Bridging the Optical-Packet Network Chasm via Secure Enclaves

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Optical and Packet Networks Evolved Separately

Optical Developments

- 1968
  - wavelength division multiplexing
- 2005
  - Rebirth of coherent detection with high-speed digital signal processing
- 2019
  - Probabilistic Constellation Shaping

Packet Switched Developments

- 1988
  - TCP Congestion Control
- 2008
  - SDN adaption is accelerated with the development of OpenFlow
- 2016
  - OpenNetVM platform for network function virtualization

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Exciting work is happening in both domains, but these developments rarely overlap.
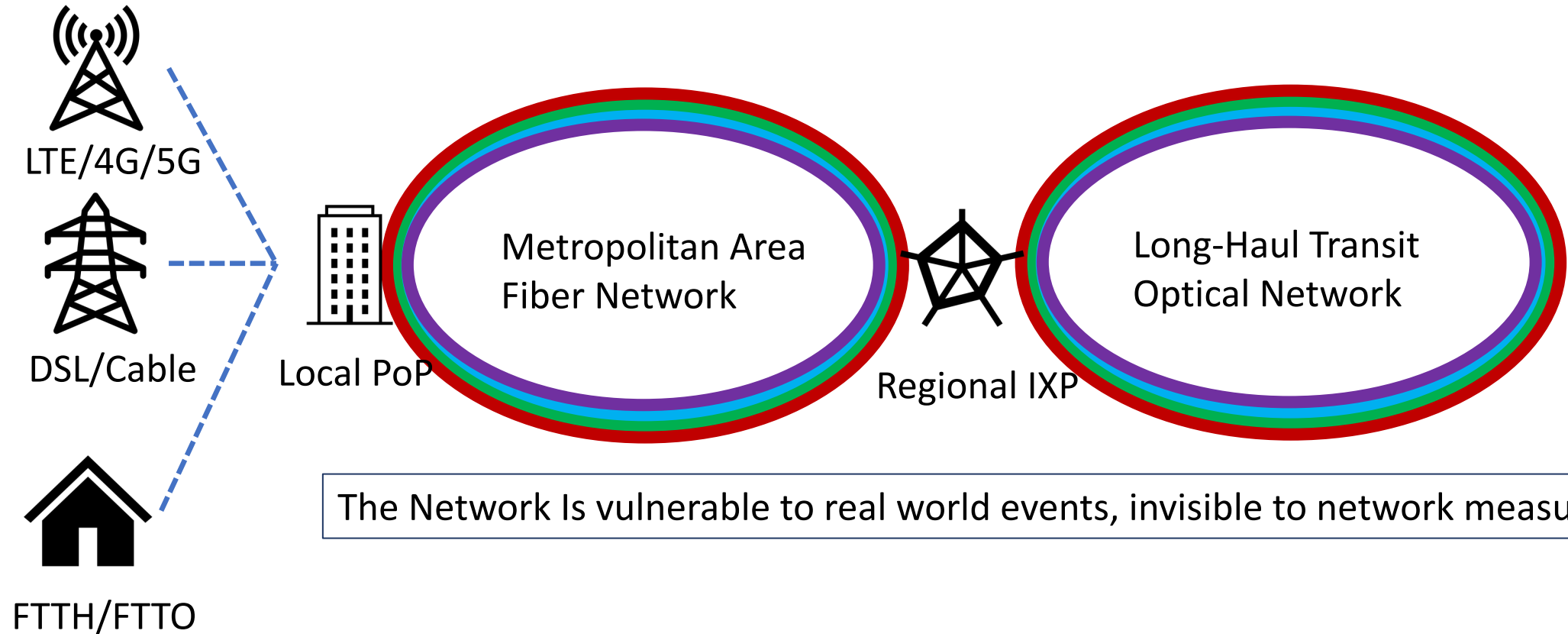
Outline

- Problem: The Chasm
- Motivating Scenarios for Cross-layer Visibility
- Our Solution: Secure Enclaves
- Use cases
- Barriers and Road Ahead
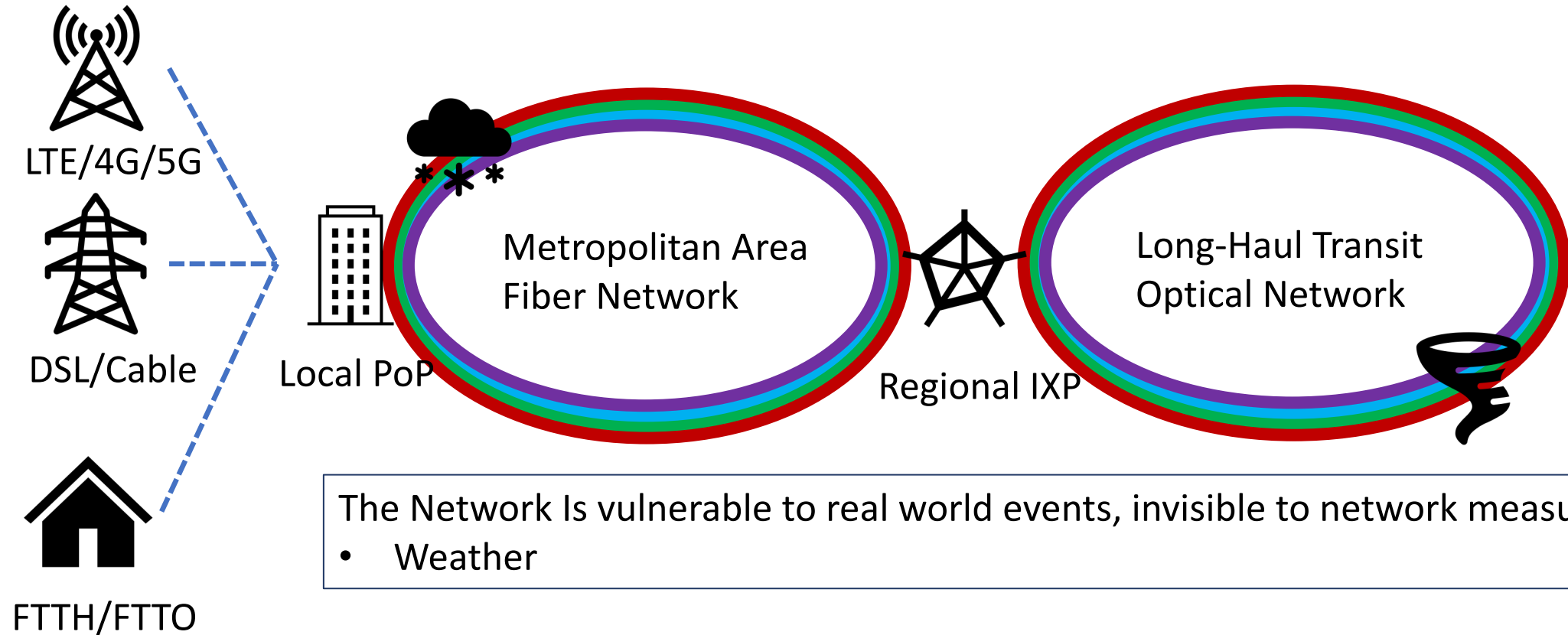- Conclusion

