



# ESnet6: Handling the data deluge

Inder Monga  
Executive Director  
ESnet



## Mission network

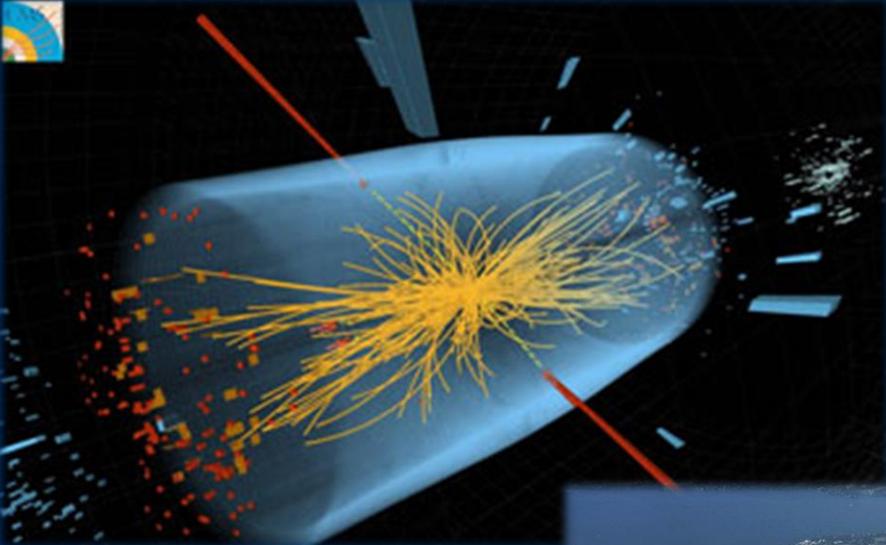
Scientific progress will be **completely unconstrained** by the physical location of instruments, people, computational resources, or data.

**Vision:**

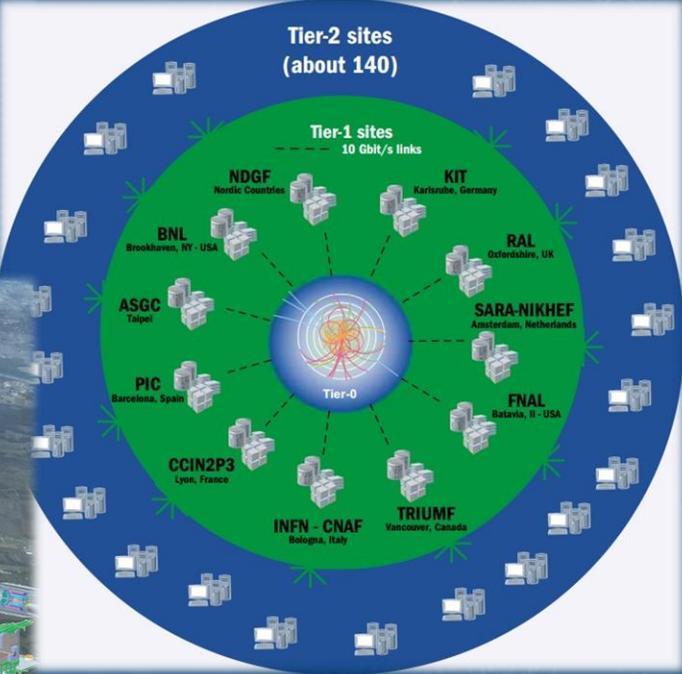
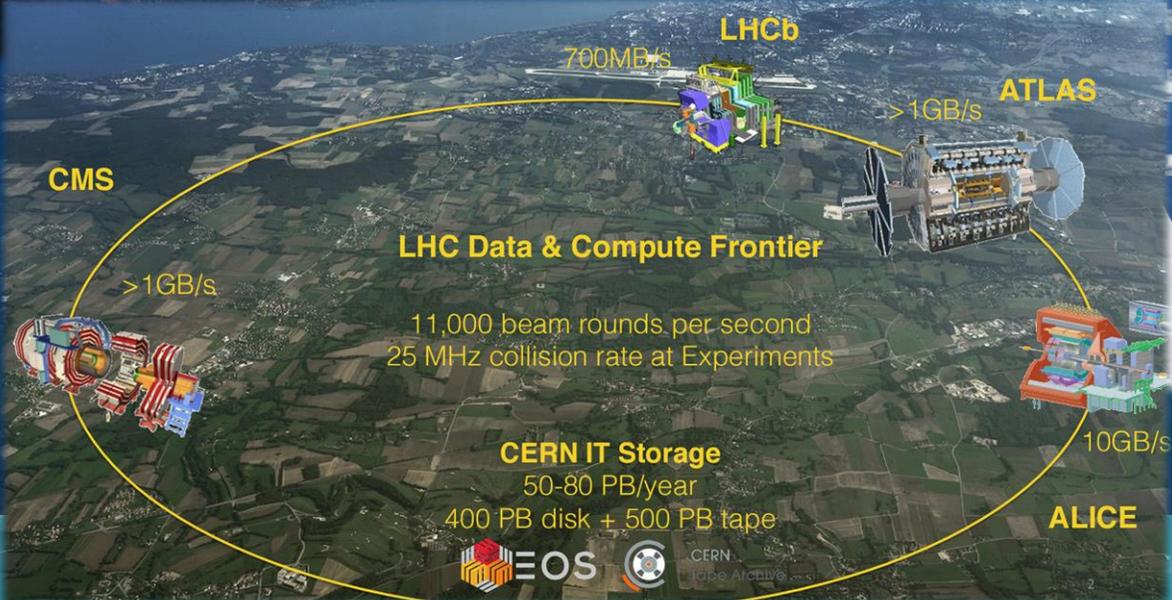
*Accelerate Scientific Discovery*

# Science is a conversation...

High Energy physicists worldwide discover the nature of matter by analyzing data from CERN thus helping create new materials and quantum technologies to solve tomorrow's critical energy problems

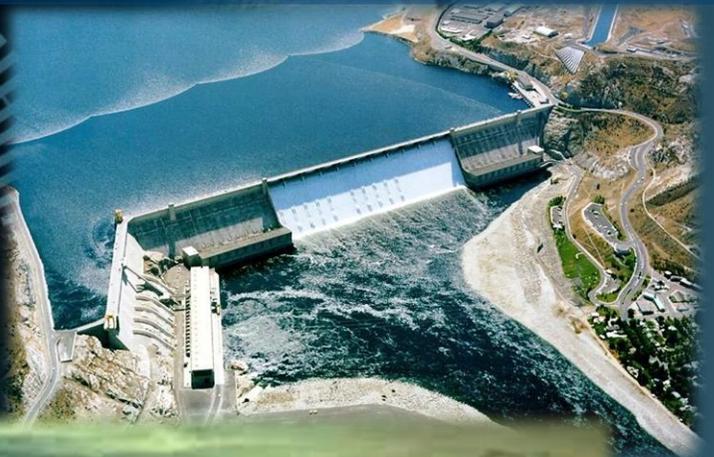


2012 Nobel prize for the discovery of the Higgs Boson



# ...a critical conversation

Climate and Life scientists worldwide analyze the data collected by sensors and simulations to prevent disaster and improve the quality of life



*Data from ARM user facility*

# ...a global conversation

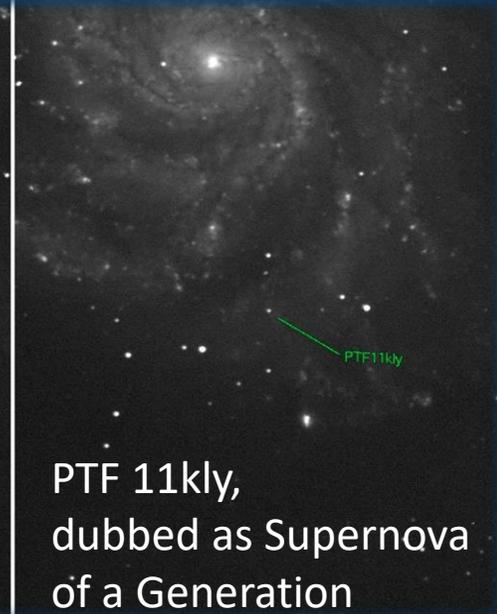
The Vera C. Rubin Observatory Project  
Cerro Pachón, Chile



Palomar Observatory,  
San Diego County, California, USA



ESnet collaborates with research networks worldwide to create a global observatory helping develop a deeper understanding how our universe was formed and our place in it



PTF 11kly,  
dubbed as Supernova  
of a Generation

# Serves connectivity needs of all DOE National Labs

>70,000  
lab staff

The Department of Energy's 17 National Laboratories are powerhouses of science and technology whose researchers tackle some of the world's toughest challenges.

