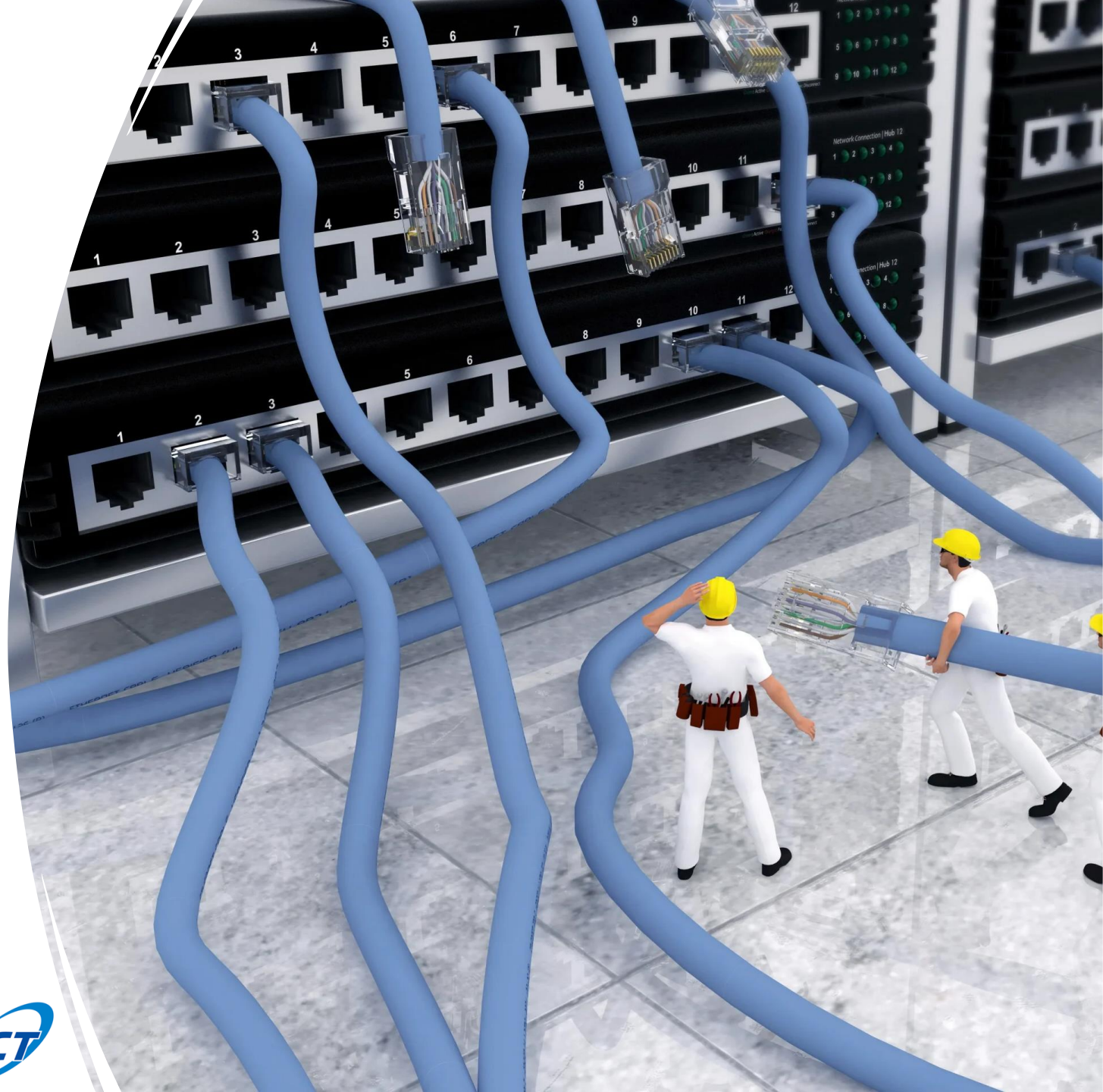


Task 4: Preemptive and Early Failure Detection and Management

May 19, 2023

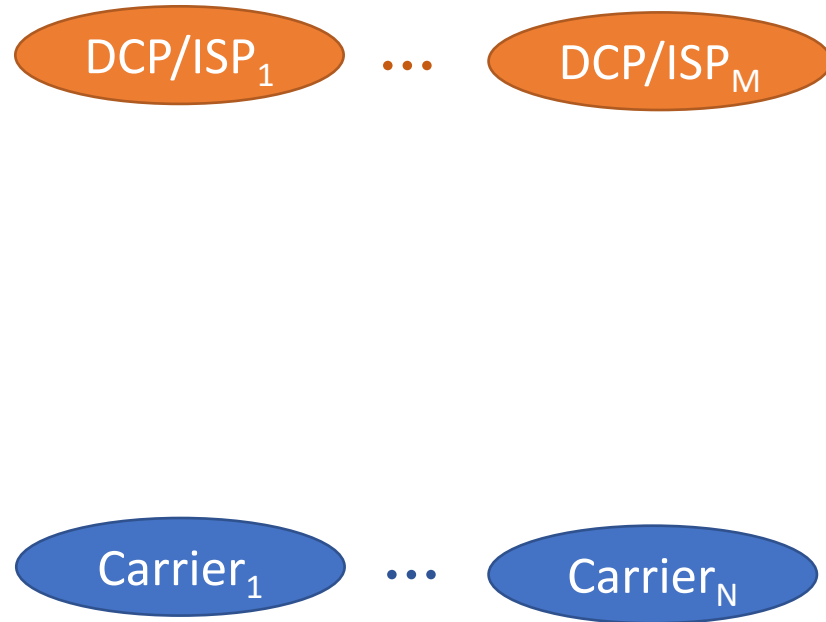
Presented by:

Forough Shirin Abkenar

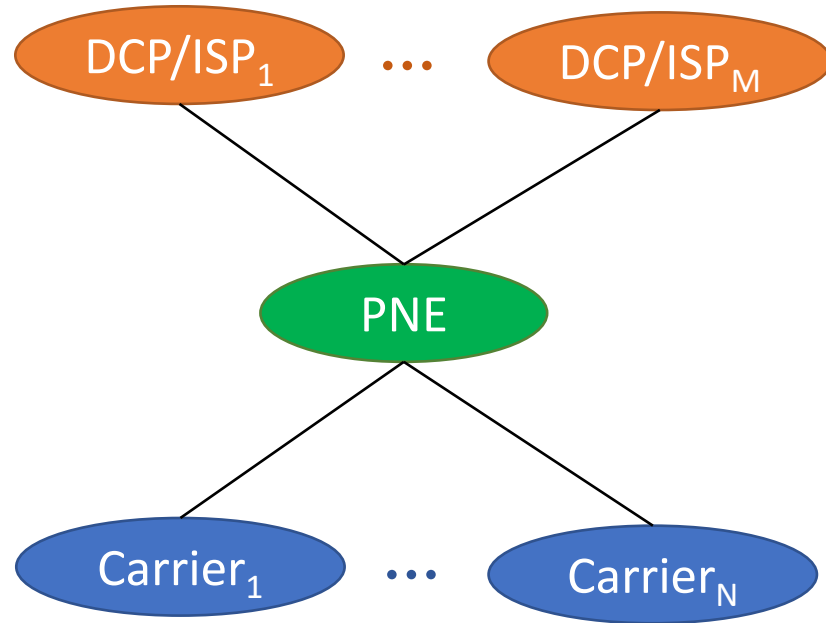


General System Architecture

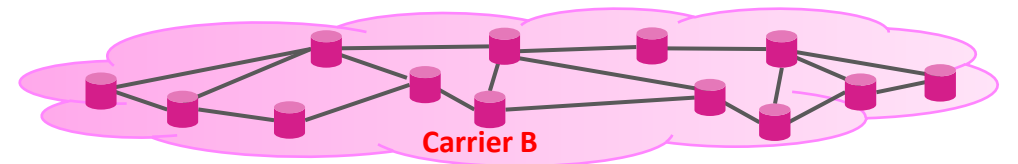
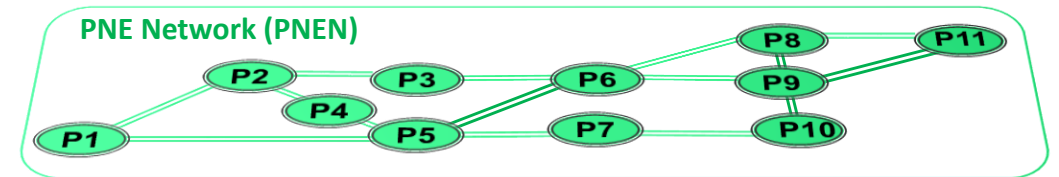
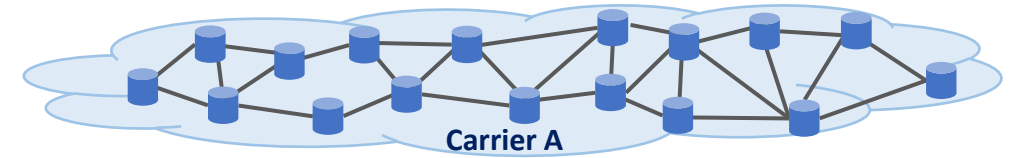
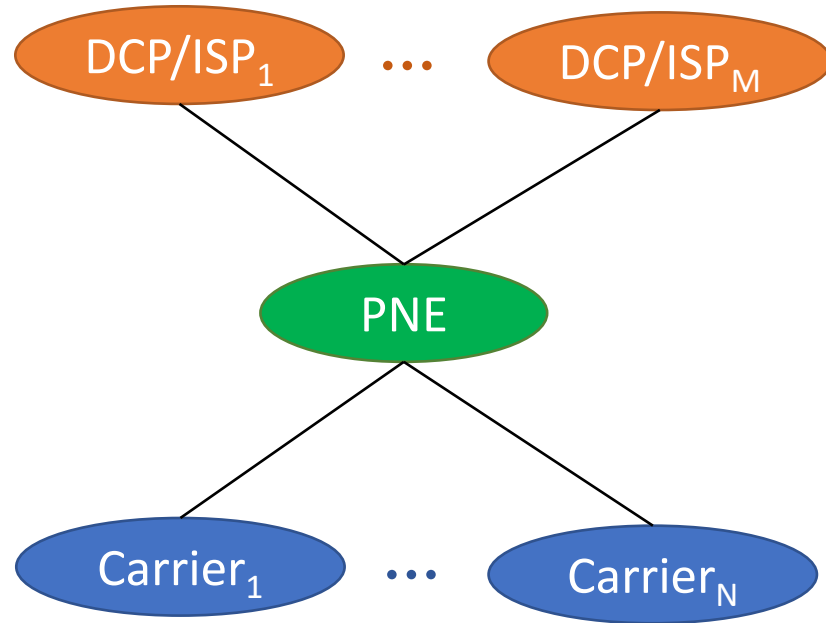
General System Architecture



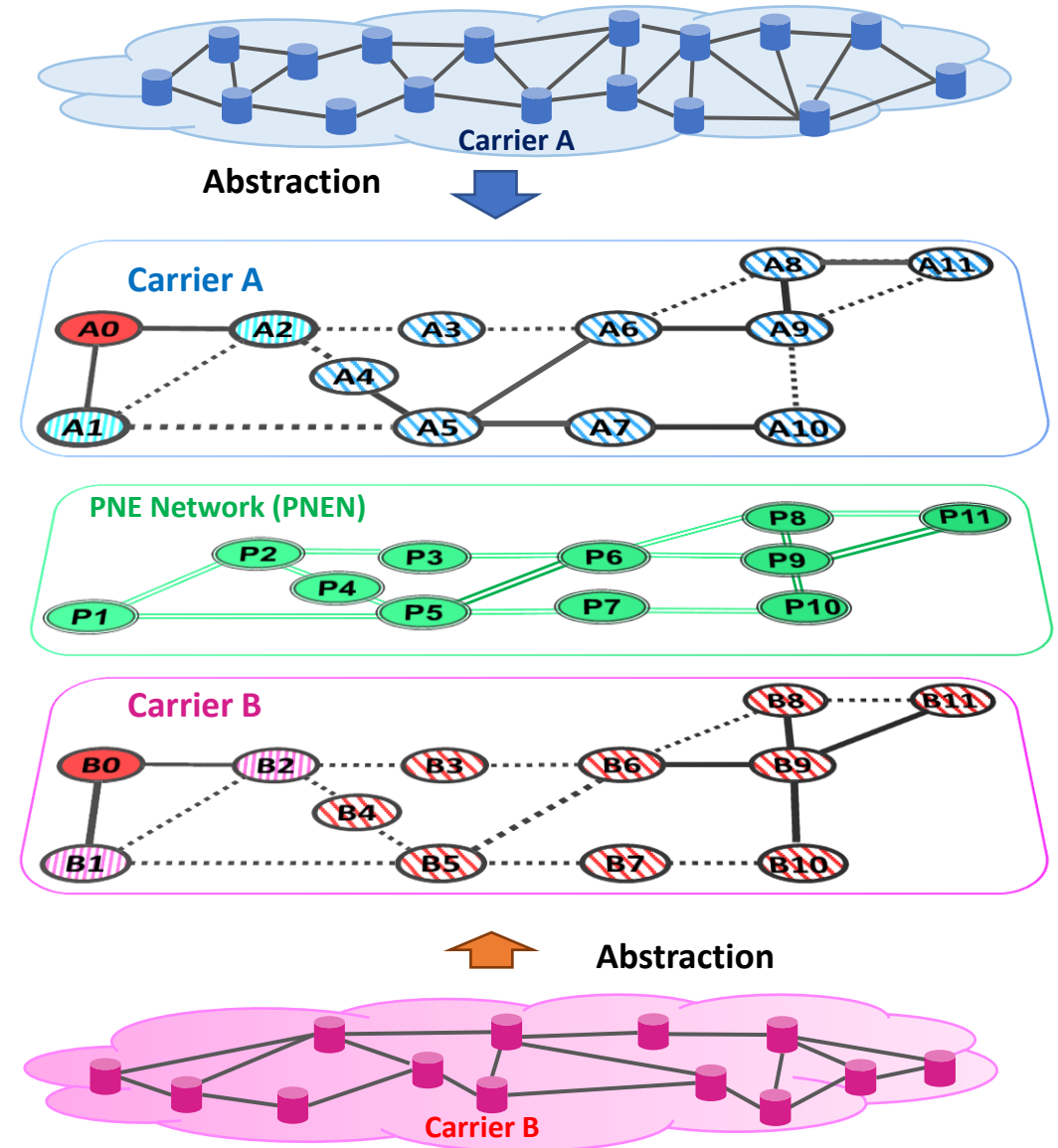
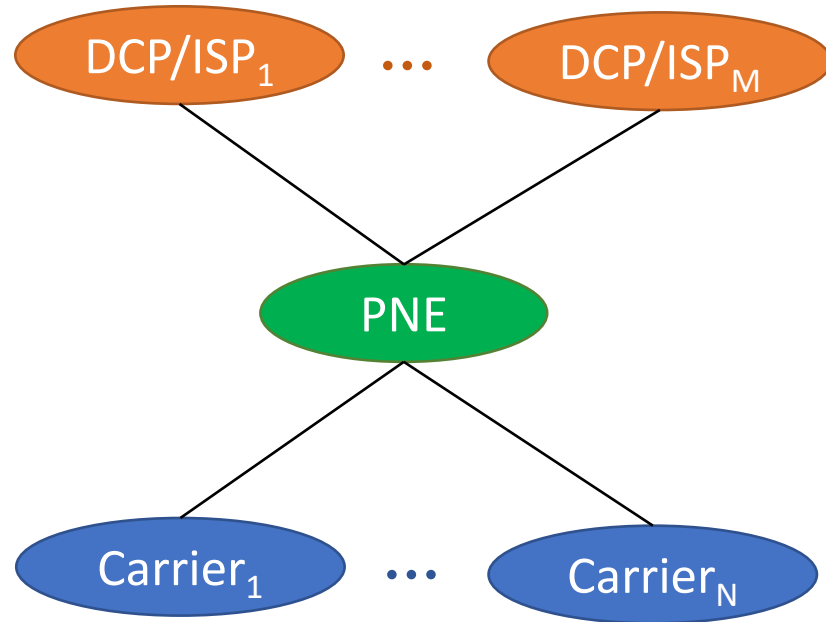
General System Architecture



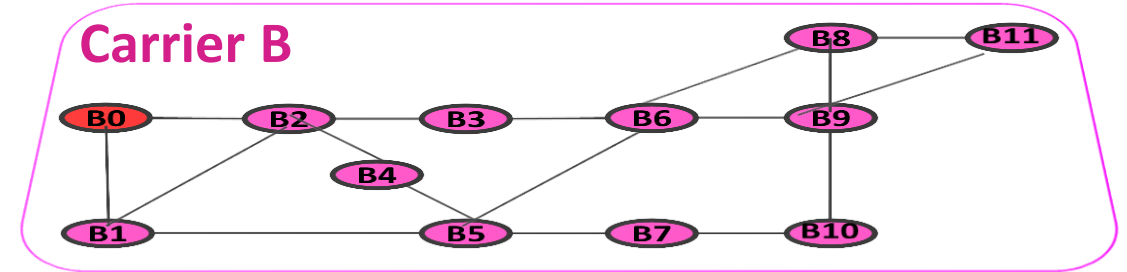
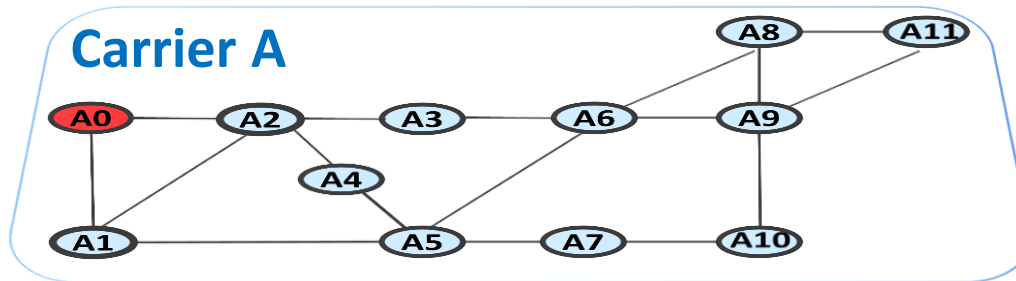
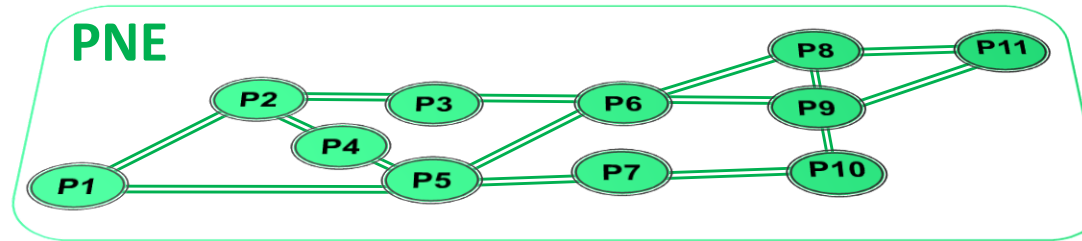
General System Architecture



