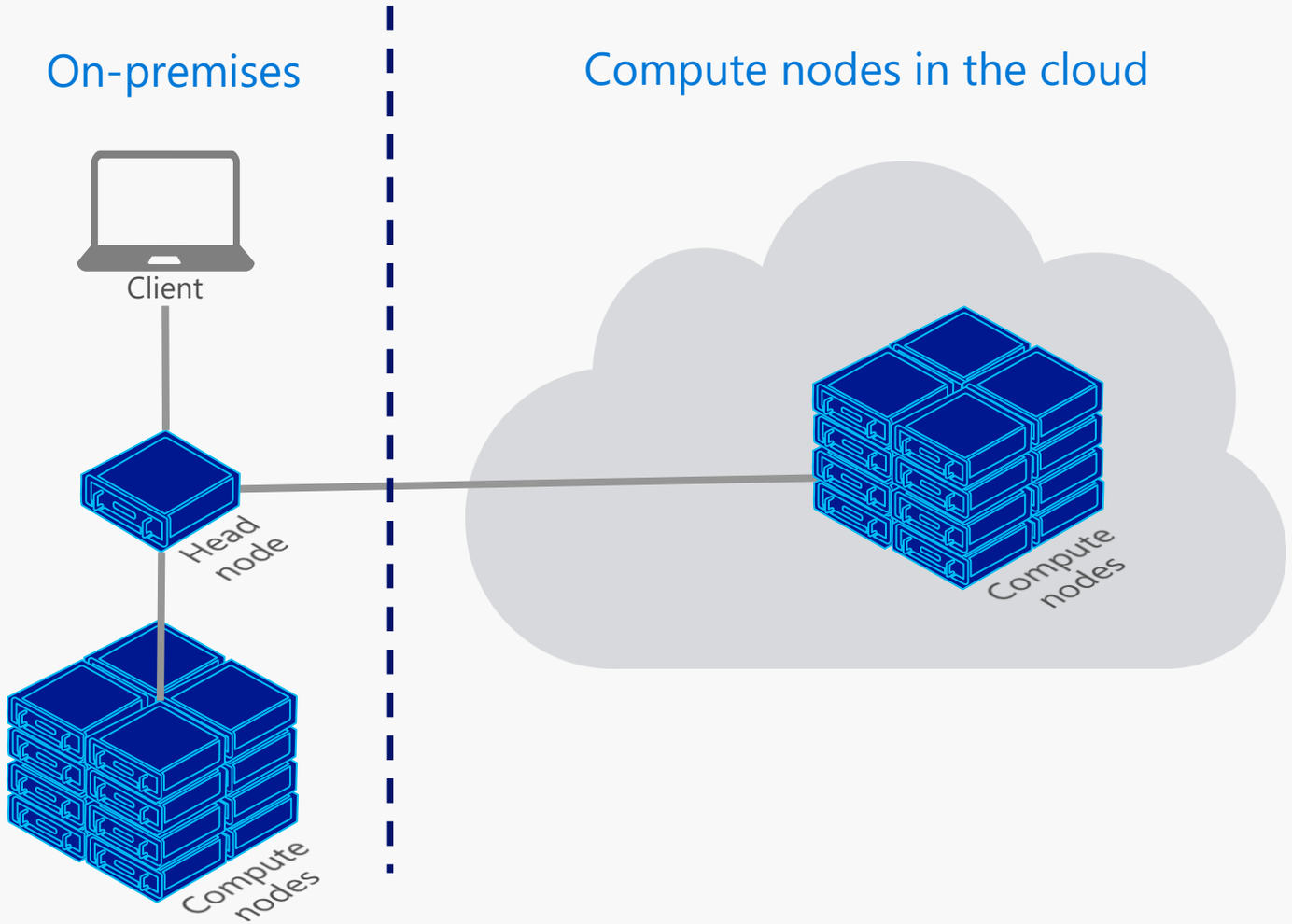


	HPC resources on demand		App Burst	Remote Scientific Desktop
Target persona vs. Solution	Hybrid burst	IaaS cluster	Batch	GPU workstations
Individual researcher/scientist		✓	✓	✓
Director of research group	✓	✓	✓	✓
Research IT team lead	✓	✓		✓
Central IT group lead	✓		✓	✓

