Fast Detection of Alternative Route under Unknown Failure on SDN Network

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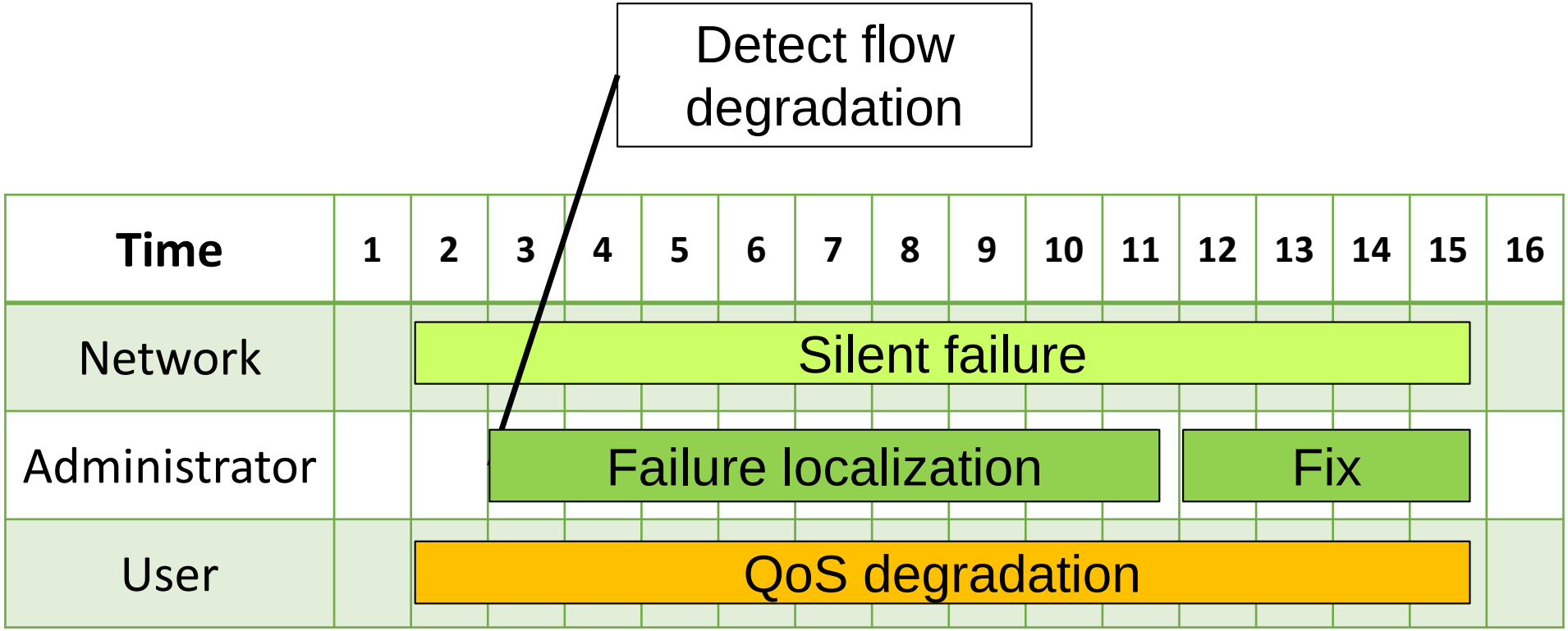
What is silent failure?

- Difficult to detect failure point automatically
  - ex. failure beyond the OAM function's coverage, a human error
- Happen under unknown situations
  - Difficult to specify the situation
- Various tests are required for localization