Optical and Packet Networks are Disconnected

- A strength of Packet Switched Network
  - Oblivious to the transmission medium
  - Works well for wireless, electrical, and optical links
- A weakness
  - Cannot optimize for a resource in the dark
  - Content distribution and transit networks largely use a single medium, optical fiber
- Optics research is making fiber more flexible, but network operators lack the tools to leverage this resource efficiently
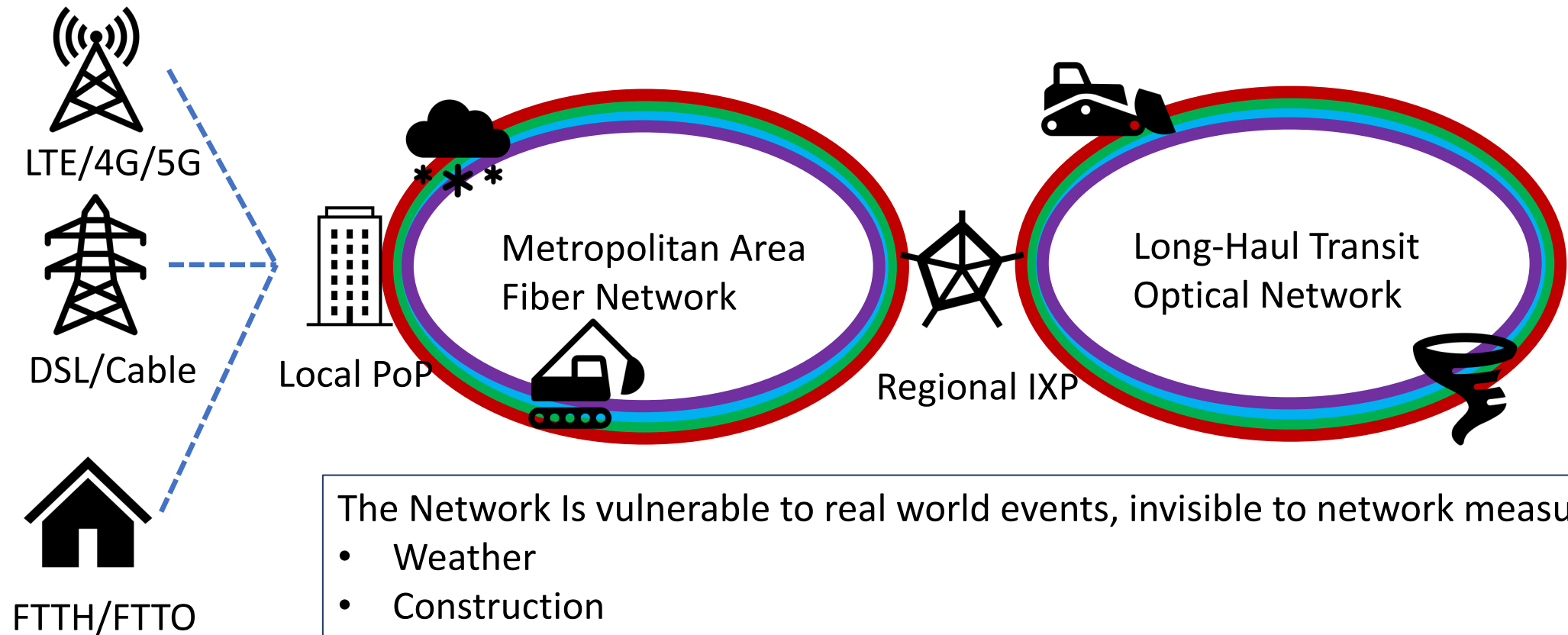
Optical and Packet Networks are Disconnected

LTE/4G/5G

DSL/Cable

FTTH/FTTO

Local PoP

Metropolitan Area Fiber Network

Regional IXP

Long-Haul Transit Optical Network

The Network Is vulnerable to real world events, invisible to network measurements