# The ESnet user facility: Data-circulatory system for all 28 SC facilities\*

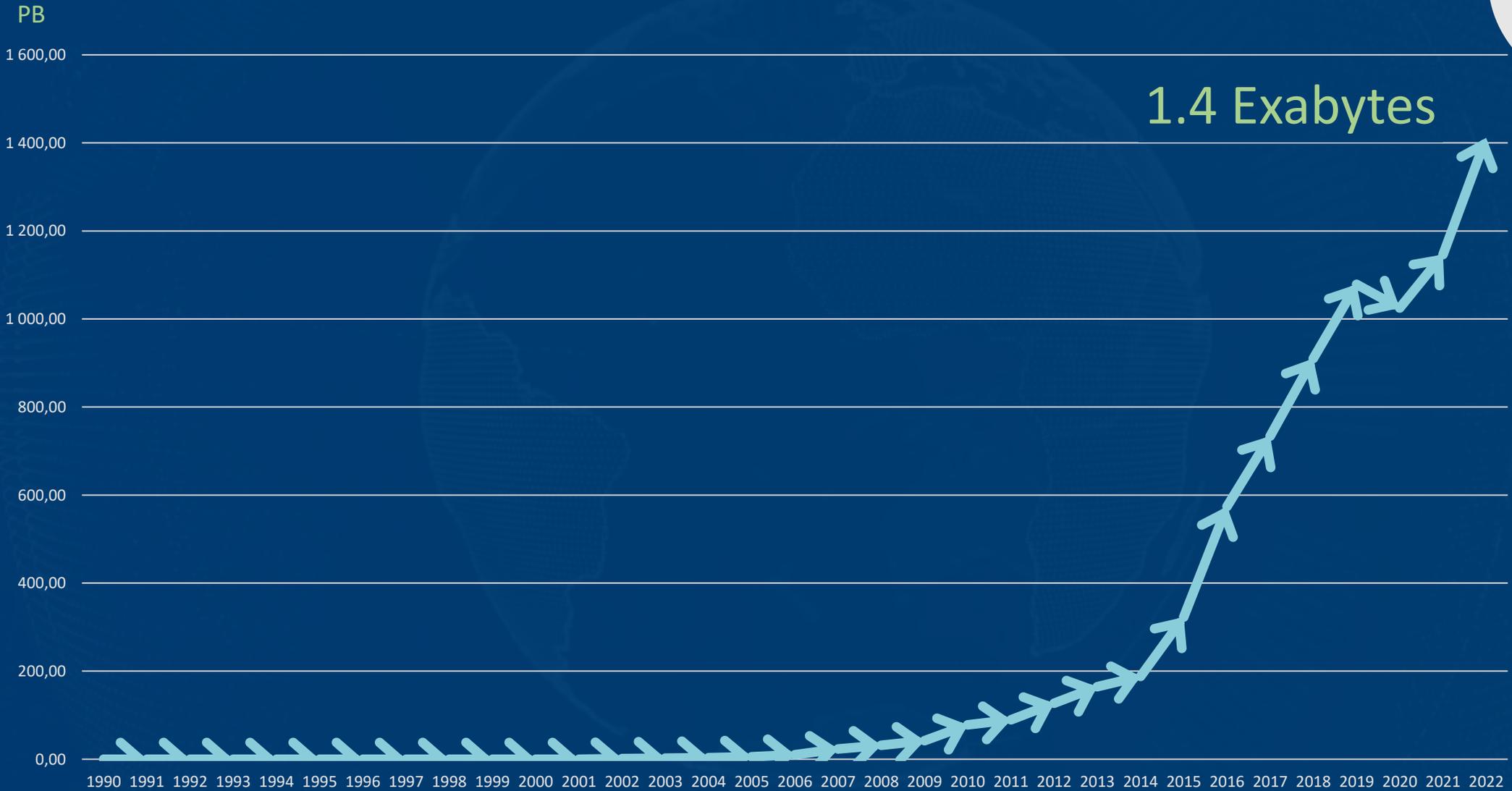
>30,000  
science  
users

ASCR High End Computing (HEC) Argonne Leadership Computing Facility (ALCF)	Advanced Photon Source (APS)	Linac Coherent Light Source (LCLS)	BES X-Ray Light Sources Stanford Synchrotron Radiation Light Source (SSRL)	Advanced Light Source (ALS)	National Synchrotron Light Source II (NSLS-II)
Oak Ridge Leadership Computing Facility (OLCF)	Center for Functional Nanomaterials (CFN)	Center for Integrated Nanotechnologies (CINT)	BES Nanoscale Science Research Centers (NSRCs) The Molecular Foundry (TMF)	Center for Nanophase Materials Sciences (CNMS)	Center for Nanoscale Materials (CNM)
National Energy Research Scientific Computing Center (NERSC)	BES Neutron Scattering Facilities Spallation Neutron Source (SNS)	High Flux Isotope Reactor (HFIR)	Joint Genome Institute (JGI)	BER Environmental Molecular Sciences Laboratory (EMSL)	Atmospheric Radiation Measurement (ARM) user facility
ASCR High Performance Scientific Network	FES National Spherical Torus Experiment - Upgrade (NSTX-U)	DIII-D National Fusion Facility (DIII-D)	Facility for Advanced Accelerator Experimental Tests (FACET)	HEP Fermilab Accelerator Complex	Accelerator Test Facility (ATF)
Energy Sciences Network (ESnet)	Argonne Tandem Linac Accelerator System (ATLAS)	Continuous Electron Beam Accelerator Facility (CEBAF)	NP Facility for Rare Isotope Beams (FRIB)	RHIC PHENIX Relativistic Heavy-Ion Collider (RHIC)	

