INDIS 2026

Genesis Mission

SciNet

Science-Aware Network Operations for Research Networks

An agentic control plane for programmable science networks



Mariam Kiran, K. K. Ramakrishnan, Harvey B. Newman

Puneet Sharma, Rafael Ferreira da Silva, A. Welch, L. Zhong, S. Murali

Oak Ridge National Laboratory · UC Riverside · Caltech · HPE Labs

Scientific discovery is becoming a distributed systems problem

Autonomous laboratories connect instruments, models, compute, and people across facilities.

Science is distributed

Experiments span instruments, national supercomputers, AI models, data repositories, and robotic facilities.

Networks have been passive

Production research networks largely move data reactively and treat multi-facility campaigns as undifferentiated flows.

The gap is growing

Agentic AI, real-time analysis, cross-site training, and feedback loops add new traffic patterns and need tighter coordination across the entire scientific discovery process.

A network bottleneck can become an experiment's bottleneck — and ultimately a discovery bottleneck.

The optimization objective must change

From moving packets efficiently to accelerating scientific outcomes.

Today · Network-centric

- Latency, throughput, utilization
- Packet delivery and reliability
- Static application or user-group priorities
- Reactive response to congestion and failure

SciNet · Science-aware

- Experiment completion time
- Scientific throughput
- Discovery rate
- Reproducibility
- Dynamic priority based on workflow lifecycle

The network becomes an intelligent collaborator in the discovery process.

A fifth-generation (new?) mindset for research networking

SciNet extends the progression of wide-area network architectures.

Traditional WAN

MPLS · OSPF · RSVP

Optimized for:
Connectivity
& reliability

Hyperscale WAN

Google B4 · Microsoft SWAN

Optimized for:
Application performance
& utilization

Intent-based networks

Self-driving networks

Optimized for:
User and business
intent

SciNet (proposed)

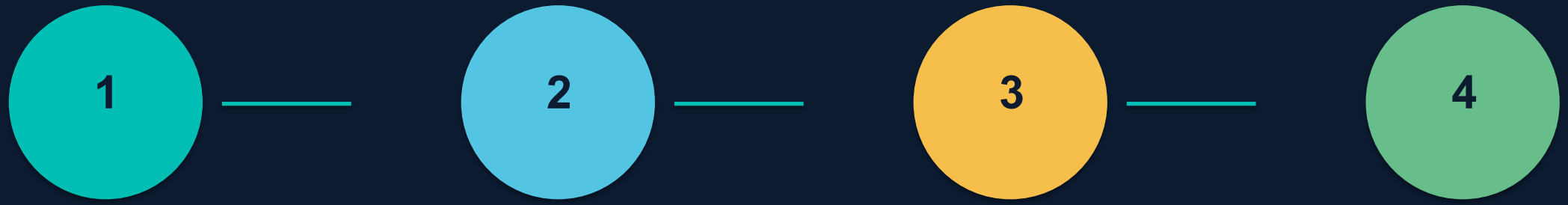
Science-aware autonomous networks

Optimizes for:
experiment velocity,
Scientific productivity,
discovery

Key shift: scientific intent and workflow state become first-class inputs to network control.

SciNet: a science-aware autonomous network

AI embedded in the network control plane observes, predicts, reasons, and adapts.