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- Weather

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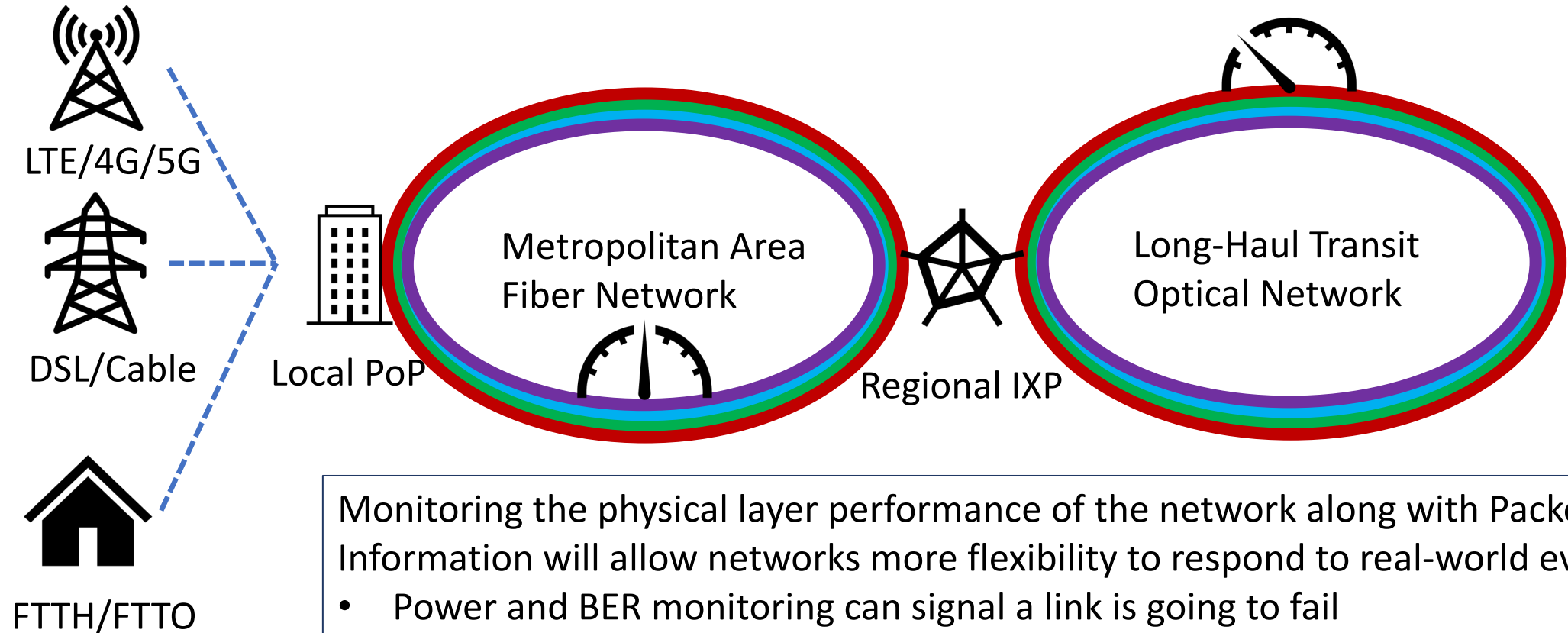- Weather
- Construction

Visibility Will Improve Networks

- Outage Avoidance
  - SIGCOMM, 2018
  - P-Cycles, Journal of Lightwave Technology, 2005
- Traffic Isolation
  - SPIN, SIGCOMM 2020
- Network Slicing and Virtualized Capacity
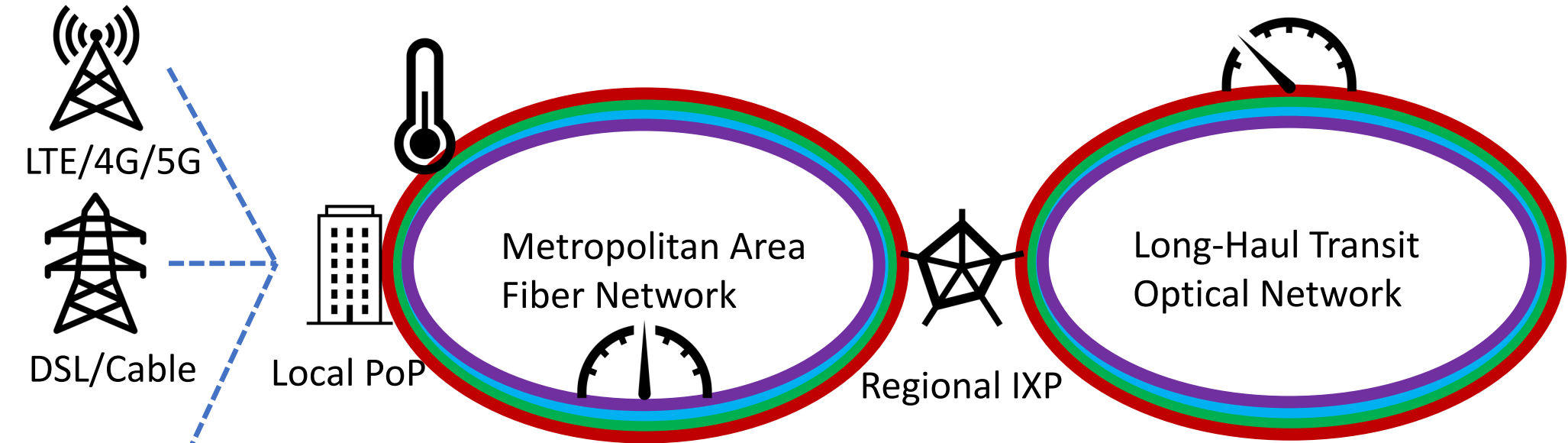 - IEEE Communications Magazine, 2020

