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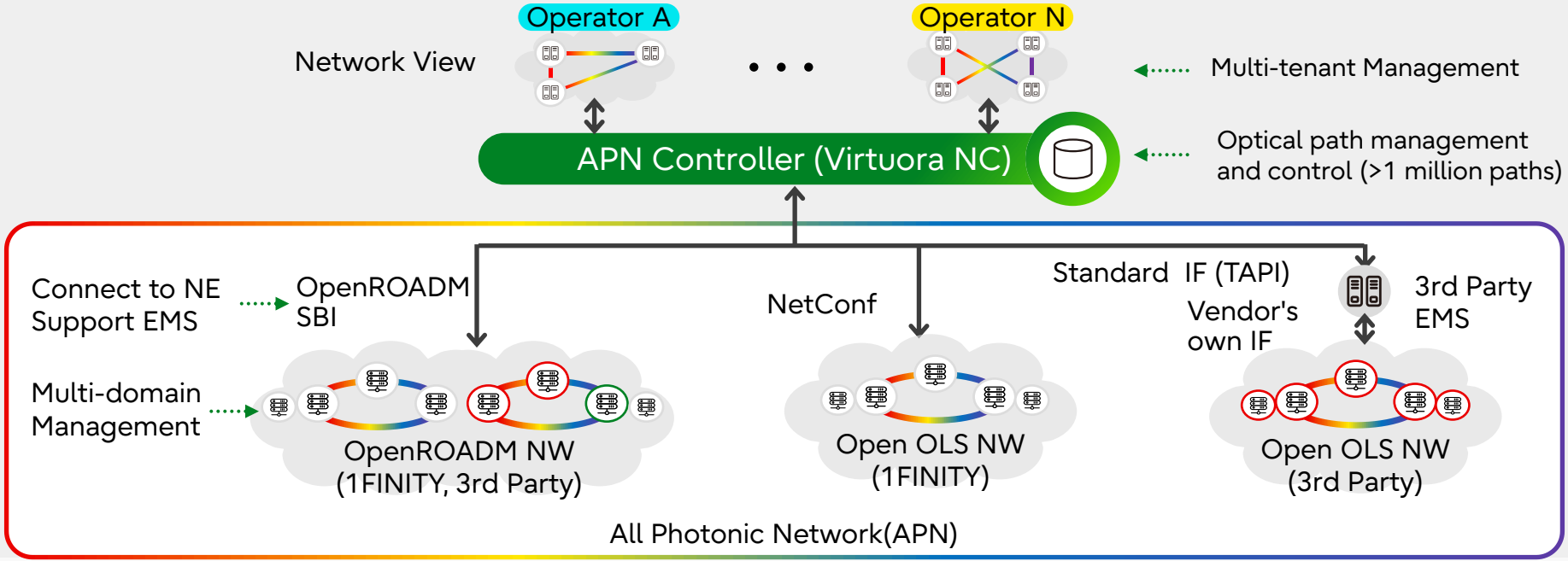
Network Digital Twin for All Photonic Network

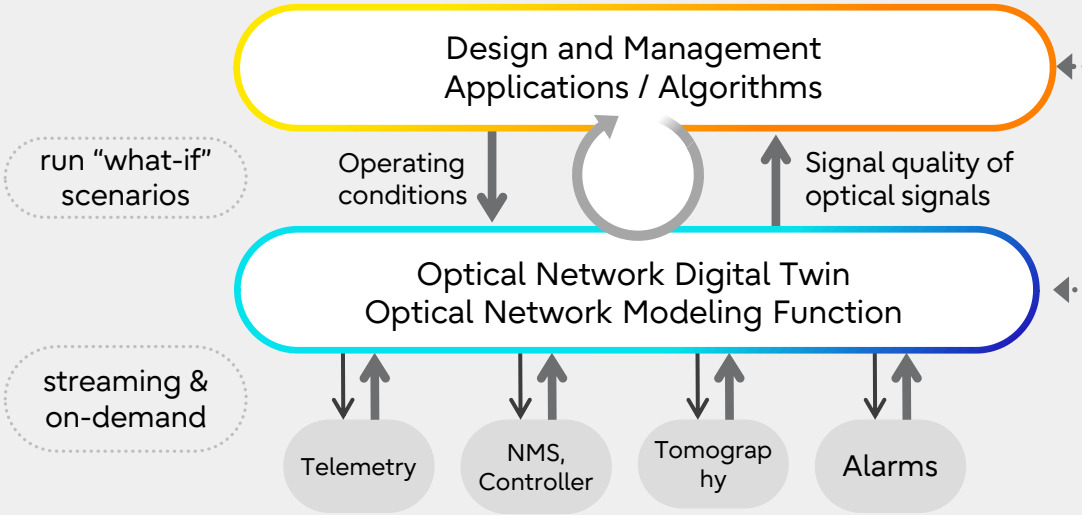
All photonic network(APN) control/management