Software & services: Cloud burst

Add cloud resources to your cluster, on demand

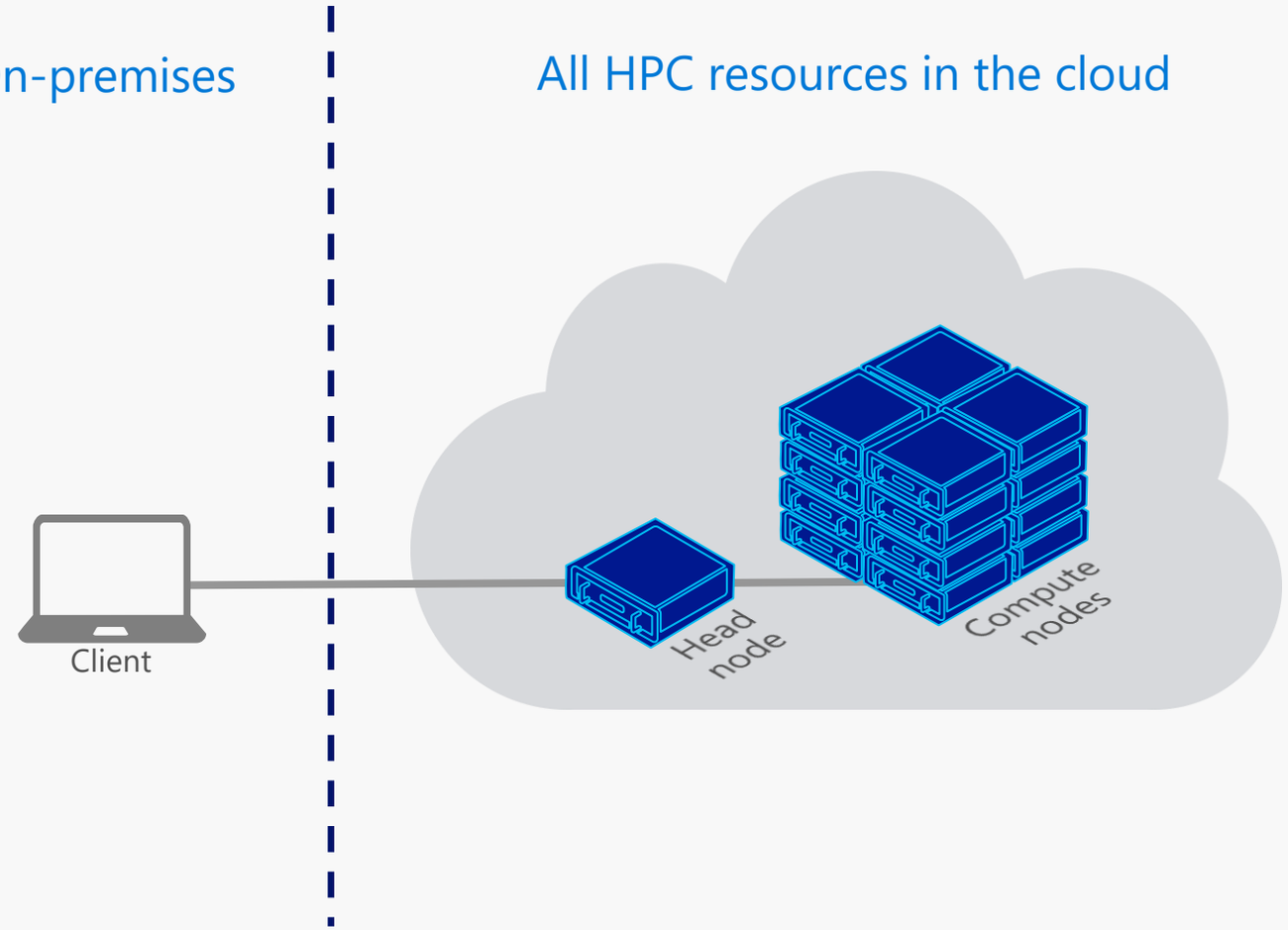
- Burst to cloud to add resources when needed
- Continue using your existing on-premises infrastructure
- Run workloads on Windows and Linux, on Azure and on-premises
- Cover peaks in demand or special projects
- Pay only for what you use
- Microsoft HPC Pack, Univa Grid Engine, and Altair PBS Pro already have this capability (and more are coming!)