No Tools For Full-Stack Network Monitoring
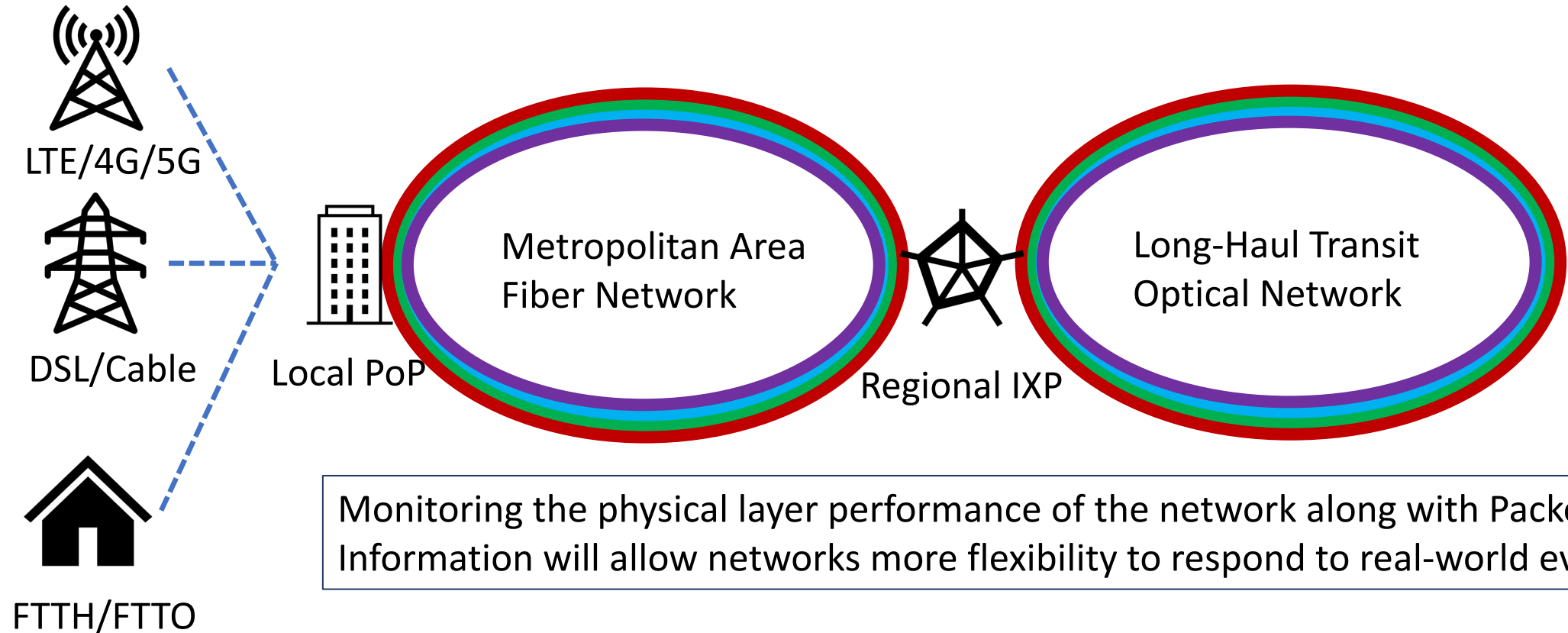
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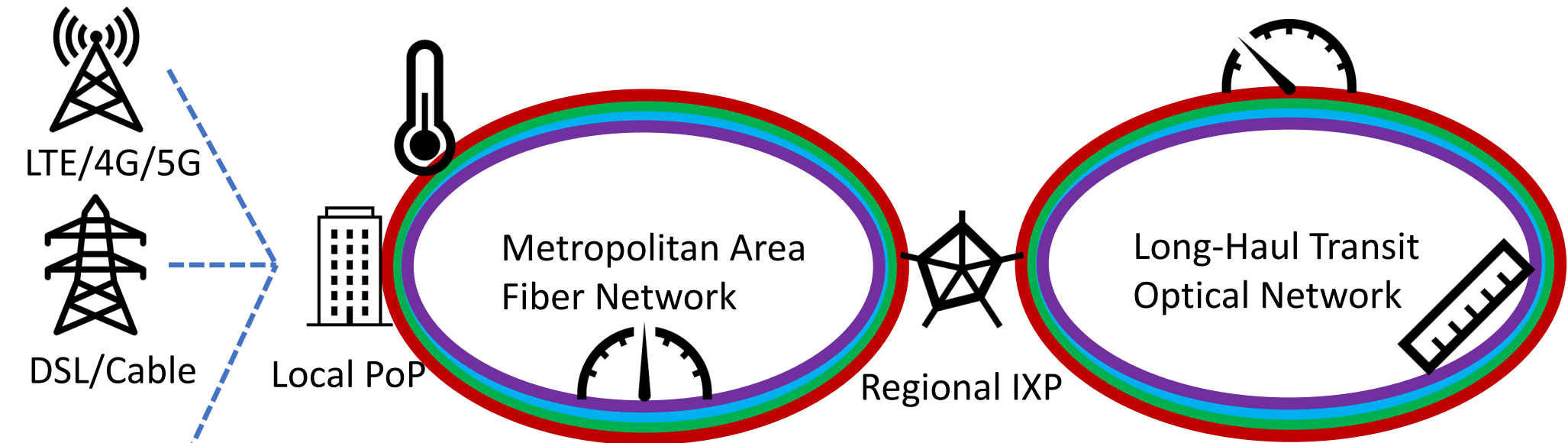Optical Network

