ESnet

ENERGY SCIENCES NETWORK

ESnet6 Project update

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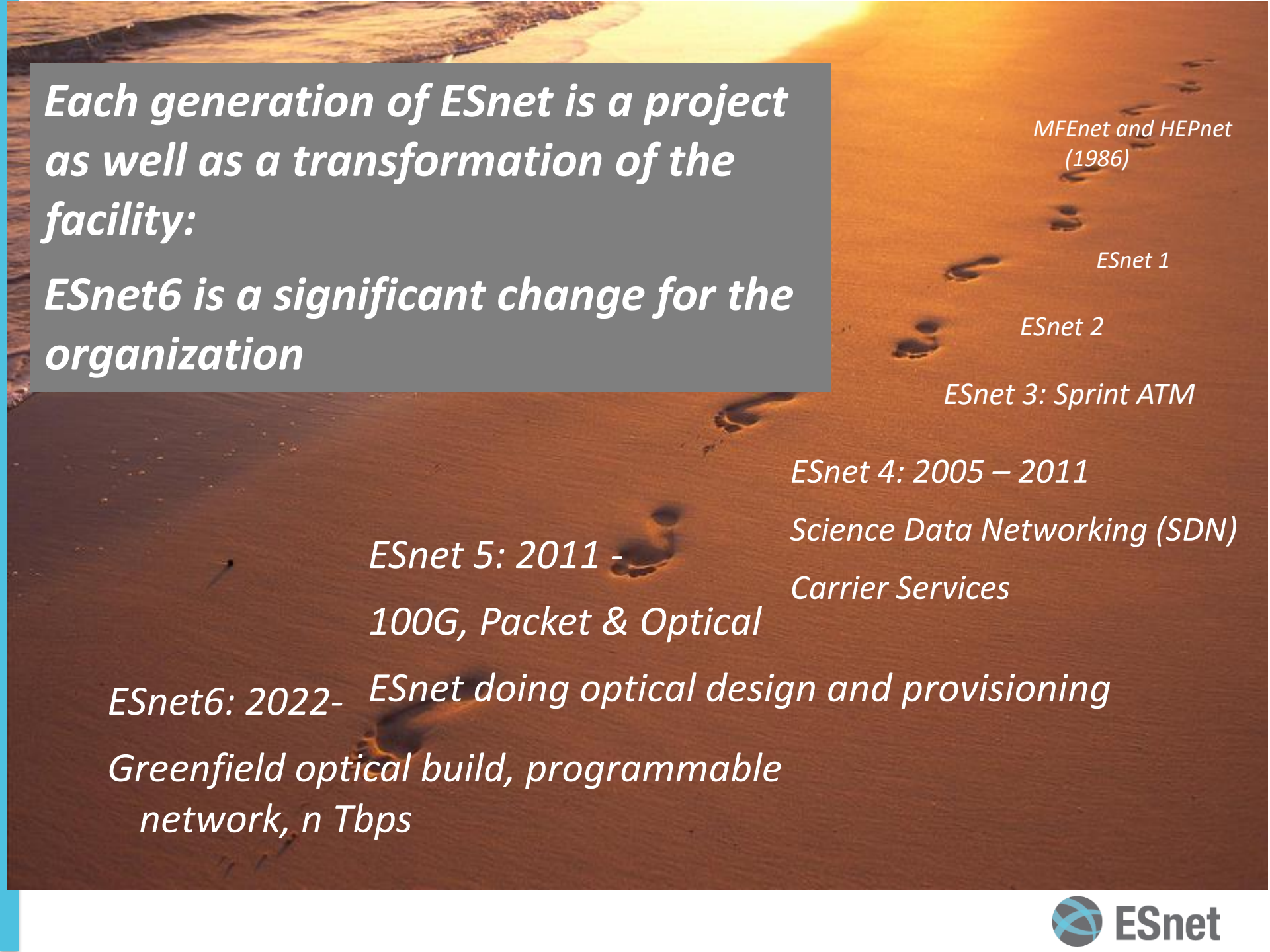
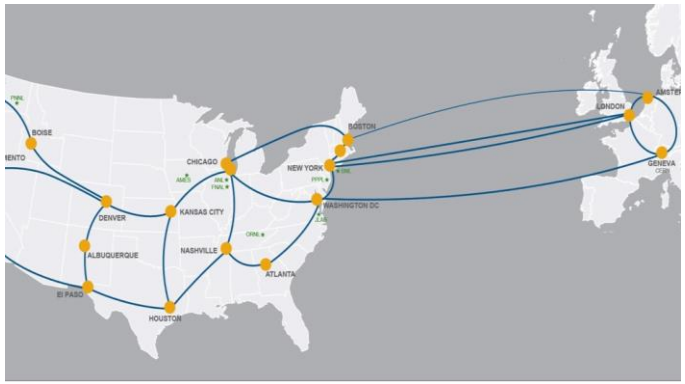
Presented to JET

20-March-2018


Each generation of ESnet is a project as well as a transformation of the facility:
ESnet6 is a significant change for the organization
MFEnet and HEPnet (1986)
ESnet 1
ESnet 2
ESnet 3: Sprint ATM
ESnet 4: 2005 – 2011
Science Data Networking (SDN)
Carrier Services
ESnet 5: 2011 -
100G, Packet & Optical
ESnet doing optical design and provisioning
ESnet6: 2022-
Greenfield optical build, programmable network, n Tbps

ESnet is a dedicated mission network engineered to accelerate a broad range of science outcomes.



ESnet5 has provided unique capabilities, optimized for science, since 2011

Now, ESnet5 infrastructure is nearing end-of-life and capacity demands continue to increase, driving the need for a new network: ESnet6

To continue to meet Mission needs, capability gaps must be resolved:

- Capacity: Network must be able to serve increasing demand
- Reliability and Resiliency: Replace end-of-life equipment, improve cybersecurity protection
- Flexibility: Network needs to adapt to changing compute models, multi-facility workflows (superfacility), real-time data analysis, streaming

ASCR approved ESnet6 Mission Needs (CD0) December 2016

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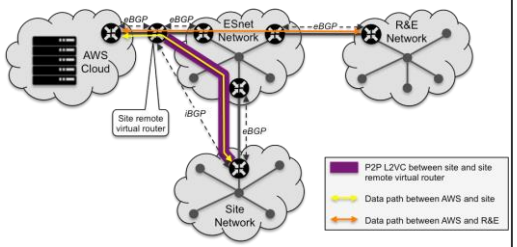
ESnet6 Architecture Design Process

Input on requirements are documented as workflows, which are then formalized as services, driving the technical requirements.

Workflows

Example workflow:

Use of Cloud compute resources as an extension of the site's resources.