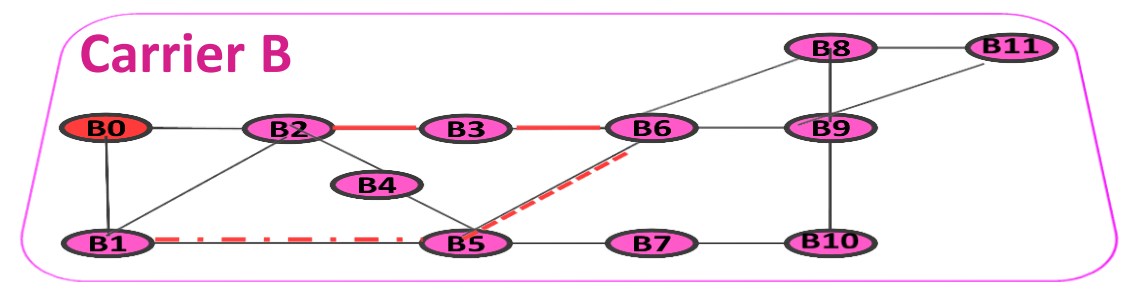
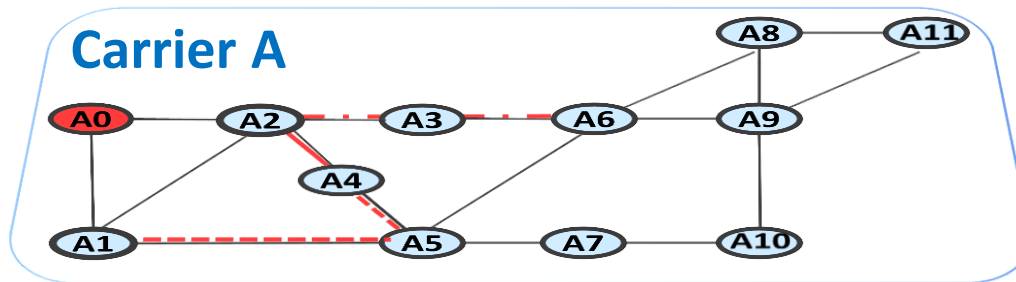
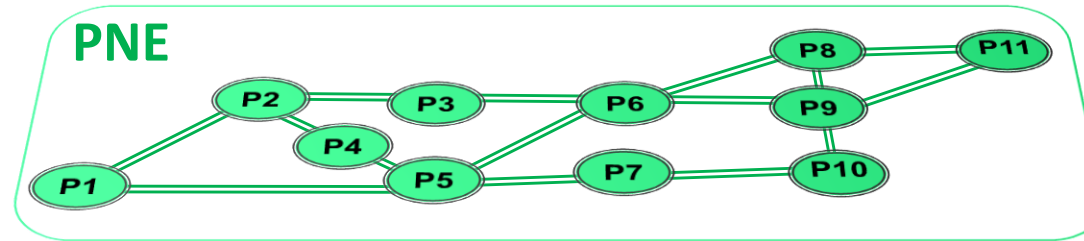
General System Architecture



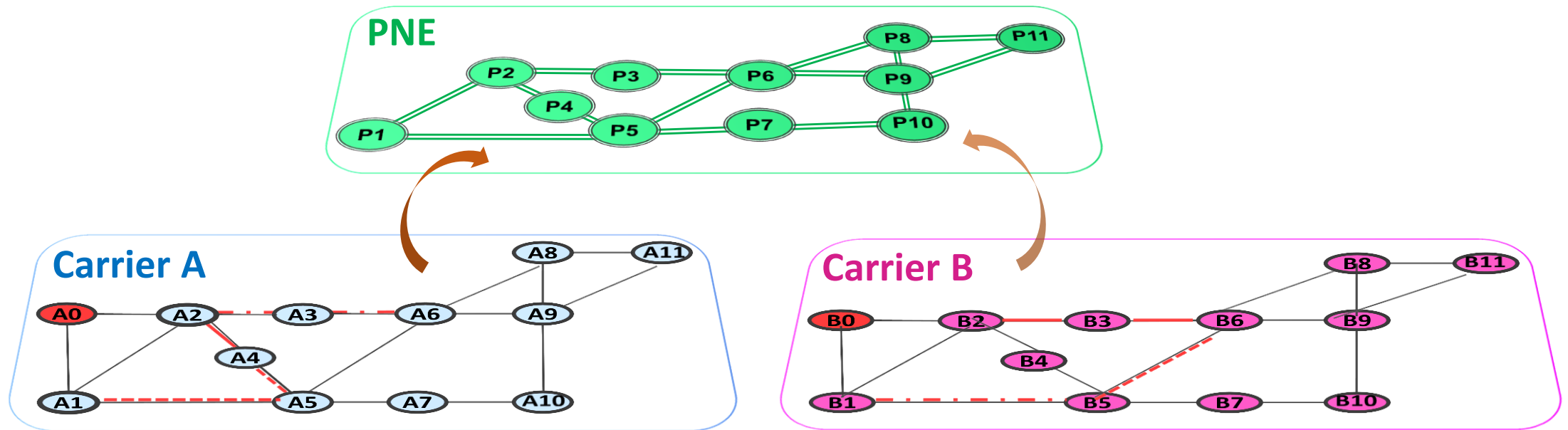
Preemptive and Early Failure Detection and Management



Preemptive and Early Failure Detection and Management

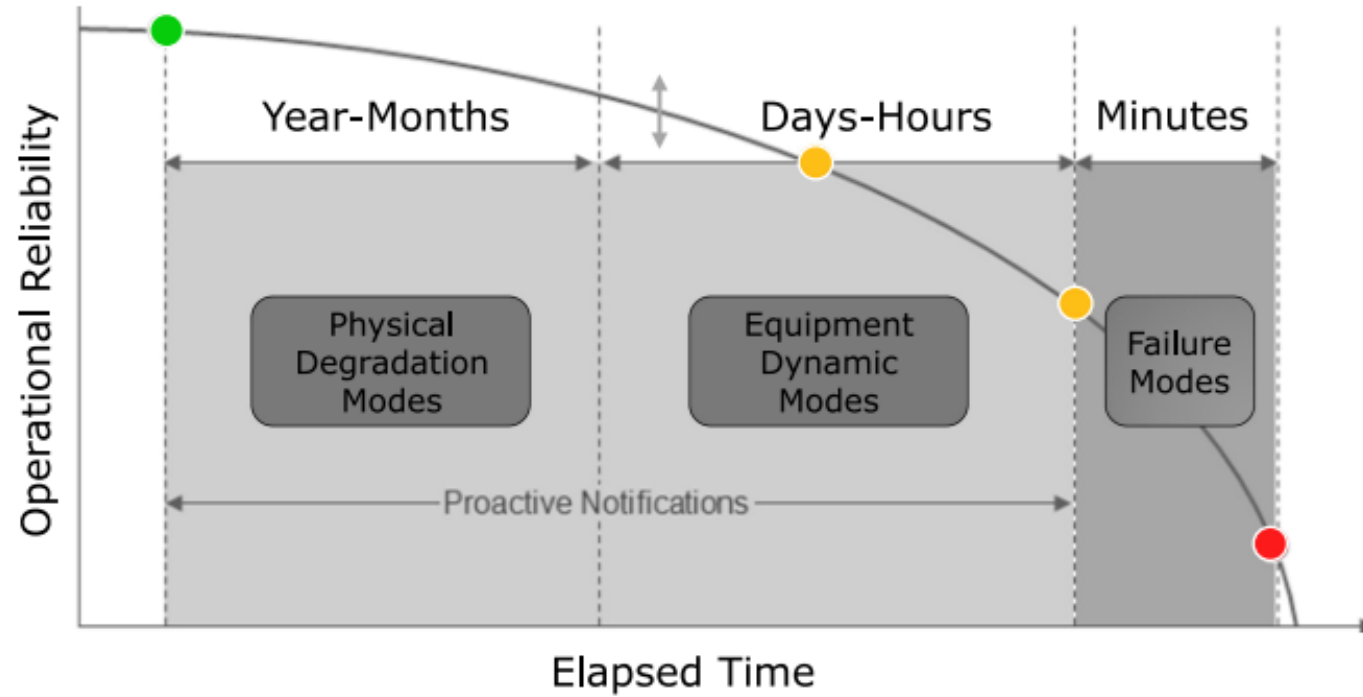


Preemptive and Early Failure Detection and Management



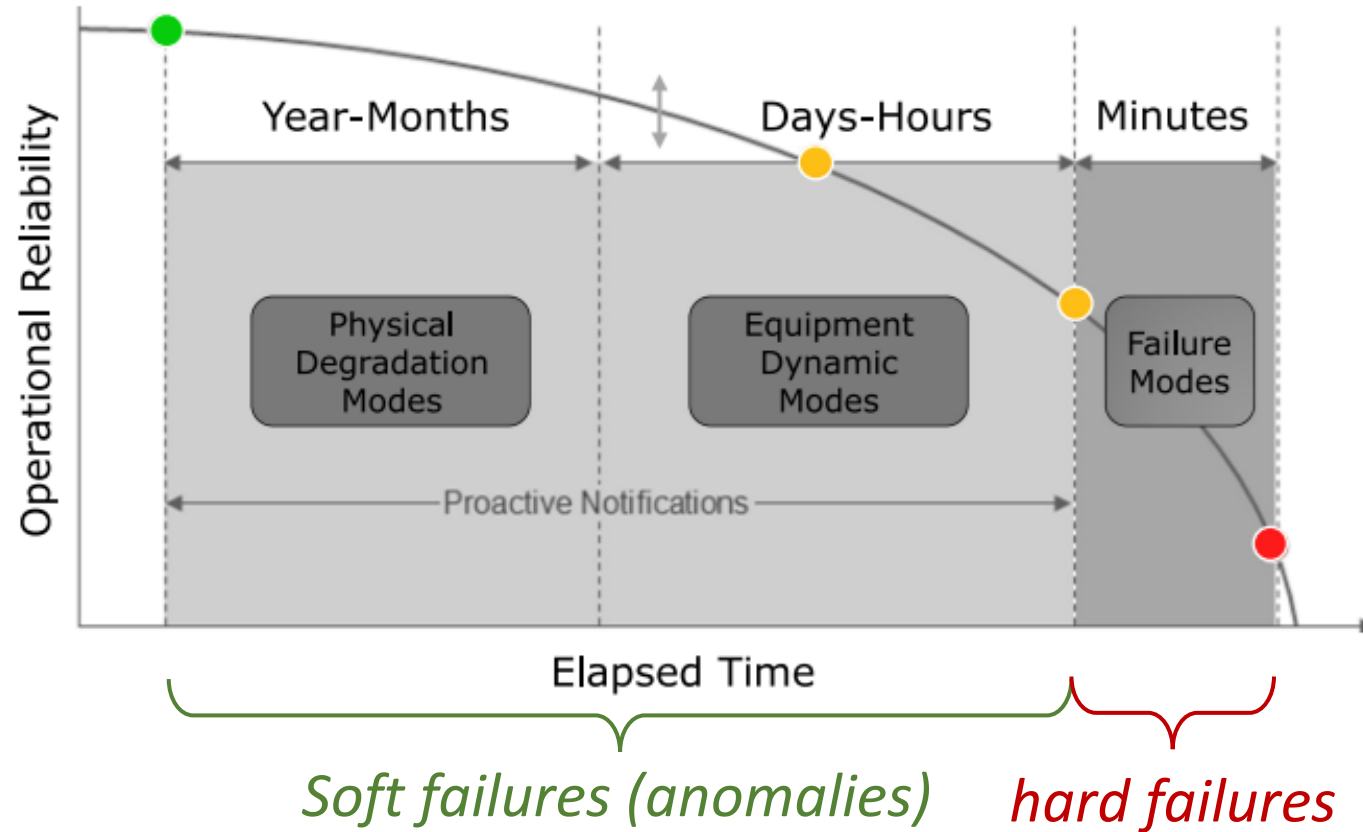
*Degradation/disconnection at the physical layer needs
preemptive and **early** detection and management*

Preemptive and Early Failure Detection and Management



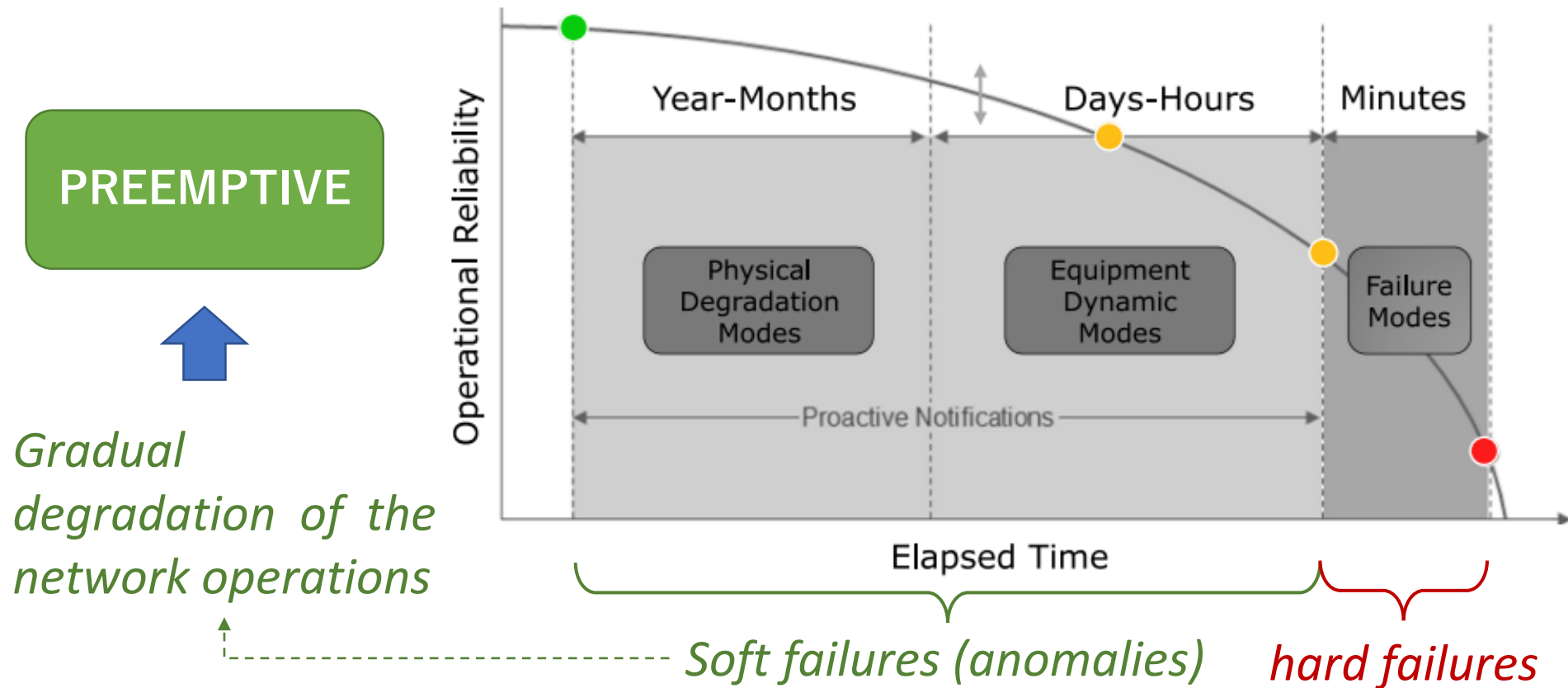
D. Rafique, T. Szyrkowiec, H. Grießer, A. Autenrieth and J. -P. Elbers, "Cognitive Assurance Architecture for Optical Network Fault Management," in *Journal of Lightwave Technology*, vol. 36, no. 7, pp. 1443-1450, 1 April 2018.

Preemptive and Early Failure Detection and Management



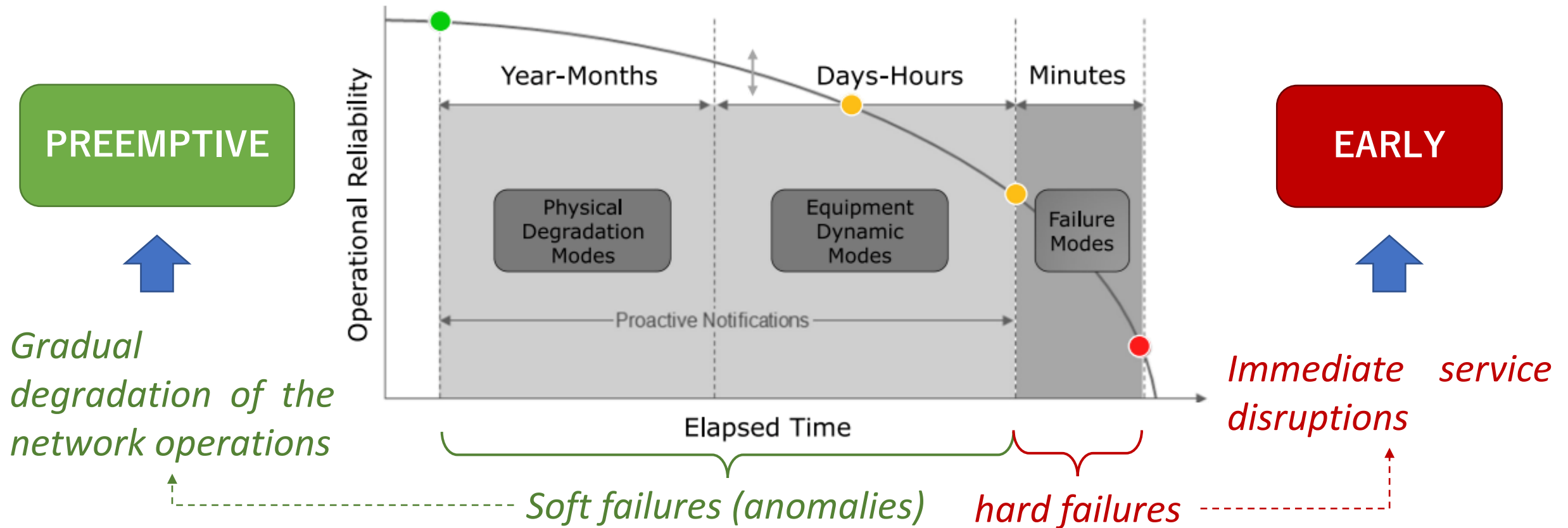
D. Rafique, T. Szyrkowiec, H. Grießer, A. Autenrieth and J. -P. Elbers, "Cognitive Assurance Architecture for Optical Network Fault Management," in *Journal of Lightwave Technology*, vol. 36, no. 7, pp. 1443-1450, 1 April 2018.

