AIOps workshop @ICSE23

Managing Cloud Health with AIOps

John Sheehan
CVP & Distinguished Engineer

Azure

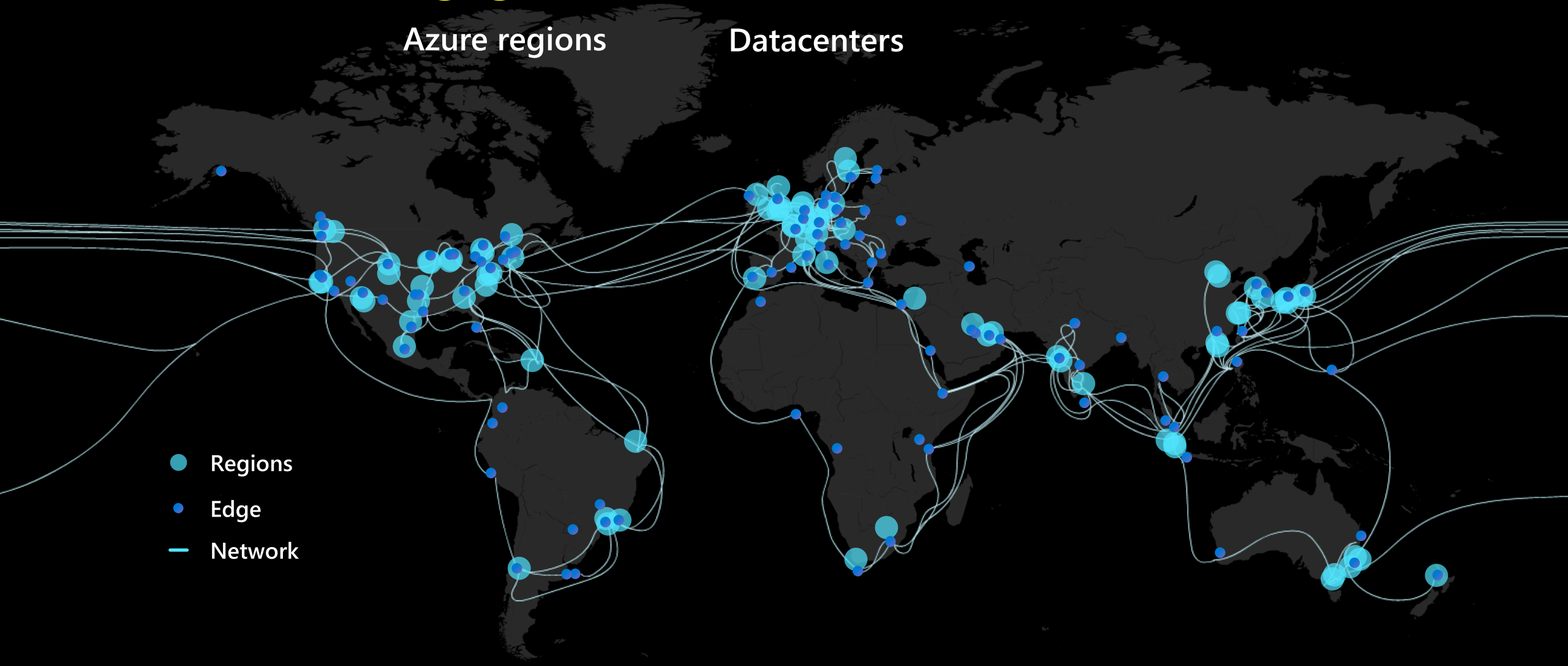
Azure

Azure is the world's computer

Azure

66+
Azure regions

200+
Datacenters



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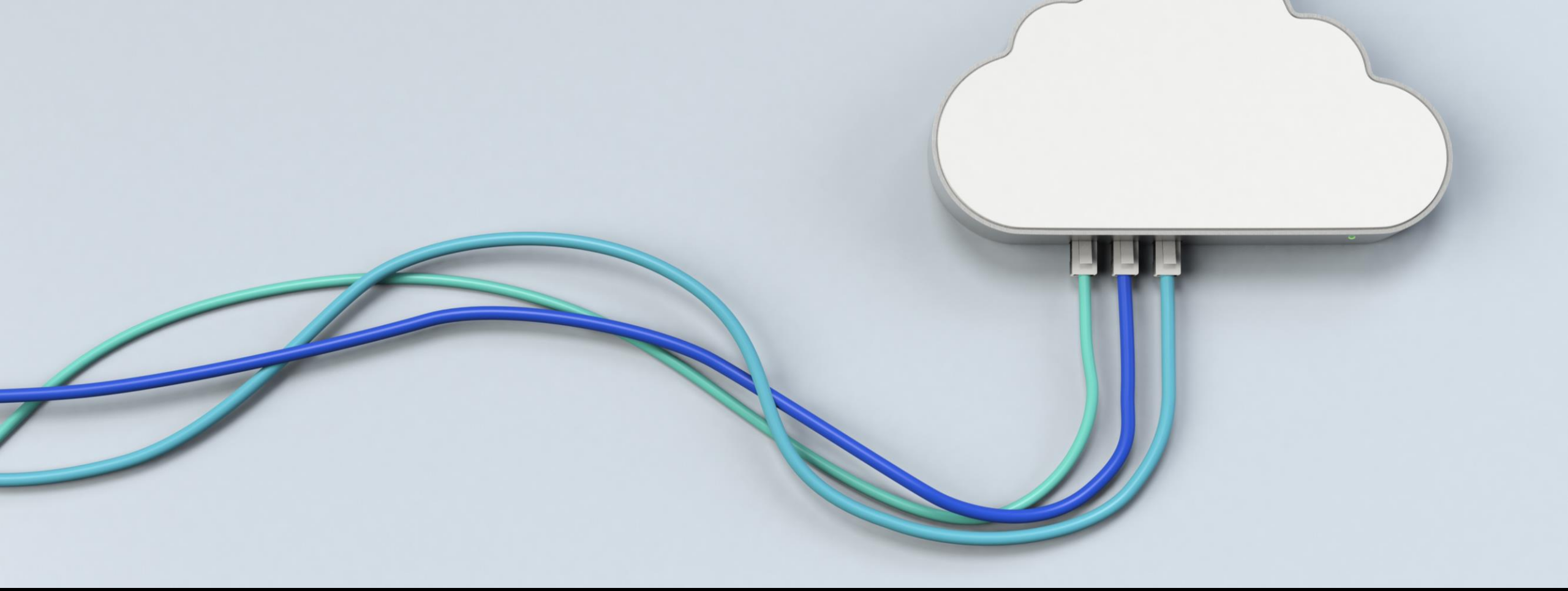
Our Approach