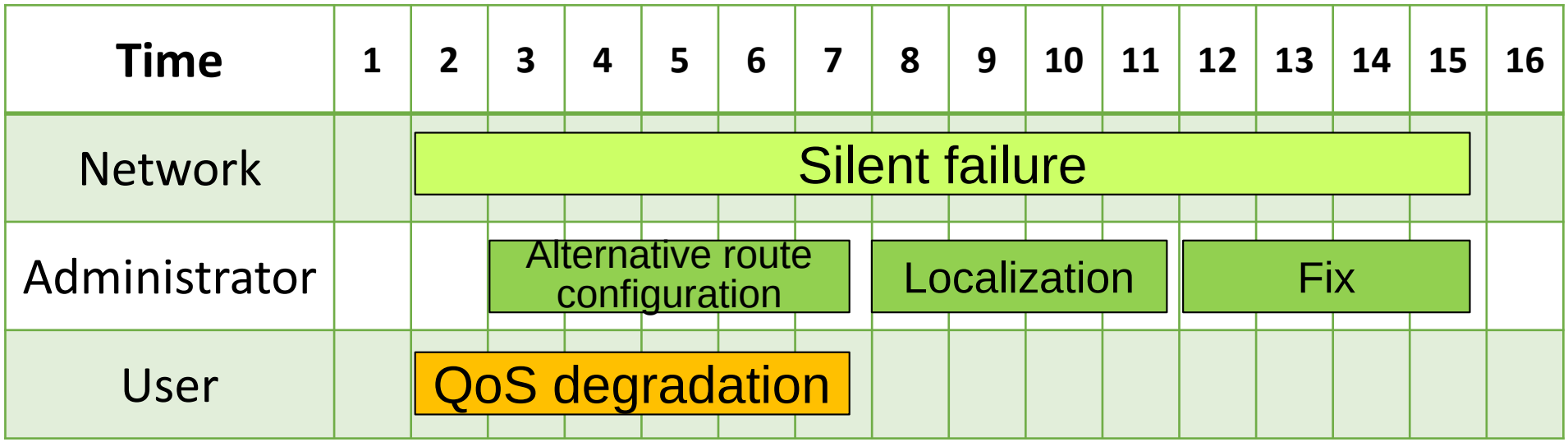
⇒ Long-term measurement is required

Example of silent failure (1/2)



- How to shorten QoS degradation term?
  - An alternative route is effective

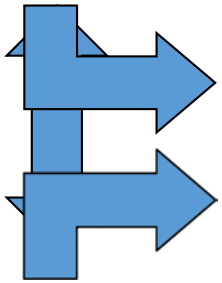
Example of silent failure (2/2)



- What if an alternative route is not found immediately?
  - The flow's allowable delay may **not** be satisfied

Strategy

- An alternative route for recovery from silent failure
  - Localize the failure
    - pros: Flexible route search
    - cons: Long-term measurement