OBSERVE

Workflow state & telemetry

PREDICT

Future demand & dependencies

REASON

Plan and schedule across resources

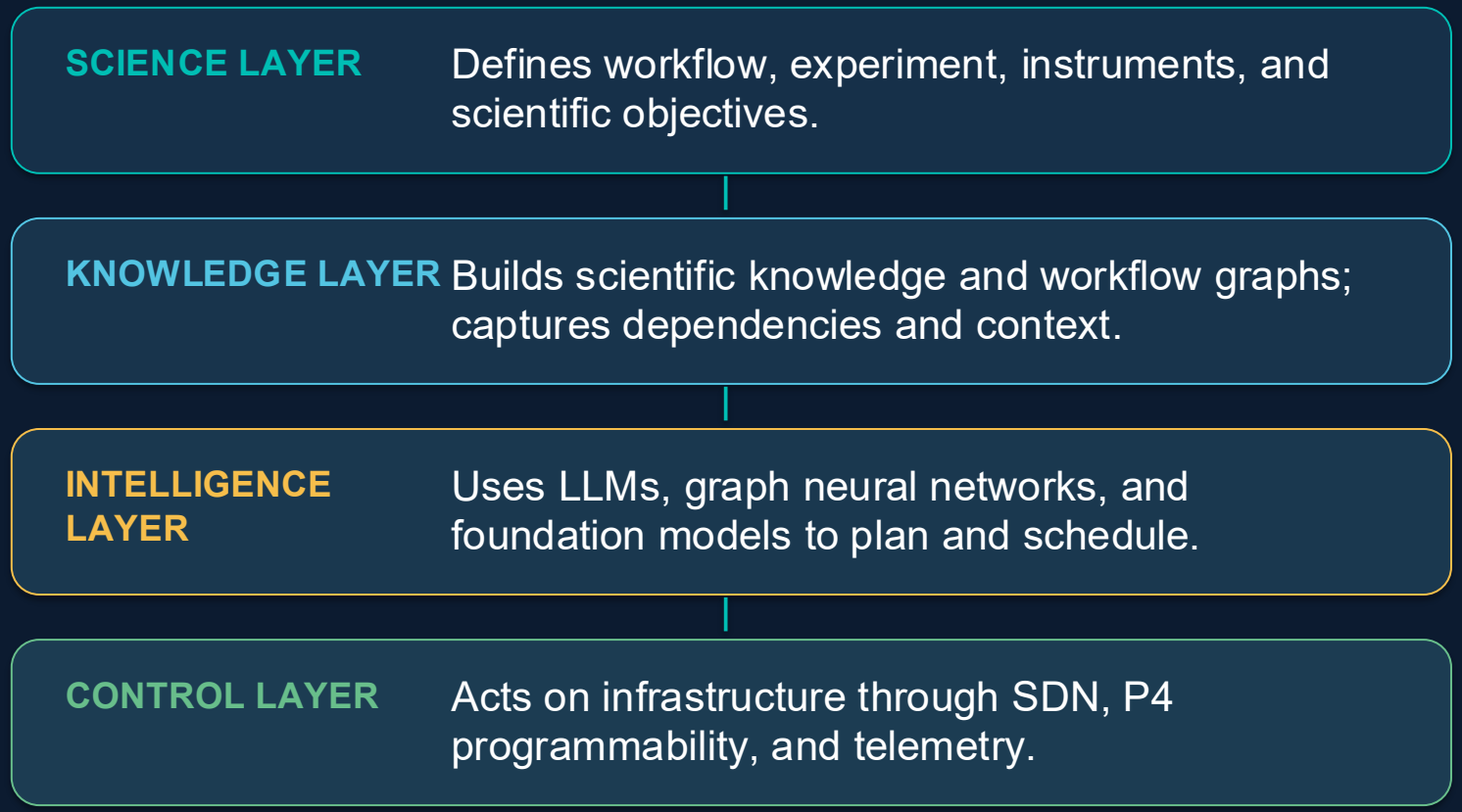
ACT

Configure network & mitigate failures

Unlike conventional AIOps, SciNet optimizes for scientific productivity — not utilization or reliability in isolation.

Four-layer SciNet architecture

A common representation connects science intent to programmable infrastructure.



Cross-layer feedback

Monitoring and evaluation observe all layers and inform adaptation.

Shared interfaces

Agentic APIs, infrastructure descriptors, and pluggable telemetry/policy hooks.

Agents coordinate the end-to-end science workflow

A science goal drives a coordinated plan spanning network, data, facilities, and compute.



Agent coordination traffic is bursty, latency-sensitive, and mesh-structured — unlike bulk data movement.

Six recurring network use cases in science workflows

Stakeholder interviews informed a common set of use cases and associated QoS classes.