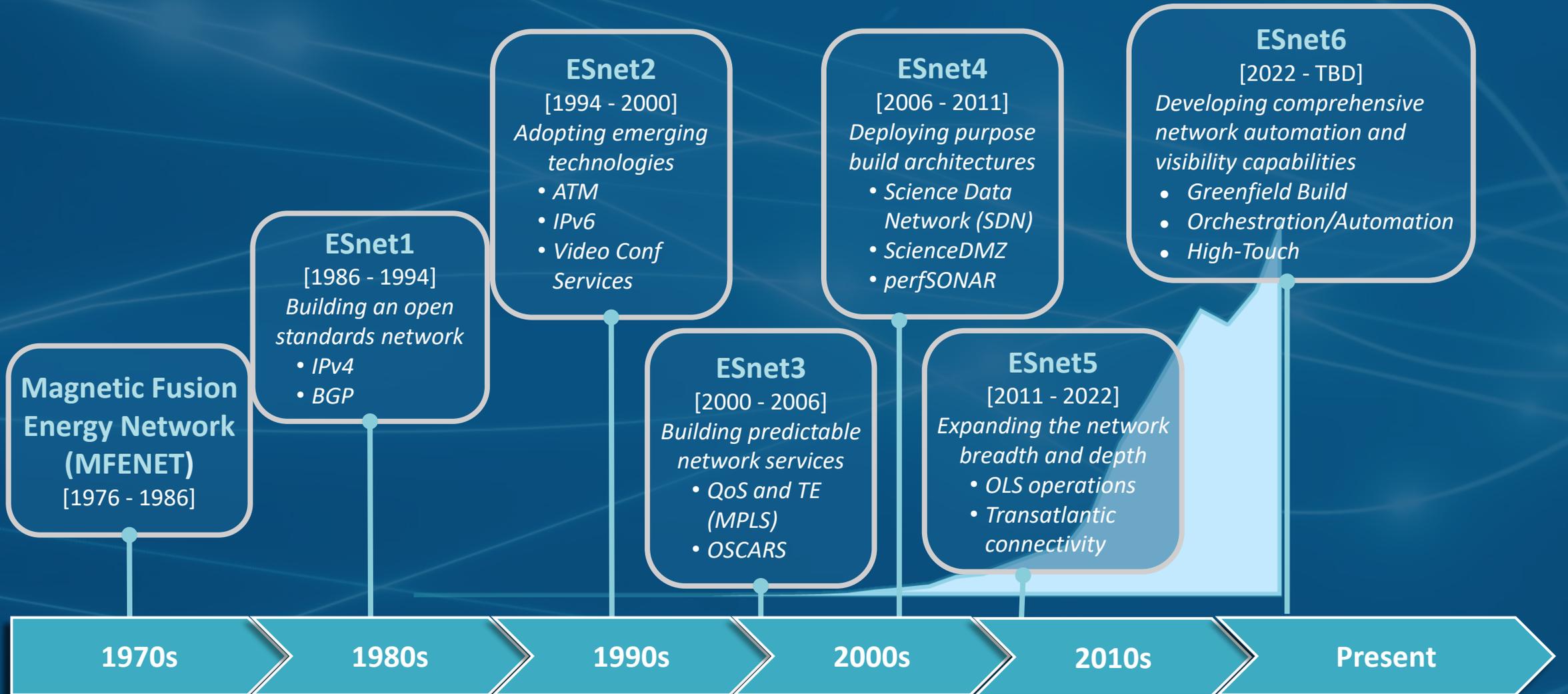


# Network traffic growing exponentially 60% yearly since 1990

>1.4  
Exabytes  
past 12  
months



# Evolution of the ESnet over the past 30+ years



# ESnet6: the project

# Goals of ESnet6 project

## Manage Exponential Data Growth

- Cost-effective design
- 5 - 7 years operation
- Just-in-time capacity

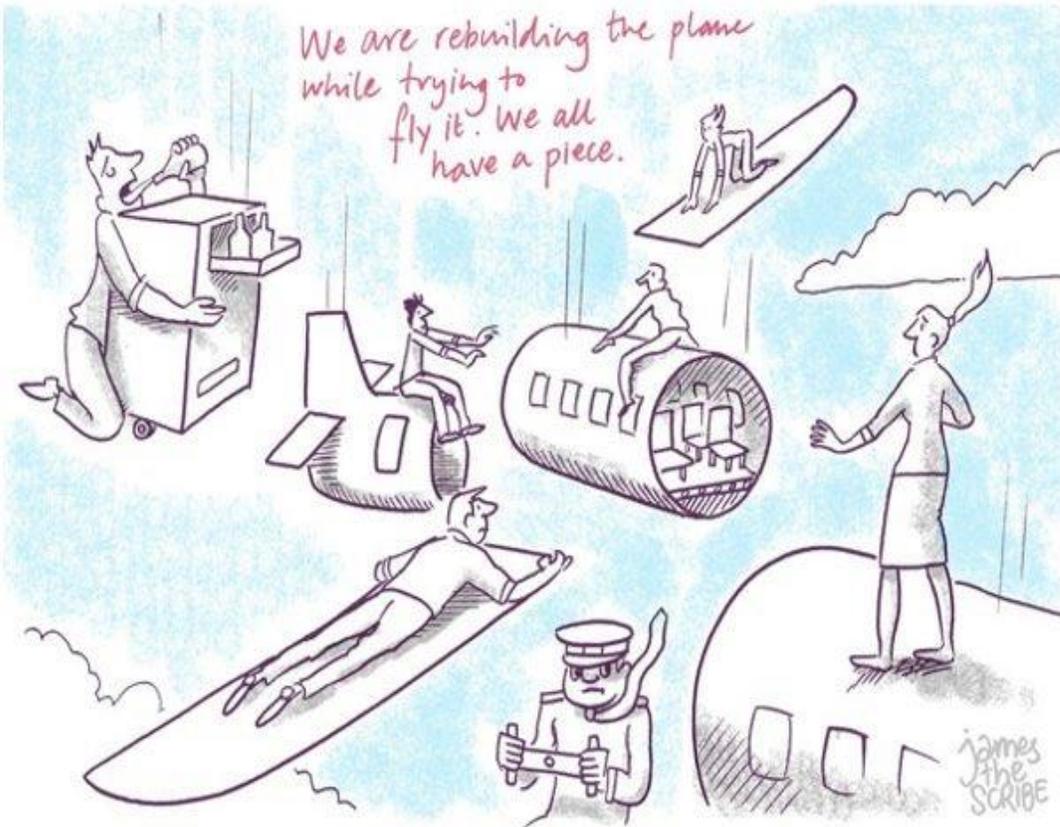
## Increase resiliency and reliability

- Scientific progress impeded by lack of network availability
- Protect against malicious behavior

## Lay foundation to handle future science workflows

- Enable custom science workflows and services
- Allow integration of new technologies