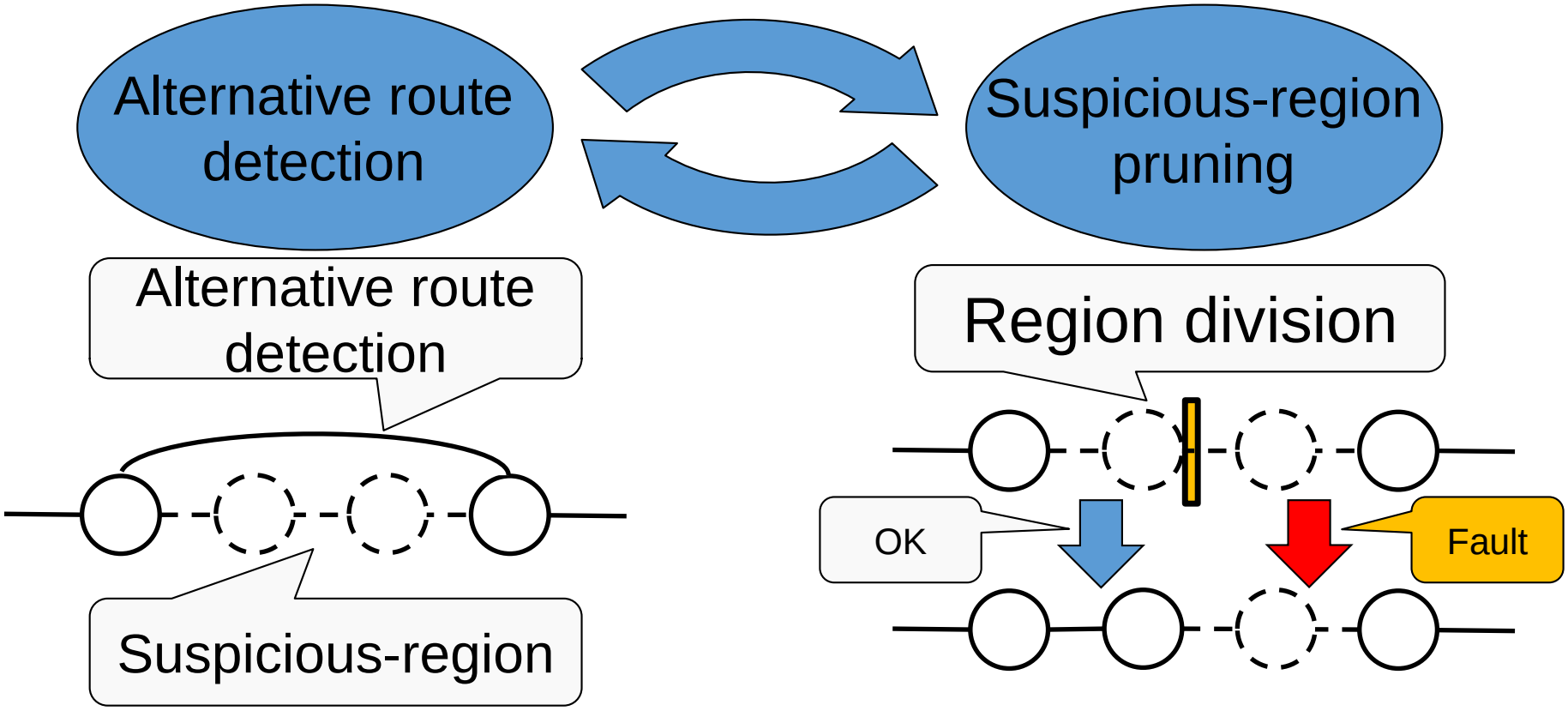


A method to quickly detect
an alternative route
within the flow allowable delay

  - Avoid all suspicious nodes and links
    - pros: Minimum measurement
    - cons: An allowable delay may not be satisfied

Key idea

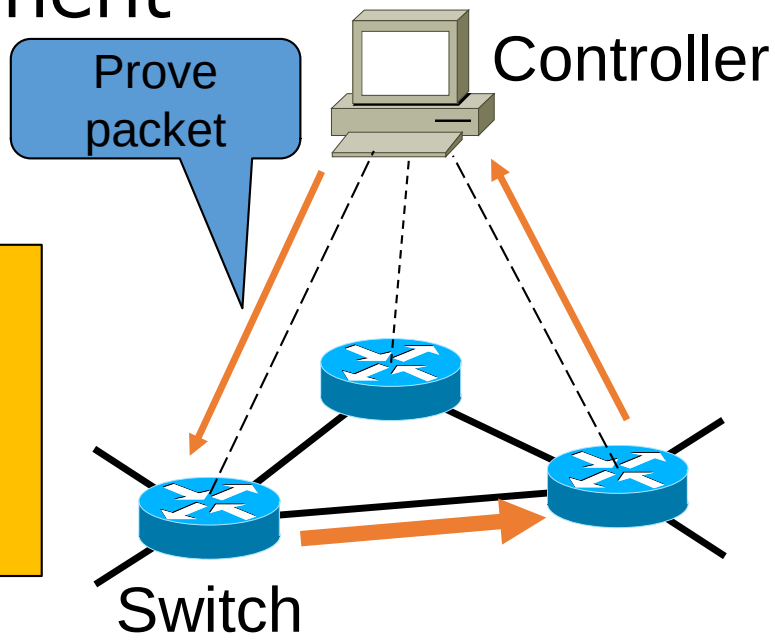
- Suspicious-region pruning by recursive division



SDN

- Flexible route management
  - Traffic management per flow
  - Easy to change flow route
- Partial network measurement