Monitoring the physical layer performance of the network along with Packet-layer
Information will allow networks more flexibility to respond to real-world events

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- Power and BER monitoring can signal a link is going to fail
- Changes in polarization mode dispersion can single fiber shaking, due to earthquakes or construction activity
- Tracking channel occupancy and power configurations on amplifiers can give us better flexibility to quickly re-route optical channels in case of a disaster

Bridging the Chasm with Secure Enclaves

- Expose optical layer Information with software hooks
  - Possibly with gNMI/gRPC
  - Present in many optical networks today, backed by Google
- Two Properties of information gained
  - Preserve the privacy of the network
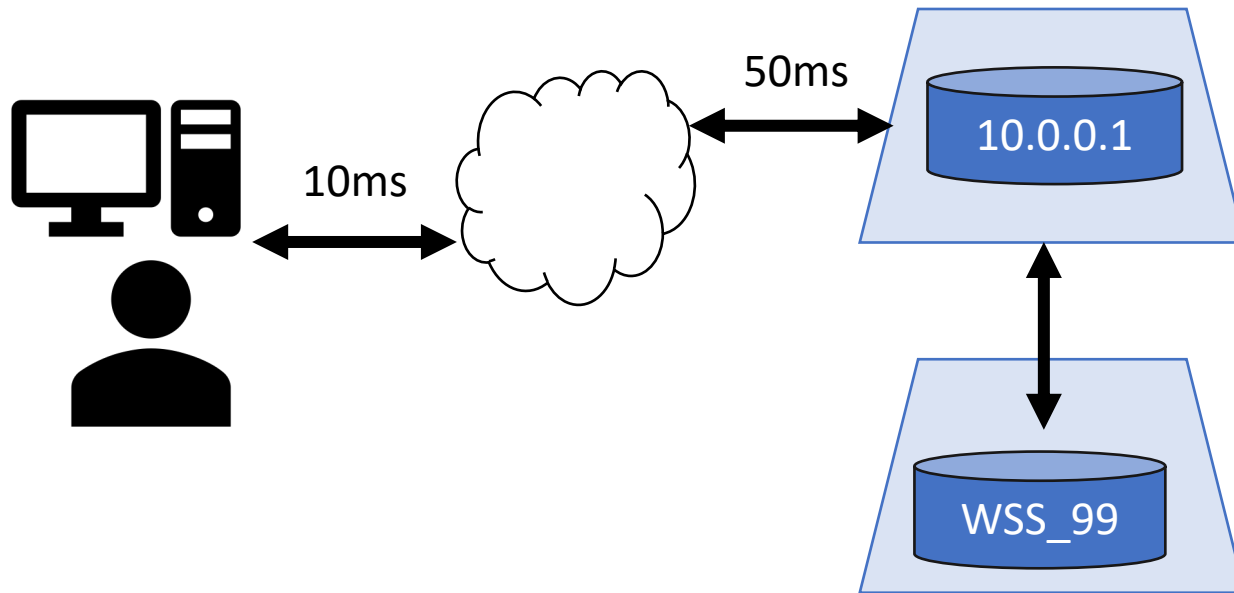 - Anonymized view is consistent between vantage points
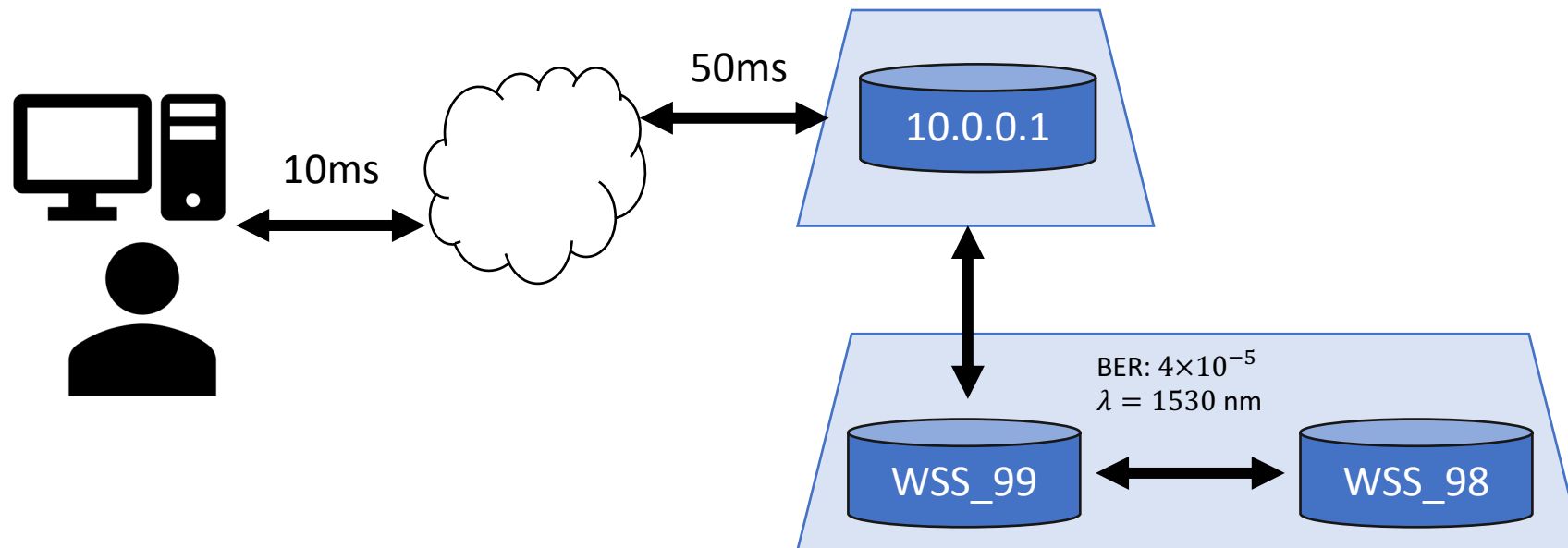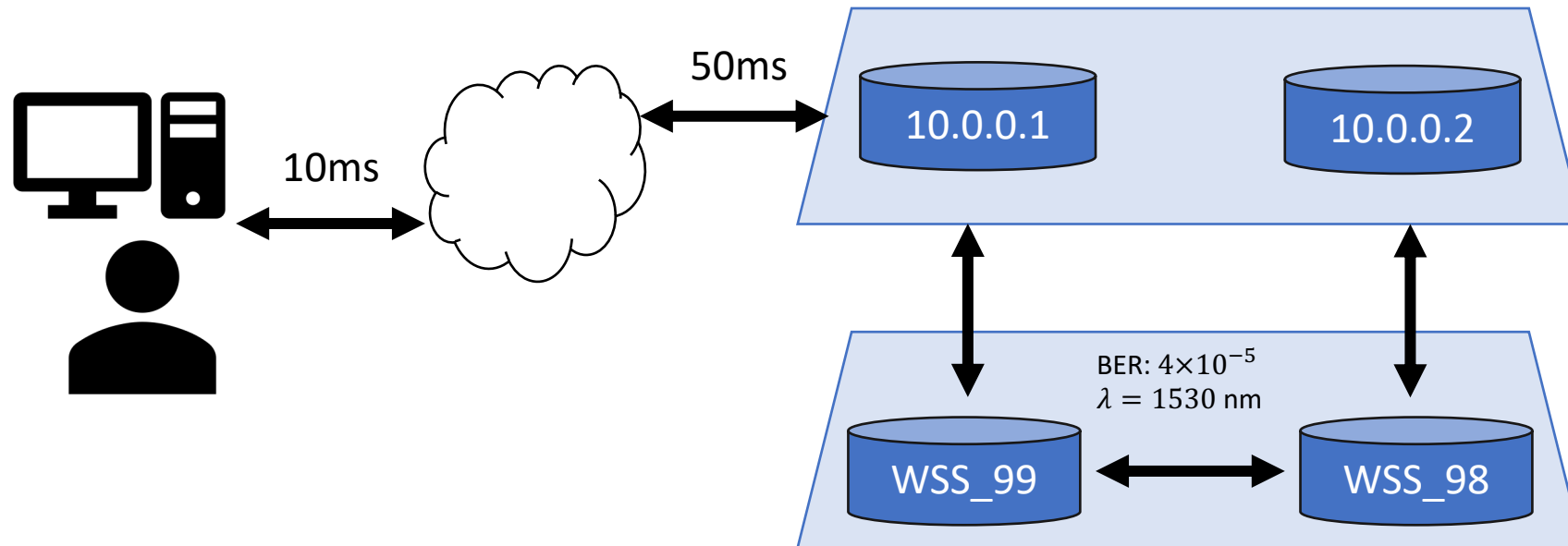
Use Case 1: End-to-end Network Awareness
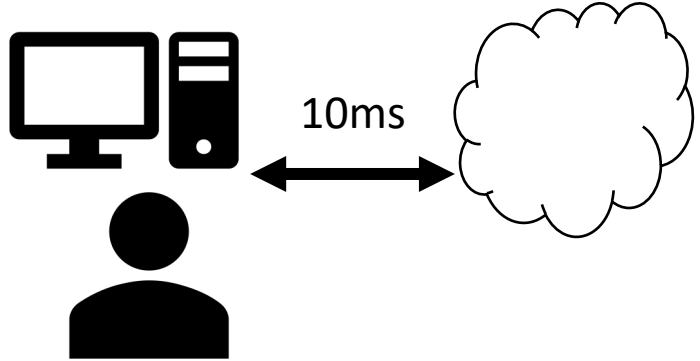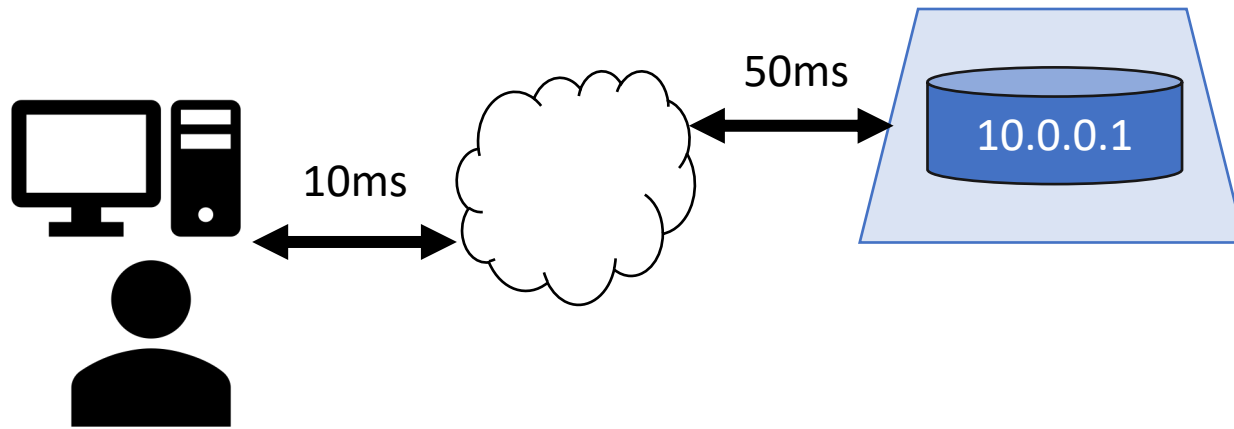
10ms