Software & services: Cluster on the cloud

Provision one (or more) new clusters in minutes

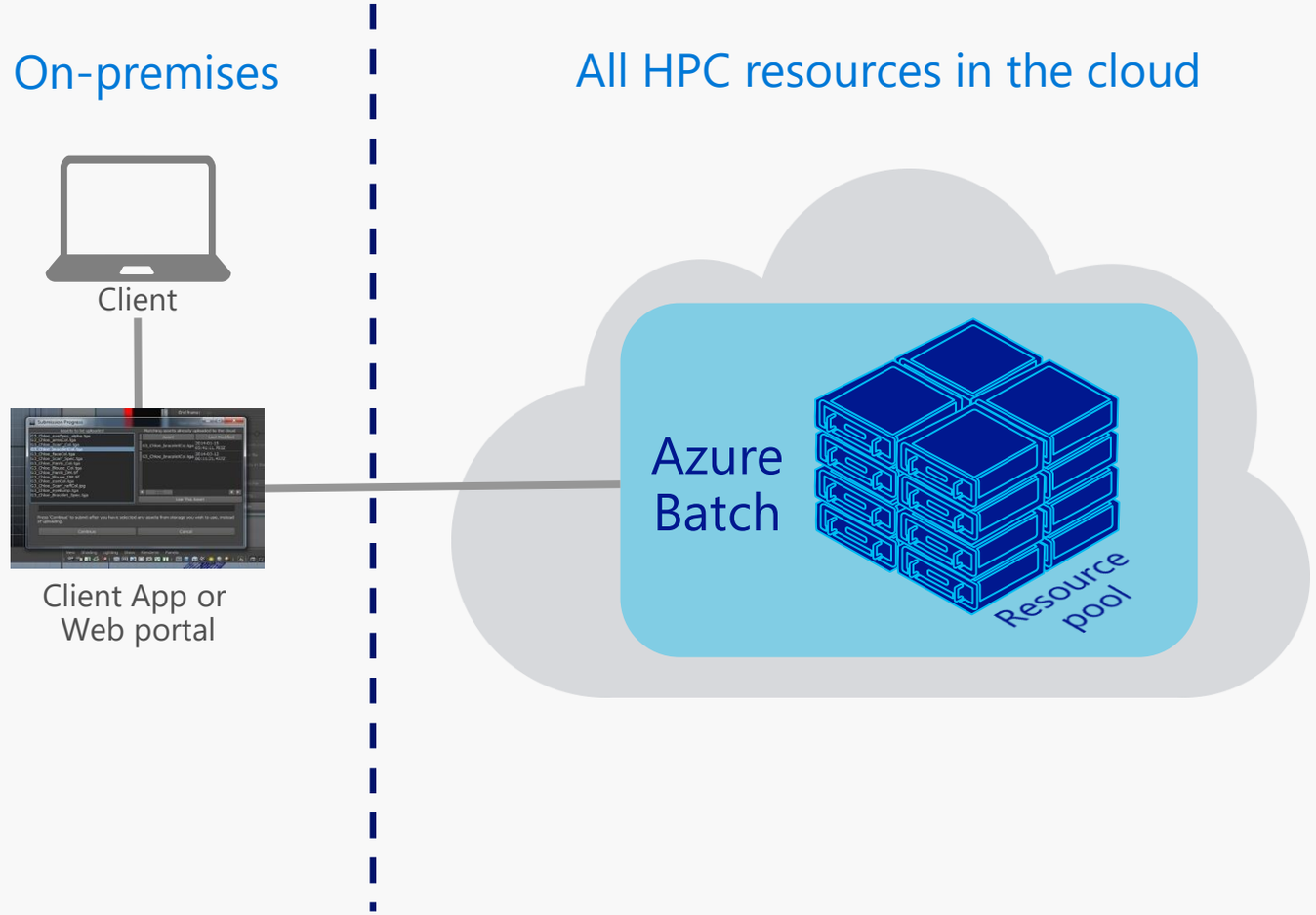
- Deploy a complete HPC cluster, all in the cloud, in just minutes
- Use templates, scripts, and images to quickly deploy at any scale
- Use your current HPC scheduler
- Shift existing applications, scripts and tools to cloud
- Deploy as many clusters as you need!