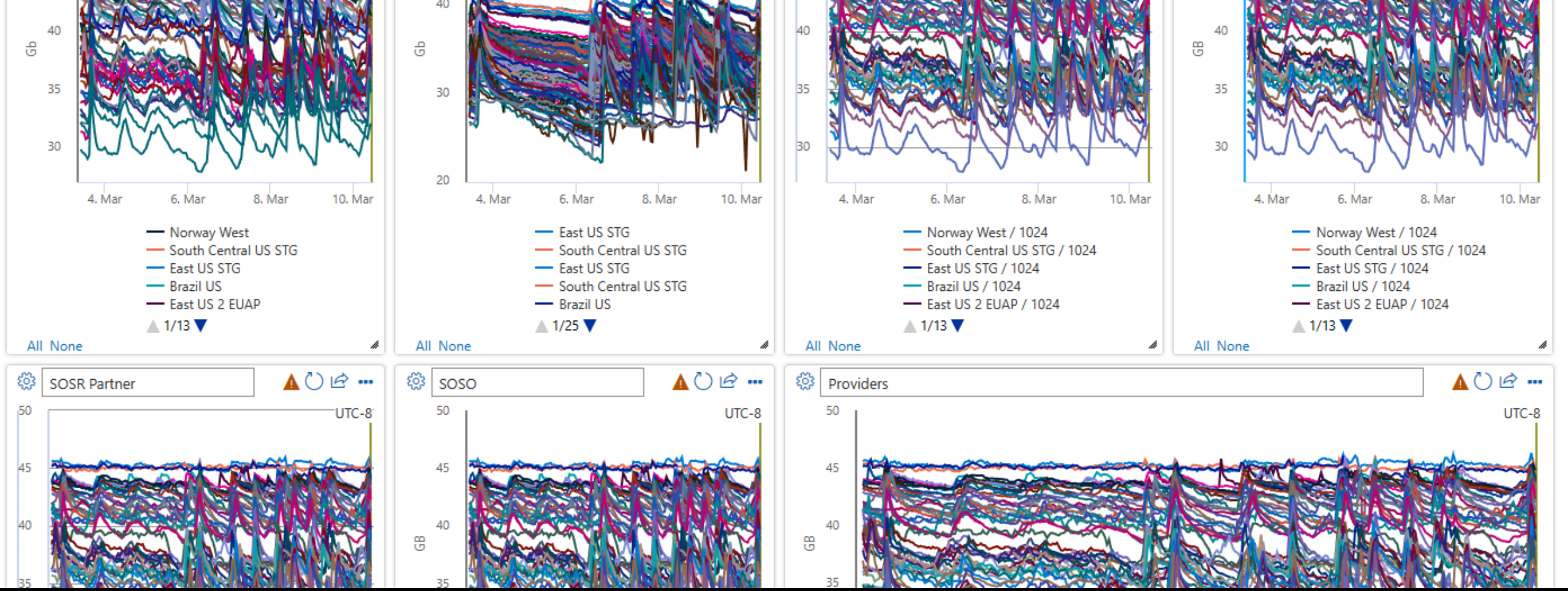


Comprehensive standardized, accurate and reliable understanding of service health

Service Health in Near Real Time using Service Level Indicators (SLIs) and Service Health Indicators (SHIs)