Preemptive and Early Failure Detection and Management



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Preemptive and Early Failure Detection and Management

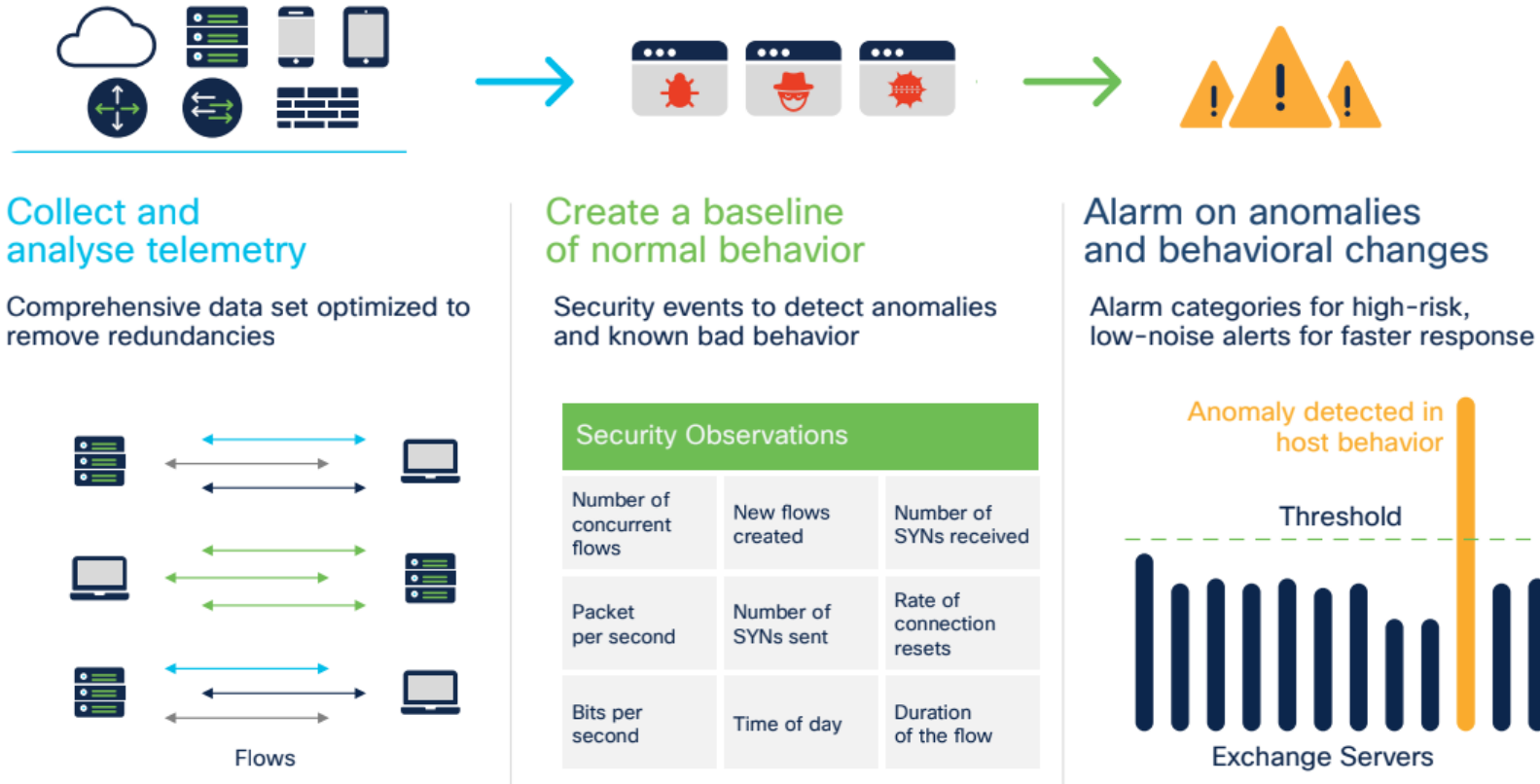


D. Rafique, T. Szyrkowiec, H. Grießer, A. Autenrieth and J. -P. Elbers, "Cognitive Assurance Architecture for Optical Network Fault Management," in *Journal of Lightwave Technology*, vol. 36, no. 7, pp. 1443-1450, 1 April 2018.

Behavioral Modeling and ML Techniques for Threat Detection

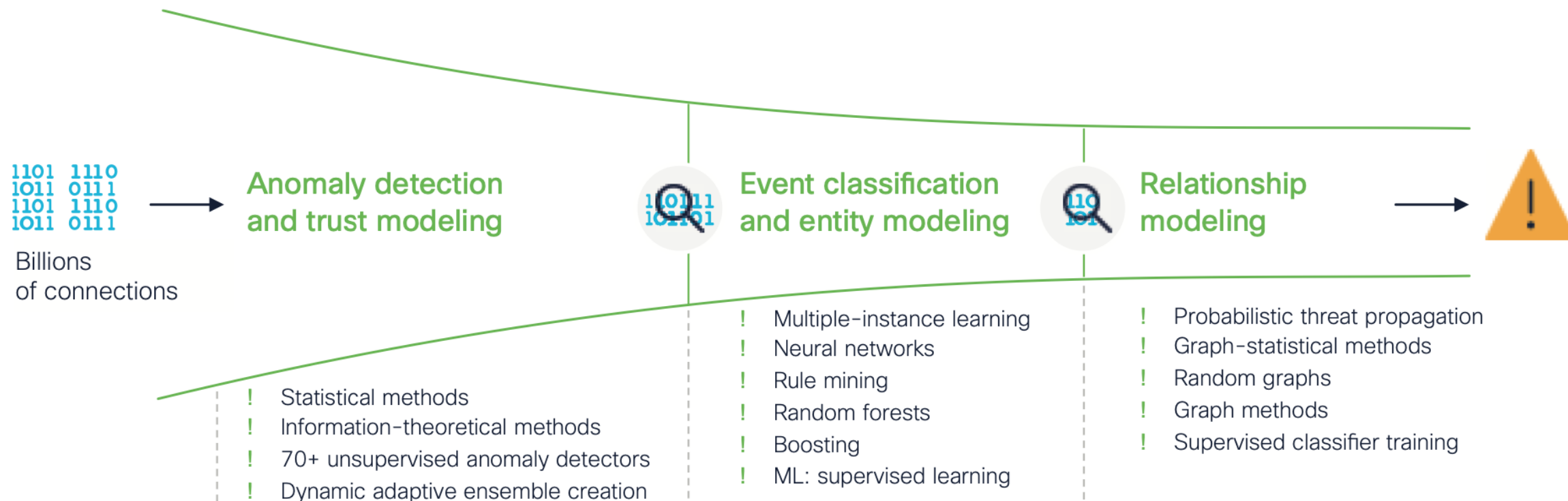
Cisco Security Analytics (2020), “A deep-dive into the unique behavioral modeling and machine learning techniques for advanced threat detection and response [White Paper],” <https://www.cisco.com/c/en/us/products/collateral/security/stealthwatch/white-paper-c11-740605.pdf>.

Behavioral Modeling and ML Techniques for Threat Detection



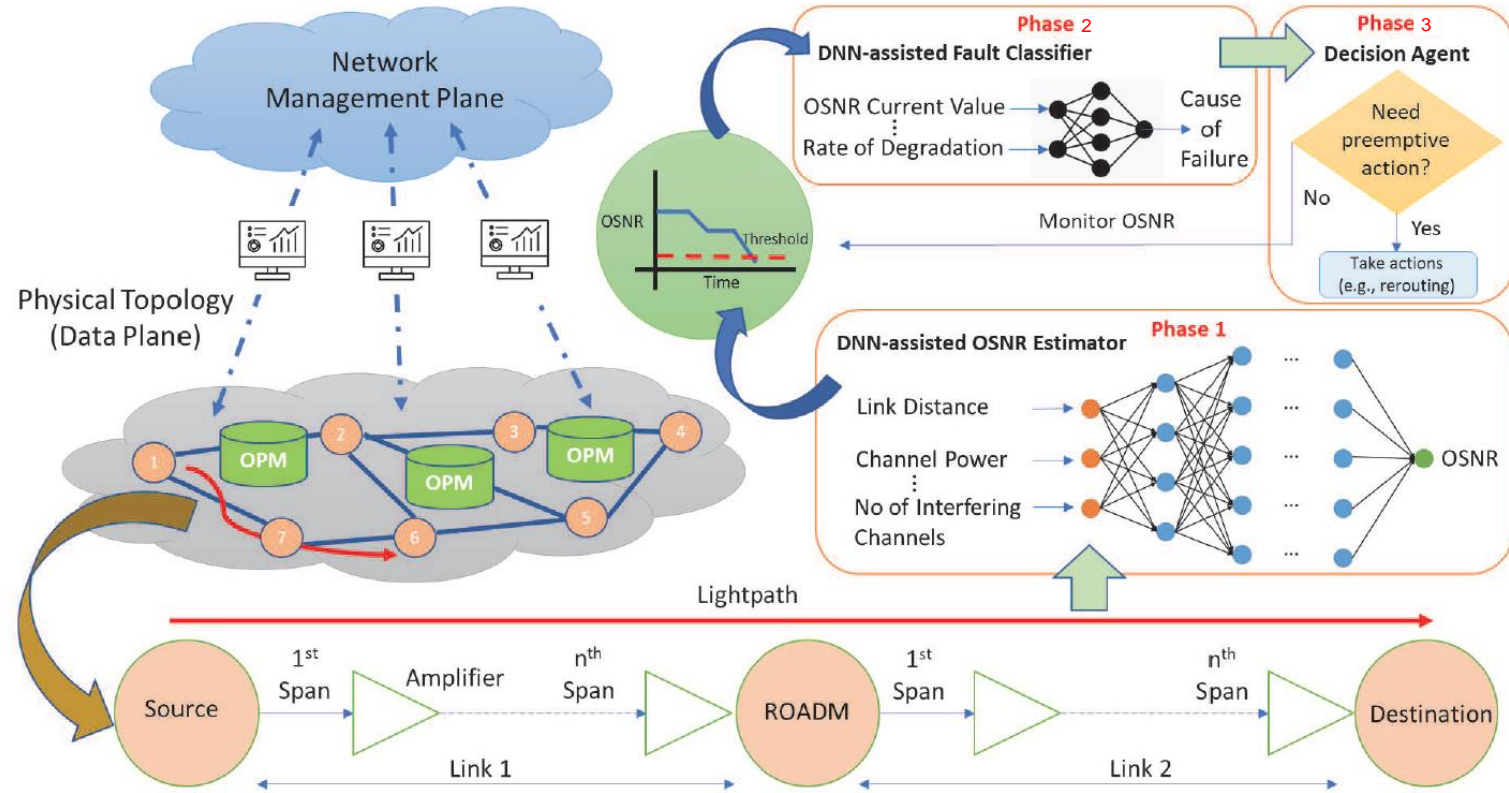
Cisco Security Analytics (2020), "A deep-dive into the unique behavioral modeling and machine learning techniques for advanced threat detection and response [White Paper]," <https://www.cisco.com/c/en/us/products/collateral/security/stealthwatch/white-paper-c11-740605.pdf>.

Behavioral Modeling and ML Techniques for Threat Detection



Cisco Security Analytics (2020), "A deep-dive into the unique behavioral modeling and machine learning techniques for advanced threat detection and response [White Paper]," <https://www.cisco.com/c/en/us/products/collateral/security/stealthwatch/white-paper-c11-740605.pdf>.

General Overview of The Proposed Framework in Single Entity

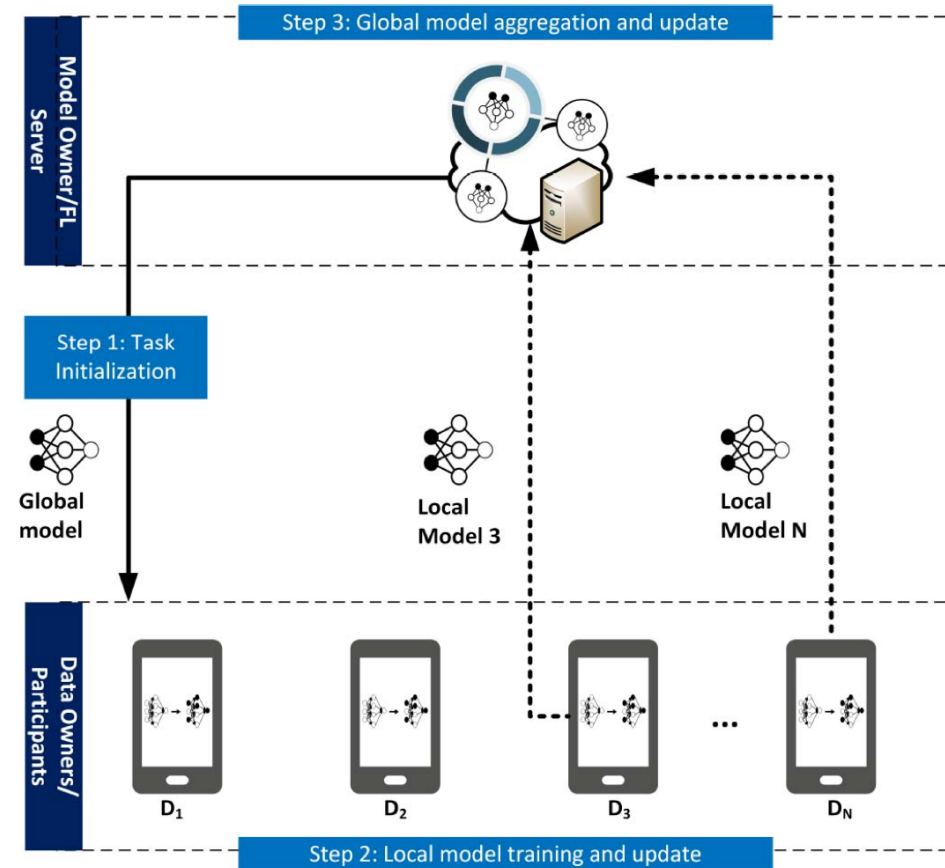


Preemptive failure detection and management (PFDM) framework

Highly Efficient Estimations and Classifications using Federated Learning

W. Y. B. Lim et al., "Federated Learning in Mobile Edge Networks: A Comprehensive Survey," in *IEEE Communications Surveys & Tutorials*, vol. 22, no. 3, pp. 2031-2063, thirdquarter 2020.

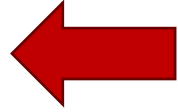
Highly Efficient Estimations and Classifications using Federated Learning



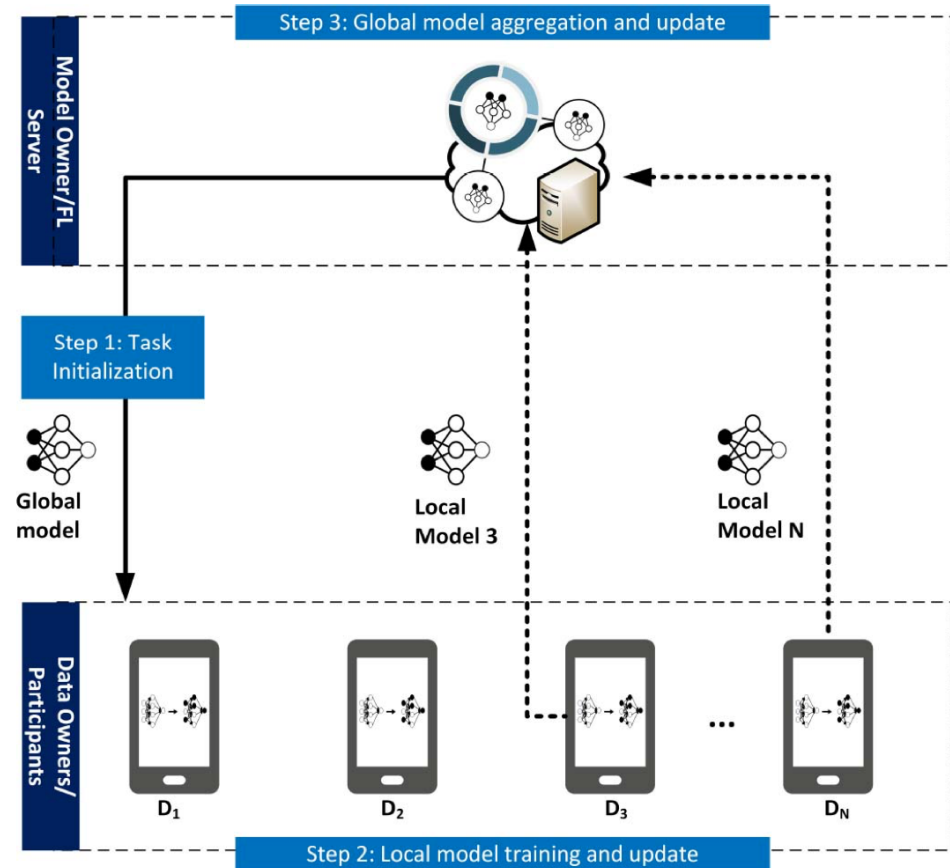
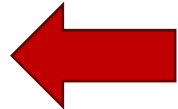
W. Y. B. Lim et al., "Federated Learning in Mobile Edge Networks: A Comprehensive Survey," in *IEEE Communications Surveys & Tutorials*, vol. 22, no. 3, pp. 2031-2063, thirdquarter 2020.

Highly Efficient Estimations and Classifications using Federated Learning

PNE



Carriers



W. Y. B. Lim et al., "Federated Learning in Mobile Edge Networks: A Comprehensive Survey," in *IEEE Communications Surveys & Tutorials*, vol. 22, no. 3, pp. 2031-2063, thirdquarter 2020.

From Local to Federated

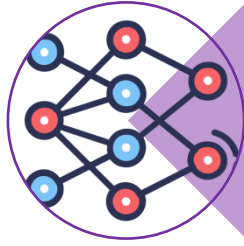


From Local to Federated



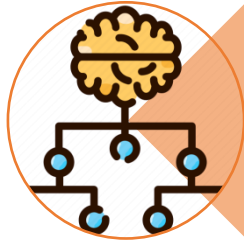
Federated Survivability Framework in Multi- Domain Optical Networks

Phases of The Proposed Framework



Phase I

- Abstraction and OSNR Estimation



Phase II

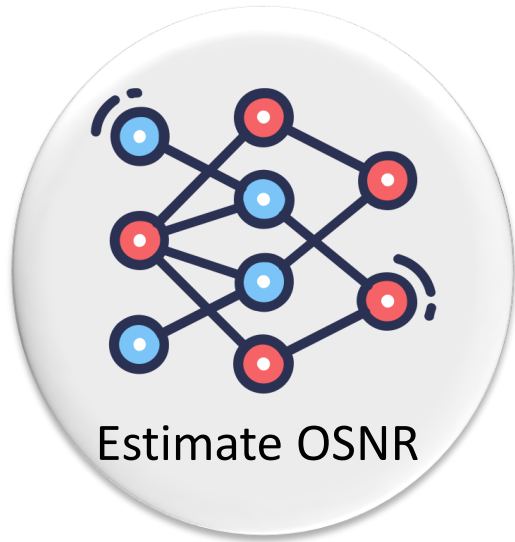
- Failure Classification and Cost Evaluation