Software & services: HPC as a service

Run at scale directly from your application

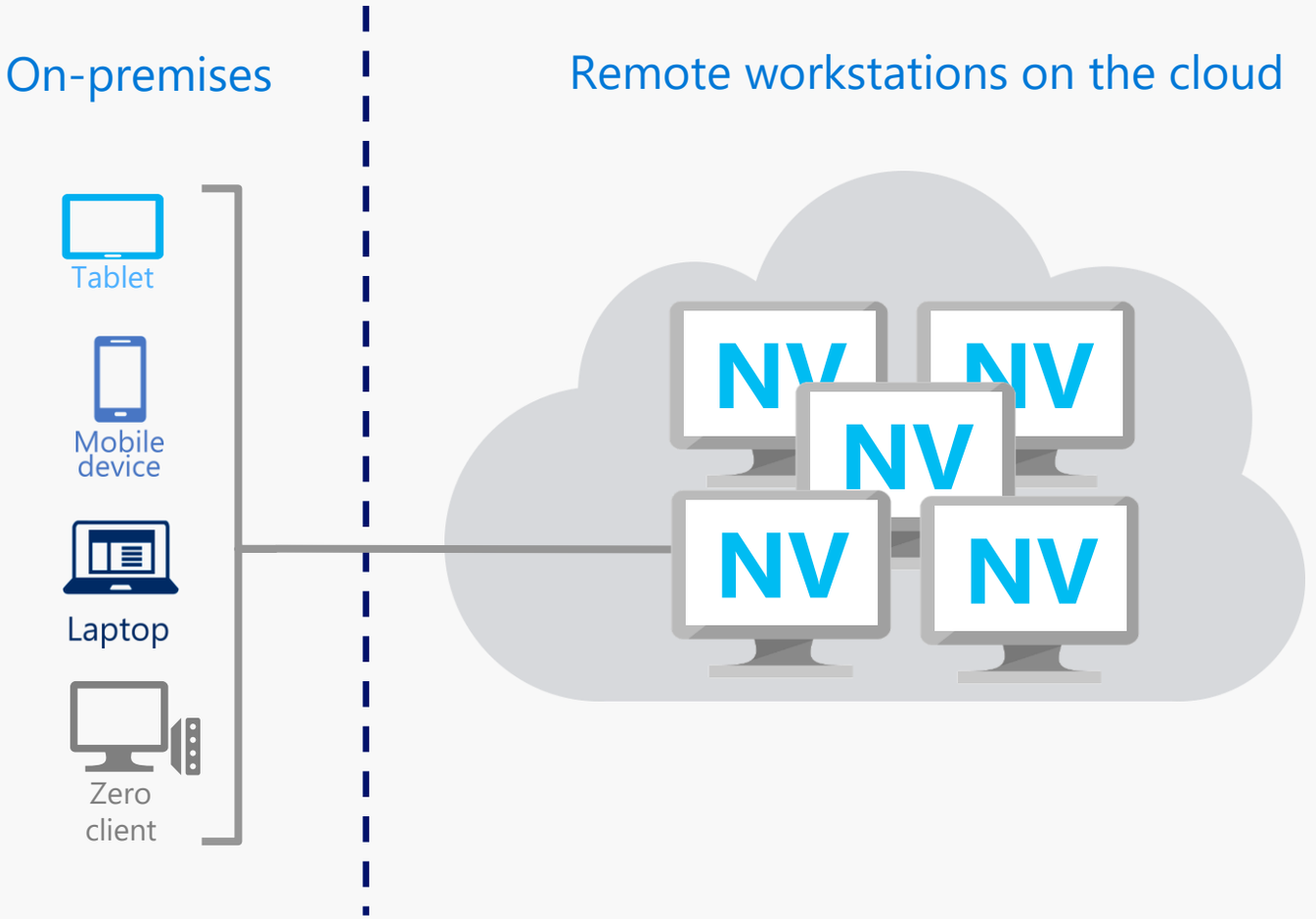
- Integrate with Azure Batch, directly from a client application (GUI or CLI) or online portal
- Batch abstracts resource management and scheduling completely
- Supports small to extremely large deployments and can deploy any VM size
- Provides auto-scaling and stopping of resources
- Run HPC jobs at scale on Docker containers
- Using Batch is free, you only pay for the underlying compute!