# Transformative but challenging project

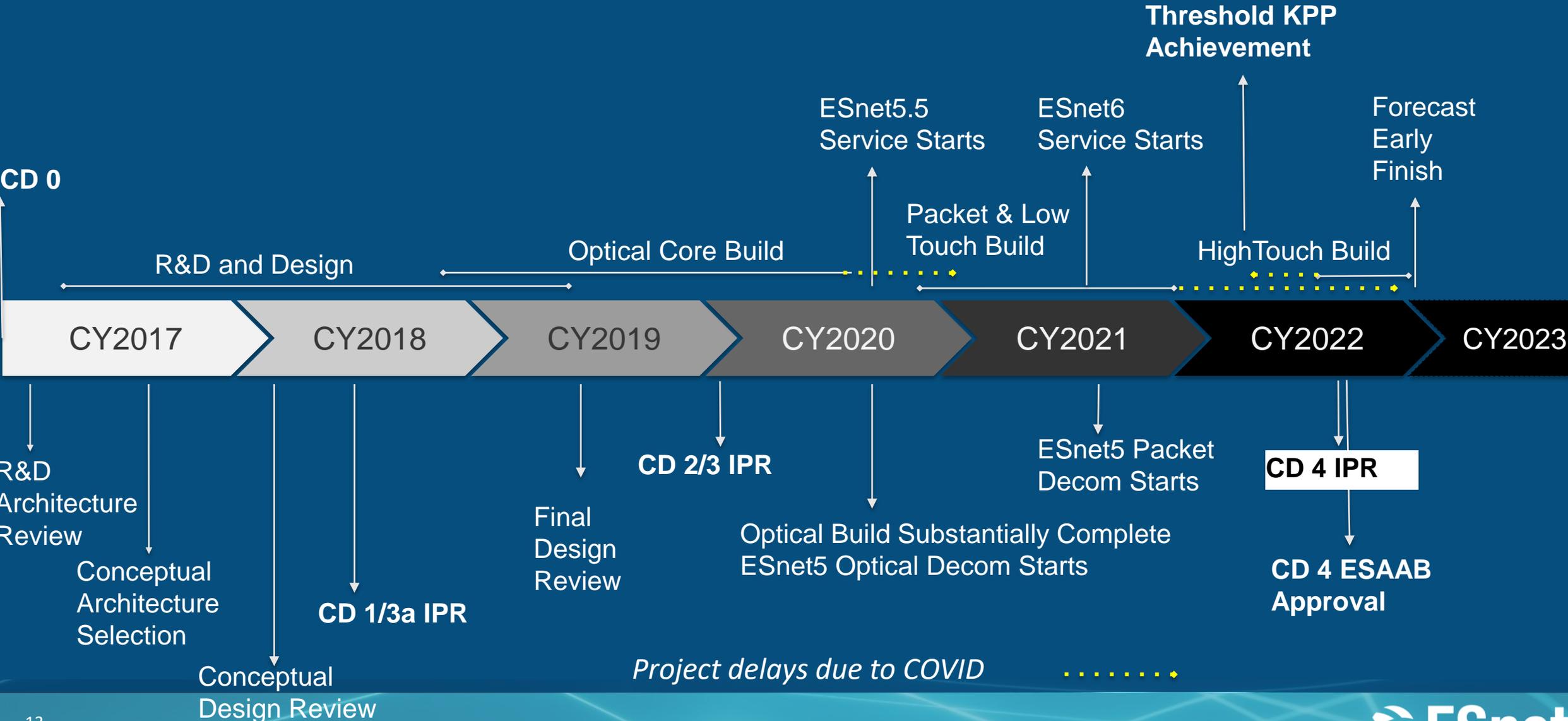


- First greenfield design and build of the entire network by ESnet team
- First time implementing and operating the optical layer
- ~10x increase in coordination, communication and reporting due to the Pandemic
- ~Zero unplanned downtime, and limited off hours planned downtime

**Thanks to strong support from ASCR/DOE and Congress**

*..and we are deconstructing the older plane and transferring the passengers to the new one in parallel*

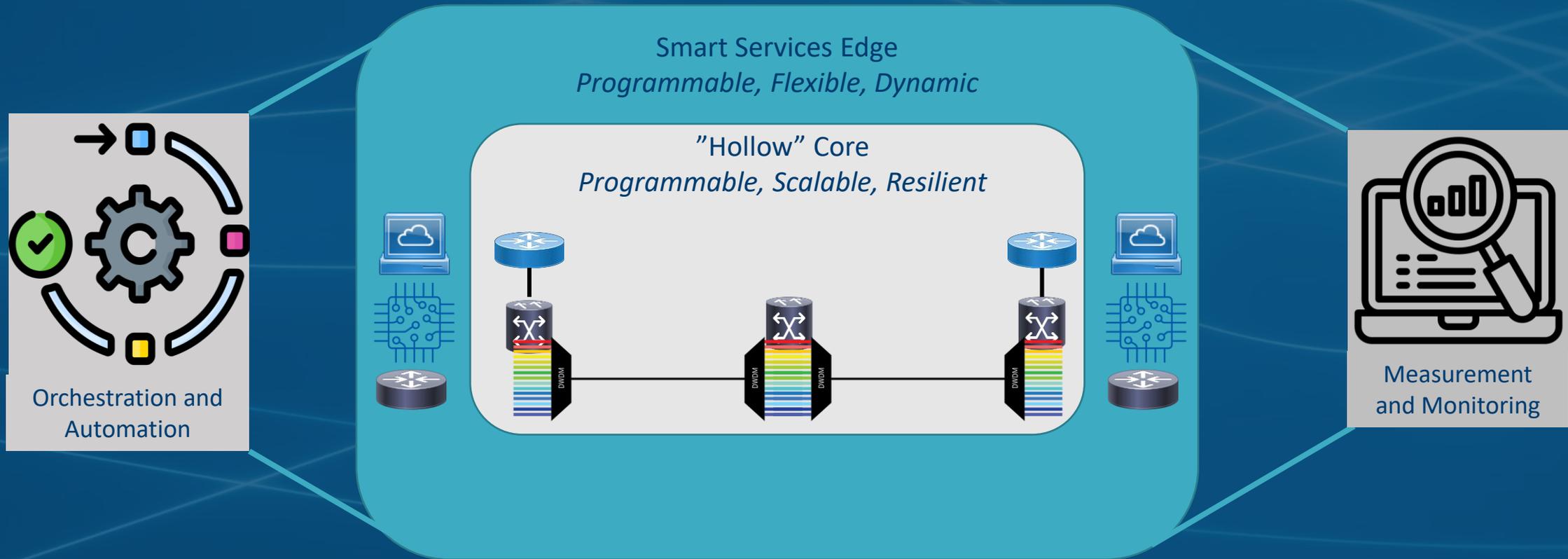
# ESnet6 Project: Six years from concept to done



# ESnet6: design and implementation

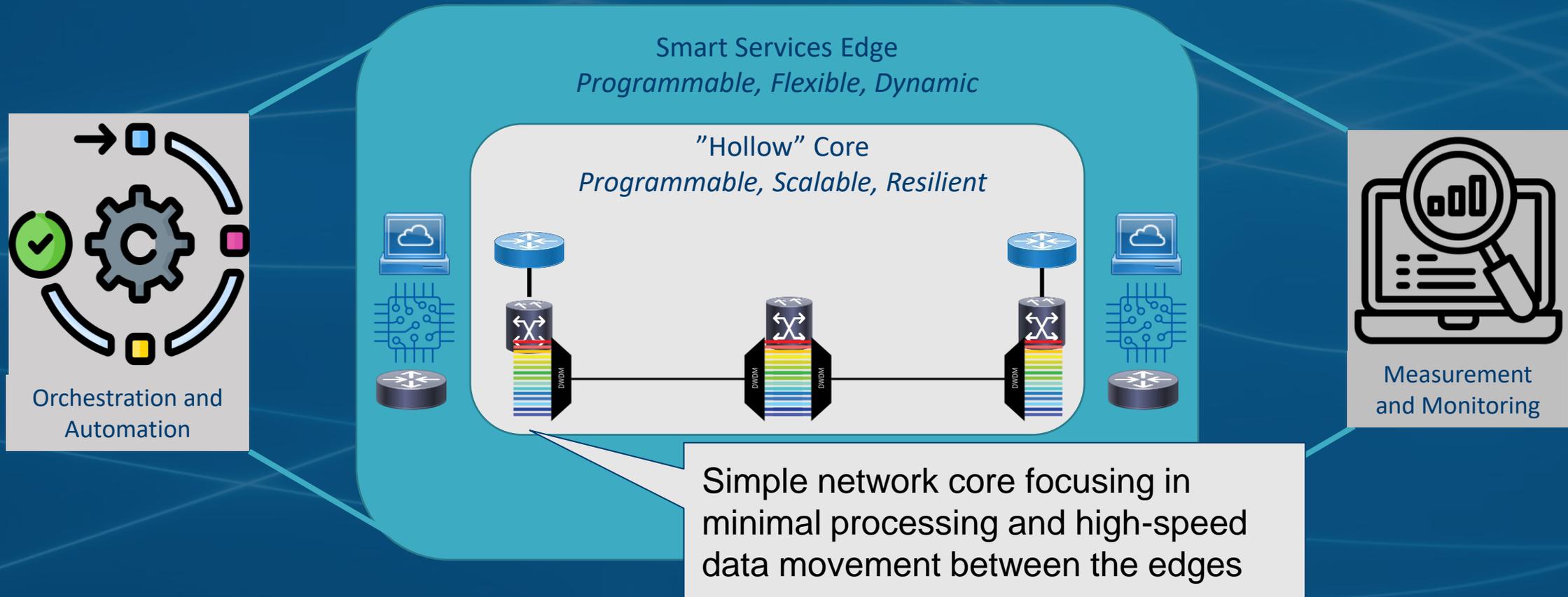
# ESnet6 design represents a transformational change in the way science networks are built