Production changes integrated with service health

If an incident occurs, communication
is automated and timely

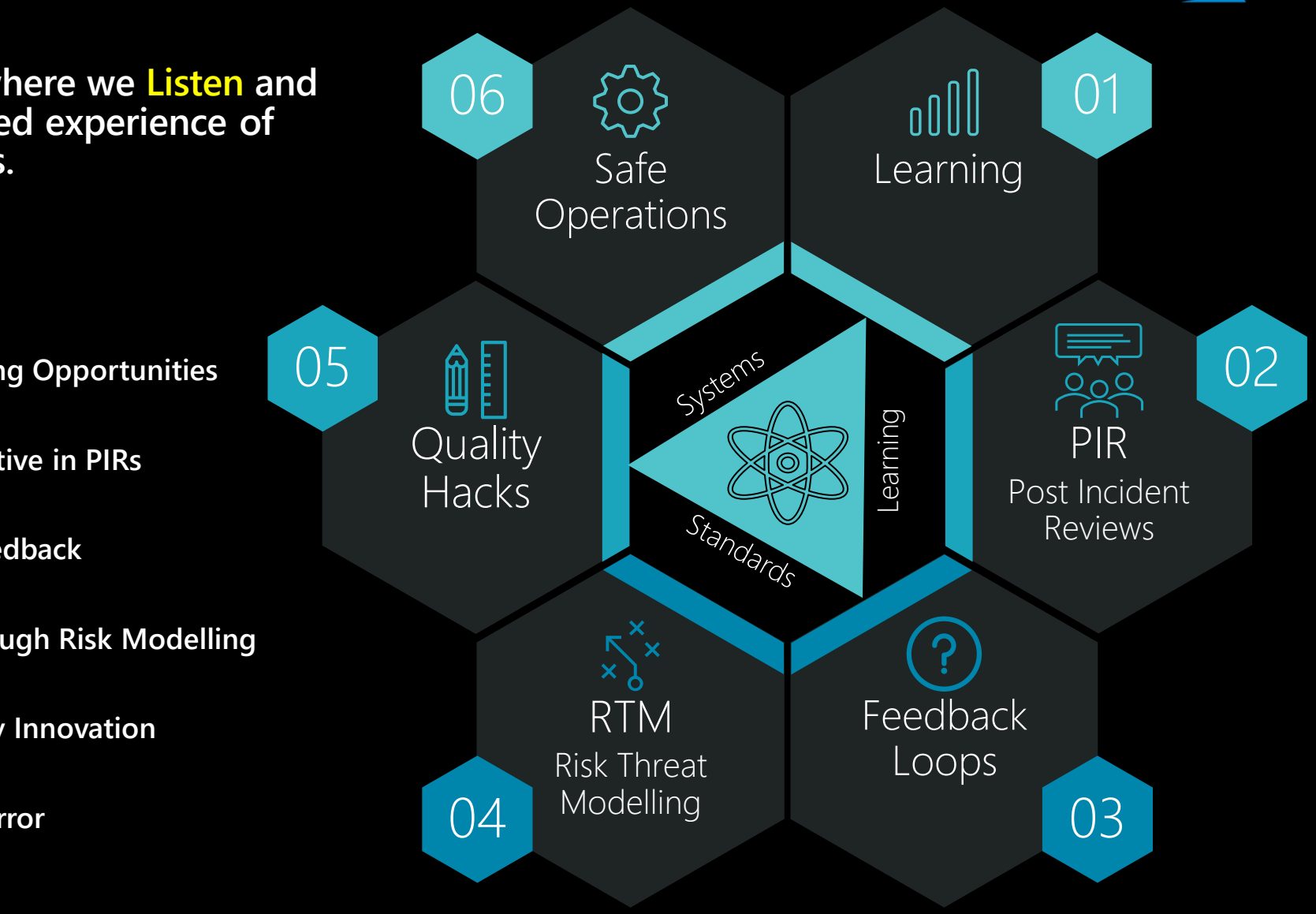


Diagnosing issues is simple / automated,
requiring little DRI toil or manual touches

Culture of Quality

Cultivate an environment where we Listen and Learn to understand the lived experience of our DRIs and our customers.

- Local Learning and Sharing Opportunities
- Seek Diverse Perspective in PIRs
- Create Safe Space for Feedback
- Quality Planning through Risk Modelling
- Dedicate Time for Quality Innovation
- There is No Human Error



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The pivot to AIOps

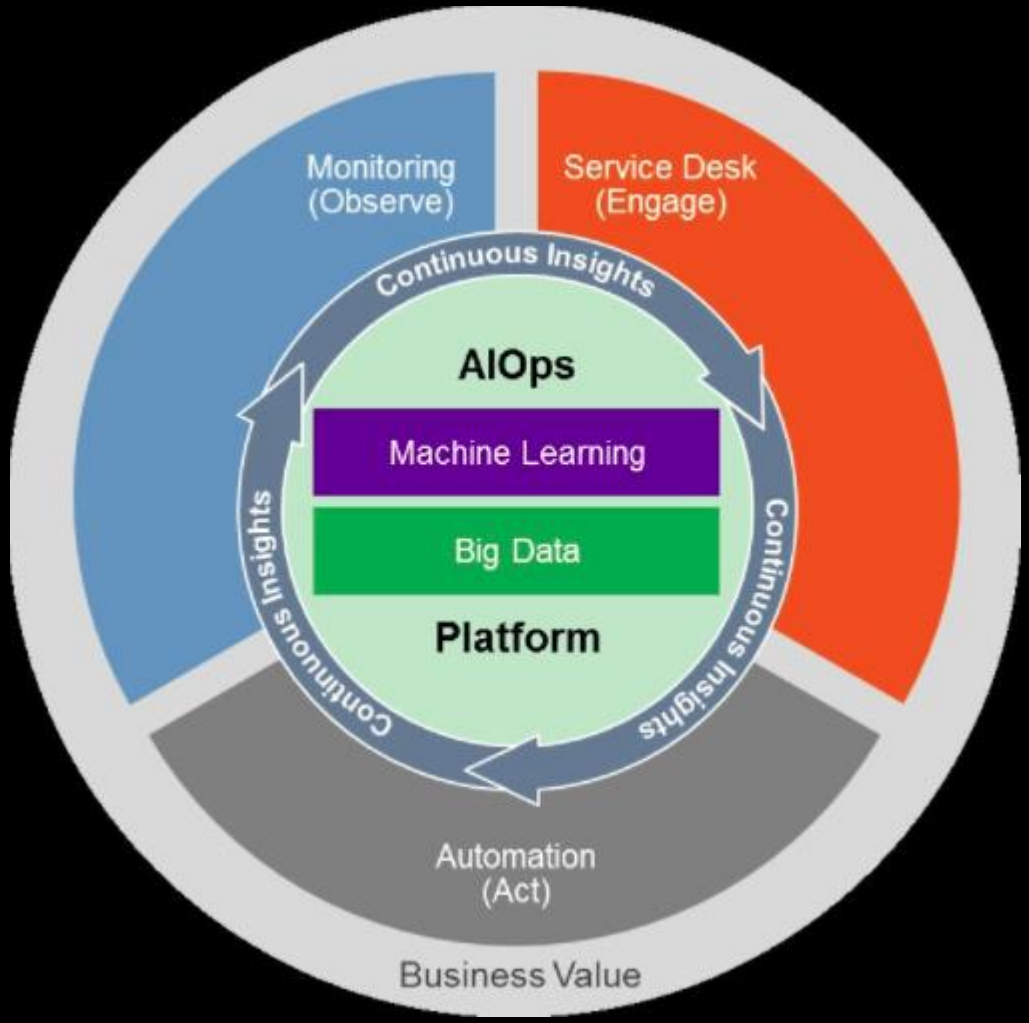
AIOps – Gartner's definition

Big data and ML driven IT operation automation process

Adoption has increased with the uptick of digital transformation

Business value

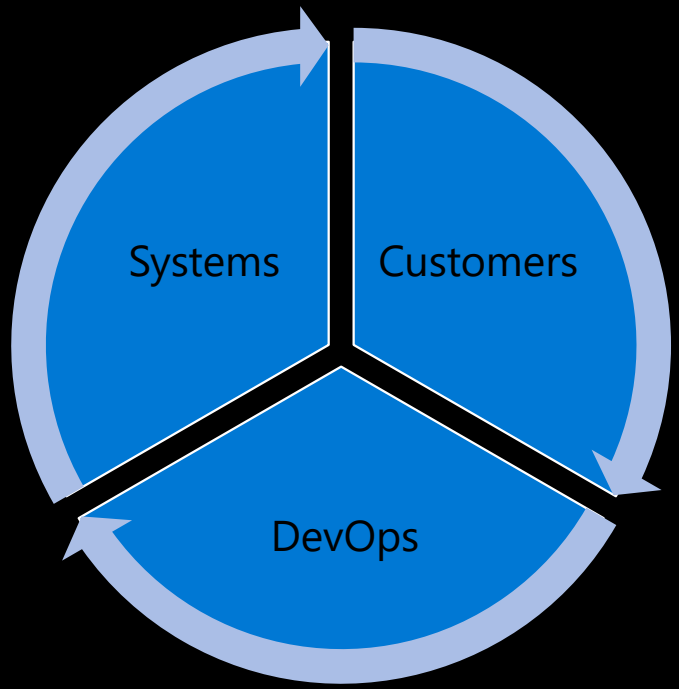
- Higher efficiency
- Higher Service quality
- Lower COGS