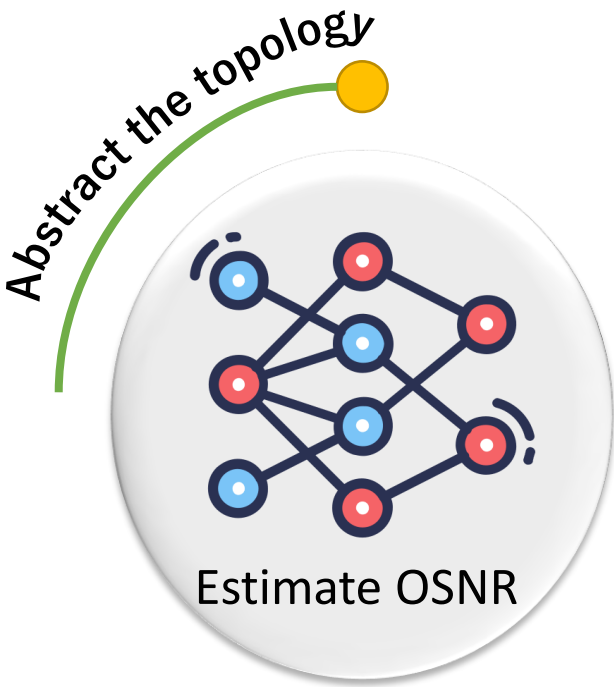
Phase III

- Negotiation and Post-Failure Action

Flow of The Proposed Framework

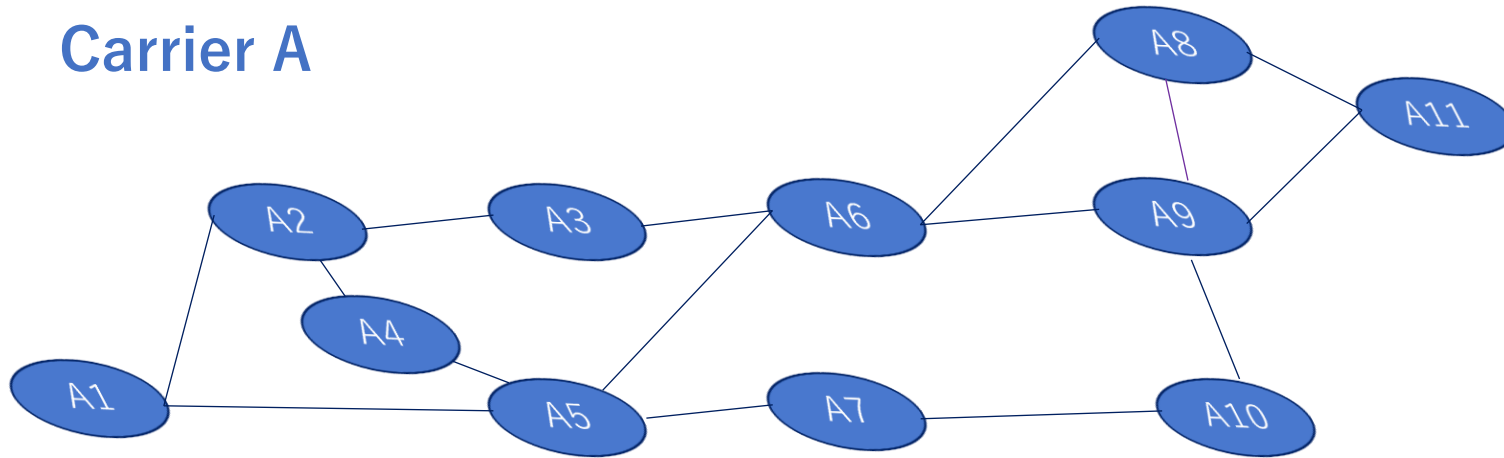


Flow of The Proposed Framework

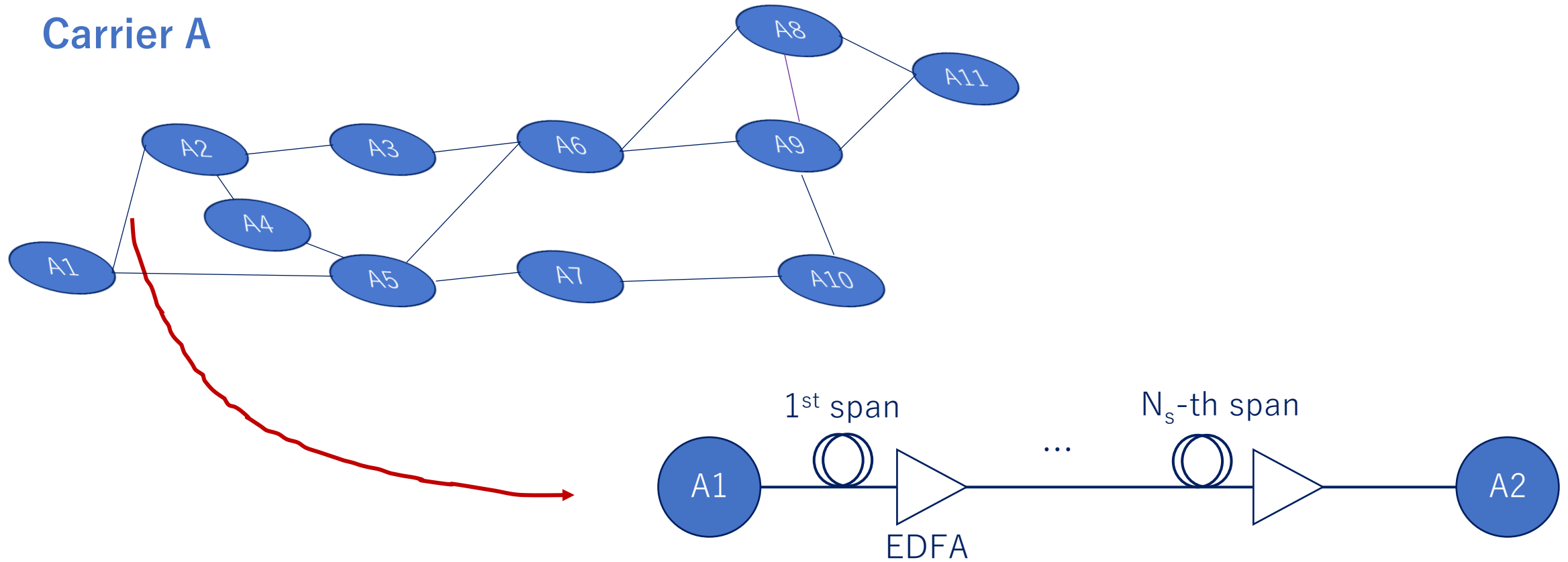


Phase I: Abstraction and OSNR Estimation

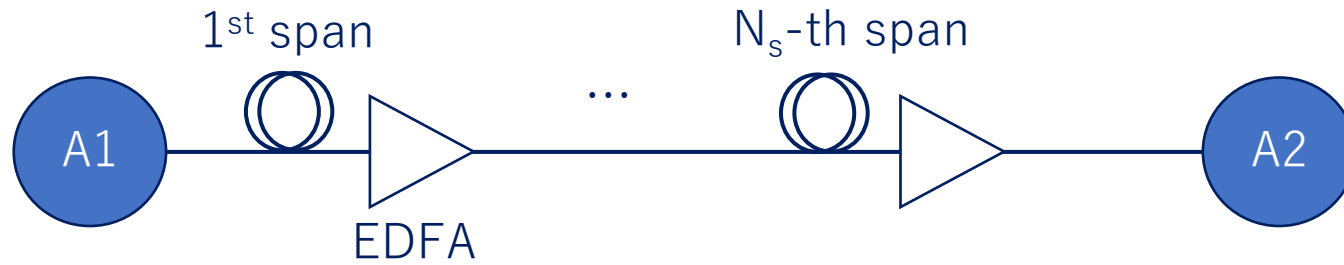
Carrier A



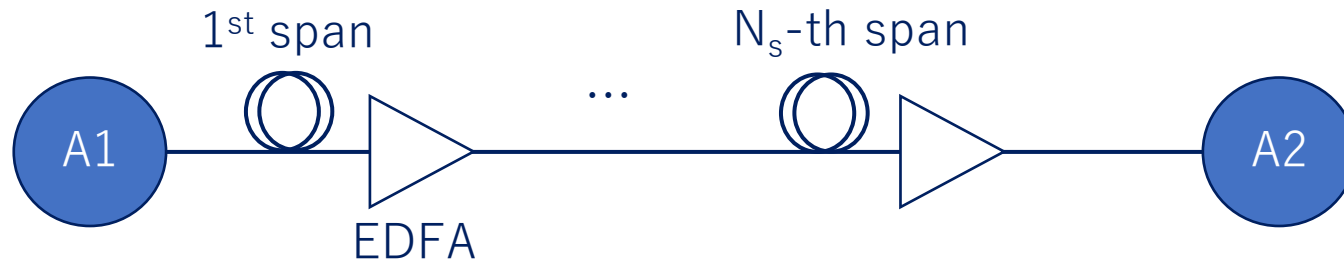
Phase I: Abstraction and OSNR Estimation



Phase I: Abstraction and OSNR Estimation



Phase I: Abstraction and OSNR Estimation



$$OSNR_l^{-1}(f) = \frac{P_{ASE}^l(f) + P_{NLI}^l(f)}{P_{ch}}$$

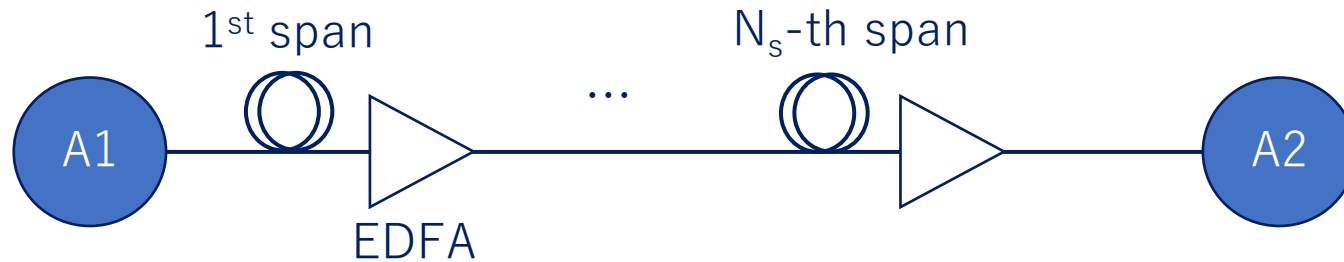
Phase I: Abstraction and OSNR Estimation



$$OSNR_l^{-1}(f) = \frac{P_{ASE}^l(f) + P_{NLI}^l(f)}{P_{ch}}$$

frequency

Phase I: Abstraction and OSNR Estimation

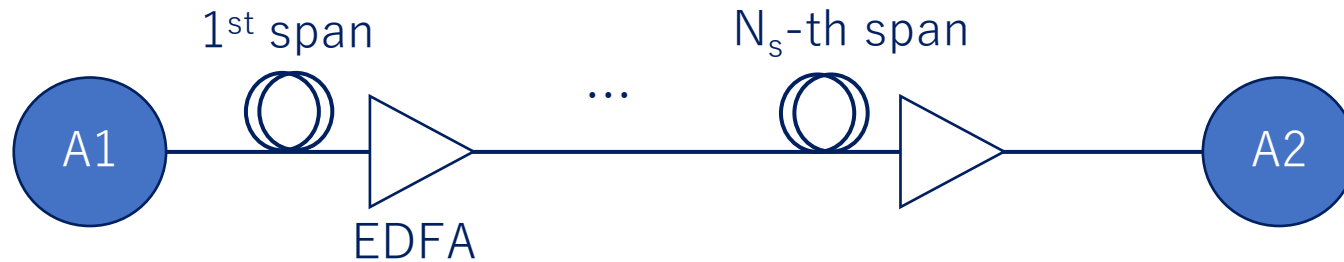


$$OSNR_l^{-1}(f) = \frac{P_{ASE}^l(f) + P_{NLI}^l(f)}{P_{ch}}$$

frequency

ASE noise

Phase I: Abstraction and OSNR Estimation



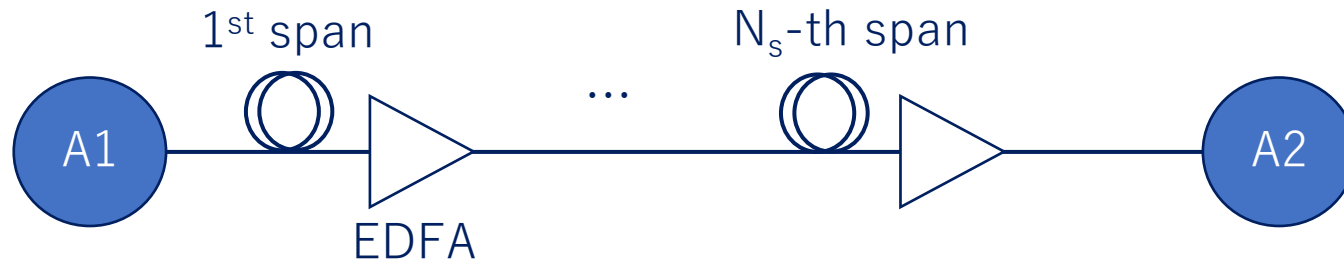
$$OSNR_l^{-1}(f) = \frac{P_{ASE}^l(f) + P_{NLI}^l(f)}{P_{ch}}$$

frequency

ASE noise

Cumulative NLI

Phase I: Abstraction and OSNR Estimation



$$OSNR_l^{-1}(f) = \frac{P_{ASE}^l(f) + P_{NLI}^l(f)}{P_{ch}}$$

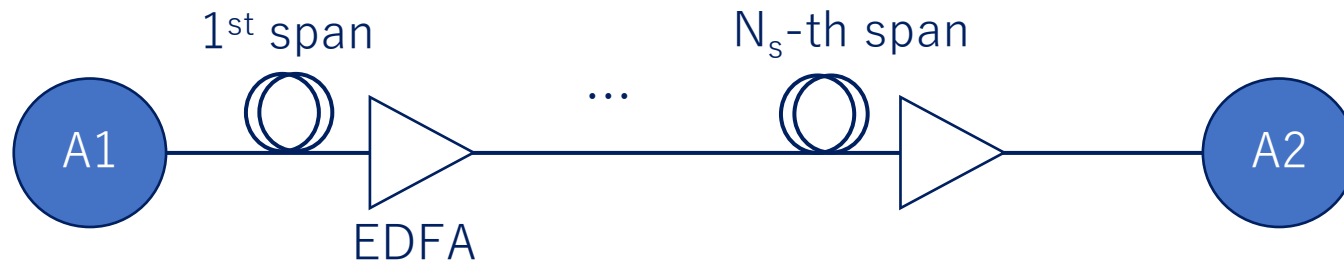
frequency

ASE noise

Cumulative NLI

Channel power

Phase I: Abstraction and OSNR Estimation



$$OSNR_l^{-1}(f) = \frac{P_{ASE}^l(f) + P_{NLI}^l(f)}{P_{ch}}$$

Labels for the equation components:

- $P_{ASE}^l(f)$: ASE noise
- $P_{NLI}^l(f)$: Cumulative NLI
- f : frequency
- P_{ch} : Channel power

General Features

Channel Power
Modulation Level
Link Length
Frequency

ASE Features

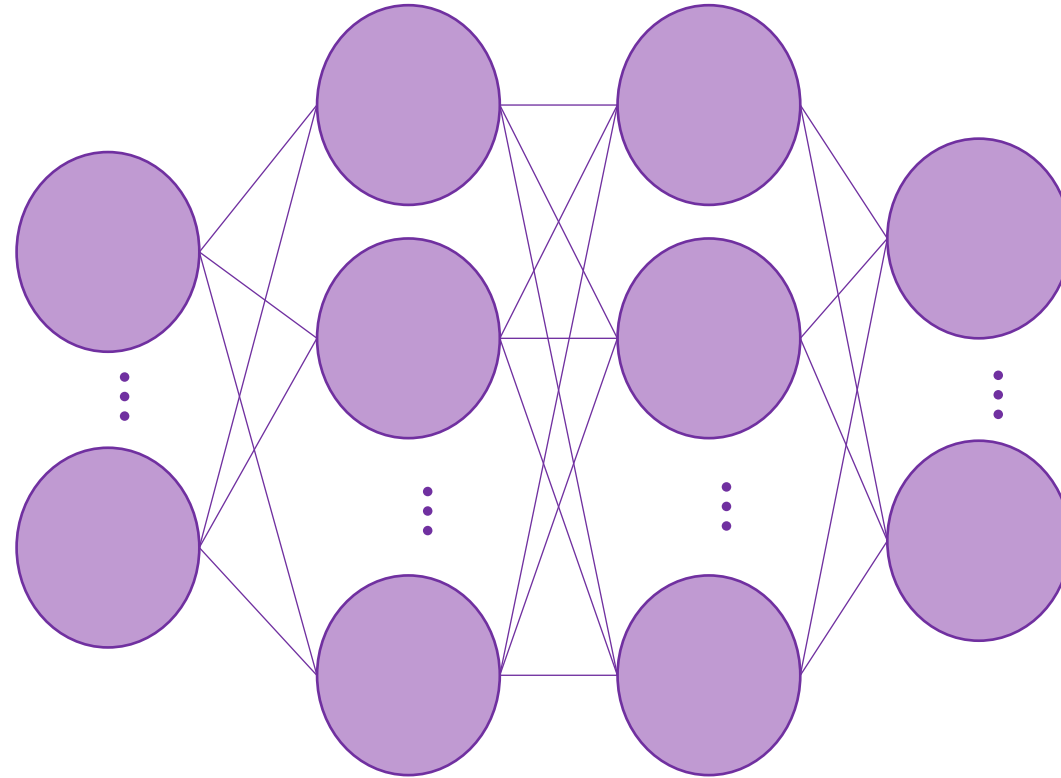
of span
Span length
Spontaneous emission factor
In-line EDFA gain

NLI Features

of active channels
Power of interfering channels
NL coefficient
Phase mismatch
Loss

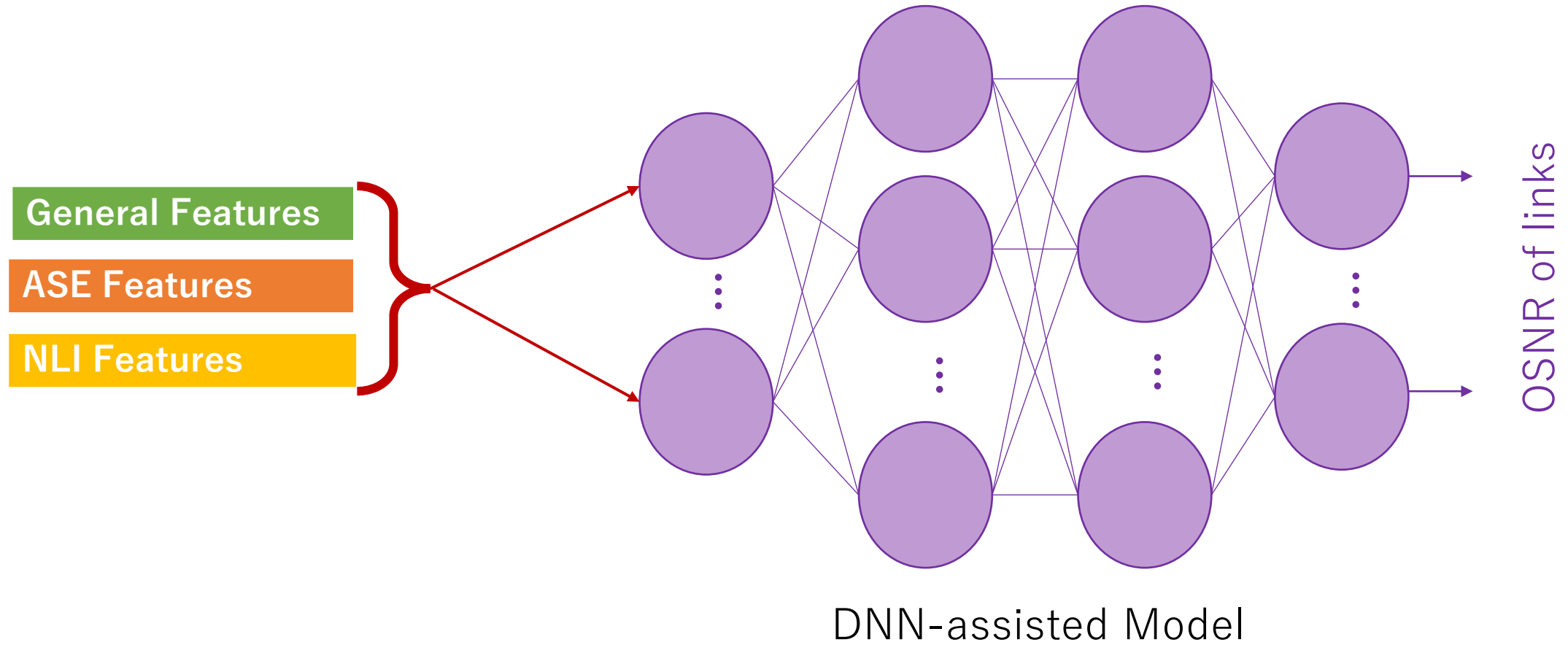
Phase I: Abstraction and OSNR Estimation