Services

Example Service:

Virtual Private Cloud

- Service Description
- Service Attributes
  - Scale
  - Scope
  - Demarcation
- Functional Requirements

Technical Requirements

Example Requirements:

- L2VPN
  - EVPN
  - MPLS
  - ISIS-SR
  - BGP-SR-TE
- e/iBGP
- …

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Service attributes & Defining characteristics

Services

Characteristics that define end-user services

Drive functional & technical requirements: hardware, software, systems components

Scale & Scope

Control & data-plane interaction

Service Level Expectations

Defines required hardware capabilities

Defines software functions needed to support the services

Defines systems behavior

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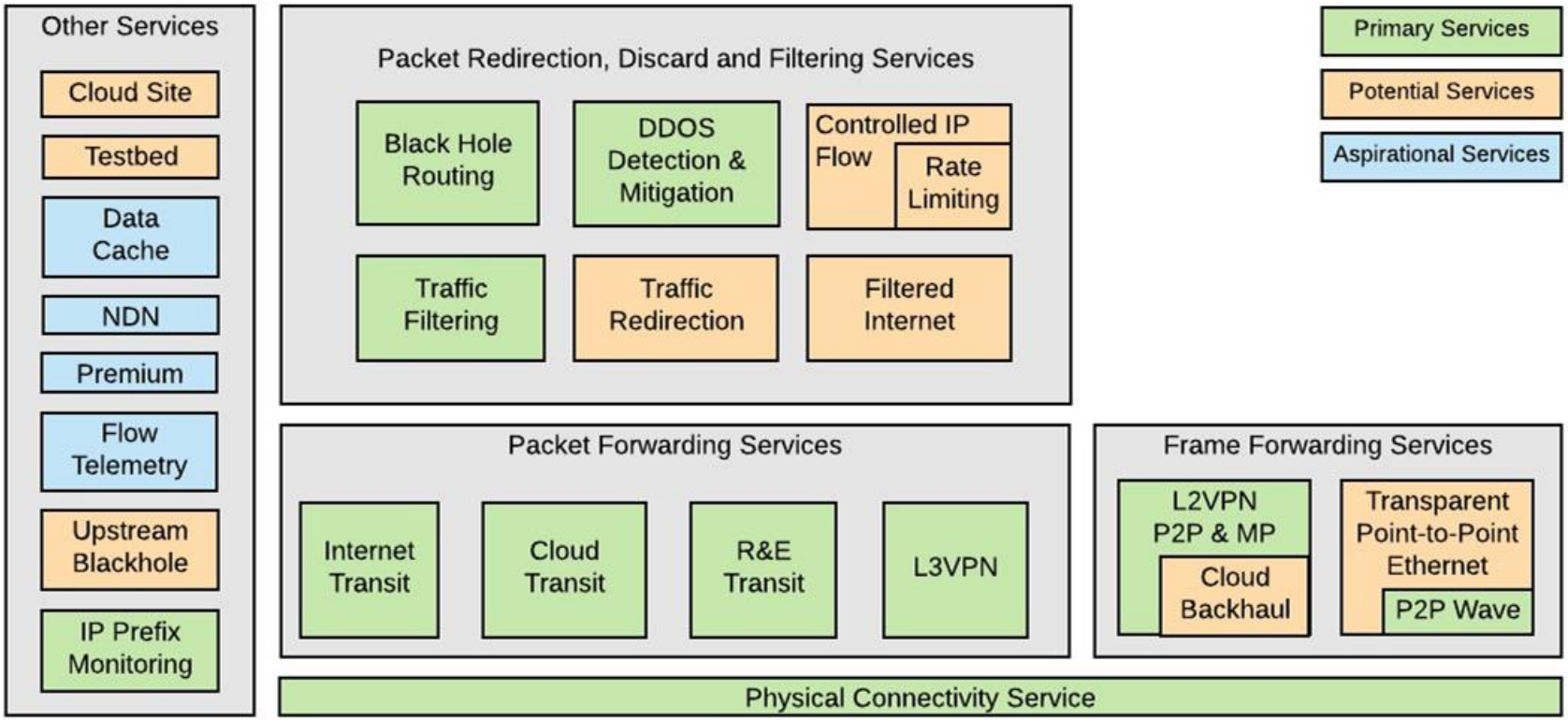
ESnet6 Network Services



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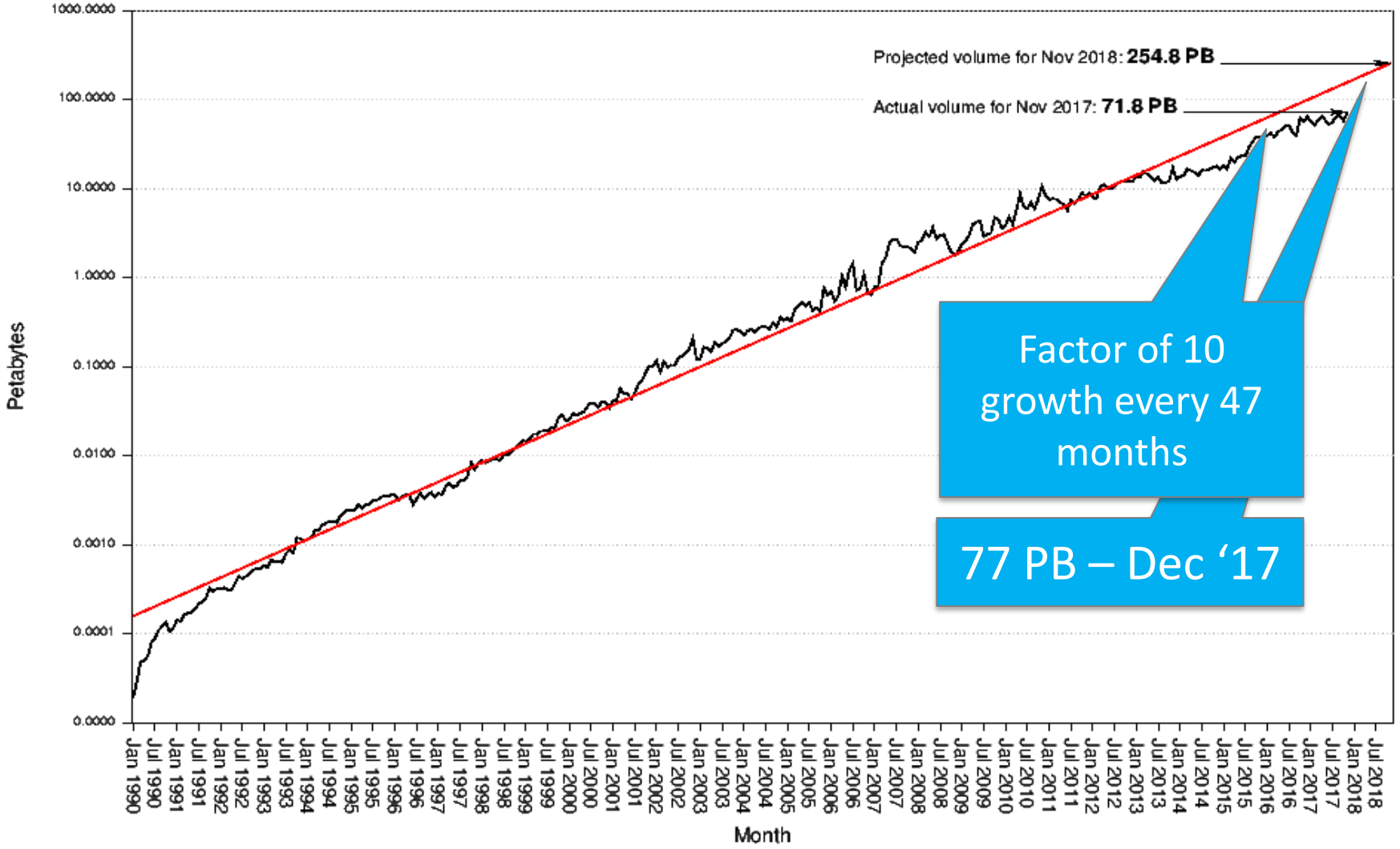
Mission Need #1: Capacity and Capability to handle exponential traffic growth