Source: Gartner

AIOps in Azure

Innovating AI/ML technologies to effectively and efficiently **design**, **build**, and **operate** complex **cloud services** at **scale**



- **AI for Systems**

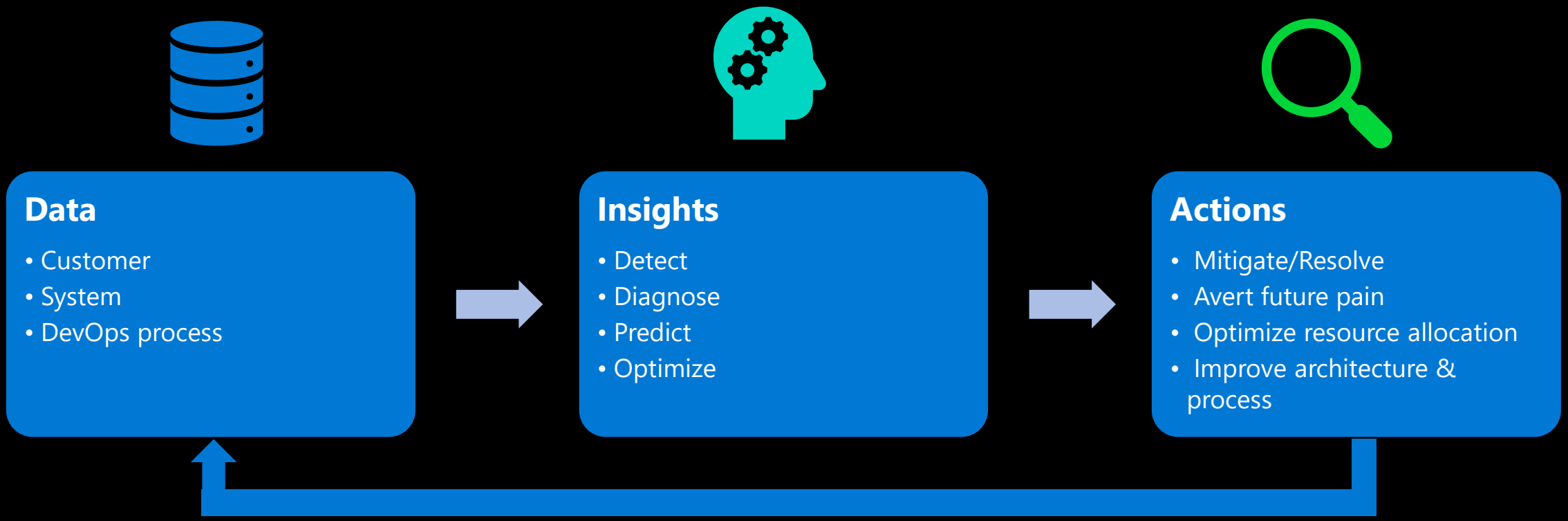
  Building high-quality services with better reliability, performance, and efficiency
- **AI for DevOps**

  Achieving high productivity in DevOps via empowering engineers with intelligent tooling
- **AI for Customers**

  Improving customer satisfaction with intelligence and better user experiences

Reference: Advancing Azure service quality with artificial intelligence: AIOps published in Azure Reliability Blog Series

AIOps Methodologies: From Data to Actions



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How we do it at scale

Azure

Azure BRAIN

Cloud Reliability

Azure

State-of-the-art Cloud Reliability

- 5/6-9s' availability
- High degree of automation and intelligence
  - >95% auto failure detection within minutes
  - Comprehensive monitoring and diagnosis platforms/tools
  - >95% automated response

Endless pursuit of reliability & Effective Management

- Incident: interruption or performance degradation of a component*
- Outage: severe incidents with widespread impact
- Costs: $17K/Outage·min (2016)**
- Incidents/outages take a long time to mitigate
- Incident management is non-trivial with cloud scale