Phase I: Abstraction and OSNR Estimation



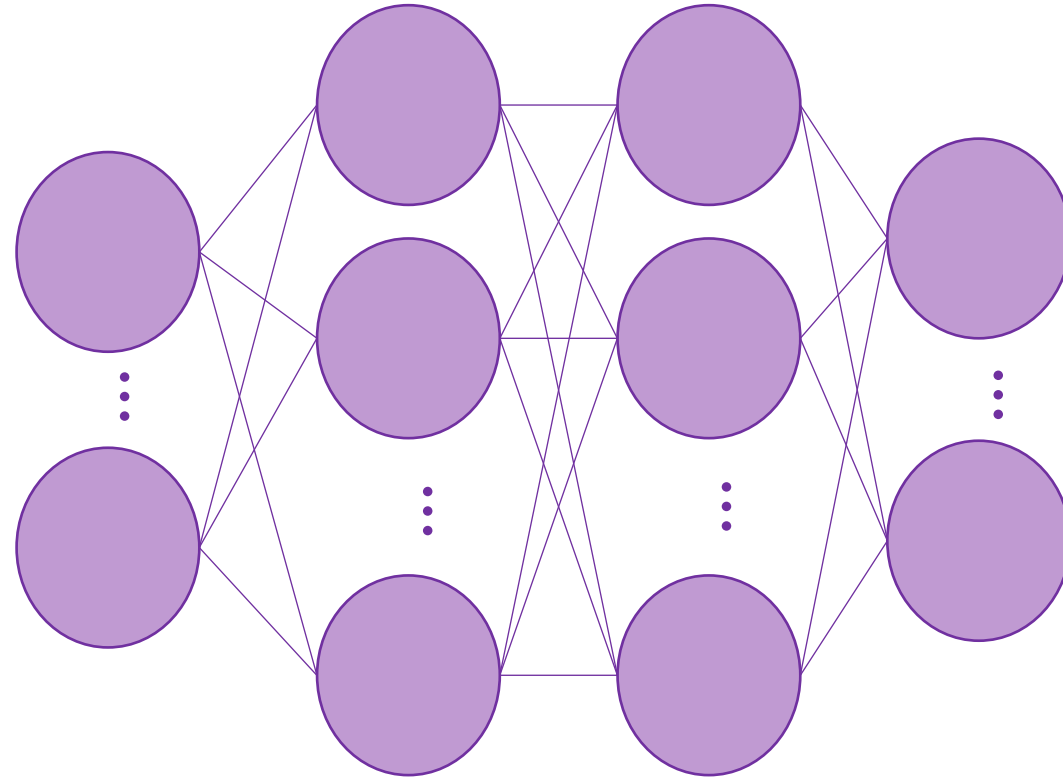
DNN-assisted Model

Phase I: Abstraction and OSNR Estimation



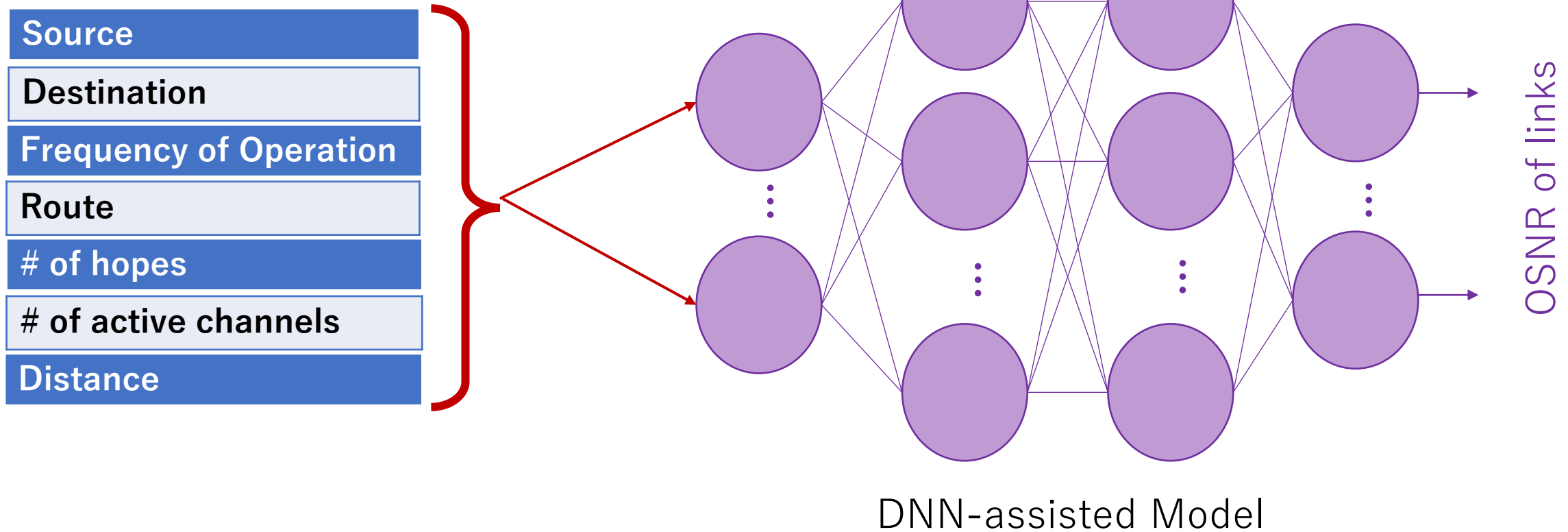
Phase I: Abstraction and OSNR Estimation

Phase I: Abstraction and OSNR Estimation

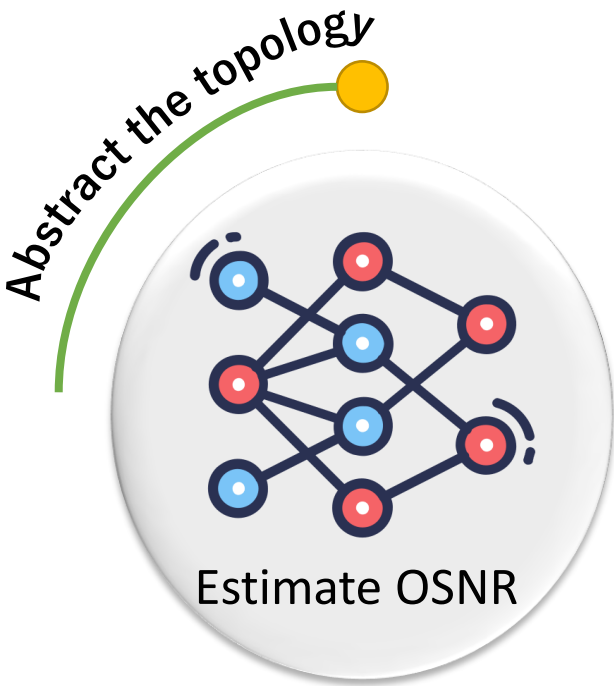


DNN-assisted Model

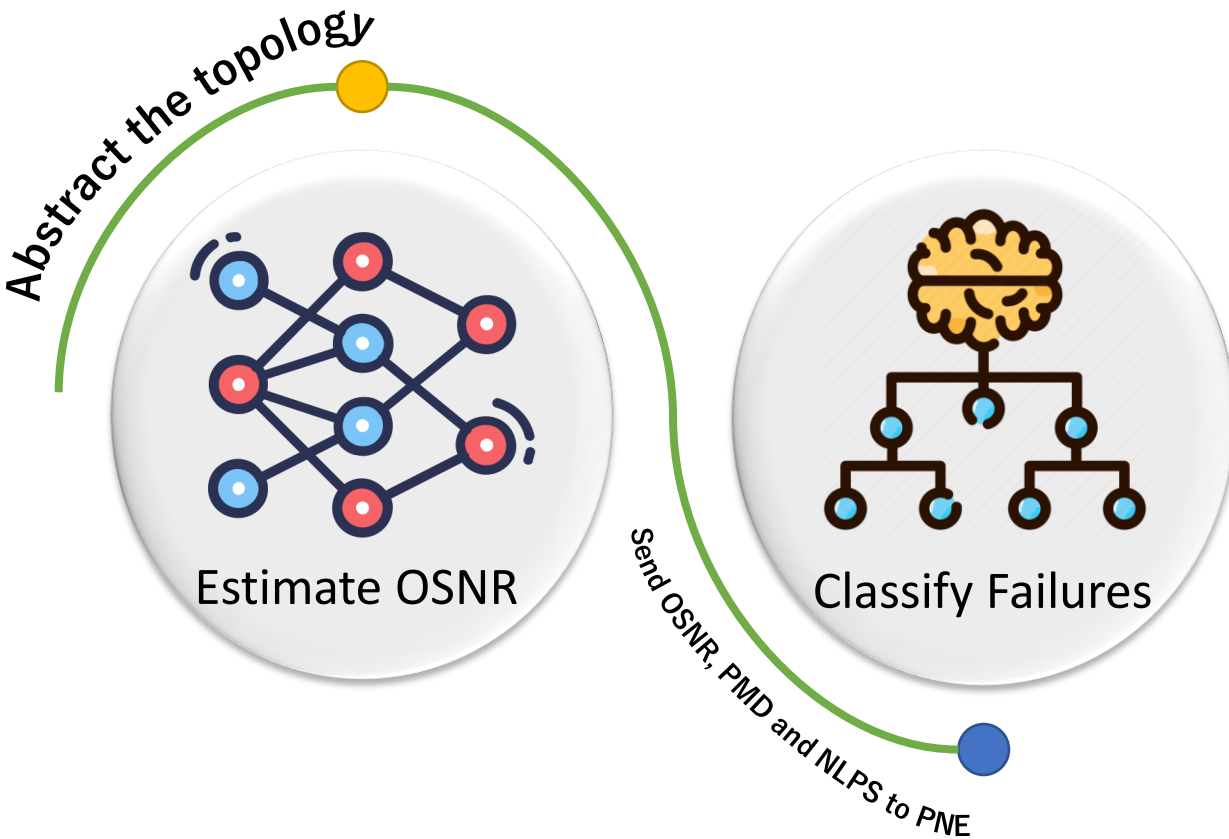
Phase I: Abstraction and OSNR Estimation



Flow of The Proposed Framework



Flow of The Proposed Framework

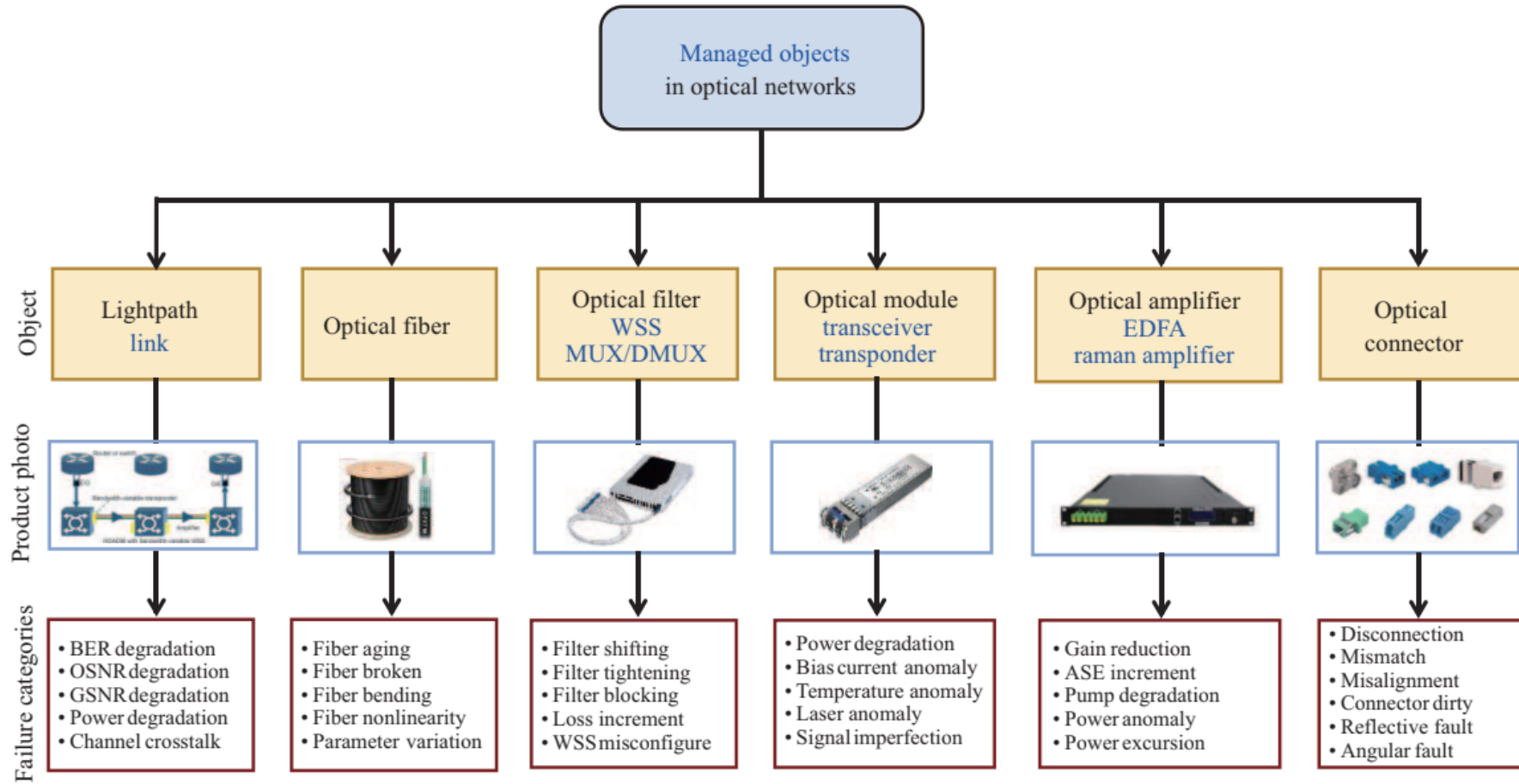


17 Phase II: Classification

Danshi Wang, Chunyu Zhang, Wenbin Chen, Hui Yang, Min Zhang & Alan Pak Tao Lau, “A review of machine learning-based failure management in optical networks,” in *Science China Information Sciences*, vol. 65, no. 211302, 2022.

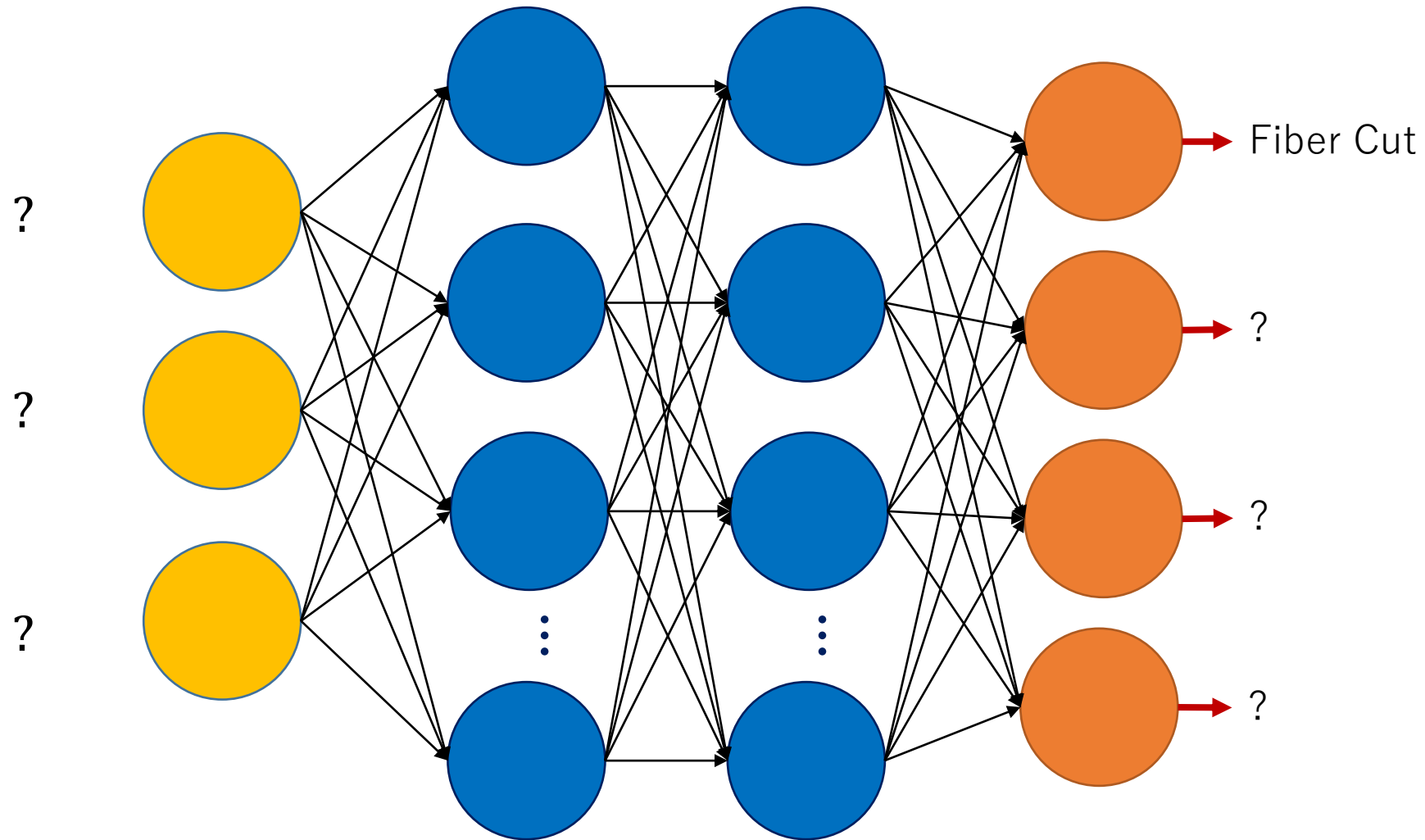
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Phase II: Classification



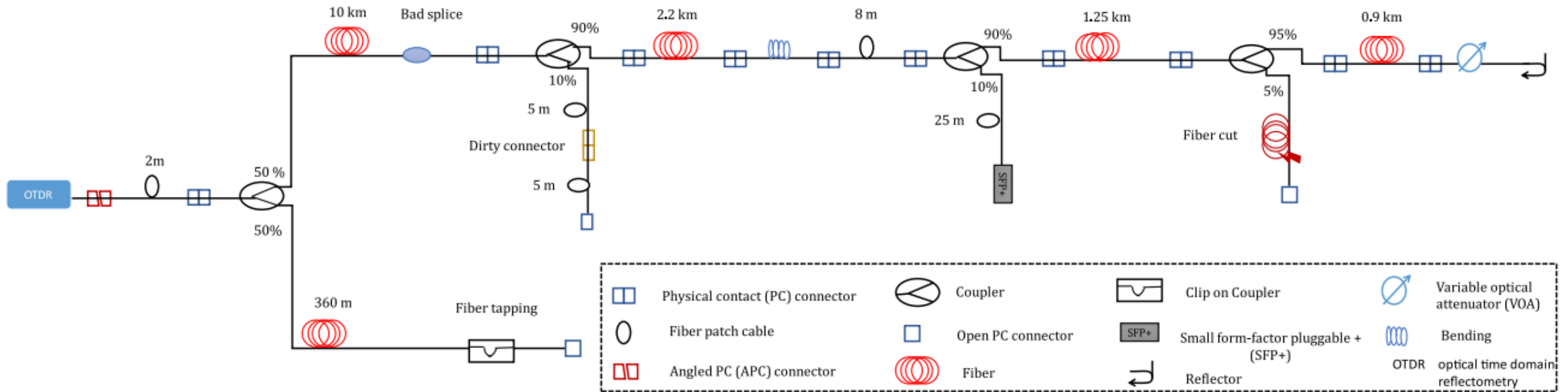
Danshi Wang, Chunyu Zhang, Wenbin Chen, Hui Yang, Min Zhang & Alan Pak Tao Lau, “A review of machine learning-based failure management in optical networks,” in *Science China Information Sciences*, vol. 65, no. 211302, 2022.