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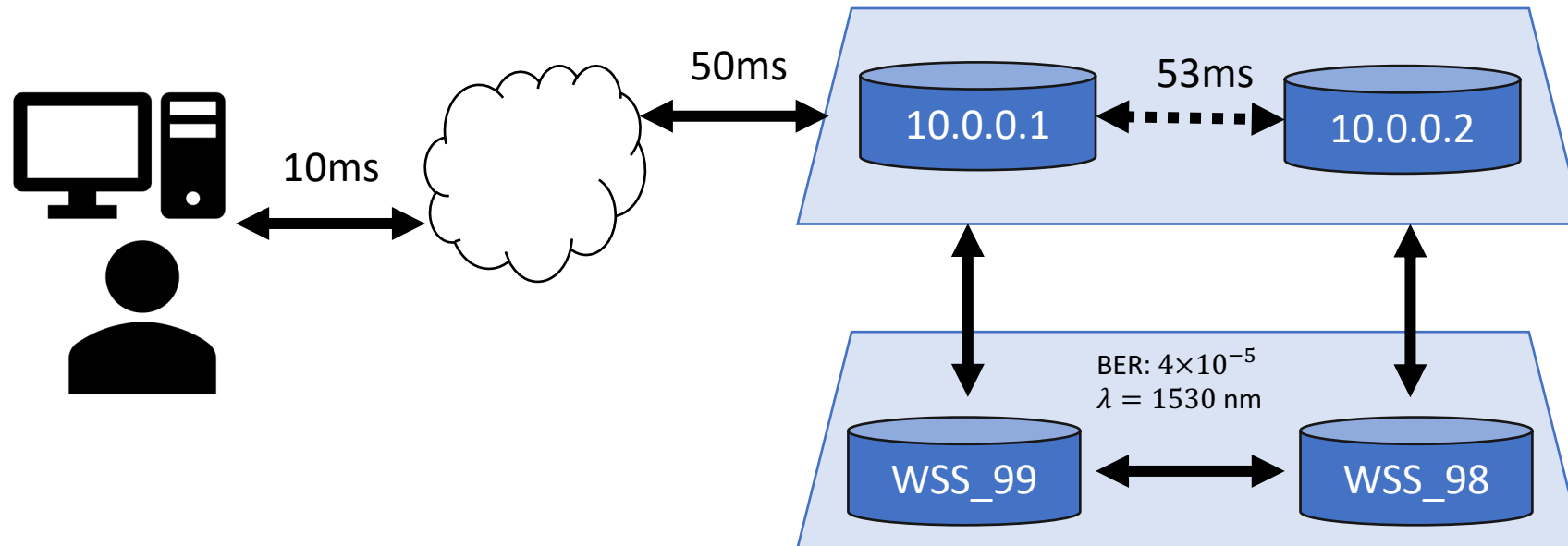
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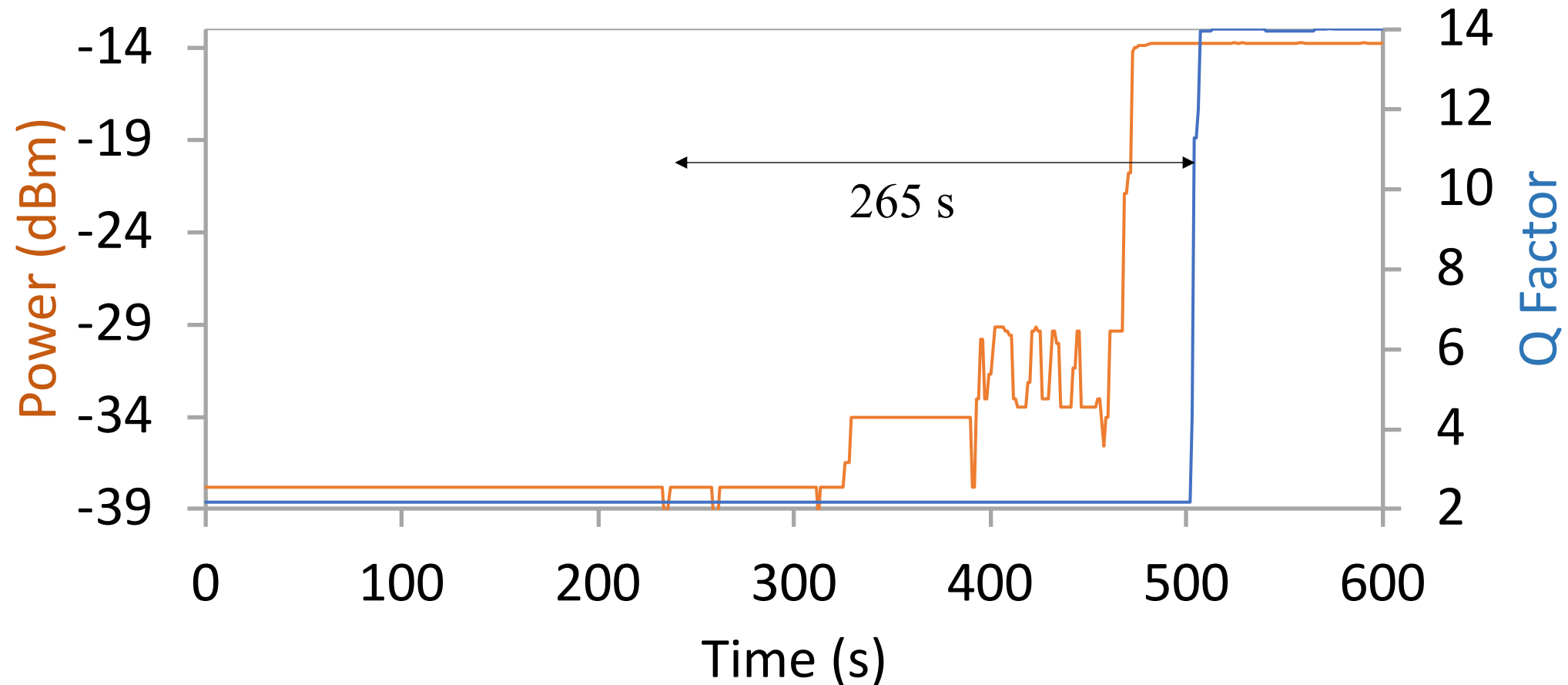
Use Case 1: End-to-end Network Awareness