*service/product/device/resource/API…
**Ponemon Institute© Research Report

Azure BRAIN

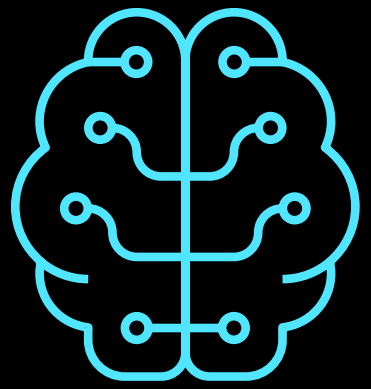
Azure

Customer Experience

Azure Services

Infrastructure devices

Critical Environment and Mechanical



BRAIN

Network of Intelligence

Automatic Alert correlation

Fast and actionable anomaly detection

Auto-communication

Automatic impacted service identification

Impact assessment

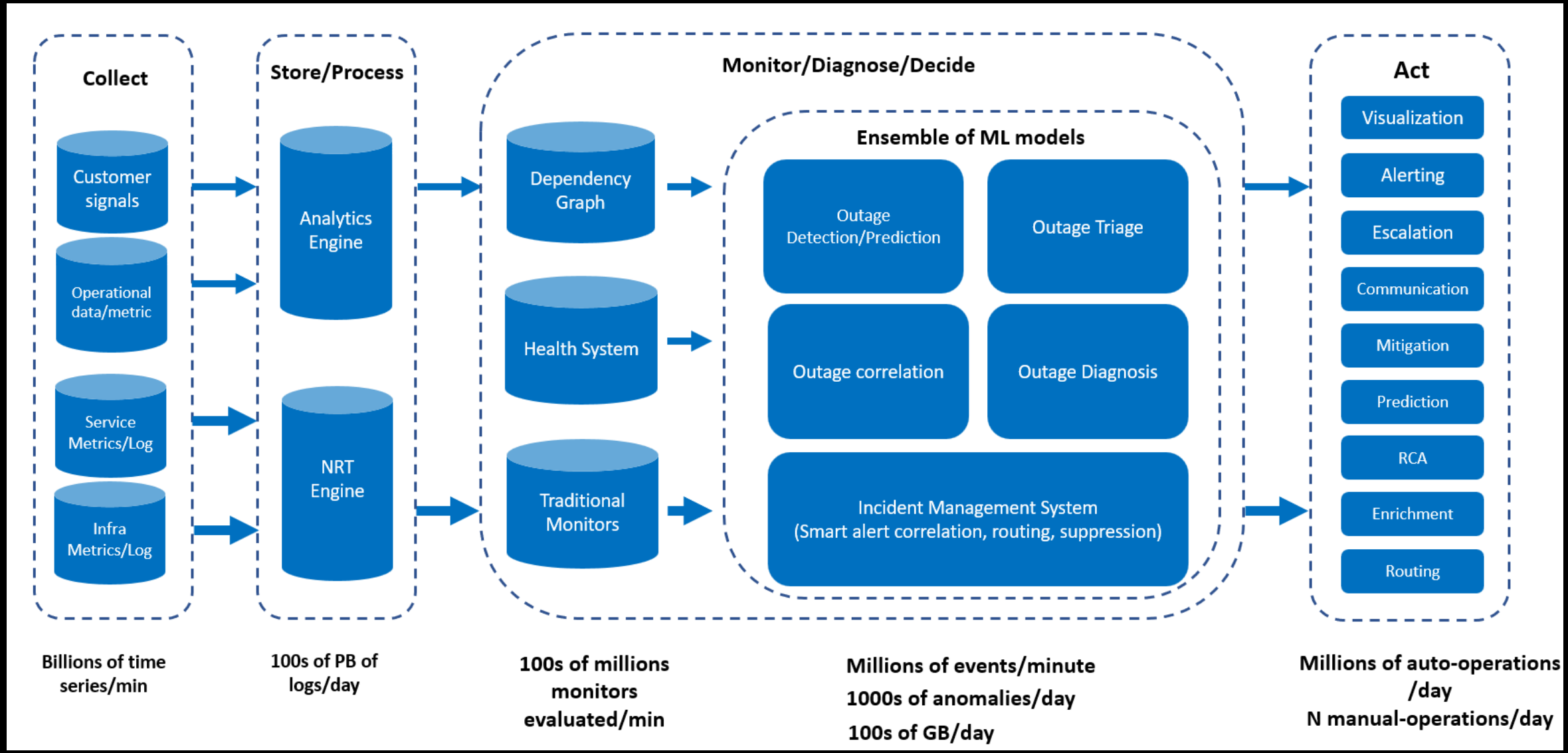
Root cause service identification

Efficient outage management

Diagnostic experiences

Auto-Mitigation

Azure BRAIN Intelligence Pipeline



Challenges

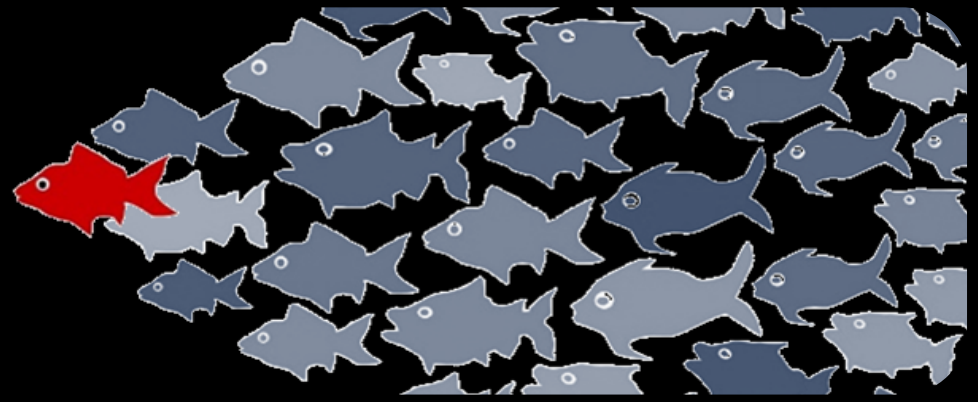
Large-volume and heterogeneous non-uniform data