Phase II: Classification



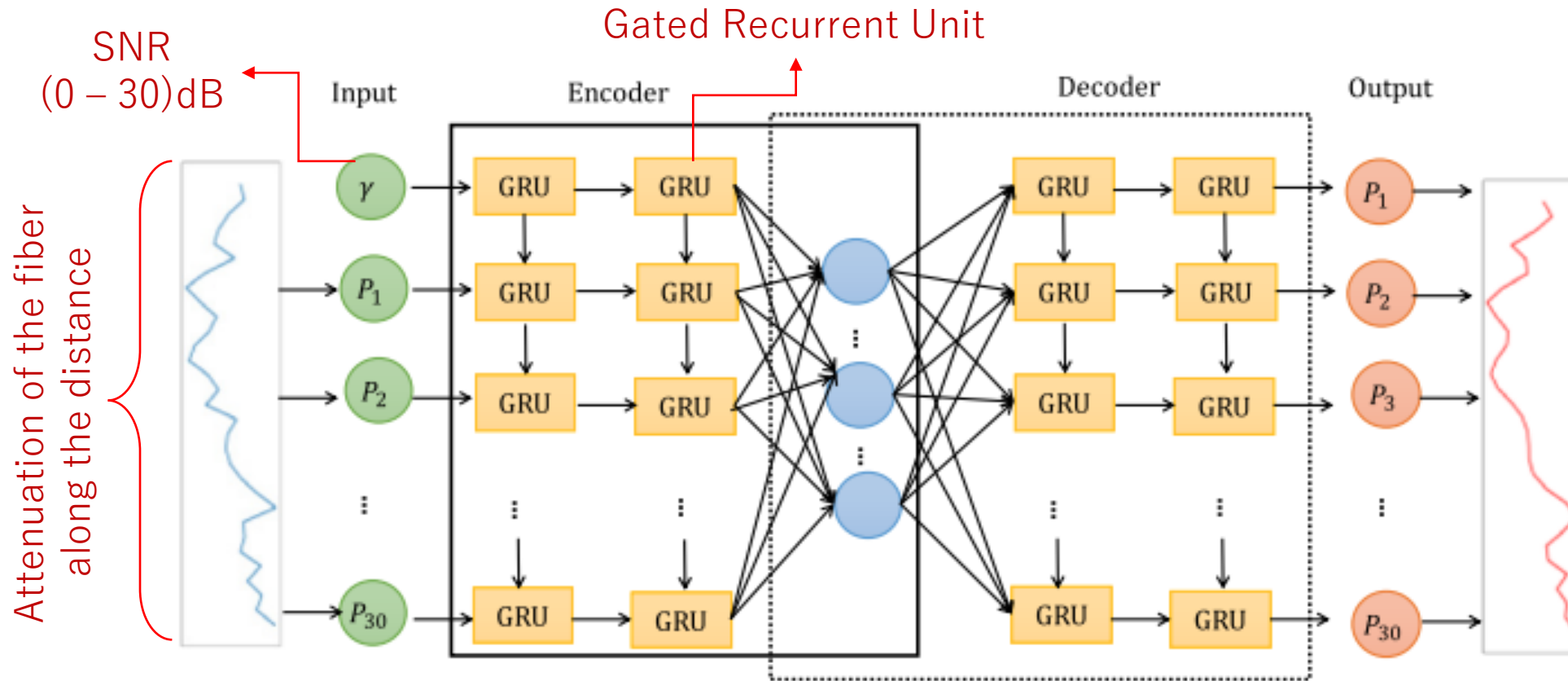
19

Phase II: Classification



Khouloud Abdelli, Joo Yeon Cho, Florian Azendorf, Helmut Griesser, Carsten Tropschug, and Stephan Pachnicke, "Machine-learning-based anomaly detection in optical fiber monitoring," in *J. Opt. Commun. Netw*, vol. 14, pp. 365-375, 2022.

Phase II: Classification



Khoulood Abdelli, Joo Yeon Cho, Florian Azendorf, Helmut Griesser, Carsten Tropschug, and Stephan Pachnicke, "Machine-learning-based anomaly detection in optical fiber monitoring," in *J. Opt. Commun. Netw*, vol. 14, pp. 365-375, 2022.

21

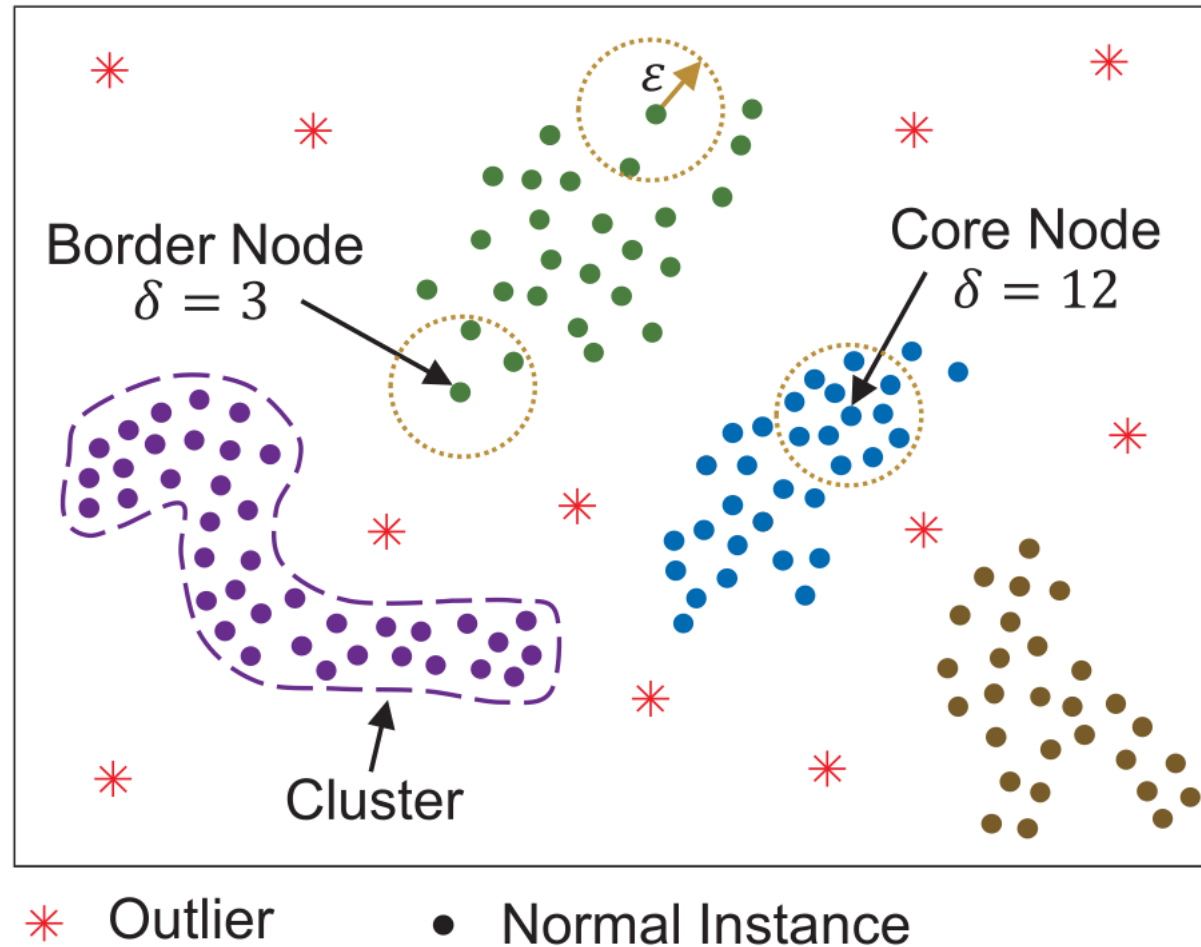
Phase II: Classification

0	1	2	3	4	5	6	7
Normal	Fiber Tapping	Bad Splice	Bending Event	Dirty Connector	Fiber Cut	PC Connector	Reflector

Khouloud Abdelli, Joo Yeon Cho, Florian Azendorf, Helmut Griesser, Carsten Tropschug, and Stephan Pachnicke, "Machine-learning-based anomaly detection in optical fiber monitoring," in *J. Opt. Commun. Netw*, vol. 14, pp. 365-375, 2022.

22

Phase II: Classification

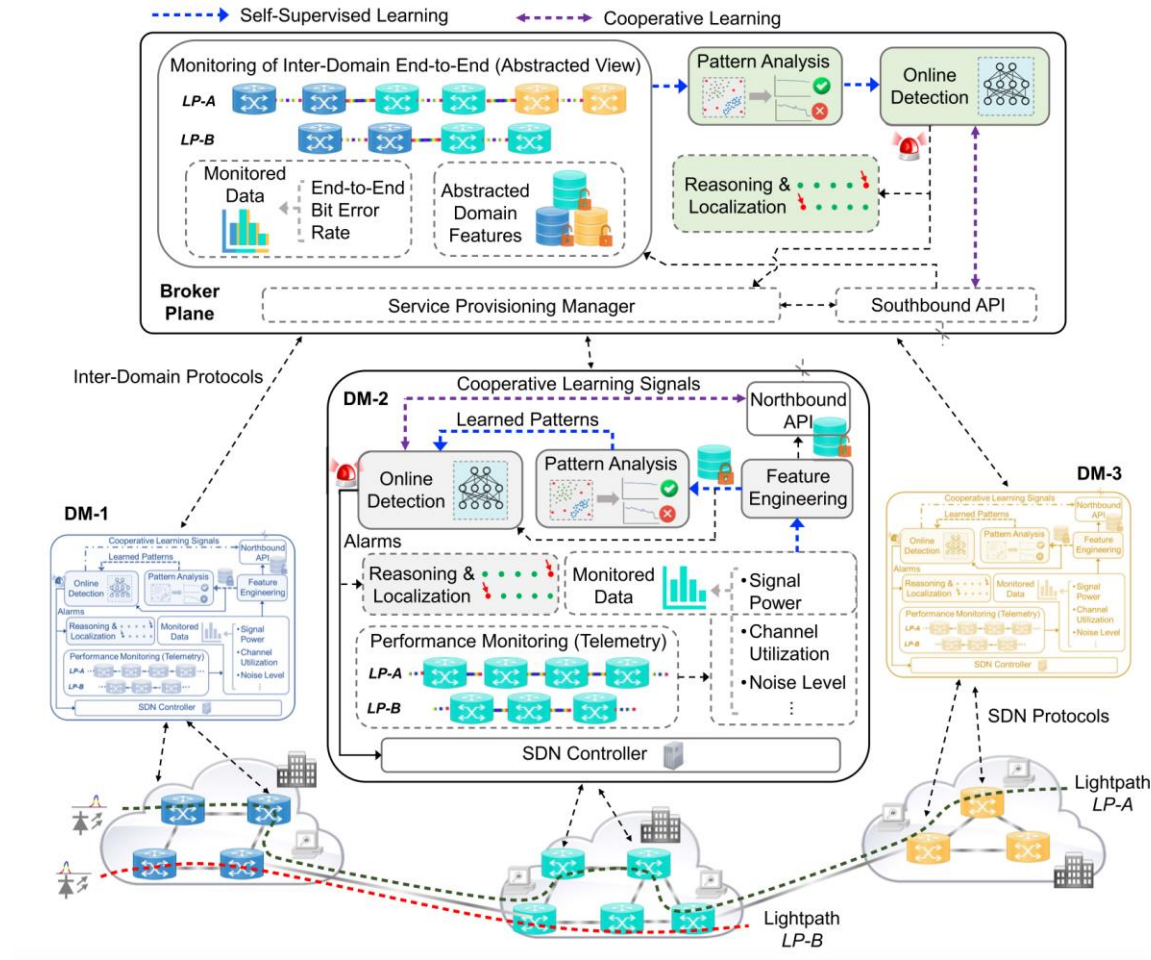


X. Chen, B. Li, R. Proietti, Z. Zhu and S. J. B. Yoo, "Self-Taught Anomaly Detection With Hybrid Unsupervised/Supervised Machine Learning in Optical Networks," in Journal of Lightwave Technology, vol. 37, no. 7, pp. 1742-1749, 1 April 1, 2019.

Phase II: Classification

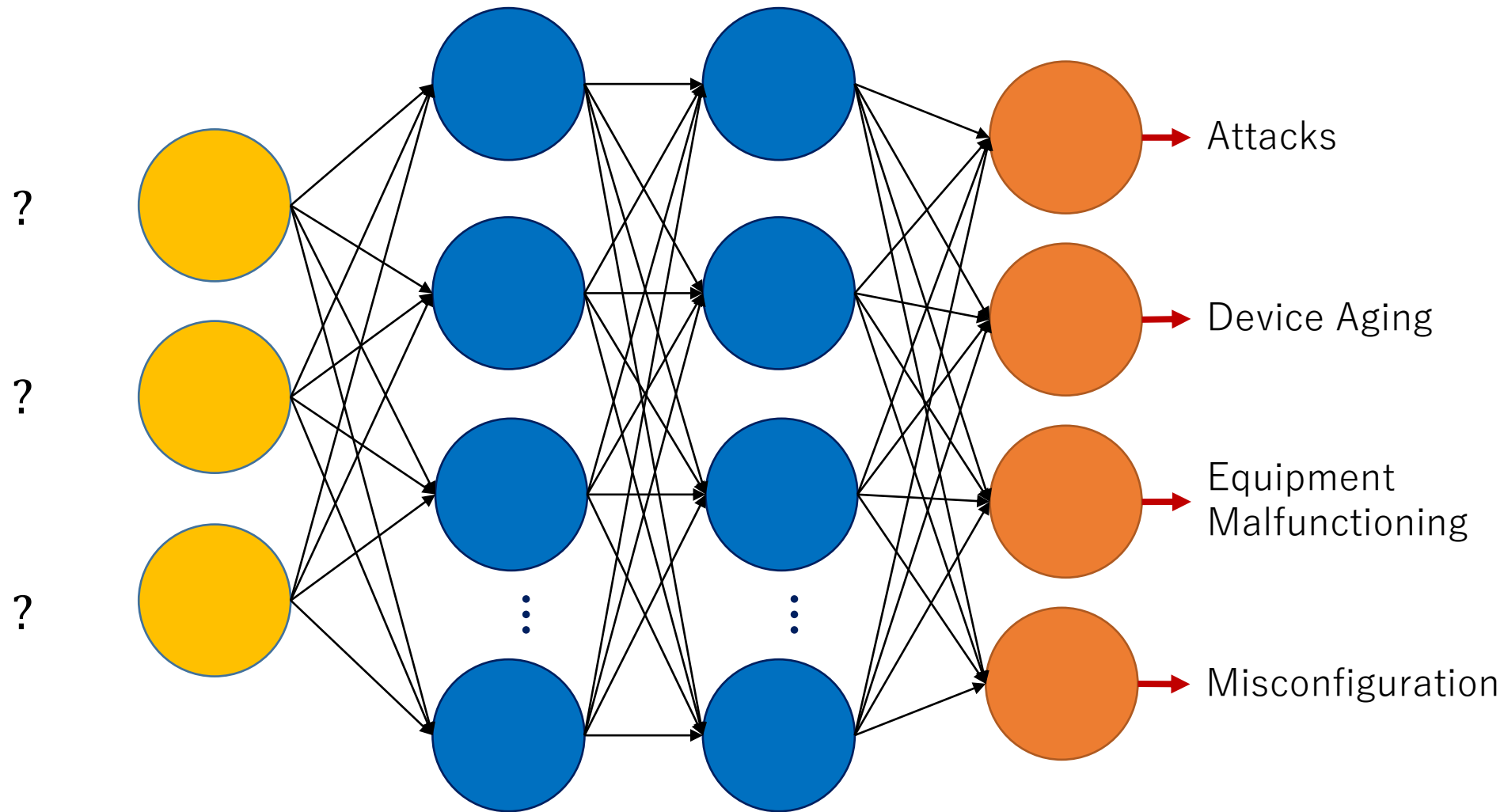
X. Chen, C. -Y. Liu, R. Proietti, J. Yin, Z. Li and S. J. B. Yoo, "On Cooperative Fault Management in Multi-Domain Optical Networks Using Hybrid Learning," in *IEEE Journal of Selected Topics in Quantum Electronics*, vol. 28, no. 4: Mach. Learn. in Photon. Commun. and Meas. Syst., pp. 1-9, July-Aug. 2022, Art no. 3700209.

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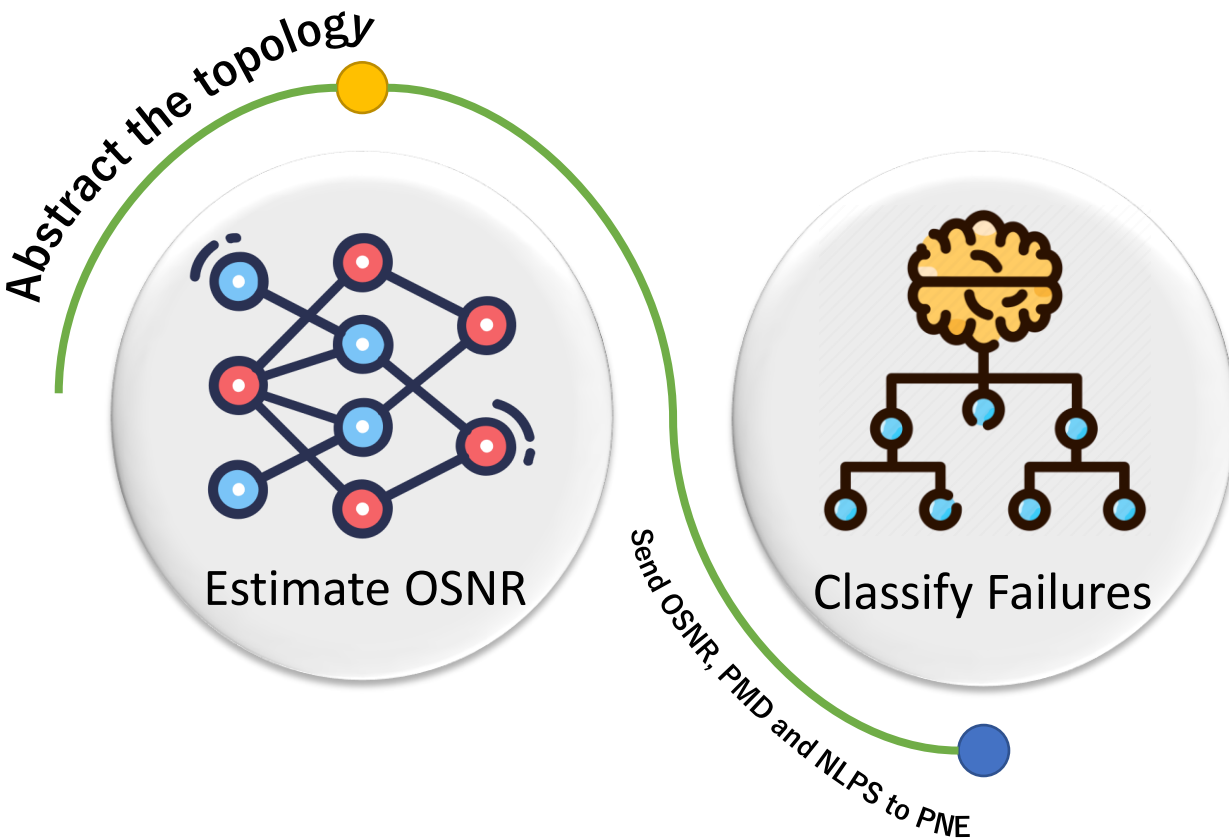


X. Chen, C. -Y. Liu, R. Proietti, J. Yin, Z. Li and S. J. B. Yoo, "On Cooperative Fault Management in Multi-Domain Optical Networks Using Hybrid Learning," in *IEEE Journal of Selected Topics in Quantum Electronics*, vol. 28, no. 4: Mach. Learn. in Photon. Commun. and Meas. Syst., pp. 1-9, July-Aug. 2022, Art no. 3700209.