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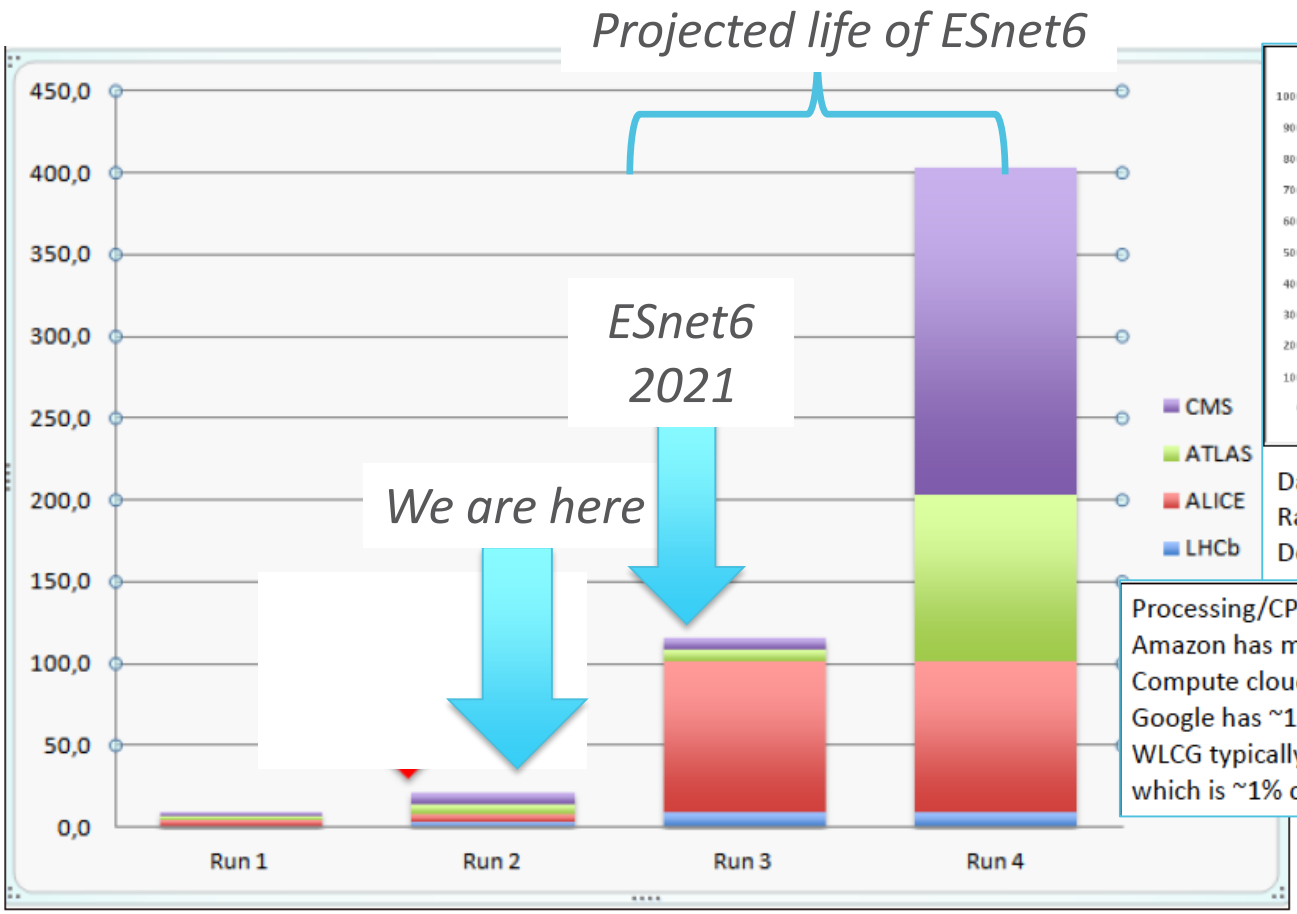
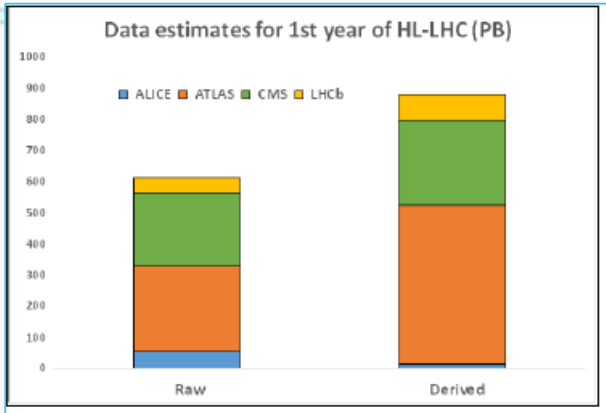
HEP data projects predict 10x-20x growth in data, including new compute models (2021-2027+)





Data:
Raw 2016: ~ 50 PB → 2027: 600 PB
Derived (1 copy): 2016: ~80 PB → 2027: 900 PB

Processing/CPU:
Amazon has more than 40 million processor cores in its Elastic Compute cloud, EC2
Google has ~1million servers and ~20 million cores
WLCG typically has ~500 thousand physical cores in use, which is ~1% of Amazon EC2 capacity

https://indico.mitp.uni-mainz.de/event/84/session/1/contribution/28/material/slides/0.pdf
Dagmar Adamova (NPI AS CR Prague/Rez) and Maarten Litmaath (CERN)

Very rough estimate of new RAW data per year of running using a simple extrapolation of current data volume scaled by the output rates (in PB, follow-up of 2015).
To be added: derived data (ESD, AOD), simulation, user data…