“Hollow” core combined with programmable, smart edge, orchestration and monitoring enables automated, custom, science workflows and proactive management of infrastructure



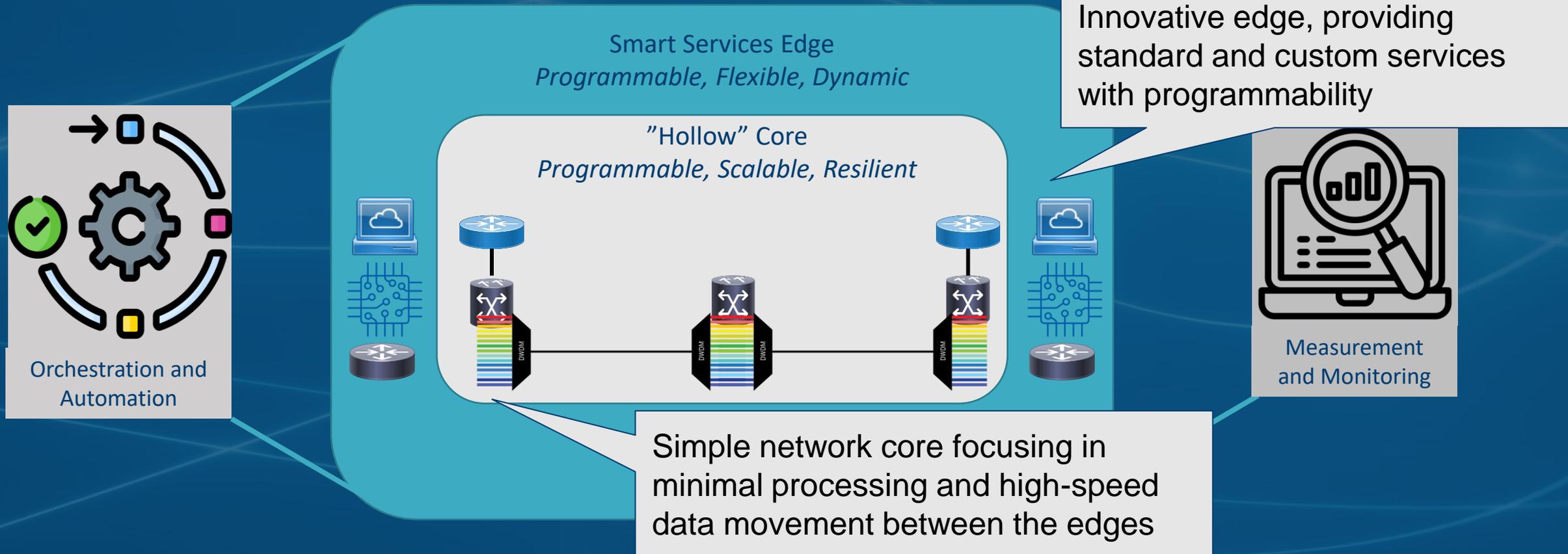
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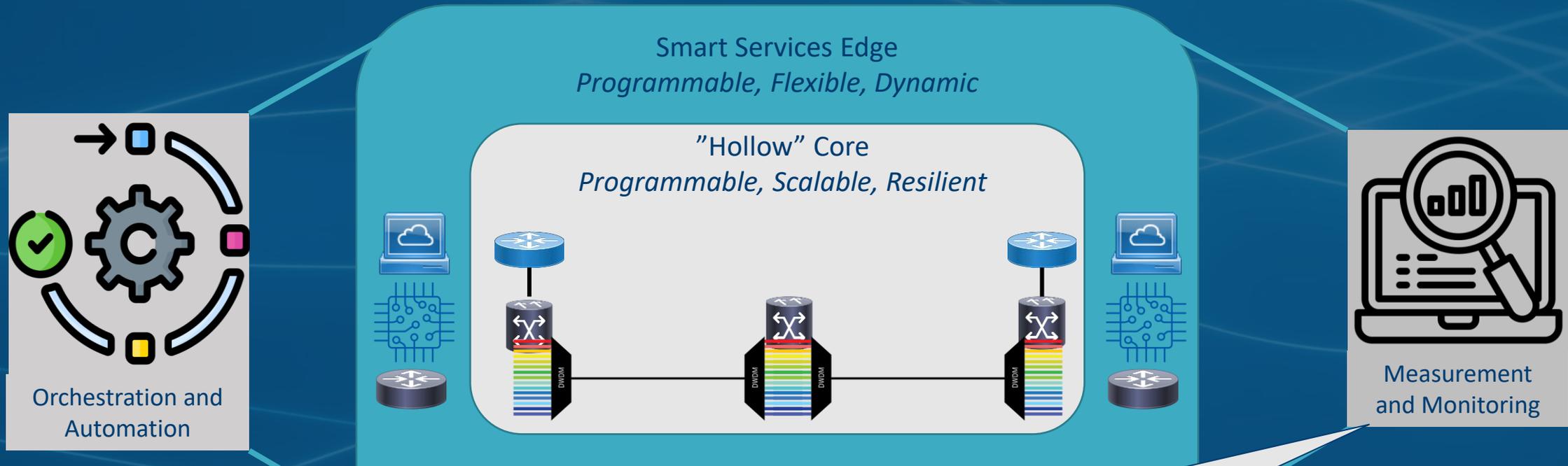
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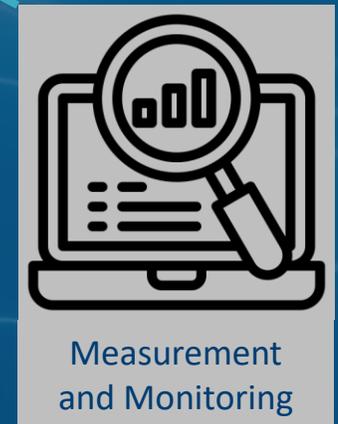
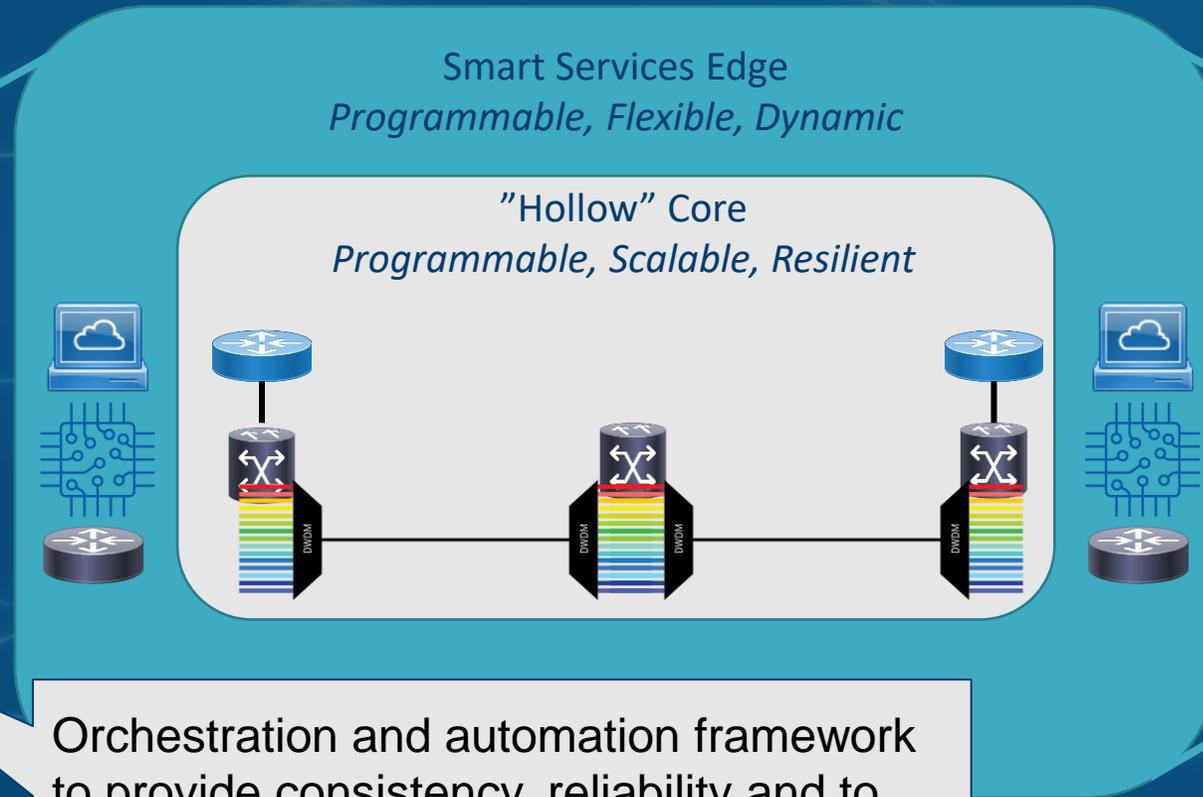
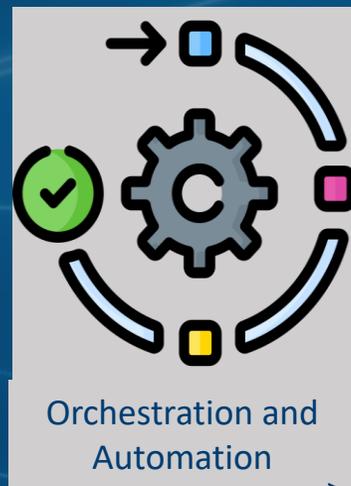
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Unprecedented visibility into the network through telemetry