Extremely imbalanced samples

Lack of canonical ground truth

AI system and human interaction

No universal intelligence for diverse scenarios



Abnormal:Normal

1:10,000

AIOps Benefits & Results

First version of BRAIN deployed in Production in early 2019

Onboarded ~60 major Azure services in two years

Major TTx improvement

Incident/alert auto-correlation -> Less noise

72% TTM Reduction

58% TTN Reduction

100% Auto-Comm percentage increase

25% Incident noise reduction

98.26% Detection Recall

98.83% Detection Precision

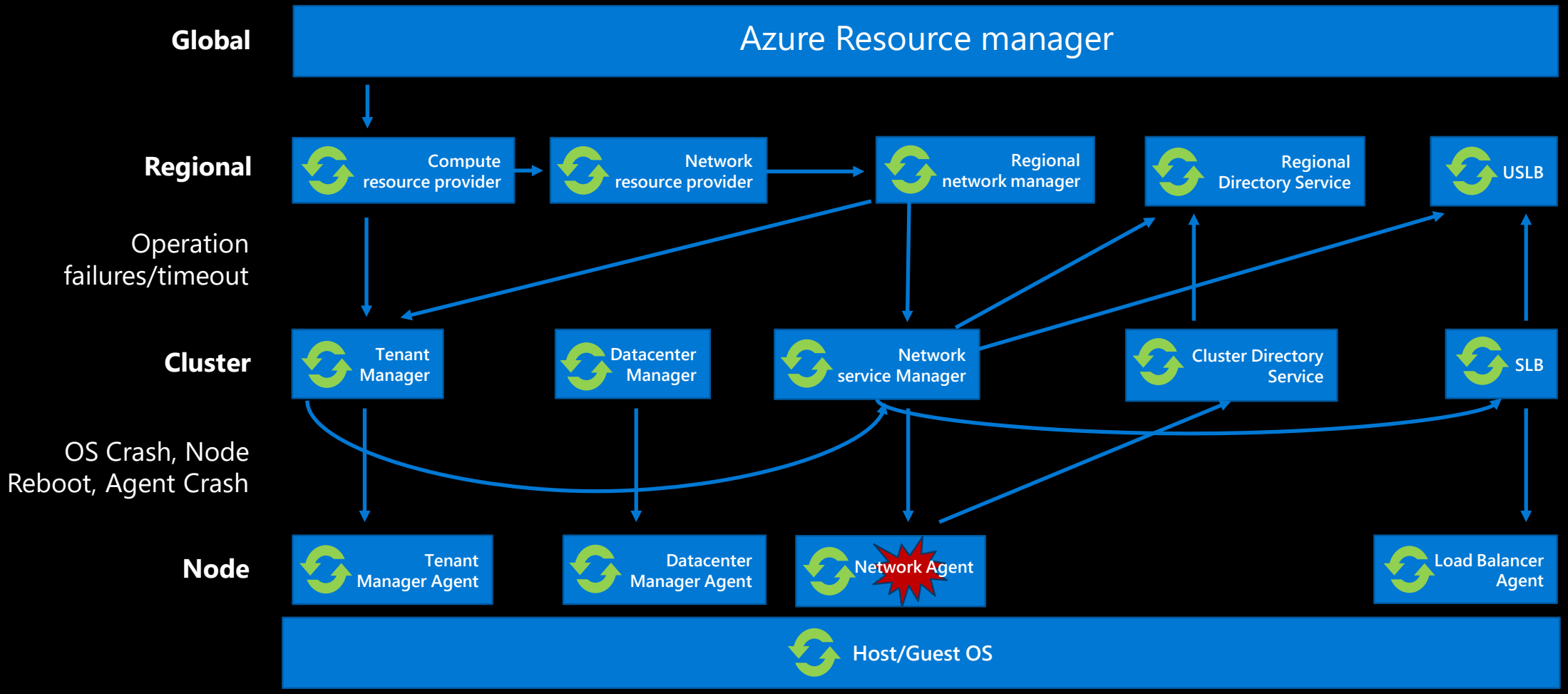
Azure

Azure Gandalf

Azure Gandalf: AIOps for Infrastructure Health

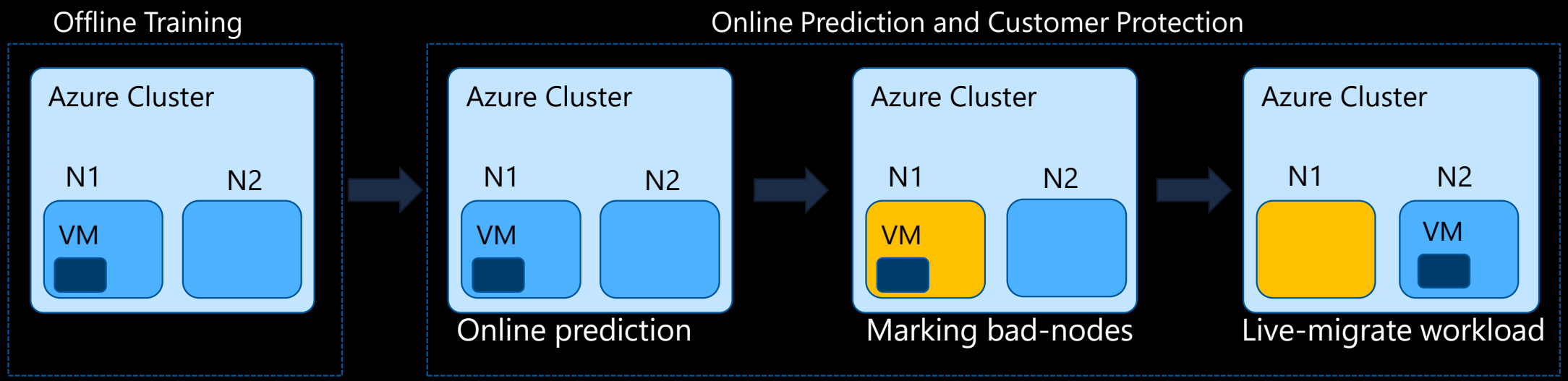
- Proactive prevention of issues: integrating intelligence into Azure Infrastructure
  - Preventing code regressions into fleet
  - Increasing host resilience
  - Governance of host resource usage
- Effective and efficient action-taking: integrating intelligence into Azure DevOps
  - Effective monitoring and diagnosis
  - Thousands of high-quality tickets filed every year
  - Increased deployment velocity by ~4 times