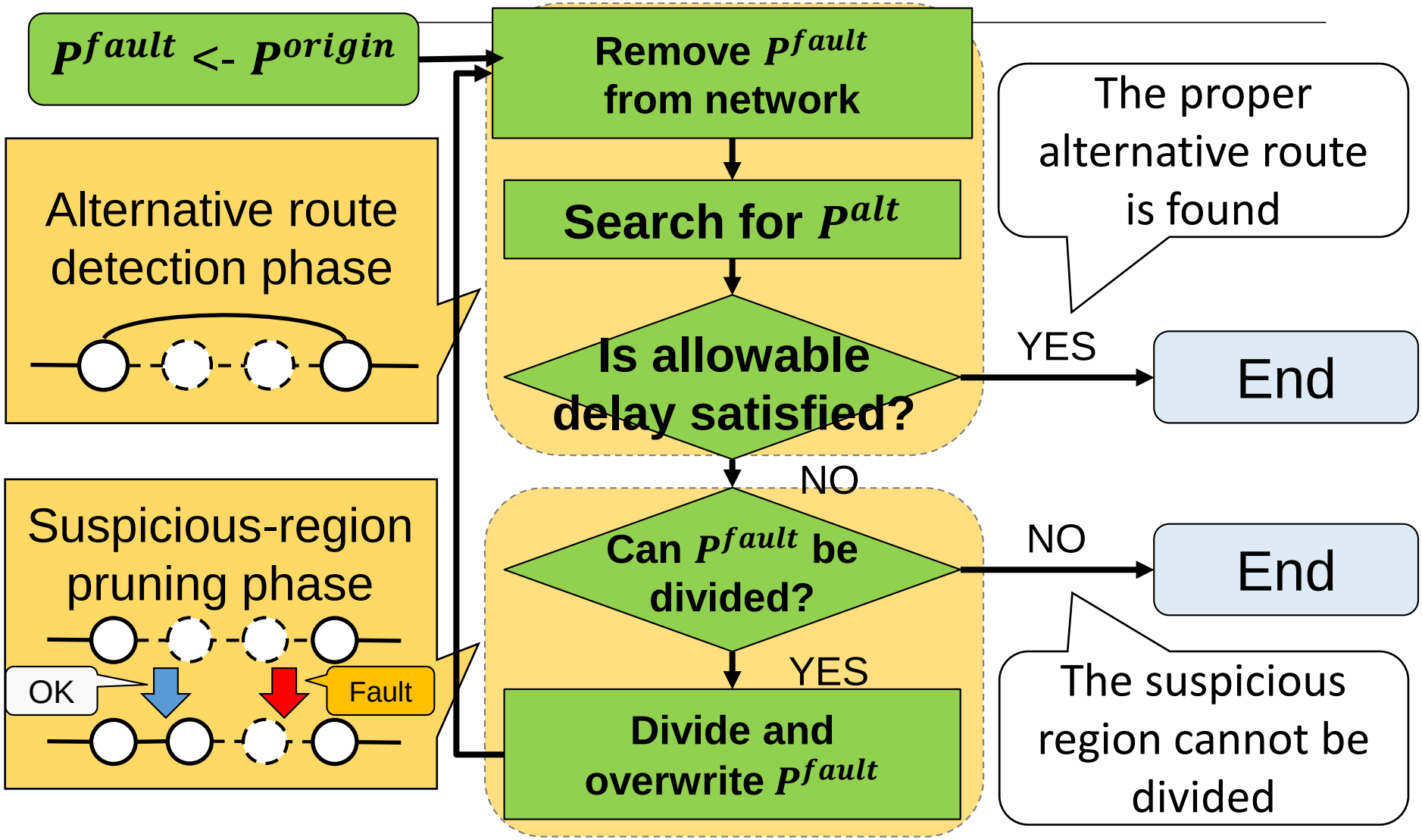
A method to configure
an alternative route quickly
by using SDN functions