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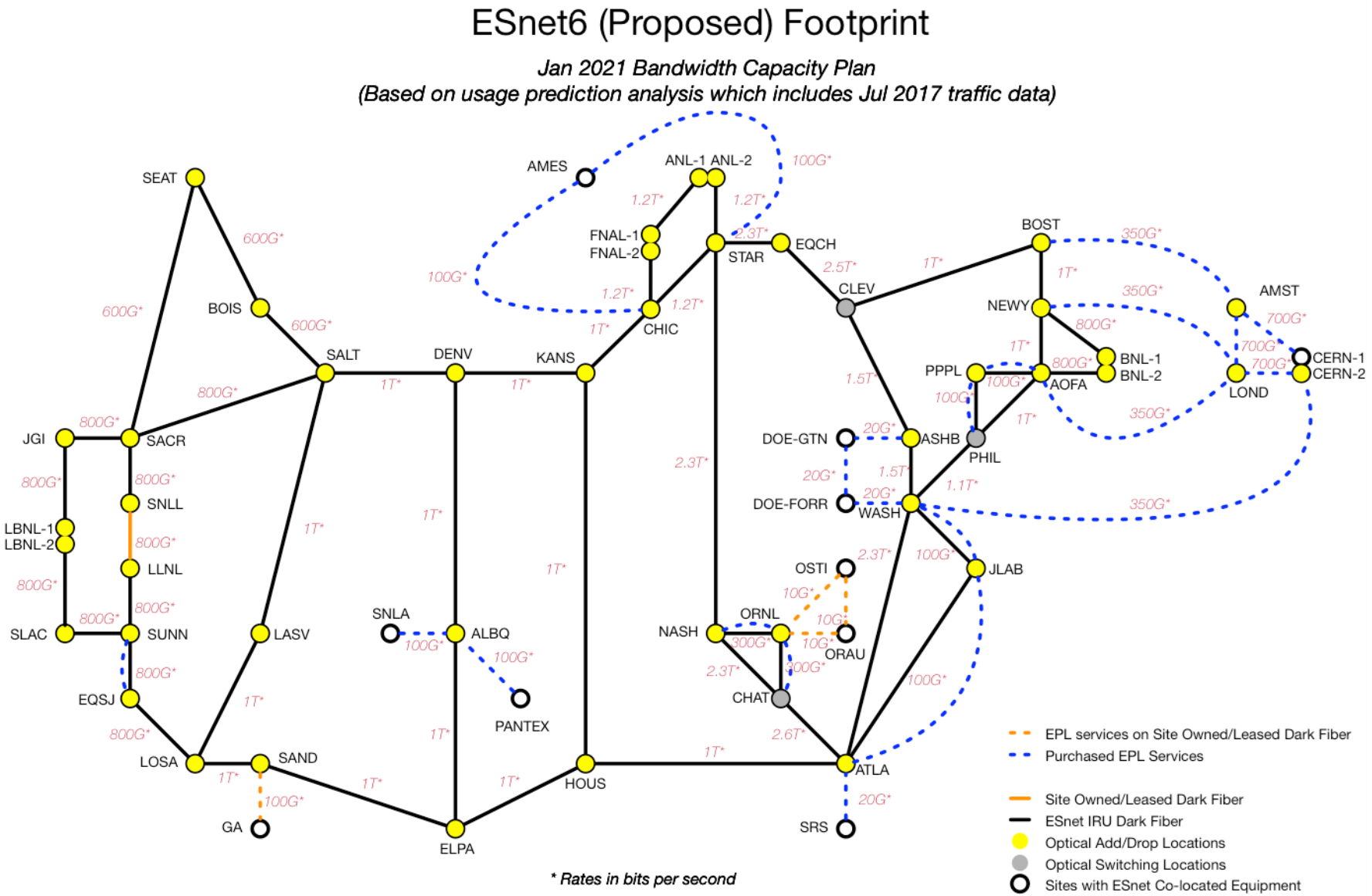
ESnet6 Day-1 Planned Capacity (Jan 2021)



NB: Some sites without PE routers on local premises are not shown in this diagram

The ESnet Dark Fiber Footprint - A Clean Canvas

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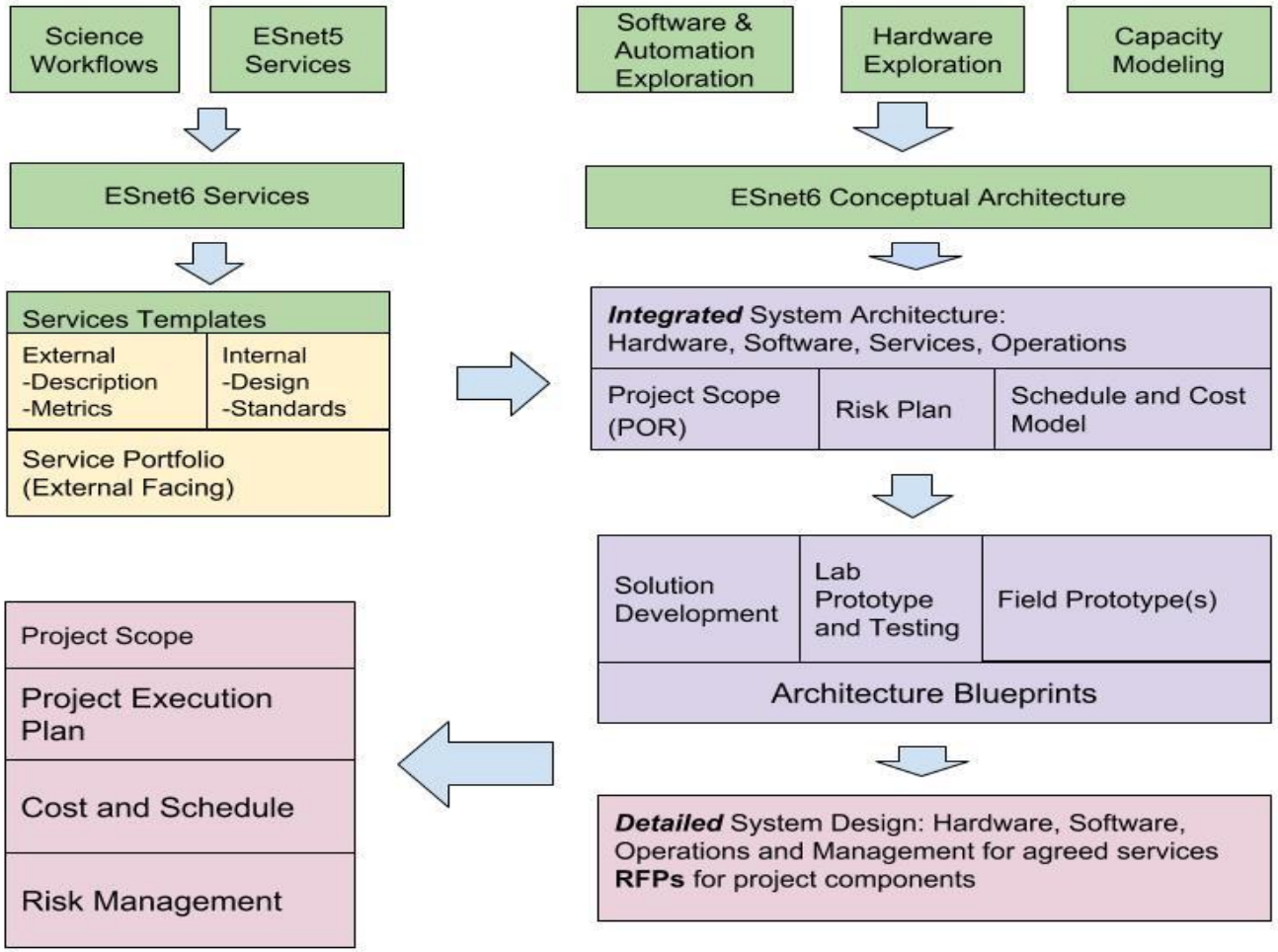
ESnet6 Project Execution Flow



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ESnet6 Optical Core Characteristics