Remote Scientific Workstations

Deploy powerful GPU-enabled workstations

- Deploy one or more GPU-enabled workstations on the cloud
- Connect from any laptop or device (iOS, Android, Windows)
- Collaborate, share, explore.
- With or without optimized remote visualization platforms (e.g., Teradici PCoIP or Citrix HDX)

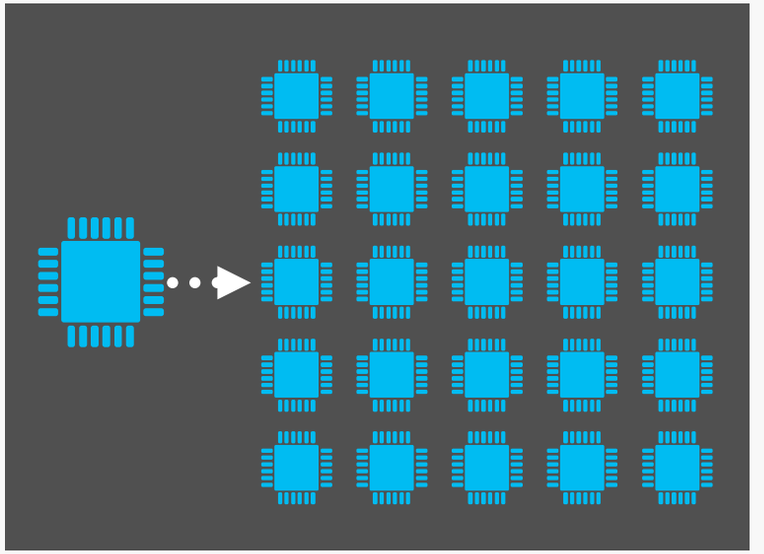


What would you do with 100x the scale?

Do more with hyper-scale:

- Service more users
- Run more projects
- Get results faster

- Run larger simulations
- Explore new insights (e.g., “What if?”)



Remove current limitations:

- Modify more parameters
- Analyze more complex models
- Visualize larger results

- Run more iterations
- Generate higher fidelity results
- Simulate longer periods of time

Breakthroughs Enabling Intelligence

Microsoft Cognitive Services

Give your apps a human side

Vision

From faces to feelings, allow your apps to understand images and video

Speech

Hear and speak to your users by filtering noise, identifying speakers, and understanding intent

Language

Process text and learn how to recognize what users want

Knowledge

Tap into rich knowledge amassed from the web, academia, or your own data

Search

Access billions of web pages, images, videos, and news with the power of Bing APIs

Labs

An early look at emerging Cognitive Services technologies: discover, try & give feedback on new technologies before general availability