01 Bulk data movement

Host-to-host transfer

02 Deadline-scheduled movement

Large dataset transfer with deadline

03 Distributed portal storage / retrieval

Data accessed across portals

04 Remote I/O access

Remote access to datasets

05 Data streaming

Data delivered as it arrives

06 VPN overlay

Secure overlay connectivity

Every use case defines BW Min Fail and BW Min Warn thresholds; some also specify endpoints and start/stop times.

Workflow-aware QoE turns science requirements into network actions

Common parameters are refined with workflow-specific service-level agreements.

Bandwidth guarantees

BW Min Fail

Minimum guaranteed bandwidth below which the experiment fails.

BW Min Warn

Minimum guaranteed bandwidth below which a warning is raised.

Workflow context

- Source and destination endpoints
- Start and stop timestamps
- Transfer size and remaining data volume
- Deadlines and workflow lifecycle

Scheduling policy

- Assign flow weights from workflow urgency
- Schedule streams to match workflow timing
- Preserve fairness across competing flows
- Support distinct streams within a connection

Example science SLA: “Run this workflow 10 times with a minimum bandwidth of 10 Gb/s.”

A unified objective: maximize scientific utility

Jointly account for scientific productivity, reliability, communication cost, and failure risk.

$$U = \alpha S + \beta L - \gamma C - \delta F$$

S · Scientific productivity

Experiment completion, throughput, discovery

L · Reliability

Consistent and resilient network service

C · Communication cost

Resources consumed to move and coordinate data

F · Failure risk

Risk of disruption to workflows and campaigns

α, β, γ, δ encode the relative importance of each term for the scientific mission.

SciNet FlowEngine: from intent to coordinated execution

A dynamic task pool lets specialized agents plan, negotiate, and act.

Science intent

Workflow parameters, requirements, deadlines

Task decomposition

Dynamic task groups and dependencies

Agent negotiation

Resource, route, security, conflict resolution, react and recover from failures

Verified execution

Traffic shaping, flow, congestion control

Monitoring + digital twin

Observe state, evaluate health, verify configurations before deployment.

Programmable infrastructure

P4Runtime · SmartNIC control · OLCF job submitter · MPQUIC agent

Ongoing research directions

The Genesis Mission research agenda links workflow understanding with adaptive control.

A	**Science workflow intent**	Build a workflow library and knowledge graphs that connect science requirements to network configurations and science SLAs.
B	**Agentic FlowEngine**	Translate science intent into dynamic task groups; agents plan, reason, manage resources, enforce security, and resolve conflicts.
C	**Monitoring, APIs & digital twins**	Verify proposed configurations against live state; use digital twins to test algorithms while hardware access is pending.
D	**Multi-facility demonstrations**	Move toward per-facility multi-agent control, integrating HPC systems, detectors, and network segments.

From virtual testbeds to resilient science infrastructure

Digital twins provide a fast, repeatable path to validating science-aware network control.

1 · Model

Represent sites as graph nodes and links as edges; model workflows as tasks, data, and resource sets.

2 · Validate

Test algorithms and agent coordination in virtual testbeds; verify network health and policy compliance before changes.

3 · Demonstrate

Integrate programmable data planes and edge control; coordinate HPC, detectors, and network segments across facilities.

Intended outcome: resilient, flexible communications infrastructure that scales across institutions and improves scientific productivity.

SciNet makes the network part of the scientific team

A shift from passive transport to science-aware, agentic coordination.

UNDERSTAND	Scientific intent, workflows, dependencies, and lifecycle
COORDINATE	Network and laboratory resources through specialized agents
OPTIMIZE	Scientific productivity while accounting for reliability, cost, and risk
VALIDATE	Use monitoring, policy checks, and digital twins before control actions

The ultimate metric is not how fast packets move — it is how quickly science advances.

Acknowledgements & Demos

ACKNOWLEDGEMENTS

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DEMO at SC

- NRE demo: Tuesday Nov. 17, 2026 16:00-16:20
- DOE Booth: Tuesday, November 17, 5:00 PM

Demo station: #2

- NRE demo: Wednesday Nov. 18, 2026 14:40-15:00

Authors: ORNL · UC Riverside · Caltech · HPE Labs