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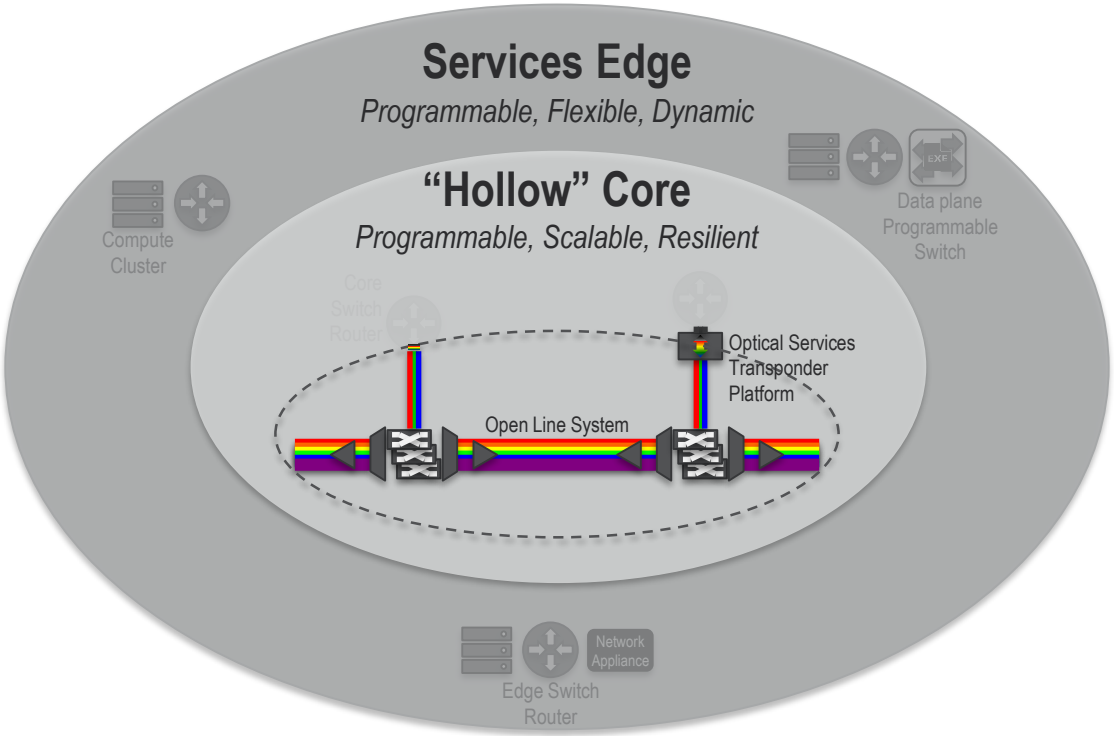
Orchestration and Automation

Monitoring and Measurement



MOTIVATION

Optical disaggregation allows cost effective scaling of long haul bandwidth and transponder vendor flexibility.

CAPABILITIES

Enables light path connections within the Core.

Hardware	Software	Systems	Security
• Flexible grid system • Colorless and directionless (not contention-less) programmable wavelength switching • Flexibility to support 3rd party transponders (Open Line system) • API for programmatic access* **NB: If needed for 3rd party optical NMS*	• Physical simulation, modeling, and topology**, +, ++ • Path computation and provisioning**, ++ • Root cause analysis**, + • NB-API for network statistics, automation and (multi-layer resource) orchestration** ***NB: Potentially dedicated optical NMS functions and capabilities* *+NB: Function of "Monitoring and Measurement" component* *++NB: Function of "Orchestration and Automation" component*	• Operations, Administration, Maintenance, Provisioning, Troubleshooting (OAMPT) functions***, +, ++ ****NB: Integrated management system to manage disaggregate optical systems components* *+NB: Function of "Monitoring and Measurement" component* *++NB: Function of "Orchestration and Automation" component*	• Physical access controls • Access restriction to management and control plane • Policy enforced execution of management and control functions

ESnet6 Packet Core Characteristics

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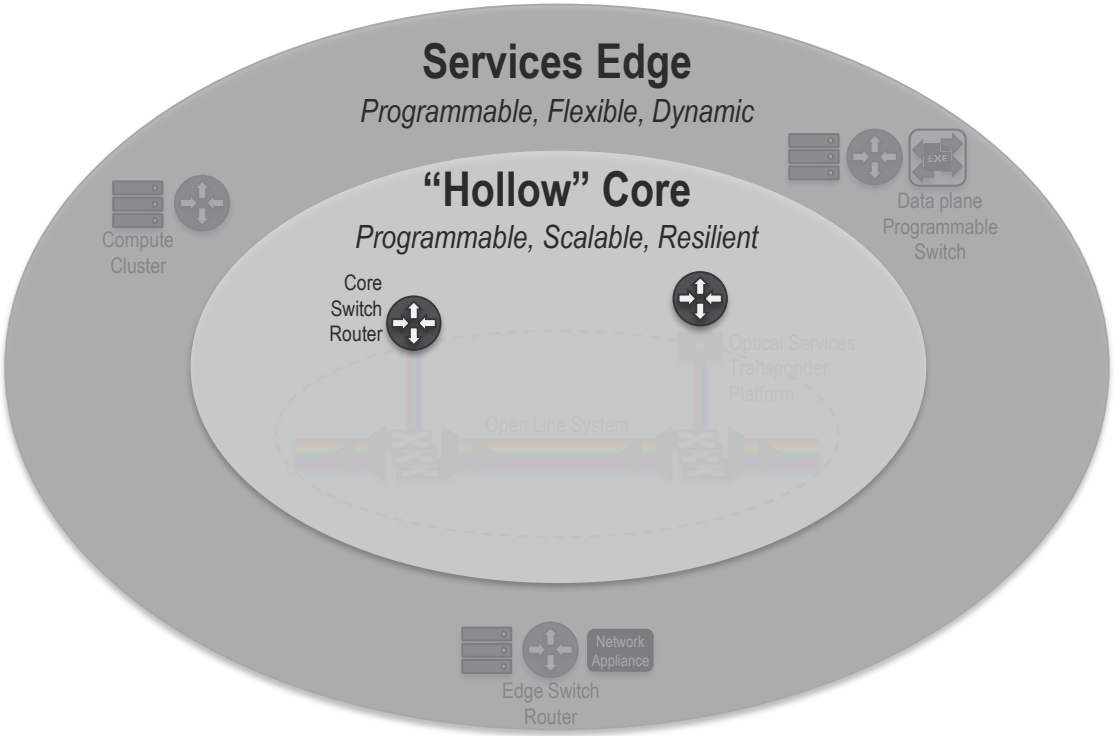
Orchestration and Automation

Monitoring and Measurement



MOTIVATION

Simplified core feature set (vs core+edge) allows switch/router platforms w/ greater scaling and resiliency.

CAPABILITIES

Enables resilient (P2P) packet "tunnels" within the Core by leveraging traffic engineering, protection, restoration, and QoS functions.