Microsoft Genomics

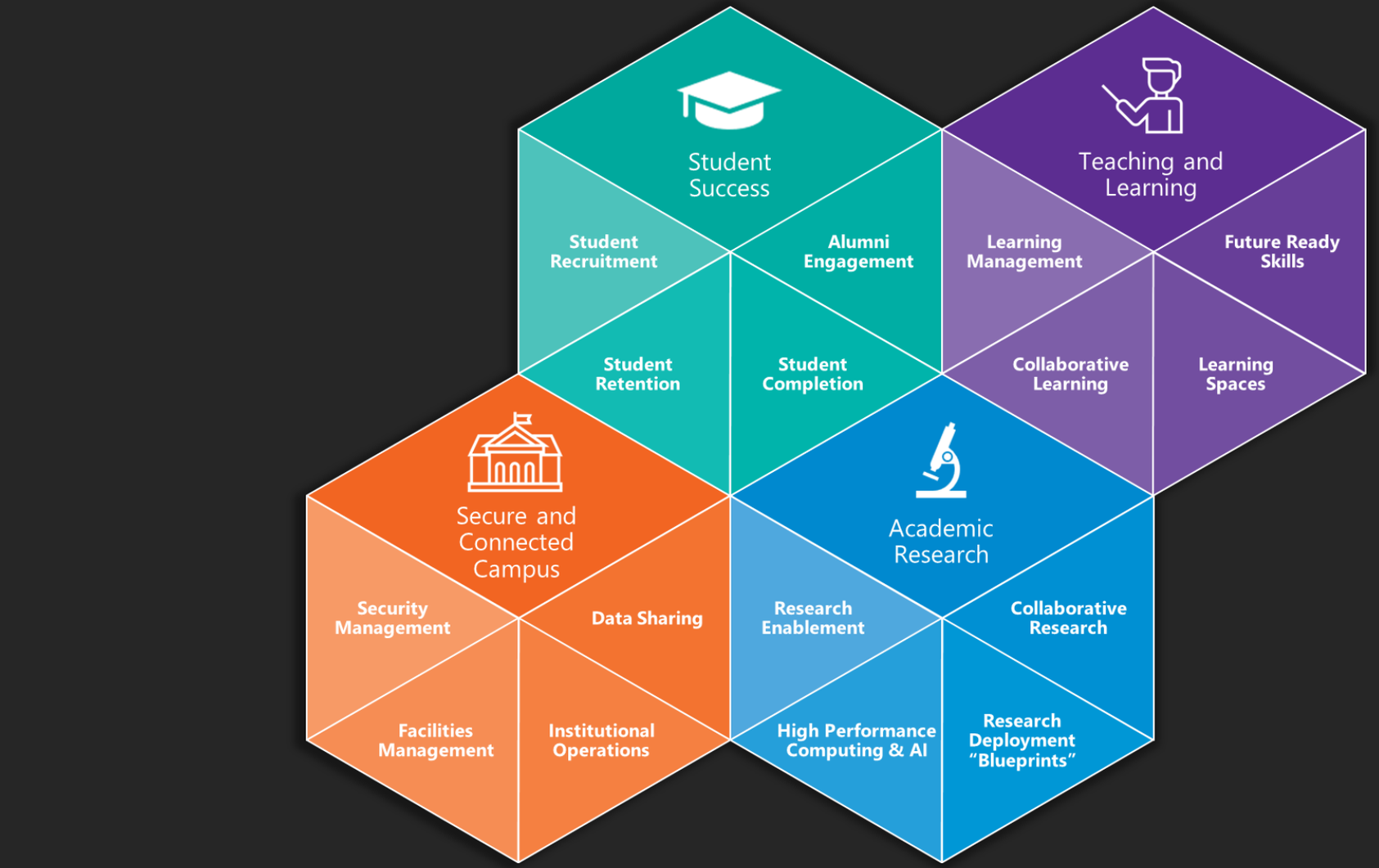
Power genome sequencing and research insights

- ✔ Cloud implementation of Burrows-Wheeler Aligner (BWA) and the Genome Analysis Toolkit (GATK) for secondary analysis
- ✔ ISO-certified and covered by Microsoft under the HIPAA BAA
- ✔ Global coverage to meet your data sovereignty needs
- ✔ Only pay for what you use with no commitment
- ✔ Easy-to-use API for integration with partner solutions

Strategic help from Microsoft

University Vision, Strategy and Business Objectives	Education Transformation Framework
Methodology, Governance and planning	Cloud Adoption Framework
Assessment, readiness and cost estimation	Cloud Economics Assessment
Architecture & Design, Deployment and training	Azure Migration Program

Align to
University strategy and objectives



Strategic Engagement

Empowering Transformation

Education Management

- D365 Finance & Operations
- D365 Customer Service
- D365 Talent Management
- PowerApps

Teaching, Learning, Collaboration & Productivity

- Class Notebook
- Edge
- Flipgrid
- Forms
- Education Edition
- Surface
- Office 365
- OneDrive
- Stream
- Immersive Reader
- Teams for Education
- Windows