- On-demand optical path provisioning: An optical path can be provisioned on-demand between any pair of transponders
- APN Controller Management: Integrated management of multi-vendor networks with end-to-end path, containing a domain controller (EMS) terminating vendor IF
- Multi-tenant Management: Supports network view management for multiple operators to provide services on the same network



Optical network digital twin

- Automated control, management and optimization of all photonic network through digital twin technology



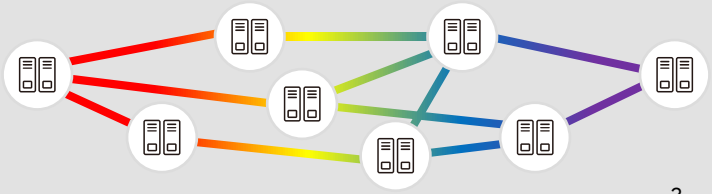
- Alien wave design (OLS Designer App)
- SOP Localization
- RWA, protection, restoration
- Network optimization
- Root-cause analysis
- Failure localization
- Margin-aware alarms
- Adaptive SLAs, ...

- Instrumentation control
- Data validation, screening
- Model selection/evolution
- Database of history

▲ Digital world

▼ Physical world

Physical Network

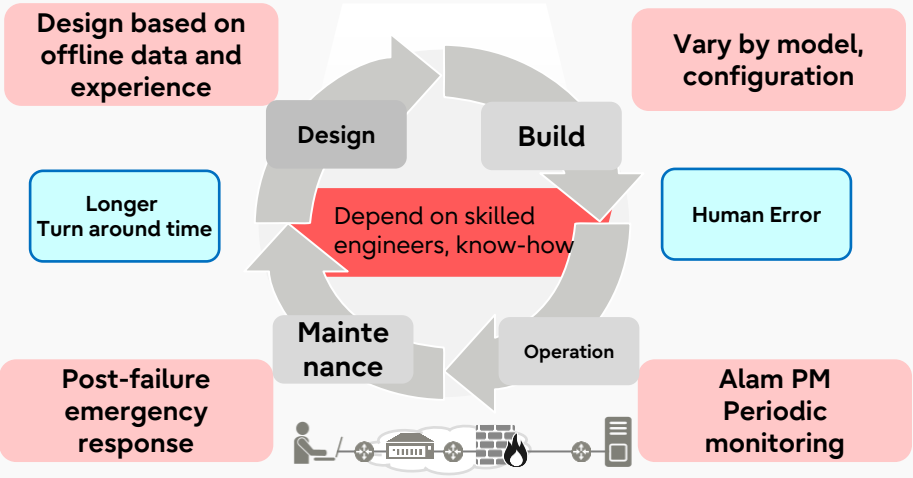


Benefit of network digital twin

- High resilience and optimization of networks through digital twin technology

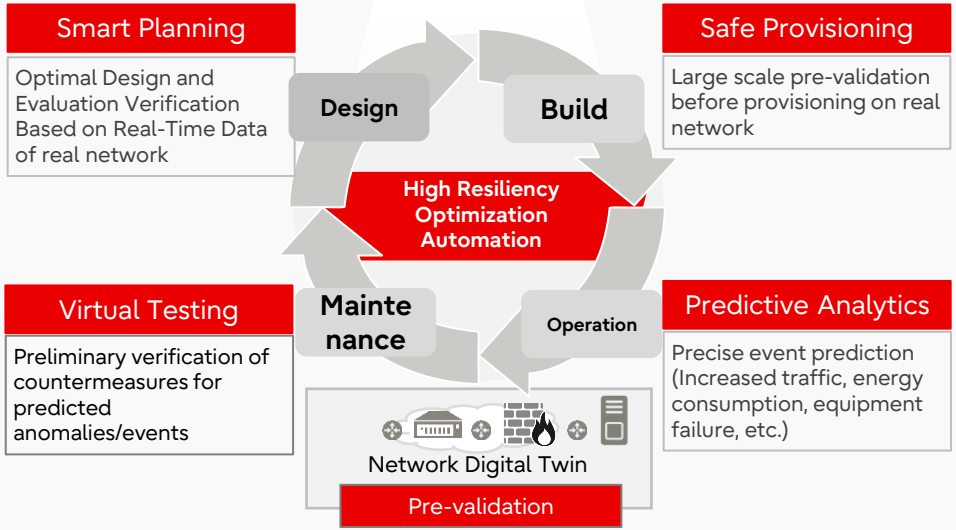
PMO: Reactive Operation

- Mainly manual labor by skilled engineers
- Responding on an ad hoc basis after a failure



FMO: Proactive Operation

- Network changes and failures are analyzed in the digital space
- Simulate and take measures in advance



Open line system design procedure

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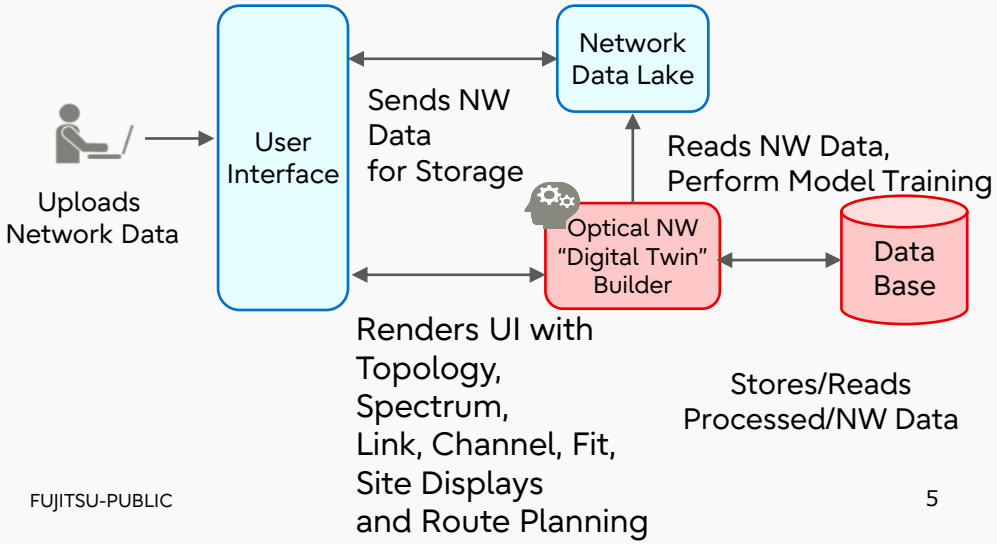
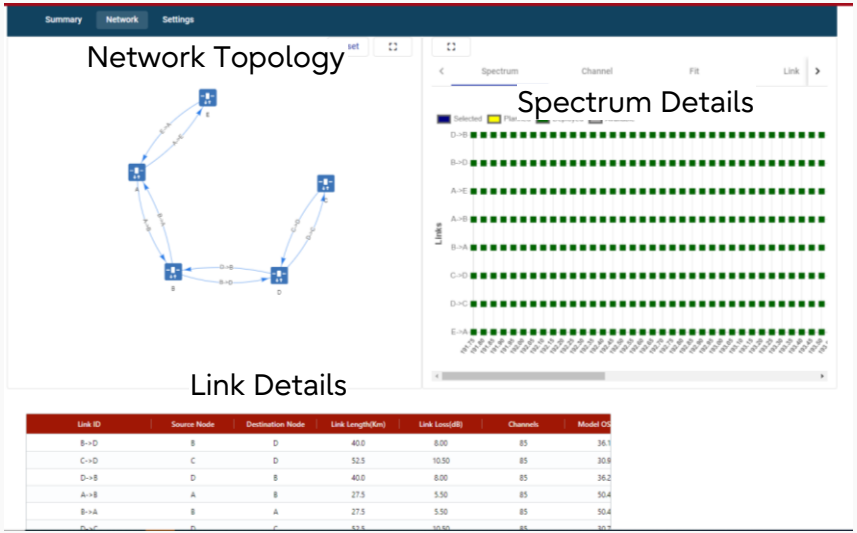
1. Upload network topology, services, PM data
2. Perform training & build optical network digital twin
3. Add alien transponder data & set Q margin
4. Select route, wavelength & plan service reachability using predicted OSNR/Q