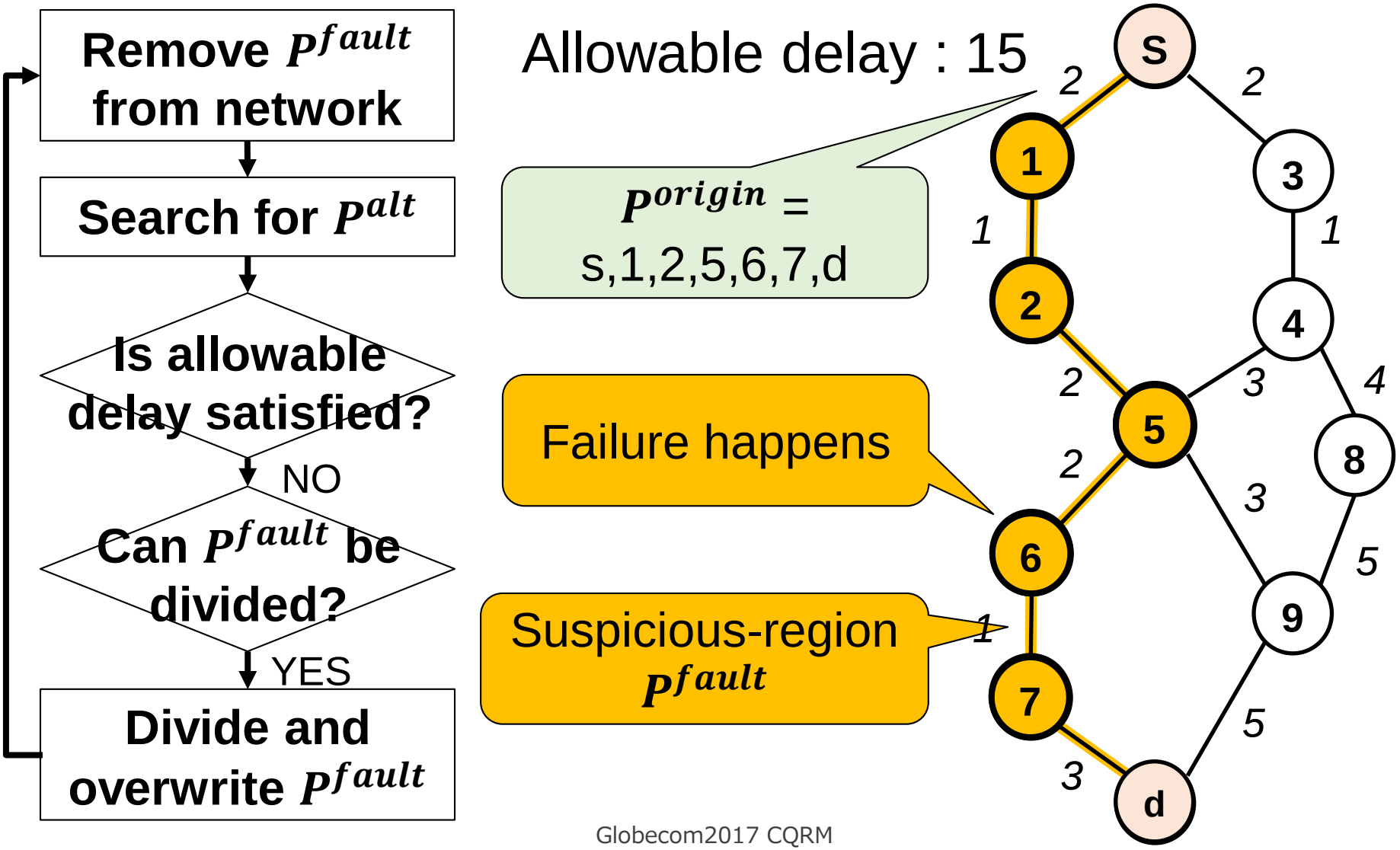
SDN network model

- $\boldsymbol{G = (V, E)}$: A non-directed graph
- $\boldsymbol{f}$: A degraded flow
- $\boldsymbol{P^{origin}}$: The route of flow f in the initial condition
- $\boldsymbol{P^{fault}}$: The route that contains a failure point
  = Suspicions-region
- $\boldsymbol{P^{alt}}$: An alternative route of flow f