Data & Intelligence

- Augmented Machine Learning
- Power BI
- Azure Data Lake

Identity

- Azure Active Directory
- Azure SQL
- Intune
- School Data Sync

Security

- Multi-Factor Authentication
- Information Protection
- EMS
- Network Security

Integration

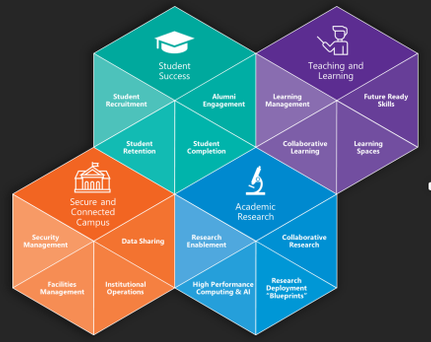
- Azure Data Factory
- API Management
- Flow
- Logic Apps

Azure Cloud

- Azure PaaS
- Azure SaaS
- Azure IaaS

Align to
University strategy and objectives

Methodology, Planning and Governance



Education Transformation Framework

Microsoft Cloud Adoption Framework for Azure

Proven guidance to accelerate your cloud adoption journey

Define strategy → **Plan** → **Ready** → **Adopt**

Define business justification and expected outcomes

Align actionable cloud adoption plan to business outcomes

Prepare people, process and environment for change

Migrate or **Innovate**

Implement desired changes across IT and business processes

Govern ← **Manage**

Comply, control and secure

Operate and optimize

Strategic Cloud Engagement

Tools, templates, and assessments

Define strategy

- Cloud journey tracker
- Business outcome template

Plan

- Azure DevOps demo generator
- Cloud adoption plan template

Ready

- Azure setup guide
- Readiness checklist
- Naming and tagging tracking template
- Landing zone blueprints

Adopt

- Strategic migration assessment and readiness tool (SMART)
- Azure migration guide
- Azure innovation guide

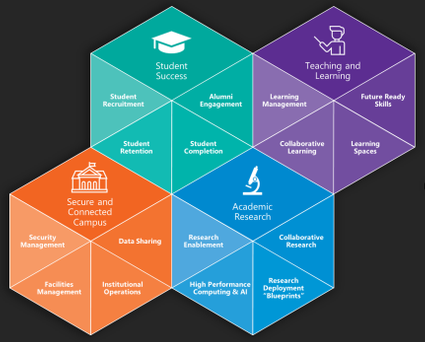
Govern

- Governance benchmark
- Governance process template
- Cost Management process template
- Deployment acceleration process template
- Identity process template
- Resource consistency process template
- Security baseline process template

Manage

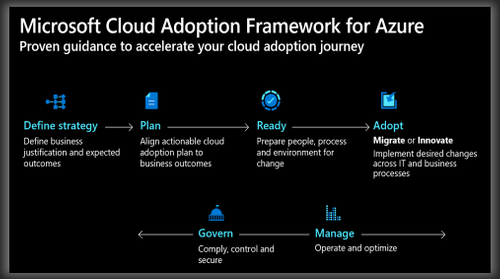
- Microsoft Azure Well-Architected Review
- Best practices source code
- Operations management workbook

Align to
University strategy and objectives



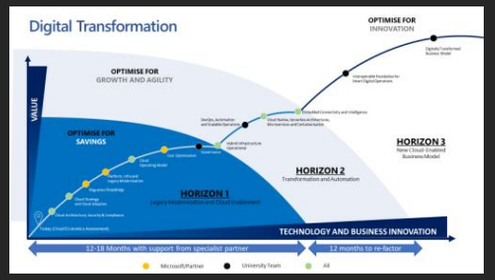
Education Transformation Framework

Methodology,
Planning and Governance



Cloud Adoption Framework

Assessment,
readiness and cost estimation



Cloud Economics Assessment

Strategic Cloud Engagement

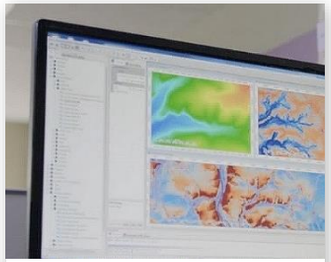
Carbon negative by 2030 - erase footprint by 2050