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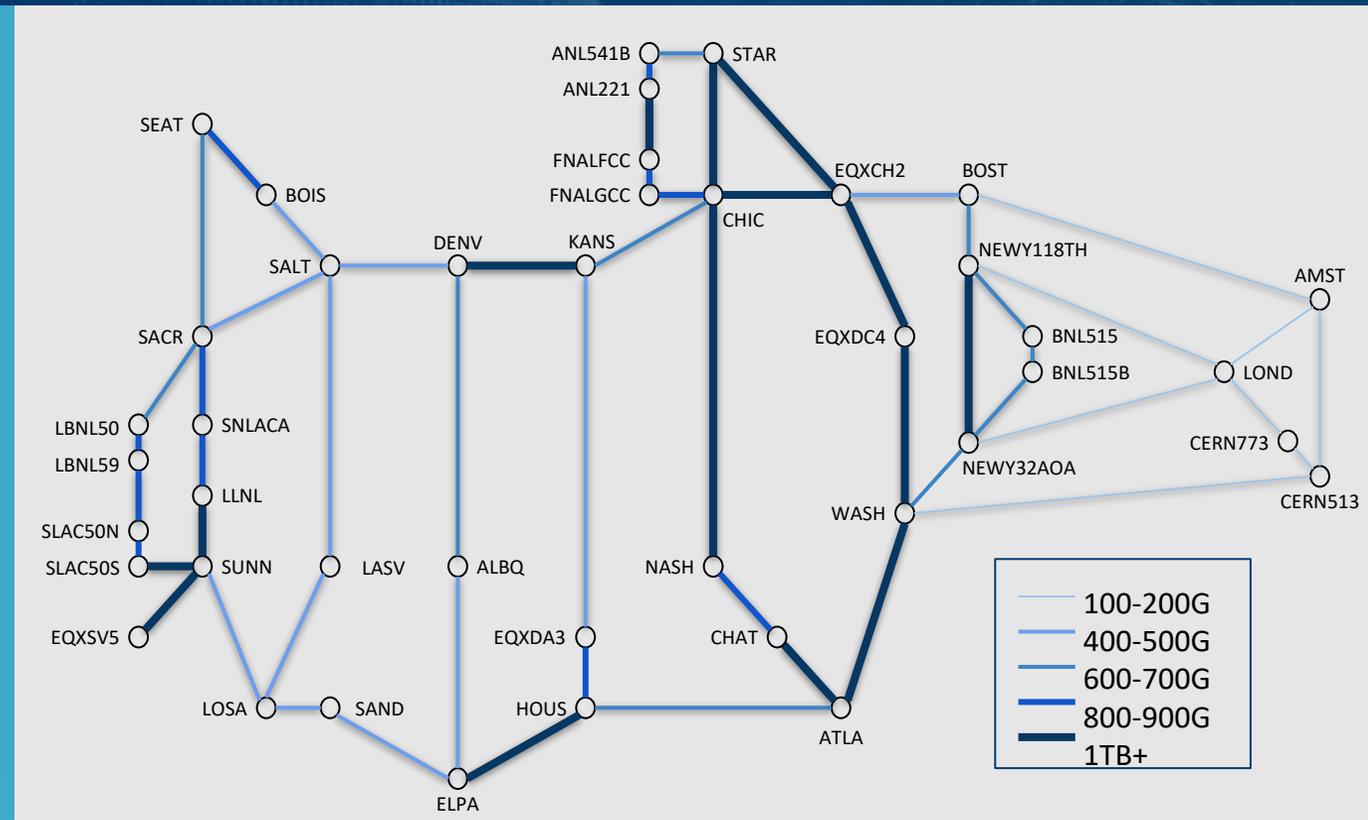


Orchestration and automation framework to provide consistency, reliability and to change the paradigm on how networks are built and run

# ESnet6 lays the foundation for future of data-intensive DOE science

Enough base capacity and ability to cost-effectively add more provides unconstrained access to data, no matter how big or distributed

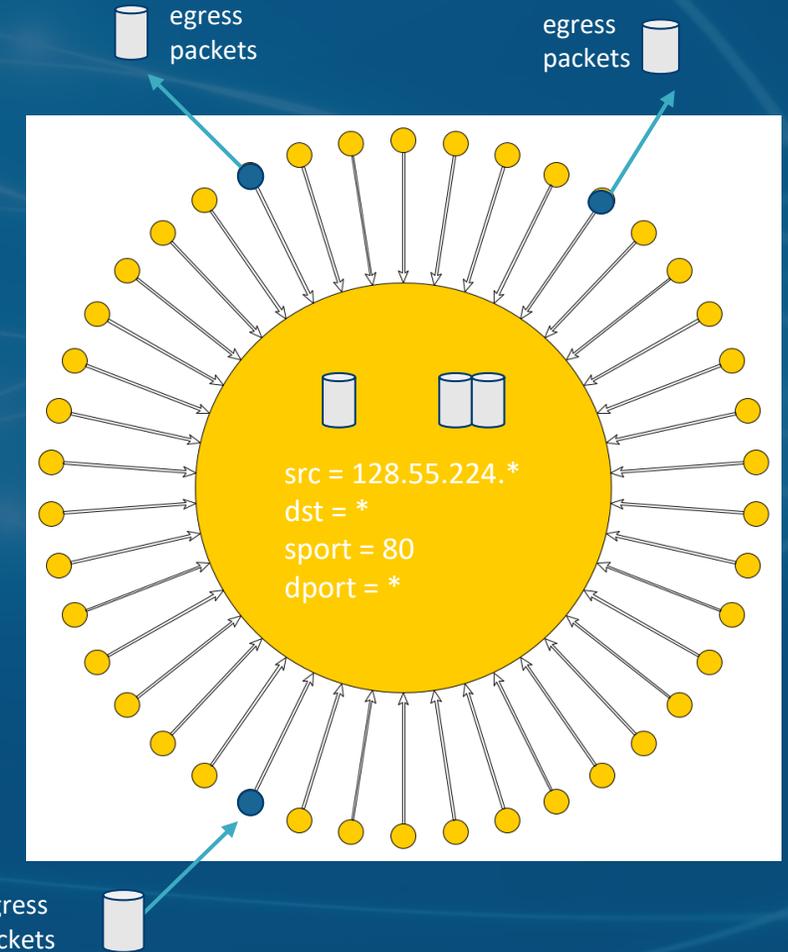
- **15,000 miles** of fiber across the continental US
- **300 leased colocation spaces** installed with ESnet optical equipment
- **46.1 Tbps** aggregate capacity deployed
- **400Gbps - 1 Tbps** services available
- New fiber spans acquired to **increase reliability and reduce latency**