Hardware	Software	Systems	Security
• Deep buffers to support bursts and aggregation • QoS functions to prioritize traffic • API for programmatic access • Cost optimize for capacity augmentation	• Modeling and topology*, +, ++ • Path computation, traffic engineering, and provisioning*, ++ • Protection and recovery* • Root cause analysis+ • Capacity planning+ **NB: Potentially "in-skin" functions and capabilities* *+NB: Function of "Monitoring and Measurement" component* *++NB: Function of "Orchestration and Automation" component*	• OAMPT functions+, ++ • Network information collection, analysis, and archiving+ *+NB: Function of "Monitoring and Measurement" component* *++NB: Function of "Orchestration and Automation" component*	• Physical access controls • Access restriction to management and control plane • Policy enforced execution of management and control functions

ESnet6 Services Edge "Low-Touch Path" Characteristics

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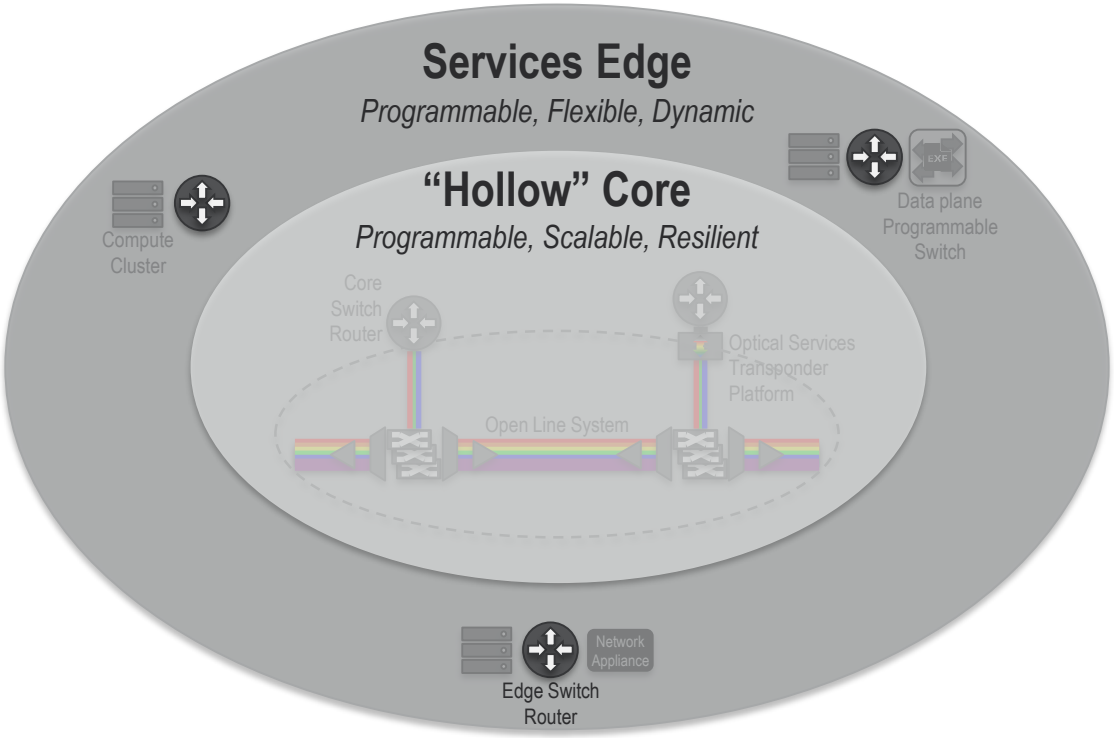
Orchestration and Automation

Monitoring and Measurement



MOTIVATION

Well-defined service edge that takes advantage of commodity switch/router scaling to support edge complexity, maintaining simplicity in the core.

CAPABILITIES

Enables service instantiations by employing (FIB) isolation, encapsulation, prioritization, forwarding, and filtering functions.

Hardware	Software	Systems	Security
• Deep buffers to manage fan-in/out and speed mismatches • QoS functions to prioritize traffic • Internet scale routing • API for programmatic access	• Protocols for external (customer) interactions* • Service instantiations++ • Usage anomaly detection+ **NB: Potentially "in-skin" functions and capabilities* *+NB: Function of "Monitoring and Measurement" component* *++NB: Function of "Orchestration and Automation" component*	• OAMPT functions+, ++ • Network information collection, analysis, and archiving+ *+NB: Function of "Monitoring and Measurement" component* *++NB: Function of "Orchestration and Automation" component*	• Physical access controls • Access restriction to management and control plane • Policy enforced execution of management and control functions • Threat detection • Data plane protection and access restrictions

ESnet6 Services Edge "High-Touch Path" Characteristics

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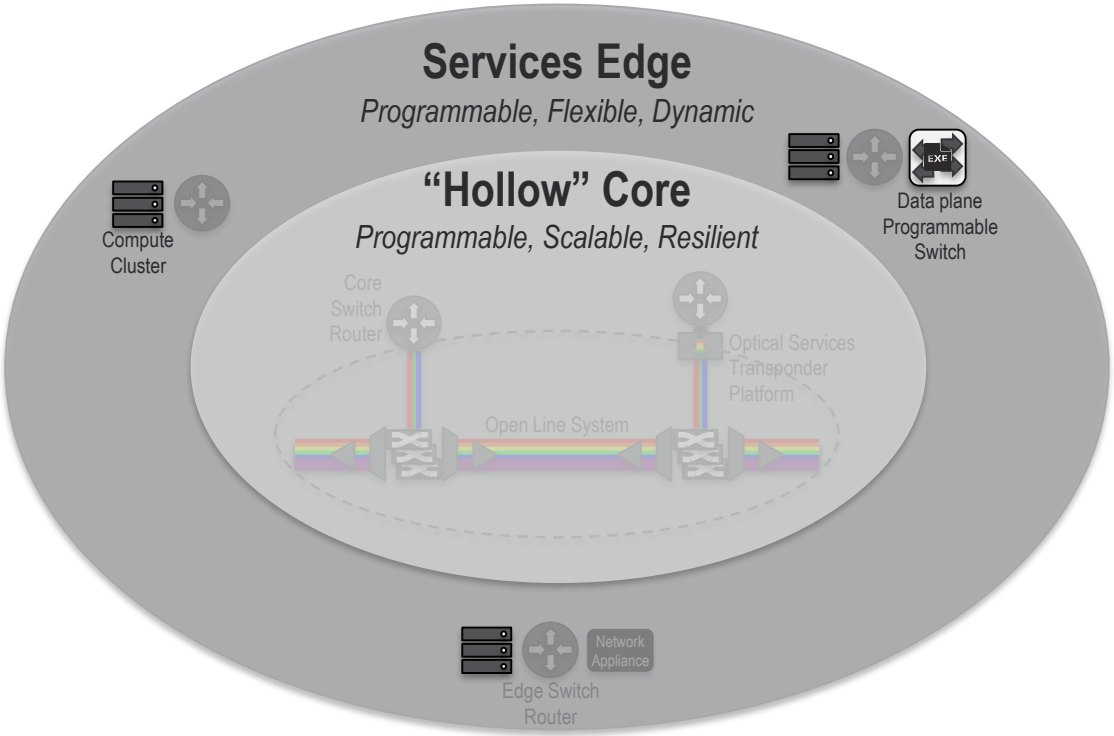
Orchestration and Automation

Monitoring and Measurement



MOTIVATION

Maximizes flexibility of services while minimizing risk by segregating high touch path.