Preventing Code Regressions: Challenges

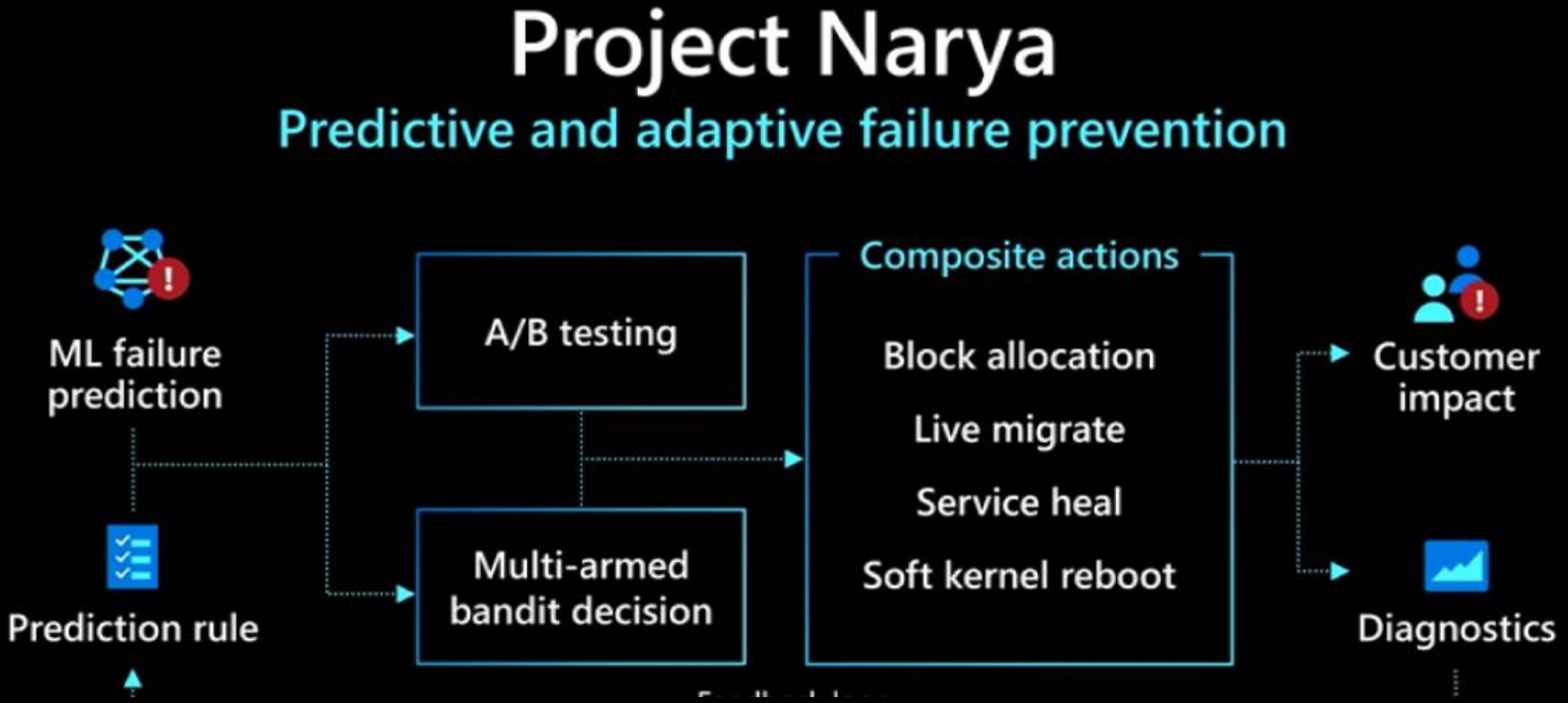


Increasing Host Machine Resilience

Goal – minimize VM reboots due to host failures by triggering Live Migration (moving VMs to healthy node with only a few seconds of blackout time) and other protection methods



Increasing Host Machine Resilience (Cont'd)



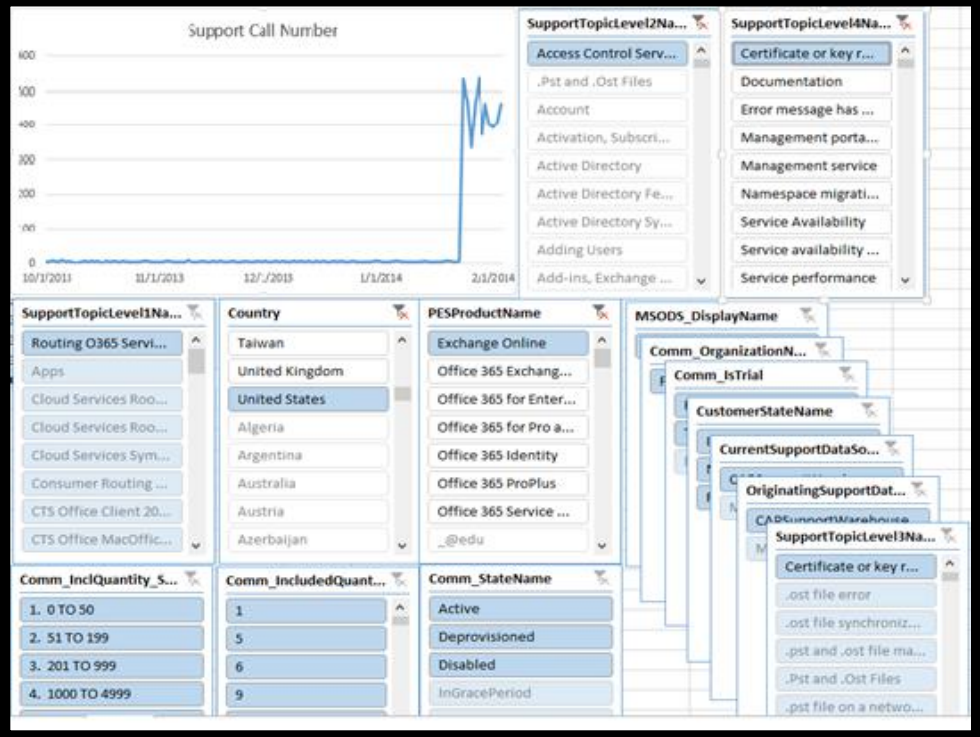
Further read

- Azure blog: https://azure.microsoft.com/en-us/blog/advancing-failure-prediction-and-mitigation-introducing-narya/
- Sebastien Levy, et. al., Predictive and Adaptive Failure Mitigation to Avert Production Cloud VM Interruptions, OSDI 2020

Multi-dimensional Anomaly Detection

Common Practice

- Manually identify monitor combinations with pivot table
- Set up pipelines to monitor hundreds of thousands of time series
- Total Time Series: 100,000+*



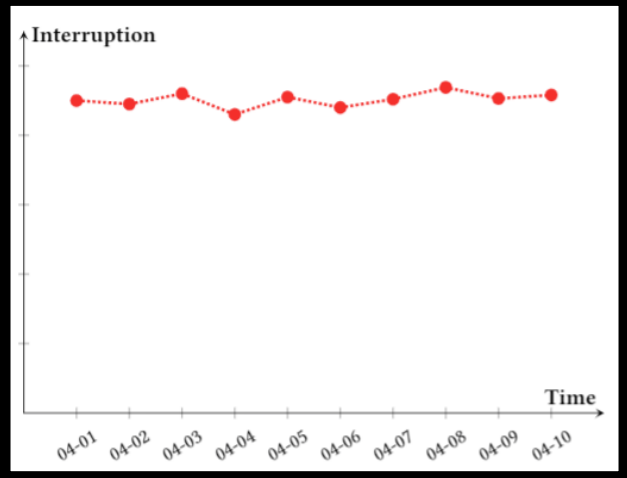
Our solution

- Formulated as a "combinatorial optimization problem"
- Solved by a specific-tailored "meta-heuristic search" method
- Details see the paper* from our Microsoft Research partners