Ground our work in the best available science and the most accurate math

Take responsibility for Microsoft's own carbon footprint, getting to negative by 2030, 55% Scope 3 reduction

Fund $1B for better carbon reduction and removal

Support and empower suppliers and all customers with new tools, products and partnerships



Work to advance transparency for reporting on emissions and removals

Use our voice on carbon-related public policy issues

Enlisting our employees to enable them to contribute to our efforts

We're taking action ourselves

We're empowering our customers

We're investing in broader innovation

We're supporting government action

What it means for customers

Ground our work in the best available science and the most accurate math

Take responsibility for Microsoft's own carbon footprint, getting negative by 55% Scope ction

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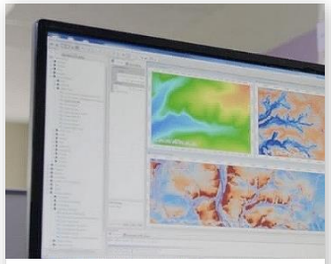


Work to advance transparency for reporting on emissions and removals

Use our voice on carbon-related public policy issues

Enlisting our employees to enable them to contribute to our efforts

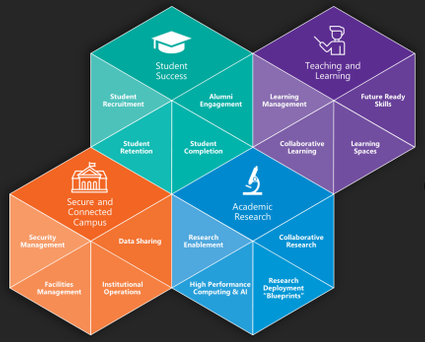
Microsoft cloud services are up to **98%** more CO_2 efficient vs. on-prem

Microsoft cloud services are up to **93%** more energy efficient vs. on-prem

All Surface devices **meet or exceed** US and EU green IT standards

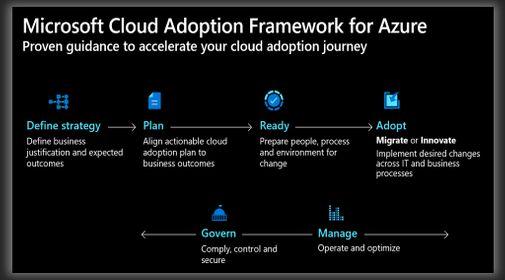
New tools available to developers and organizations

Align to University strategy and objectives



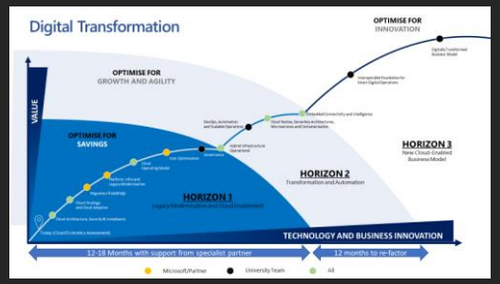
Education Transformation Framework

Methodology, Planning and Governance



Cloud Adoption Framework

Assessment, readiness and cost estimation



Cloud Economics Assessment

Architecture, Design, Deployment and training

Azure Migration Program

Strategic Cloud Engagement

Azure Migration Program (AMP)

Simplify your path to the cloud

Proven methodology: Cloud Adoption Framework for Azure

Cost-effective offers & incentives

Technical skill building

Free cloud migration tools: Azure Migrate

In-depth assistance from FastTrack Azure engineers

Expert help from specialized partners

Learn more | Azure.com/AMP

Your cloud journey

Pre-migration

Define strategy

Executive sponsorship
Stakeholder alignment
Partner engaged

Plan

Discovery and assessment
TCO/ Business case
Migration plan

Migration

Ready

Kick-off workshop
Technical skilling
Landing zone

Adopt

Migration execution

Migration waves

Post-migration

Govern and Manage

Security
Compliance
Operations

In Summary

Azure for Research

- Central IT Service
- Governance built in
- Secure and Compliant
- Faster to research publications
- Virtually immediate access
- Scalable to demand
- Kickstart initiative

Thank you

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