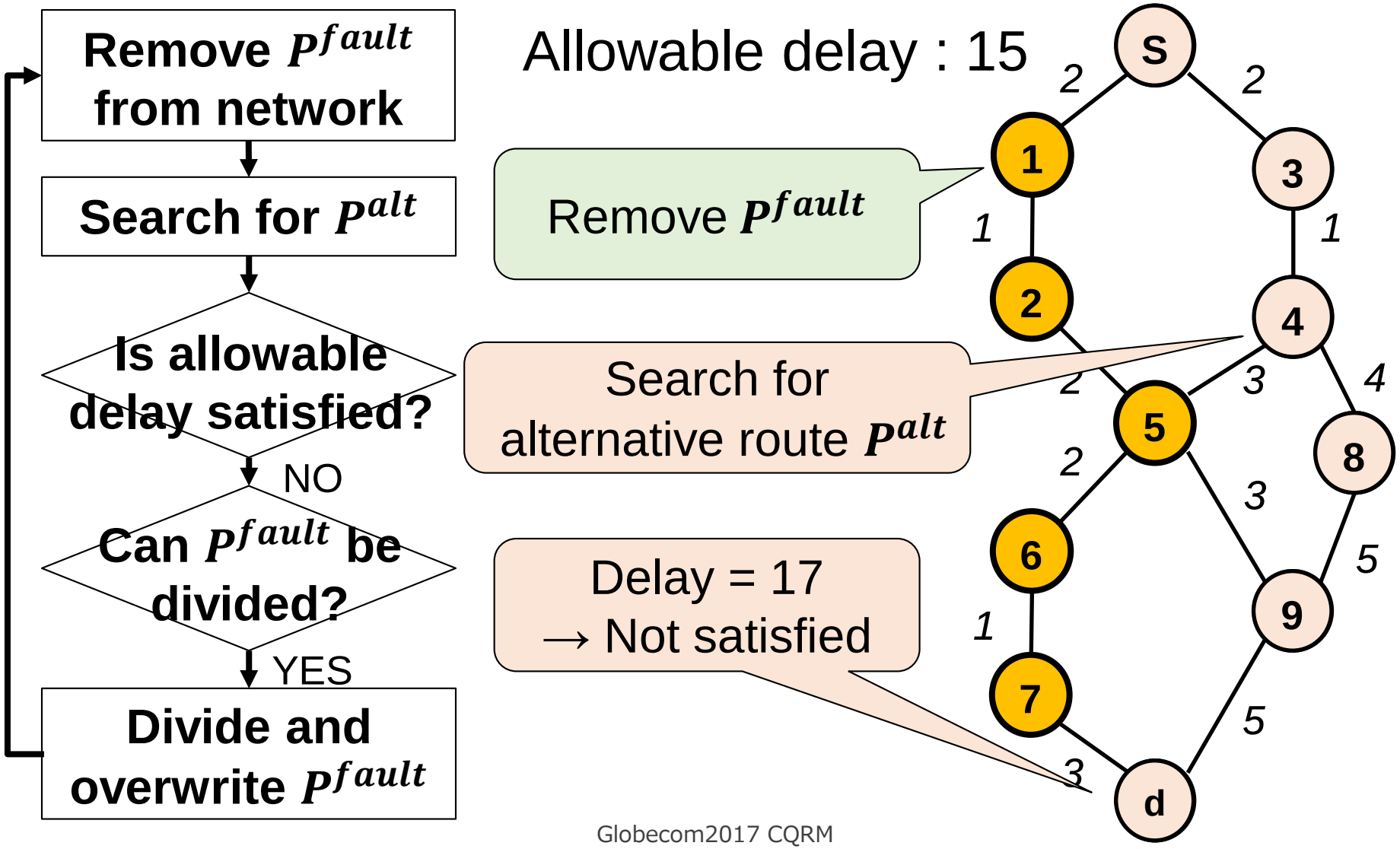
Flowchart


P^{fault} <- P^{origin}
Remove P^{fault} from network
Search for P^{alt}
Is allowable delay satisfied?
YES
End
NO
Can P^{fault} be divided?
NO
End
YES
Divide and overwrite P^{fault}
Alternative route detection phase
Suspicious-region pruning phase
OK
Fault
The proper alternative route is found
The suspicious region cannot be divided