*paper: "Efficient Incident Identification from Multi-dimensional Issue Reports via Meta-heuristic Search", FSE 2020

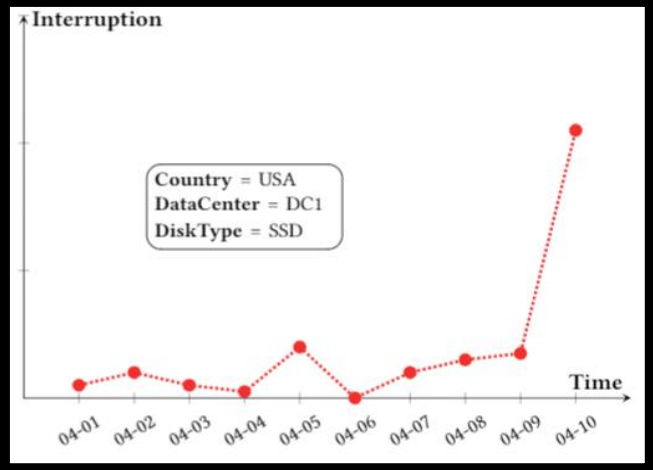
Multi-dimensional Anomaly Detection - Motivation

(Example case of Azure VM Interruptions)



Time	Interruption
2019-04-01	100
2019-04-02	99
2019-04-03	103
2019-04-04	97
2019-04-05	103
2019-04-06	99
2019-04-07	98
.....	.....

Overall KPI not having obvious spike



Time	Country	Datacenter	Disk Type	Interruption
2019-04-10	USA	DM1	SSD	1
2019-04-10	Australia	MEL21	SSD	1
2019-04-10	USA	DC1	HDD	4
2019-04-10	India	BL1	SSD	10
2019-04-10	UK	SN6	Hybrid	3
2019-04-10	USA	DM1	HDD	0
.....	.....	.....	.....	.....

Spike observed in a particular pivot

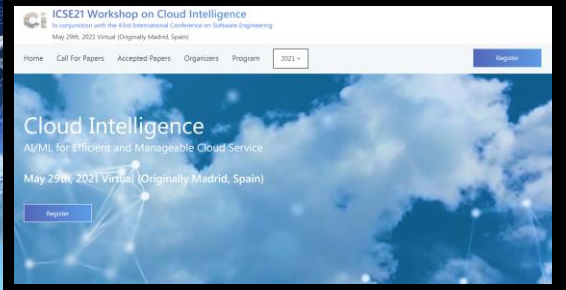
AIOps and LLM (Large Language Model)

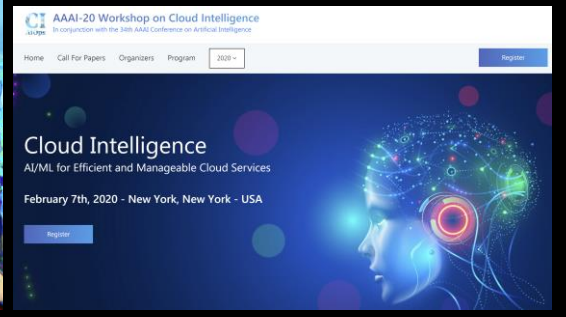
- **Cloud CoPilot**: Infuse generative AI into how we design, build, and operate cloud services for delightful customer experience and engineering efficiency

Azure

AIOps Workshop

https://www.cloudintelligenceworkshop.org





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Queen's University
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清華大學 Tsinghua University
JOHNS HOPKINS UNIVERSITY
UC San Diego

Selected Microsoft Publications on AIOps

- Fighting the Fog of War: Automated Incident Detection for Cloud Systems, ATC'21
- How Long Will it Take to Mitigate this Incident for Online Service Systems?, ISSRE'21 (best research paper award)
- HALO: Hierarchy-aware Fault Localization for Cloud Systems, KDD'21
- Efficient Incident Identification from Multi-dimensional Issue Reports via Meta-heuristic Search, FSE'20
- Toward ML-Centric Cloud Platforms: Opportunities, Designs, and Experience with Microsoft Azure, CACM'20
- Identifying Linked Incidents in Large-scale Online Service Systems, FSE'20
- Predictive and Adaptive Failure Mitigation to Avert Production Cloud VM Interruptions, OSDI'20
- Intelligent Virtual Machine Provisioning in Cloud Computing, IJCAI'20
- An Intelligent, End-To-End Analytics Service for Safe Deployment in Large-Scale Cloud, NSDI'20
- Rex: Preventing Bugs and Misconfiguration in Large Services using Correlated Change Analysis, NSDI'20
- AIOps Innovations in Incident Management for Cloud Services, Cloud Intelligence Workshop, AAAI'20
- Identifying Linked Incidents in Large-scale Online Service Systems, FSE'20
- How to Mitigate the Incident? An Effective Troubleshooting Guide Recommendation Technique for Online Service Systems, FSE'20 Industry
- Efficient Customer Issue Triage via Linking with System Incidents, FSE'20 Industry
- Towards Intelligent Incident Management: Why We Need it and How We Make it, FSE'20 Industry
- How Incidental are the Incidents? Characterizing and Prioritizing Incidents for Large-Scale Online Service Systems, ASE'20
- Robust Log-based Anomaly Detection on Unstable Log Data, FSE'19
- Towards More Efficient Meta-heuristic Algorithms for Combinatorial Test Generation, FSE'19
- Cross-dataset Time Series Anomaly Detection for Cloud Systems, USENIX ATC'19
- AIOps: Real-World Challenges and Research Innovations, Tech briefing, ICSE'19
- Outage Prediction and Diagnosis for Cloud Service Systems, WWW'19
- An Empirical Investigation of Incident Triage for Online Service Systems, ICSE'19
- Continuous Incident Triage for Large-Scale Online Service Systems, ASE'19
- Orca: Differential Bug Localization in Large-Scale Services, OSDI'18
- Identifying Impactful Service System Problems via Log Analysis, FSE'18
- Predicting Node Failure in Cloud Service Systems, FSE'18
- BigIN4: Instant, Interactive Insight Identification for Multi-Dimensional Big Data, SigKDD'18
- Improving Service Availability of Cloud Systems by Predicting Disk Error, USENIX ATC'18

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Q&A

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Thank you!