CAPABILITIES

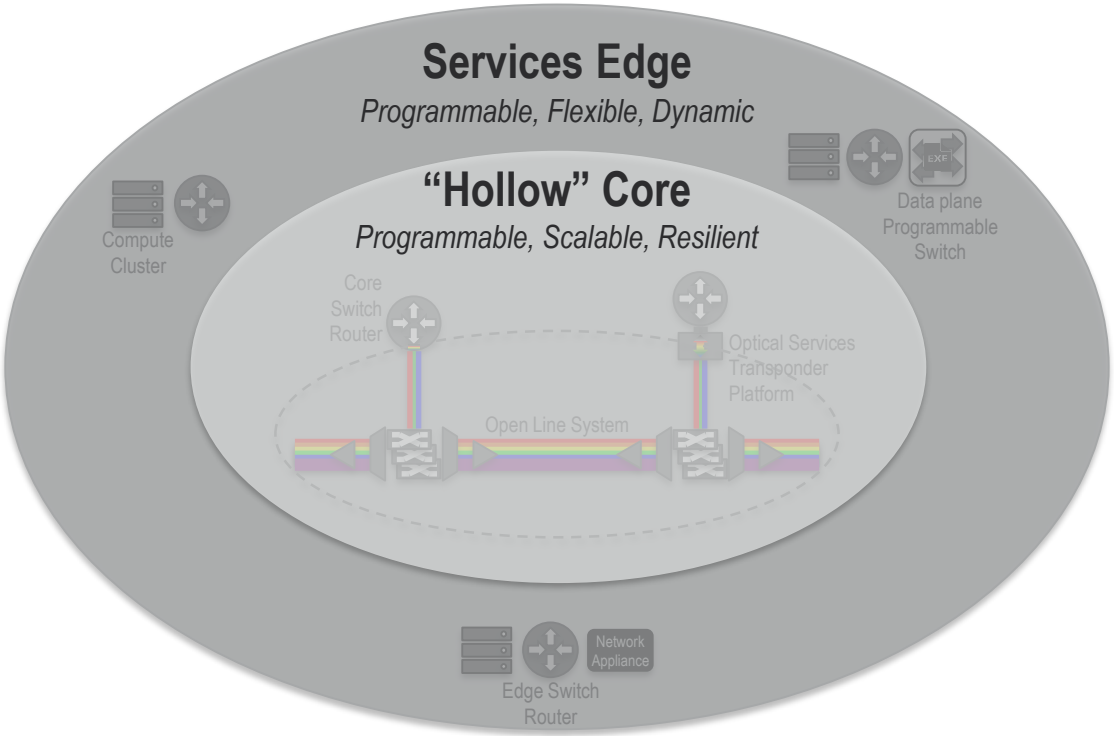
Enables new service creations by providing flexible packet pipeline configurations to facilitate custom encapsulations and match forwarding.

Hardware	Software	Systems	Security
• Compute resources (and necessary virtualization) to support NFV / VFN • Programmable data plane (e.g. FPGA, NPU) • API for programmatic access	• NFV / VFN functions (e.g. telemetry, IDS, SDX, etc) • Service instantiations[++] *[++]NB: Function of "Orchestration and Automation" component*	• OAMPT functions (including compute resources)[+, ++] • Network information collection, analysis, and archiving[+] *[+]NB: Function of "Monitoring and Measurement" component* *[++]NB: Function of "Orchestration and Automation" component*	• Physical access controls • Access restriction to management and control plane • Policy enforced execution of management and control functions • Threat detection • Data plane protection and access restrictions

ESnet6 Orchestration and Automation, Monitoring and Measurement Characteristics

Orchestration and Automation

Monitoring and Measurement



MOTIVATION

Building a "zero" touch network and enabling intelligent functions

CAPABILITIES

Enables the management and scaling of services.

Hardware	Software	Systems	Security
• Compute resource (and necessary virtualization) to support orchestration and automation, and monitoring and measurement functions	• NFV / VFN functions (e.g. telemetry, IDS, SDX, etc) • Workflow management and service instantiation	• Multi-layer/resource OAMPT functions • Network information collection, analysis, and archiving • HA for services • Data storage resiliency	• Access controls • Policy enforced execution of orchestration and automation functions • Data security and integrity

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Guiding Principles

- Zero touch self regulating network
  - Avoid manual intervention in the daily operations of the network;
  - Prioritize automation of frequent operations over infrequent ones;
  - Manage network via a declarative interface.
- Highly available fault stream
  - Without fault the operational state of the network is unknown;
  - A basic fault monitoring system must always be available.
- Engineers must be able to take corrective action
  - If orchestration is not available then EMS or direct CLI access is acceptable.
- Clearly defined source of truth for all configuration data
  - Reduce data bloat and operational errors by maintaining a single “master” within the network.
- Leverage proven cloud technologies where applicable
  - Whether locally or remotely hosted, cloud technologies have matured into a reliable scalable runtime solution.

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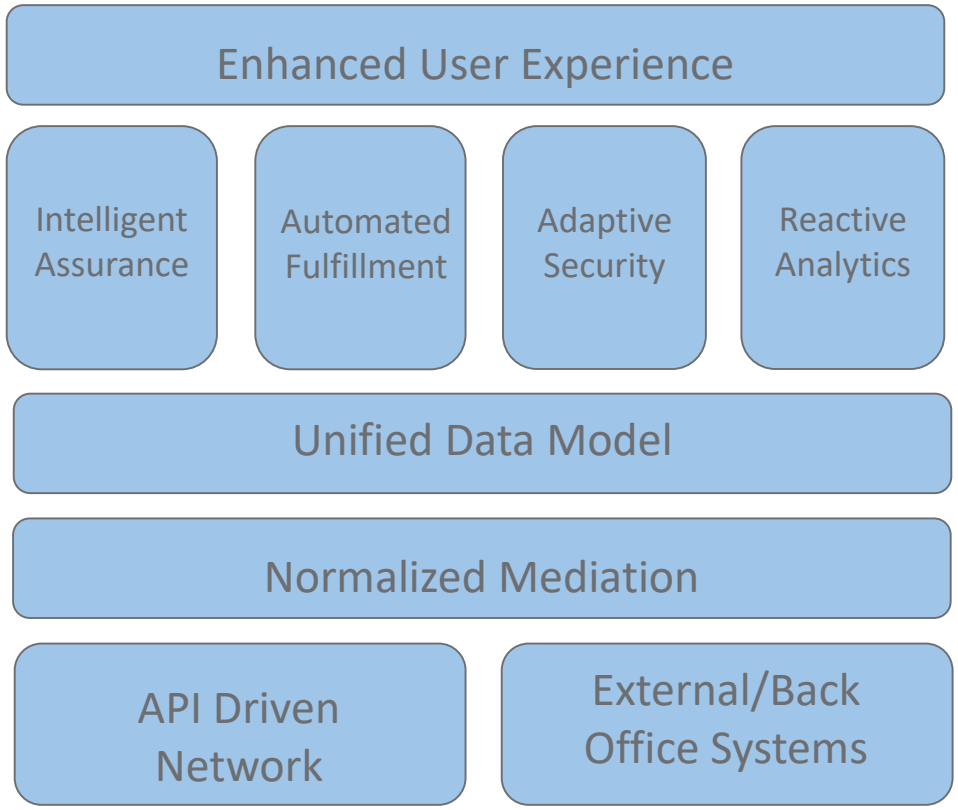
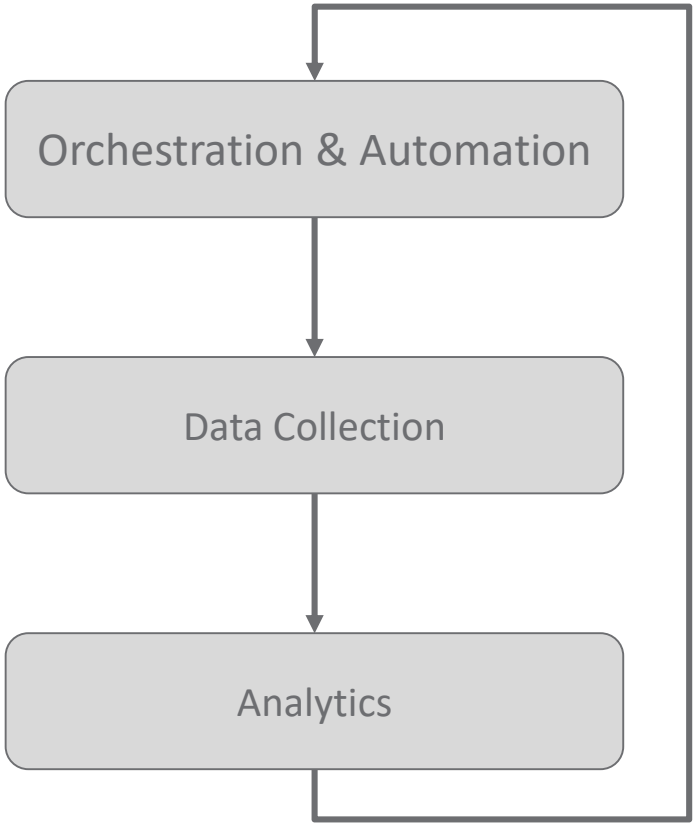
Software Architecture