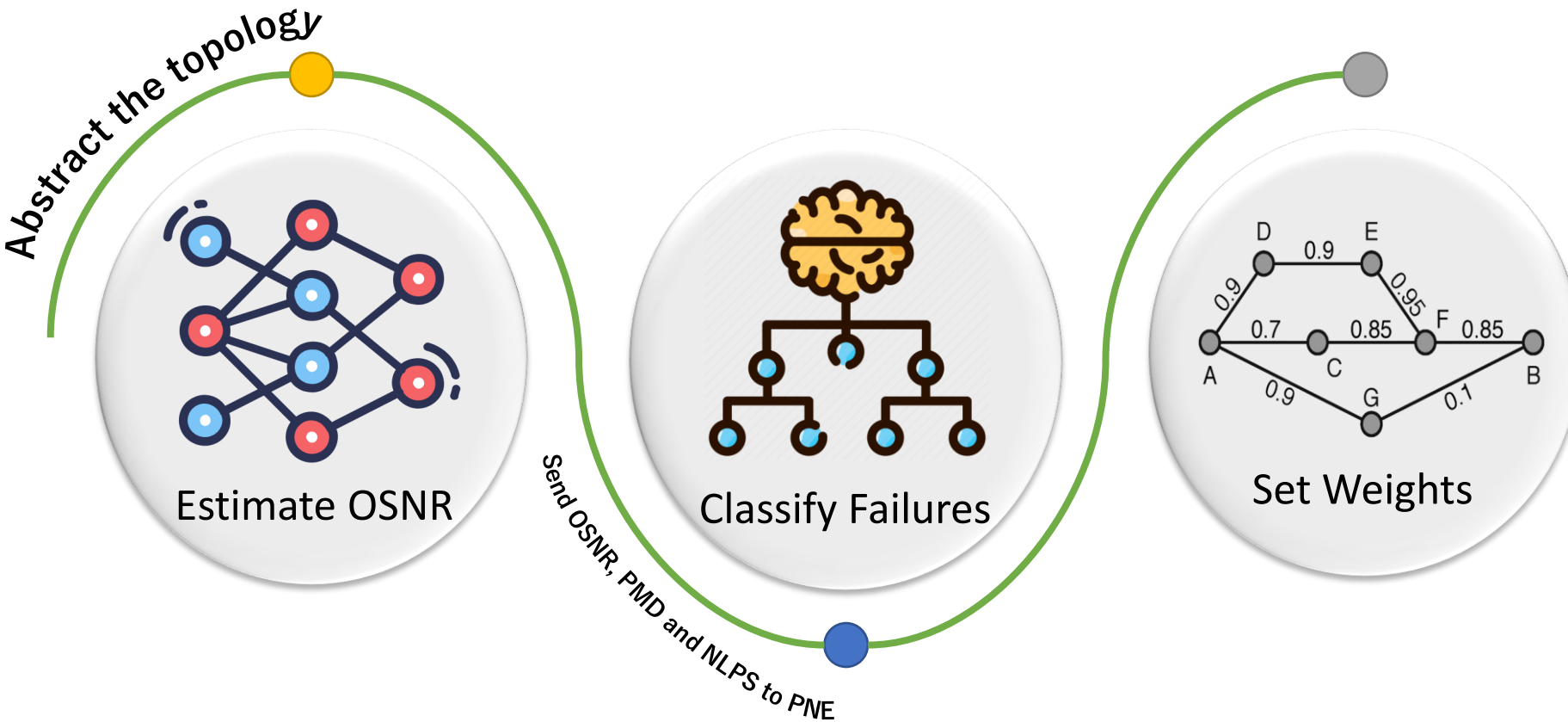
Phase II: Classification



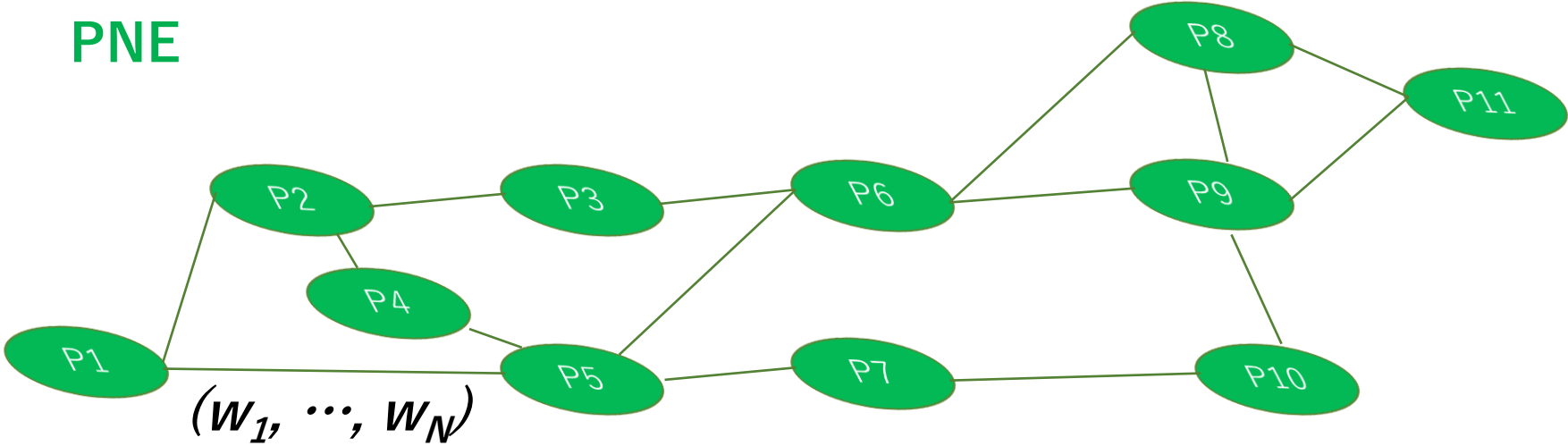
Flow of The Proposed Framework



Flow of The Proposed Framework

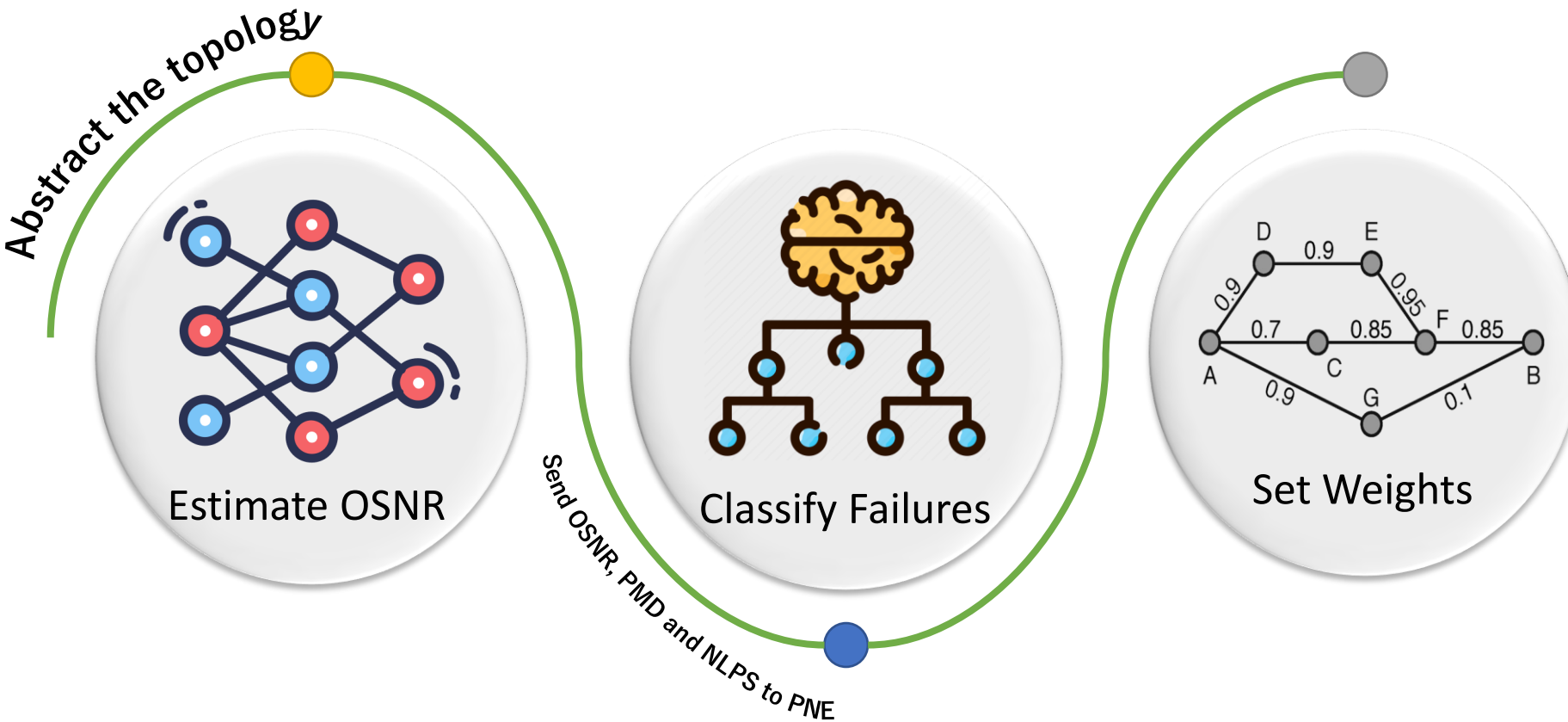


Setting Weights

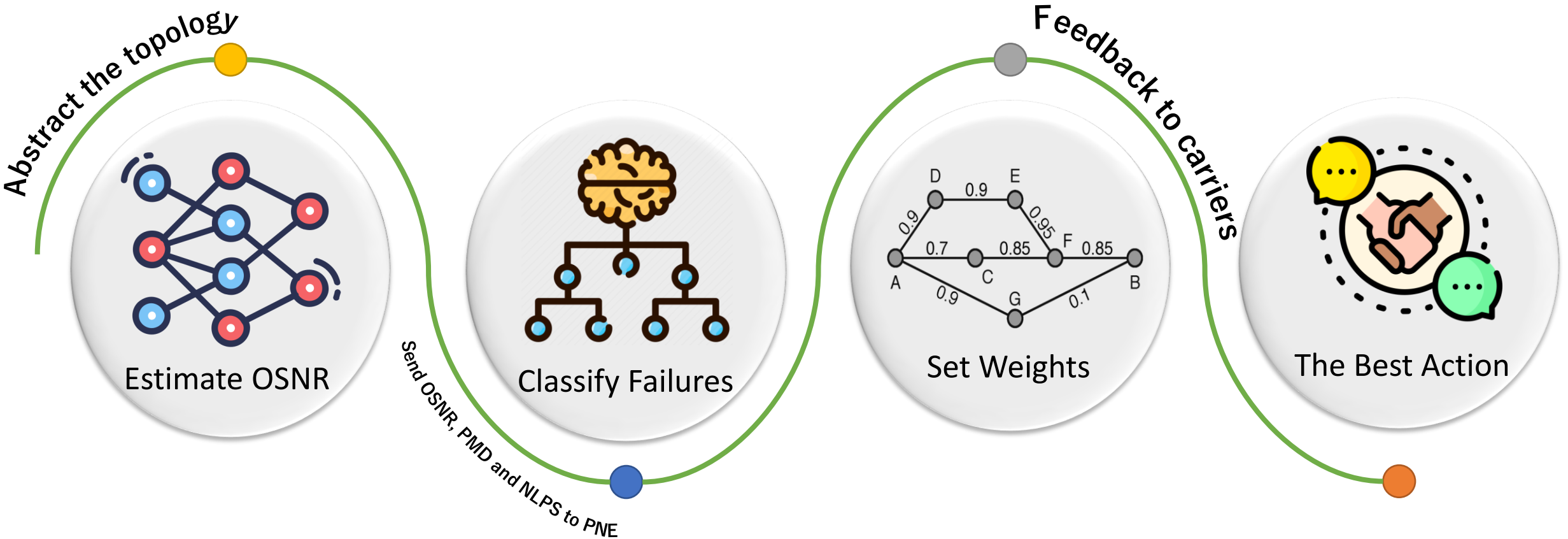


Link	Weight	Link	Weight	Link	Weight	Link	Weight
(P1-P2)	(w_1, \dots, w_N)	(P3-P6)	(w_1, \dots, w_N)	(P6-P8)	(w_1, \dots, w_N)	(P8-P11)	(w_1, \dots, w_N)
(P1-P5)	(w_1, \dots, w_N)	(P4-P5)	(w_1, \dots, w_N)	(P6-P9)	(w_1, \dots, w_N)	(P9-P10)	(w_1, \dots, w_N)
(P2-P3)	(w_1, \dots, w_N)	(P5-P6)	(w_1, \dots, w_N)	(P7-P10)	(w_1, \dots, w_N)	(P9-P11)	(w_1, \dots, w_N)
(P2-P4)	(w_1, \dots, w_N)	(P5-P7)	(w_1, \dots, w_N)	(P8-P9)	(w_1, \dots, w_N)		