# ESnet6 built capabilities not presently available in commercial products

High Precision telemetry platform forms a packet microscope that can examine 300 million packets per second per node

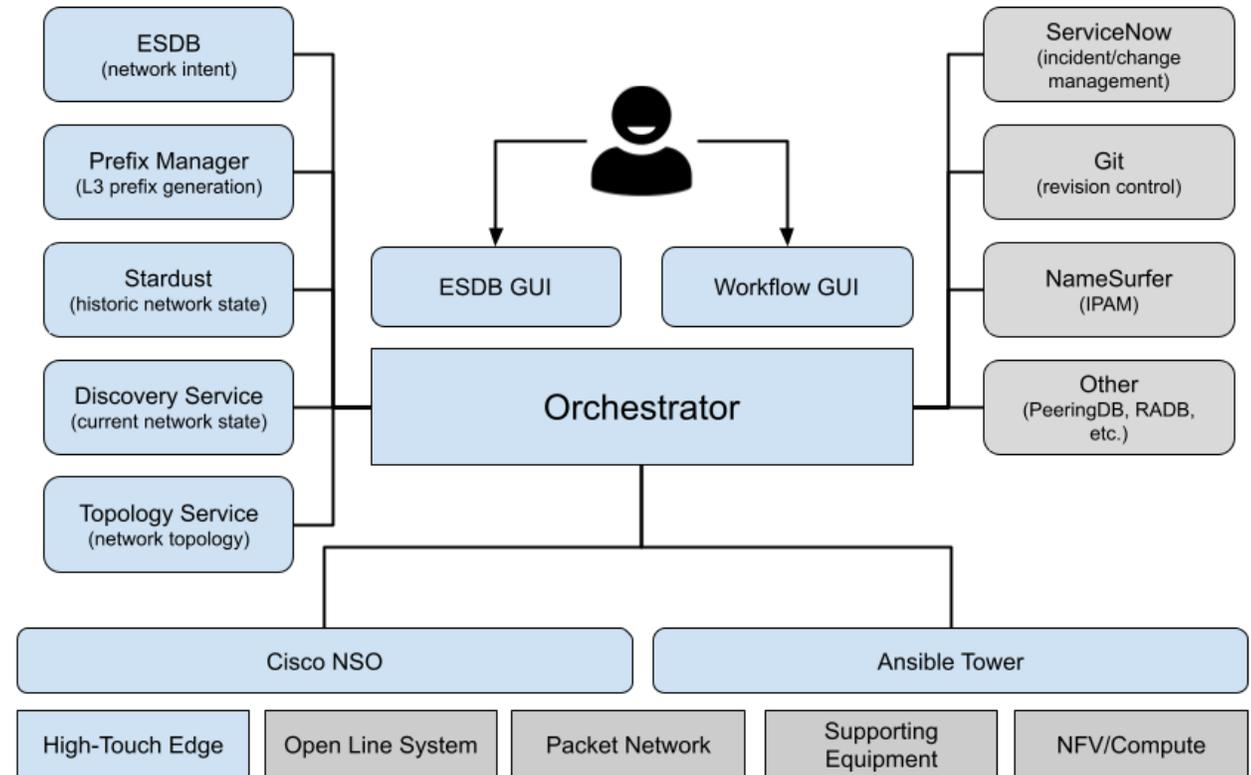
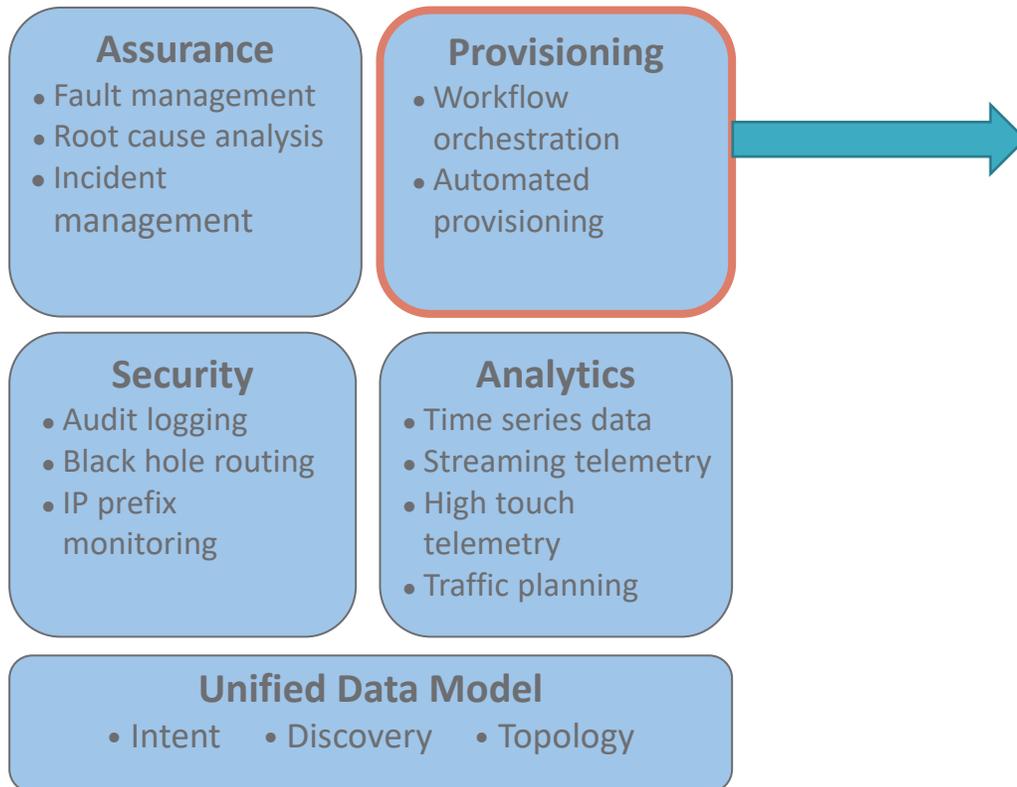
- Ability to choose and follow the flows we want to look at with this 'packet microscope' and 'packet GPS' functionality
- Build capabilities of advanced diagnostics and debugging with packet traces and precision nanosecond timestamps
- Instead of a sampled view (industry standard today), we can get 100% visibility into the flows that we choose to monitor
- Enables us to do continual performance monitoring especially needed with Tbps real-time flows from instruments to supercomputers within the Superfacility/IRI umbrella