Applications of optical network digital twin
Optical NW planning : Open Line System(OLS) Designer

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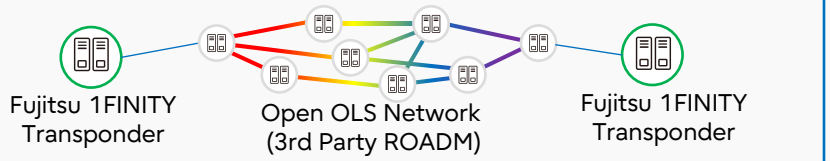
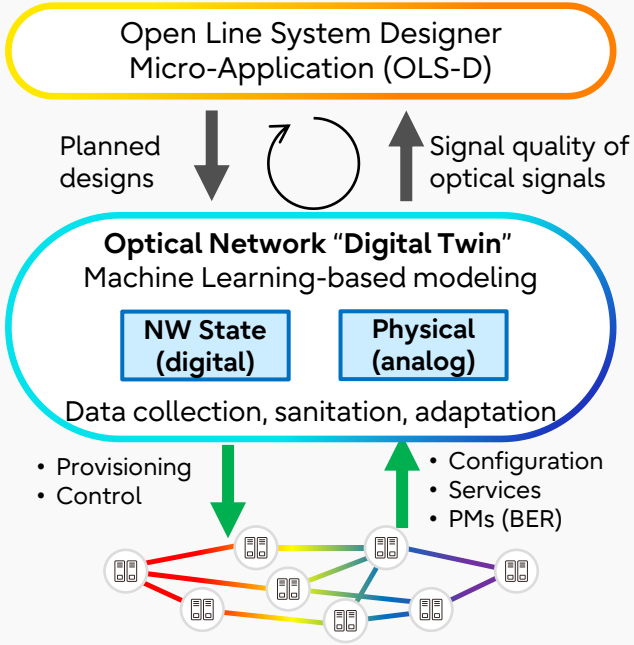
- Purpose: Alien-wave design in open line system
  - First product application of optical digital twin model
  - Measurement-based real-time transport network design – **signal quality prediction using machine learning**
  - Open optical networks – primary use case is alien wavelength design, e.g. Fujitsu transponders over 3rd party OLS