Flow of The Proposed Framework

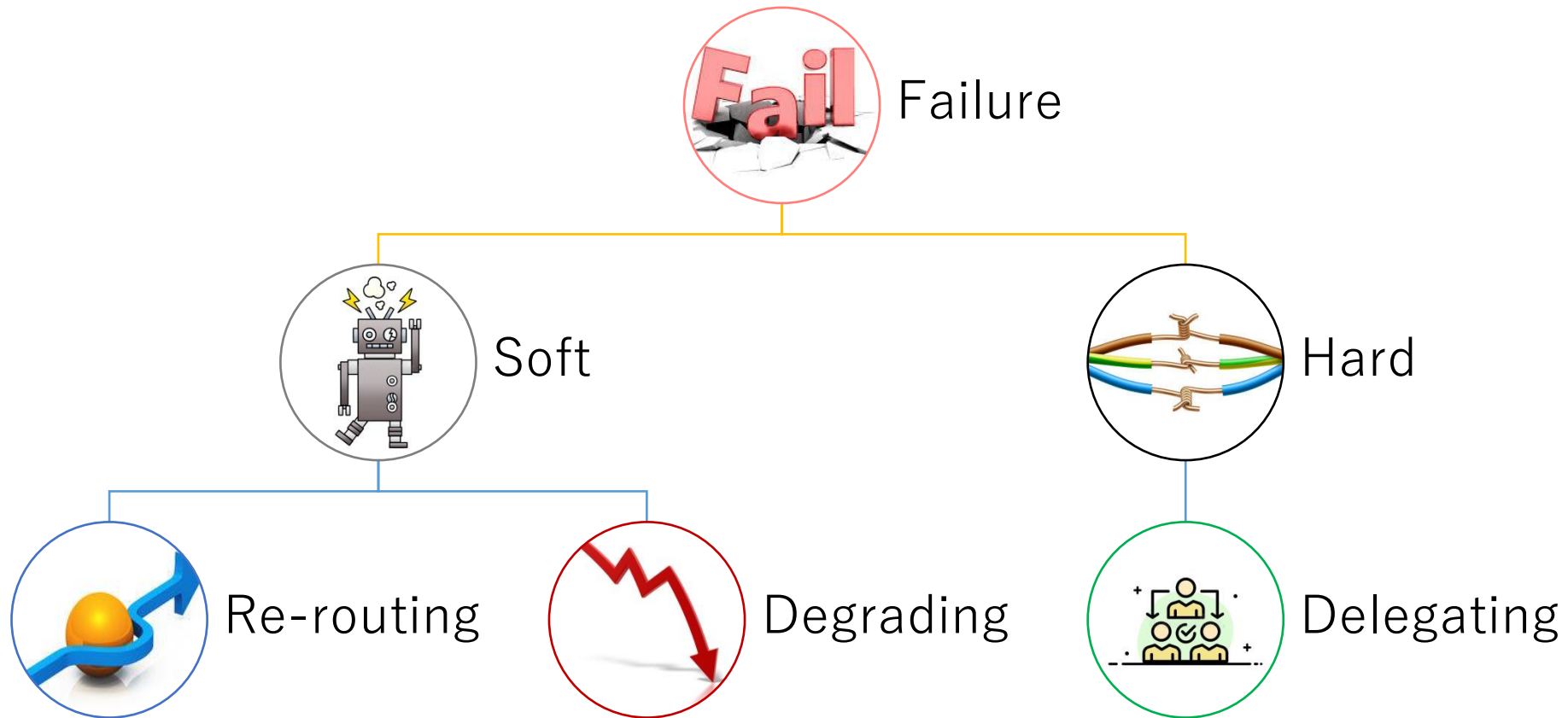


Flow of The Proposed Framework

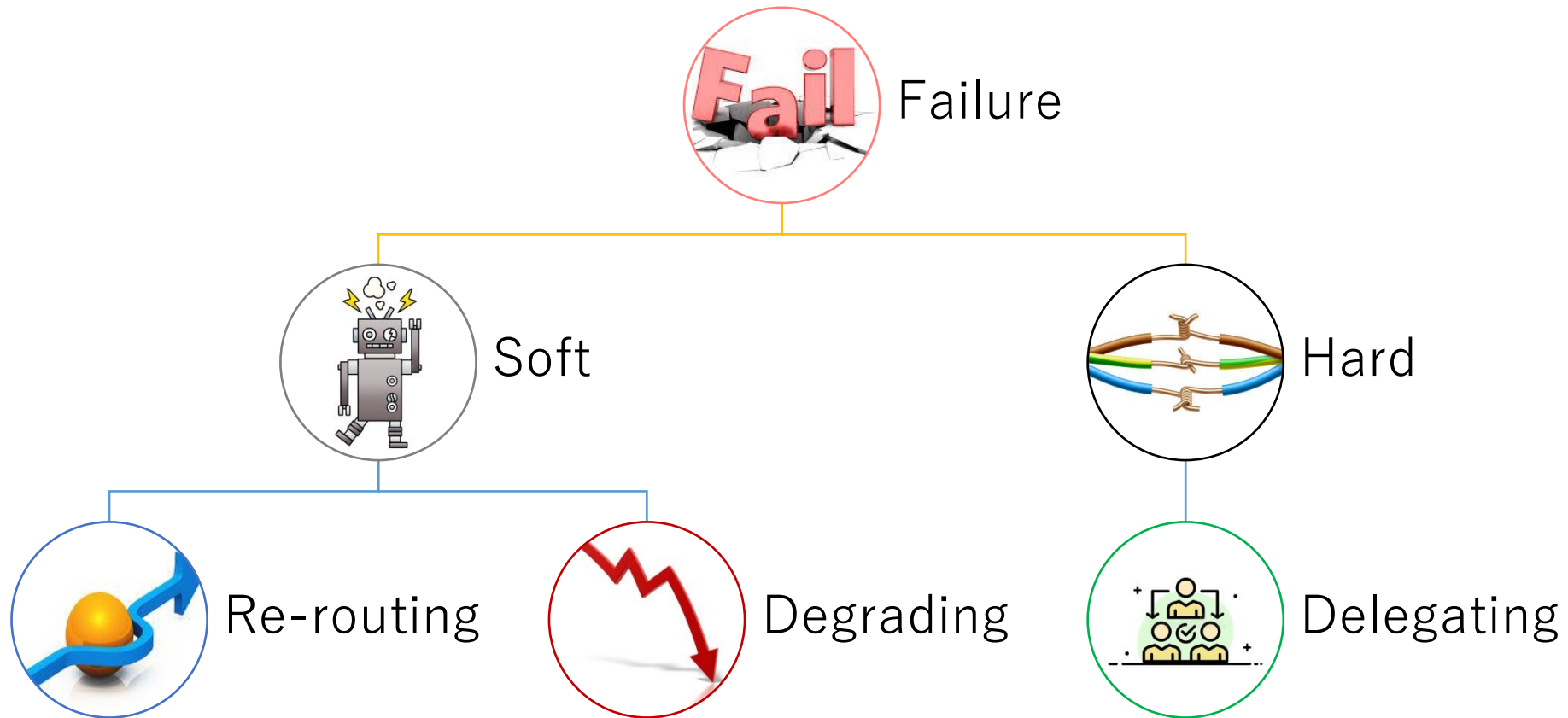


Phase III: Providing Carriers with Suggestions

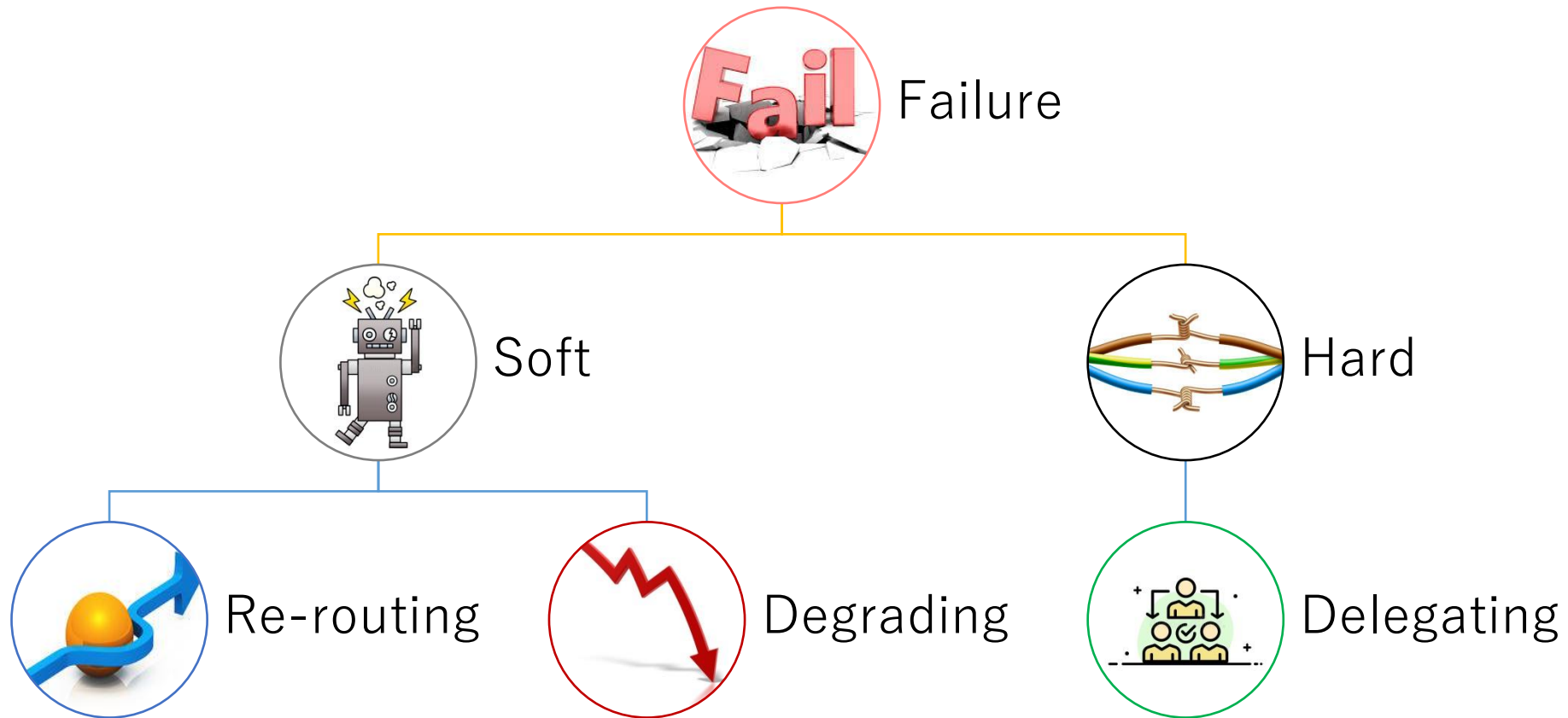
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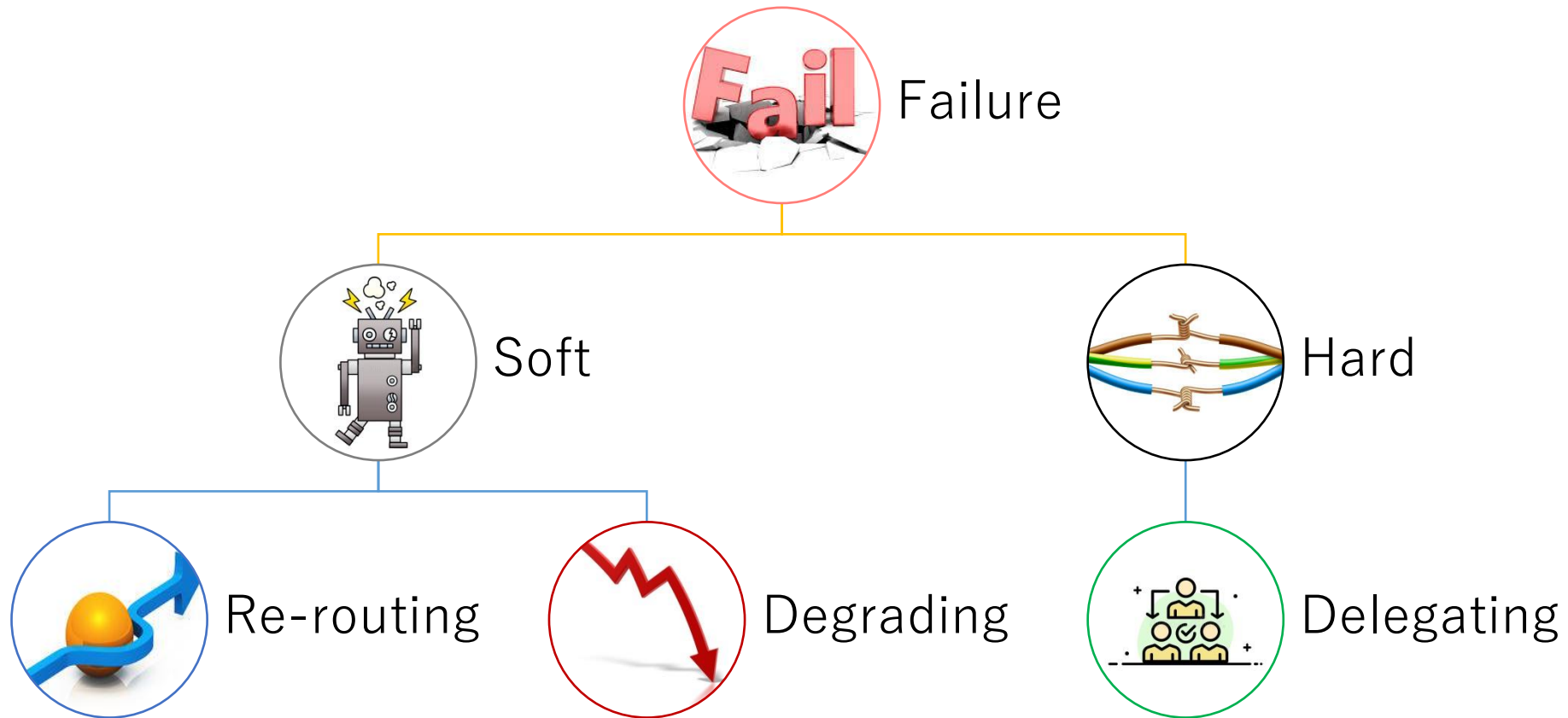
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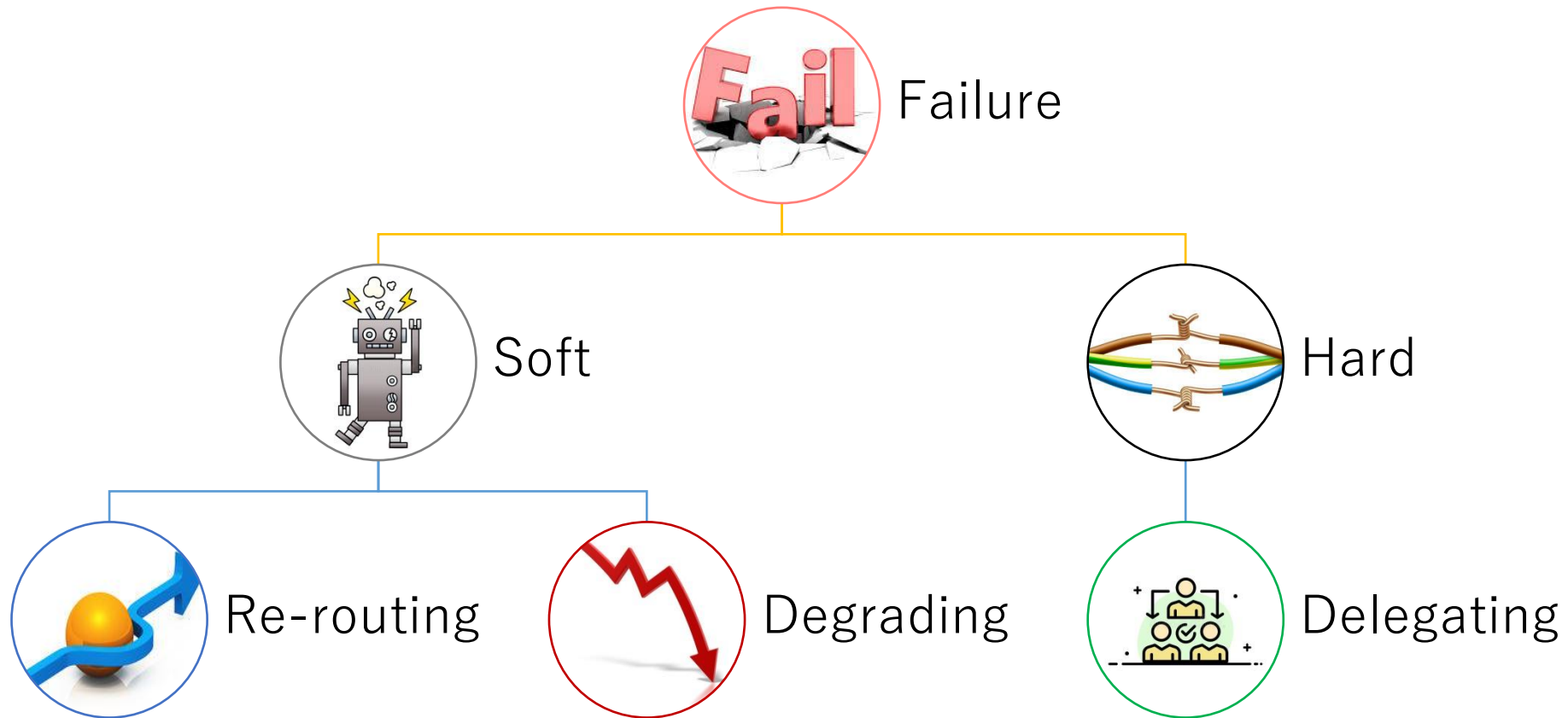
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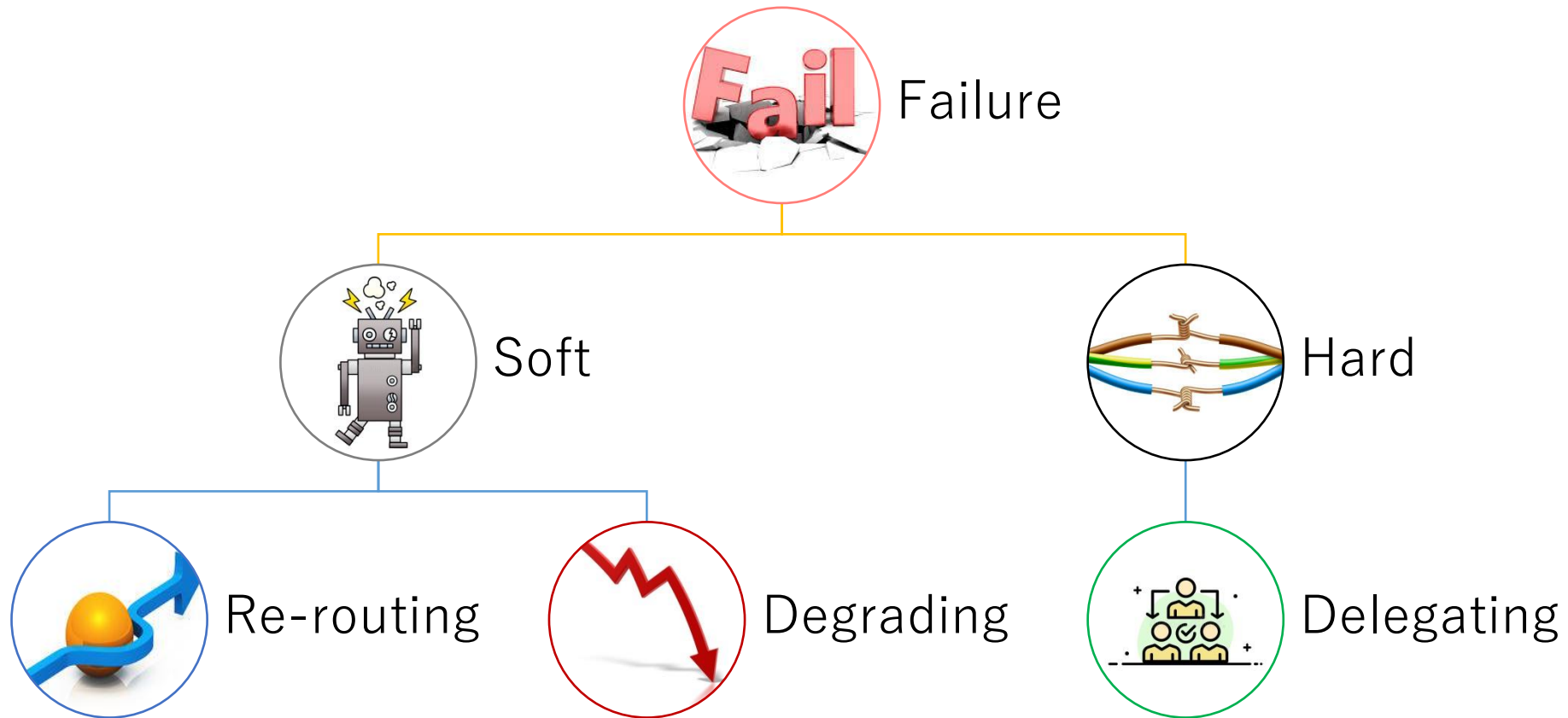
Phase III: Providing Carriers with Suggestions



Phase III: Providing Carriers with Suggestions



Phase III: Providing Carriers with Suggestions



Phase III: Negotiation



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PNE

- Enhance ecosystem survivability
- Prolong ecosystem lifetime
- Optimal resource management

Carrier

- Reduce burden (resource crunch)
- Reduce recovery cost

DCP

- Lower cost
- Higher service restoration

ISP

- Lower cost
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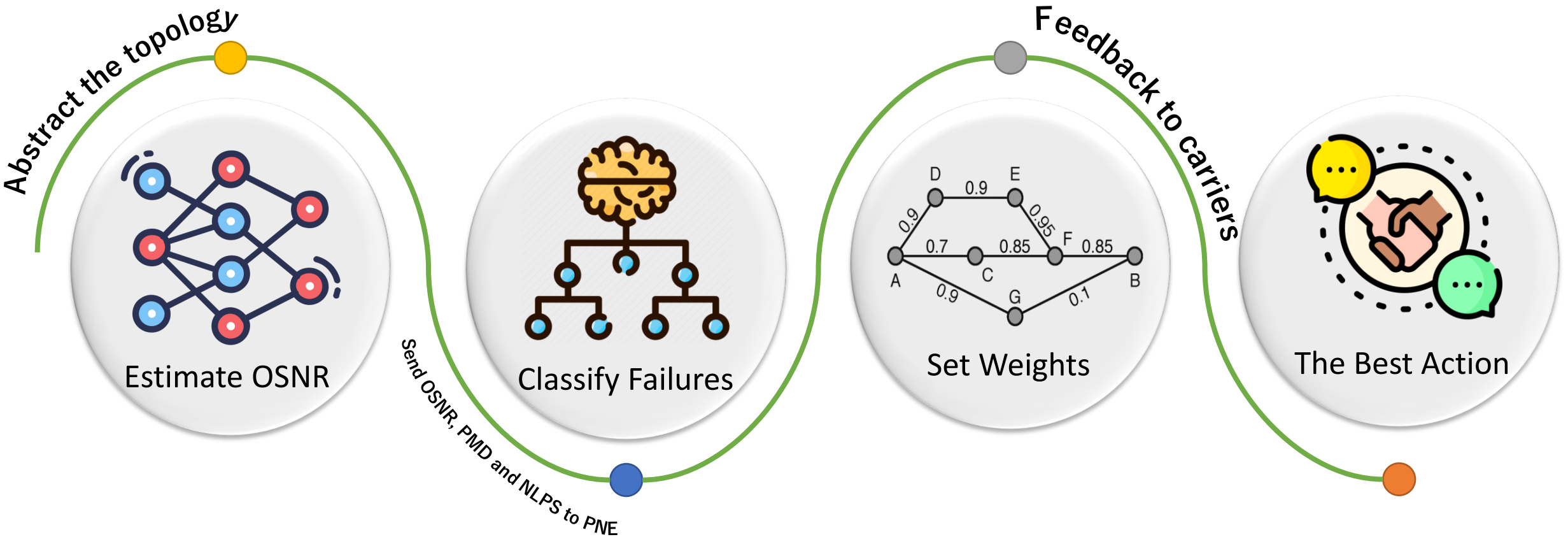
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Flow of The Proposed Framework



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