Software Pillars:



Feedback Loop:



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ESnet5 vs ESnet6 Key Differences

	ESnet5	ESnet6
Optical System	Closed optical system with single vendor integration of transponders and line system	Optical disagreggation with open line system and flexible transponder selection
Core Transport	Hop-by-hop routing at each node.	Logical tunnels switched through core with forwarding decisions made at service edge.
Automation	80% of configuration is hand-curated.	Focus on orchestration and automation with goal of removing CLI from workflows
Programmable Data Plane	Nonexistent	Colocated programmable data plane and compute enable new services

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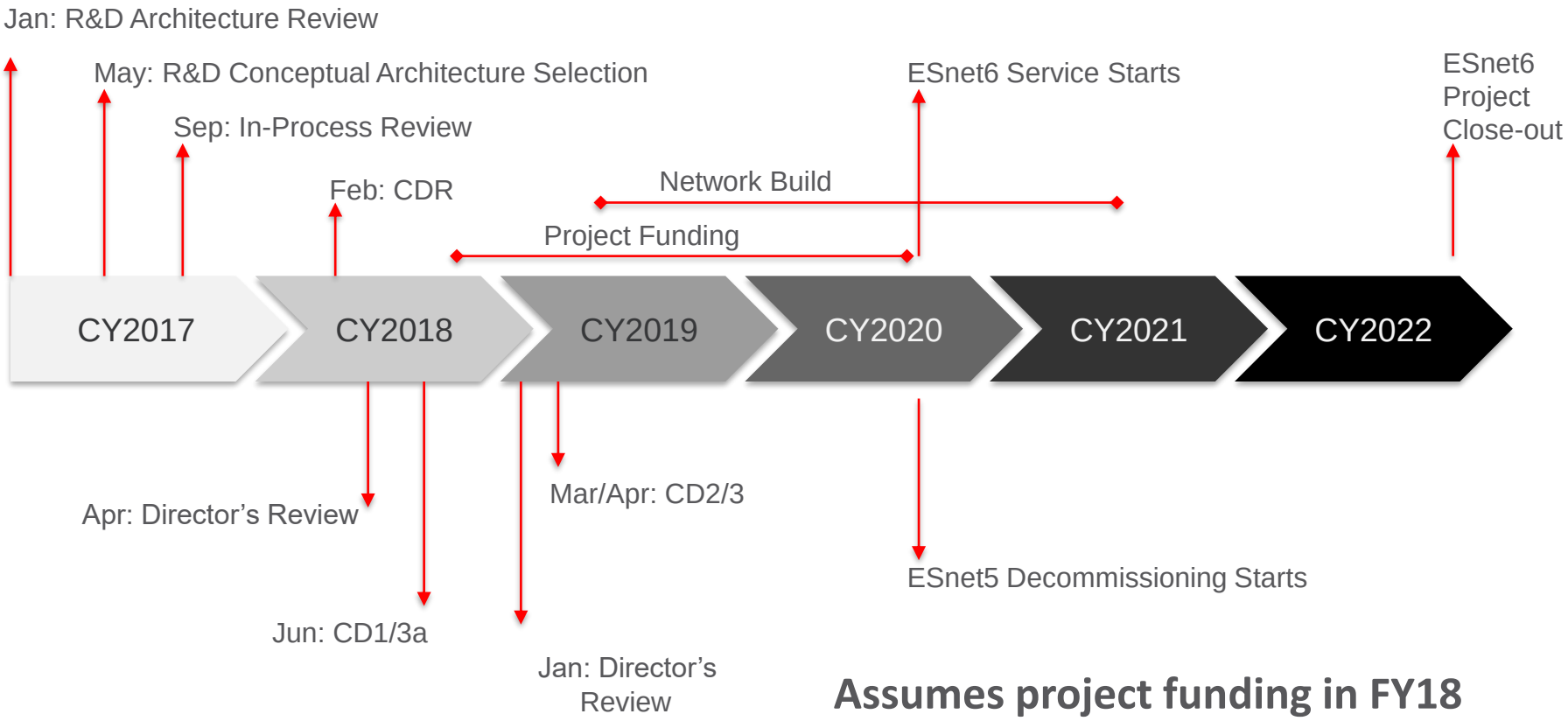
ESnet6 Proposed Project Timeline



Assumes project funding in FY18

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Conceptual Design Review: Strong endorsement Design meets mission and of continued innovation

programmable data plane and a security services architecture. The overall conclusion of this review is a solid yes to each of the charge questions. Moreover the review committee concluded:

- ESnet is essential to the success of the science mission of the Department of Energy.
- The committee is convinced that deploying an innovative hollow core optical architecture with an intelligent service edge as proposed by the ESnet team has the right properties to meet the mission of ESnet.
- The presented optical open line strategy avoids vendor lock in which heavily resonated with the committee. The software complexity is traded off against future-proofing the system, potentially reducing costs down the line, and stimulating innovation.
- The programmable data plane approach is critical to the success of ESnet being an innovative collaborator with its users.

Snapshot from the Executive Summary CDR report

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"Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Networking and Information Technology Research and Development Program."

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