# Rationale for investing in software to enable orchestration and automation

Broad vision for a facility software architecture that will drive the next generation of services and allow the facility to scale up inline with the exponential growth of data, instruments and compute

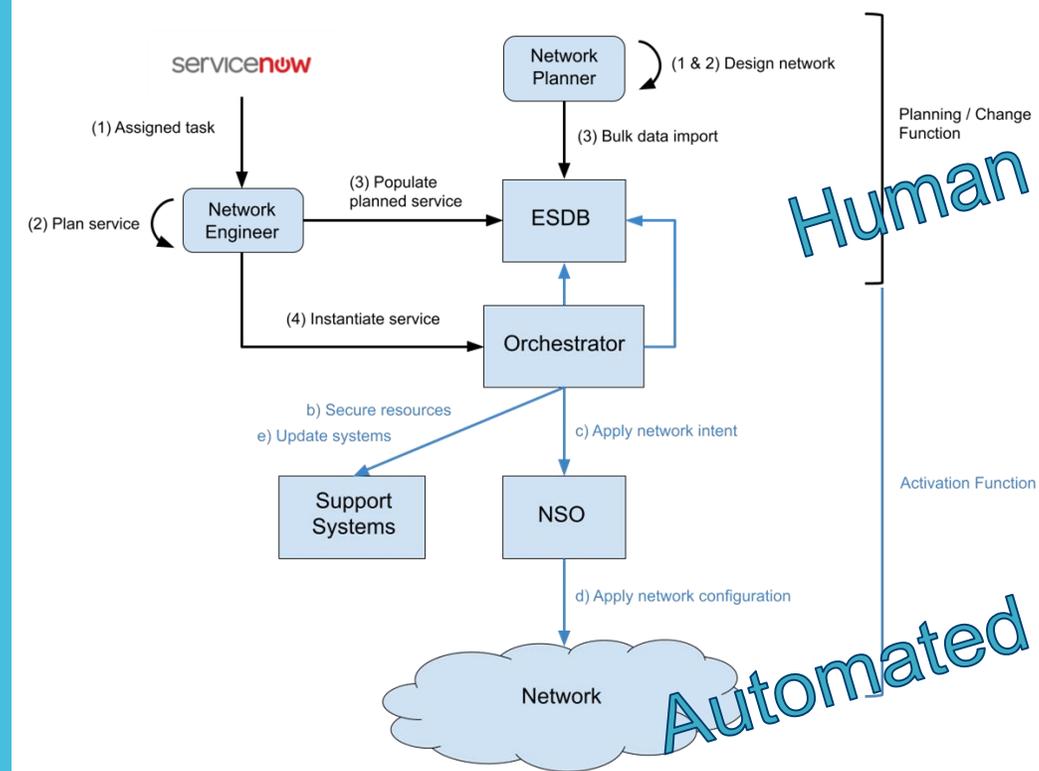
## ESnet6 Software Components



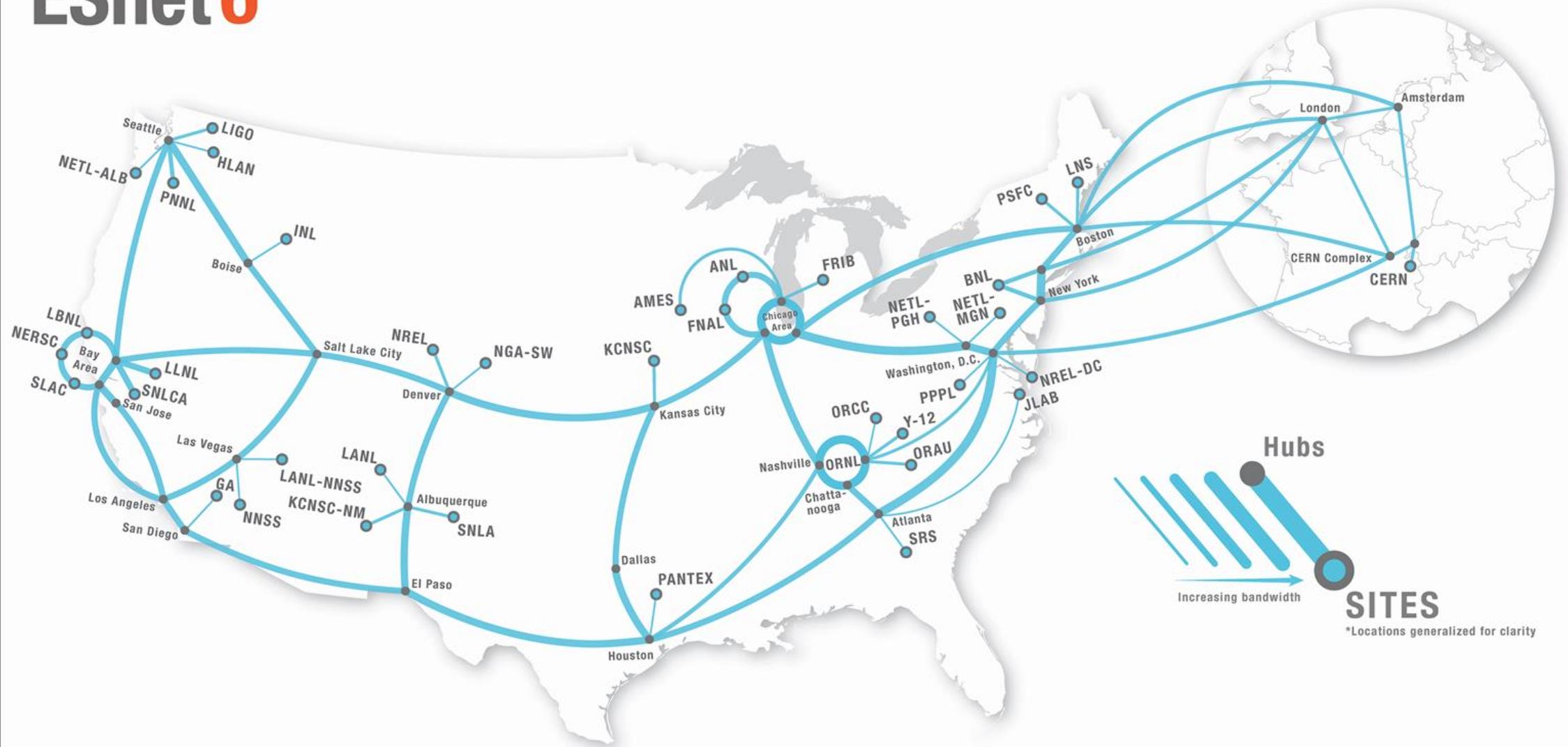
# Orchestration and automation to enable the seamless integration of user facilities and research infrastructure

Automation allows us to proactively and automatically manage configuration of the network and its services with ability to manage and redirect giant flows of science data

- Consistent configuration of the infrastructure for complex user services
- Well designed and tested methods for service deployment and ongoing management
- Reduce probability of human error
- Enhance network reliability
- Enable engineers to focus on design rather than deployment



# ESnet6





Lab, Berkeley Site Office, Project Management Office, DOE Program Managers and Project Office, Finance, Management, R&E partners, ESCC and many more

Thank you!



# ESnet6 success as a project is due to the people that contributed

- 1<sup>st</sup> .First DOE 413.3 Project for the User Facility
- 1<sup>st</sup> First greenfield build of the entire network
- 1<sup>st</sup> First time for ESnet folks to design, build and manage Optical Infrastructure
- 1<sup>st</sup> Hiring and growing the team virtually more than 50%
- 1<sup>st</sup> Dealing with 10x increase in coordination and reporting due to Pandemic
- ✓ Nearly zero unplanned downtime and minimal planned downtime