Use Case 2: Benchmarking The Optical Layer

- How dynamic can wavelength assignments be?

- Which factors impact add-time for optical circuits the most?

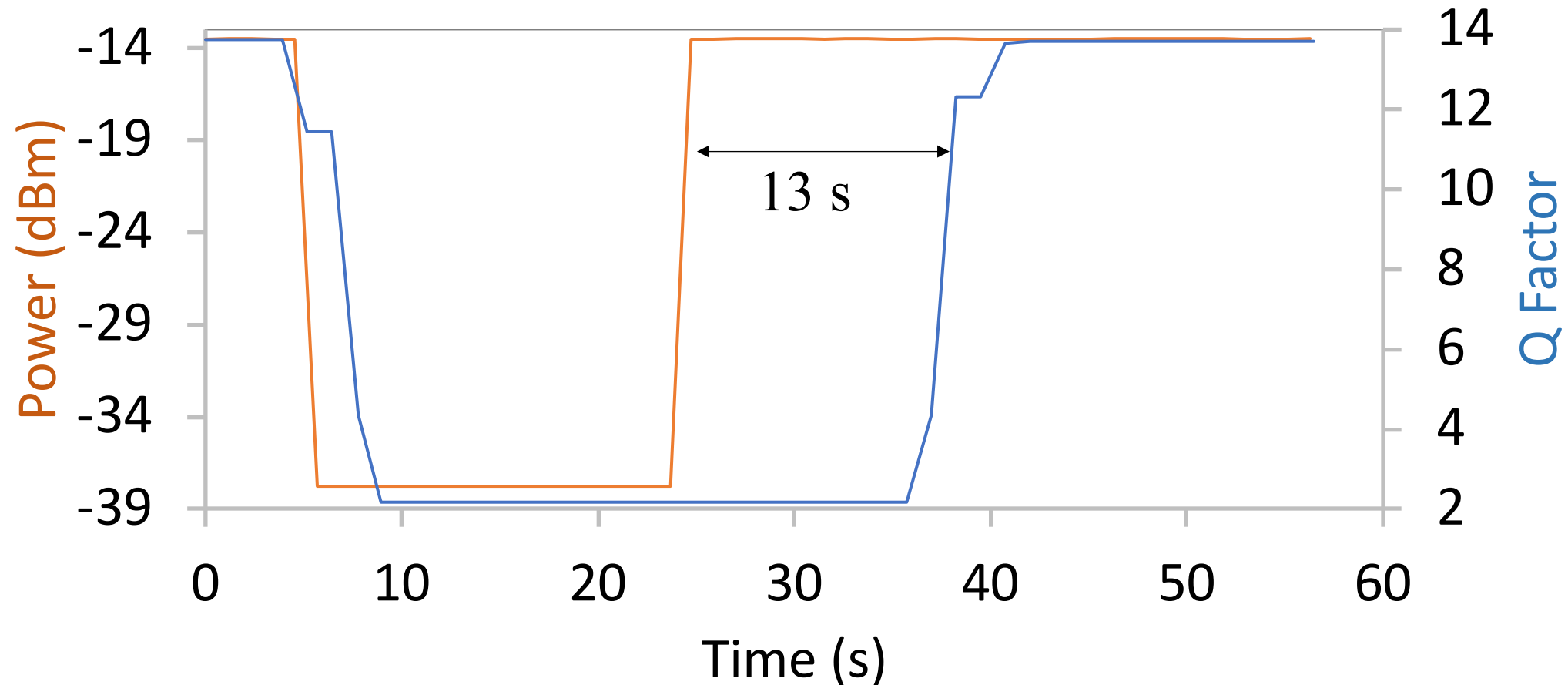- How can these factors be reduced?

Use Case 2: Benchmarking The Optical Layer

Default Time to Add Optical Super-channel

Use Case 2: Benchmarking The Optical Layer

Improved Time to Add Optical Super-channel

Use Case 2: Benchmarking The Optical Layer

- Explore the time to add optical circuits to long haul paths
  - Find ways to reduce this
  - Ensure more robust and resilient optical networks
- What about transport and application layer performance on dynamic wavelength assignments?
- This is an open question, and will continue to be without secure enclaves

Barriers and Road ahead

- The wide variety of optical network components makes designing a wholistic solution more difficult

- We would ideally like to develop a one-size-fits-all measurement solution, similar to IP traceroute

- Collaboration with hardware vendors, network operators, and researchers is essential

Conclusion

- Cross-layer optical-packet network solutions are difficult

- Bridging this gap requires new tools for optical layer visibility

- We are developing these tools and soliciting feedback and collaboration from security experts and network operators

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