Digital Twin Vendor-Agnostic Physics-Based Optical NW Model



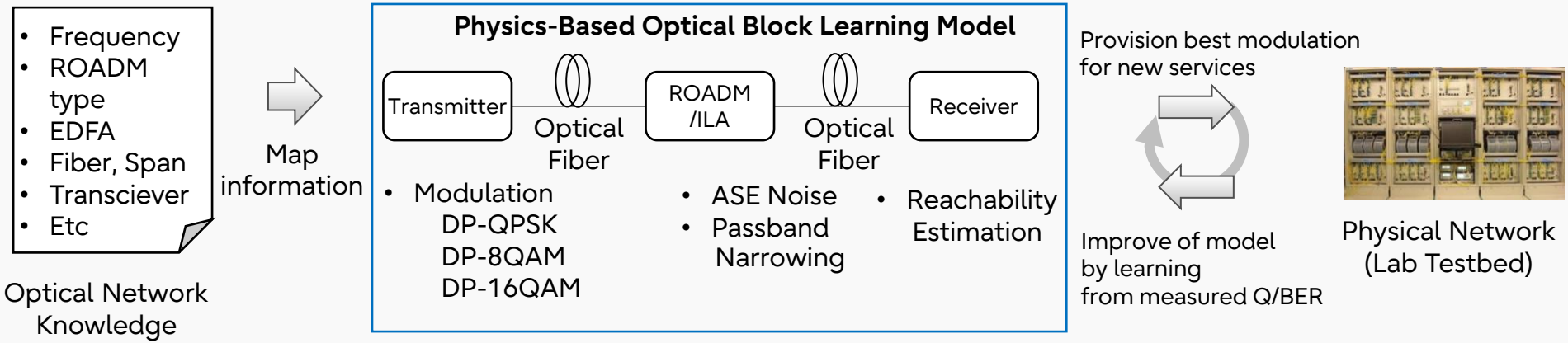
Physics-Based Optical Block Learning Model

- Modulation
  - DP-QPSK
  - DP-8QAM
  - DP-16QAM
- Fiber Parameter
  - Loss, CD, etc
- Fiber Nonlinearity Impairment
- ASE Noise
- Passband Narrowing
- Reachability Estimation



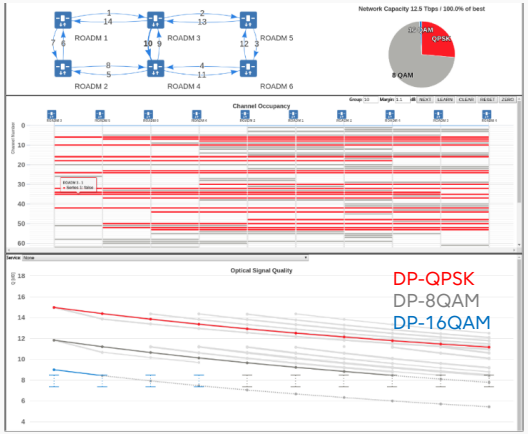
OLS-D design example

- Open line system design based on network knowledge, learning model, and physical network data



OLS-D design example

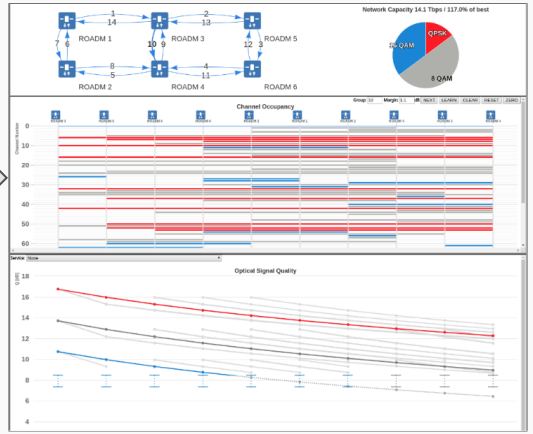
- Network capacity improvement of 15%
  - Improved accuracy of design, leading to better DP-16QAM reachability from real data of the physical network



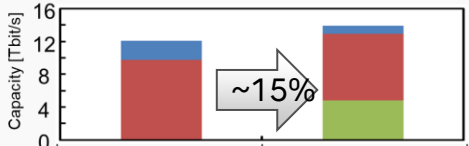
Deployment without learning

Digital Twin Trained Model

15% Network Capacity Increase



With learning: More DP-16QAM



	without learning	*with learning*
QPSK	26%	***11%***
8QAM	74%	***62%***
16QAM	0%	***27%***

Thank you