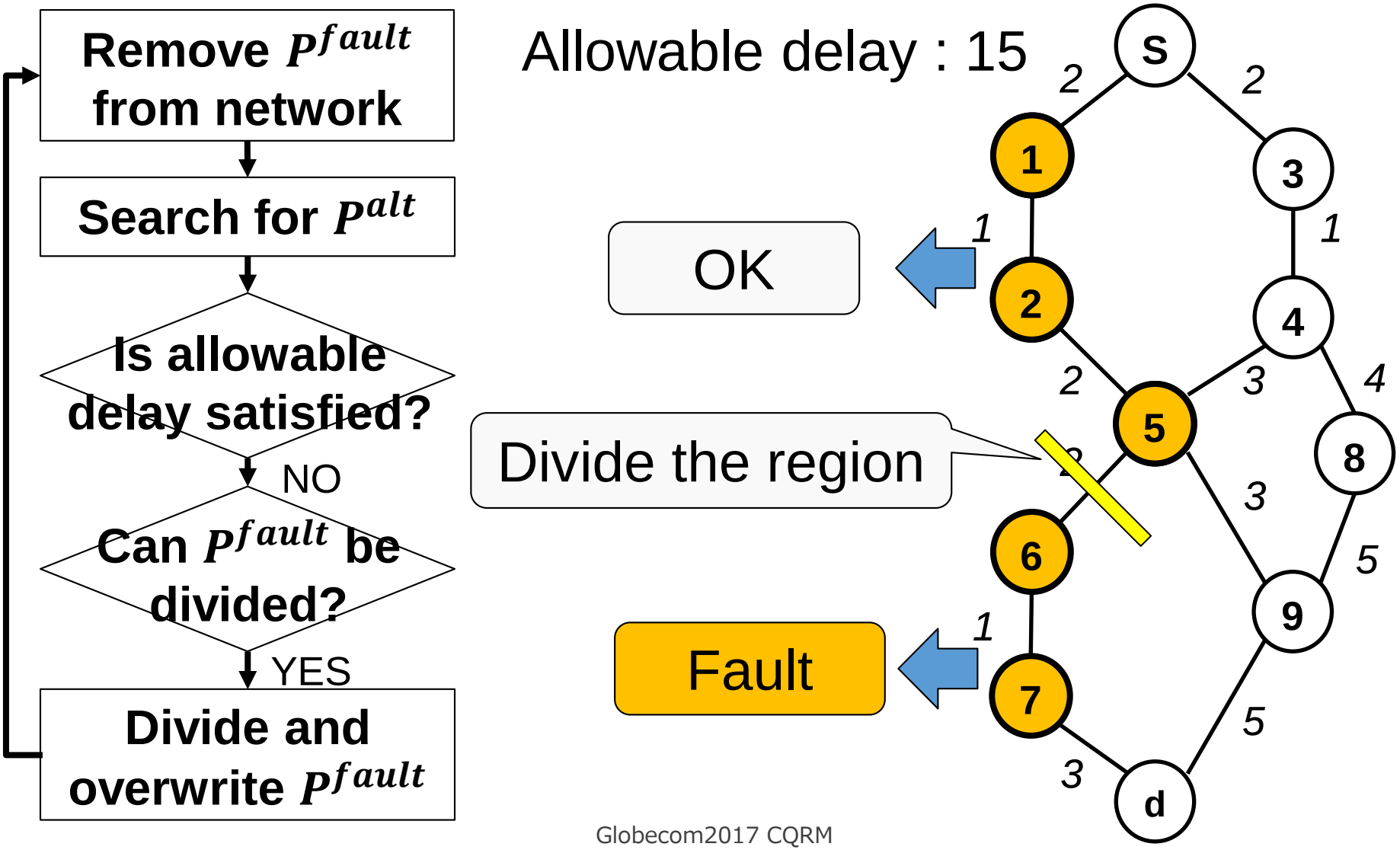
Example(1/4)


Remove P^{fault} from network
Search for P^{alt}
Is allowable delay satisfied?
NO
Can P^{fault} be divided?
YES
Divide and overwrite P^{fault}
Allowable delay : 15
P^{origin} = s,1,2,5,6,7,d
Failure happens
Suspicious-region P^{fault}
S
1
2
3
4
5
6
7
8
9
d
2
2
1
1
2
3
4
2
3
5
1
5
3

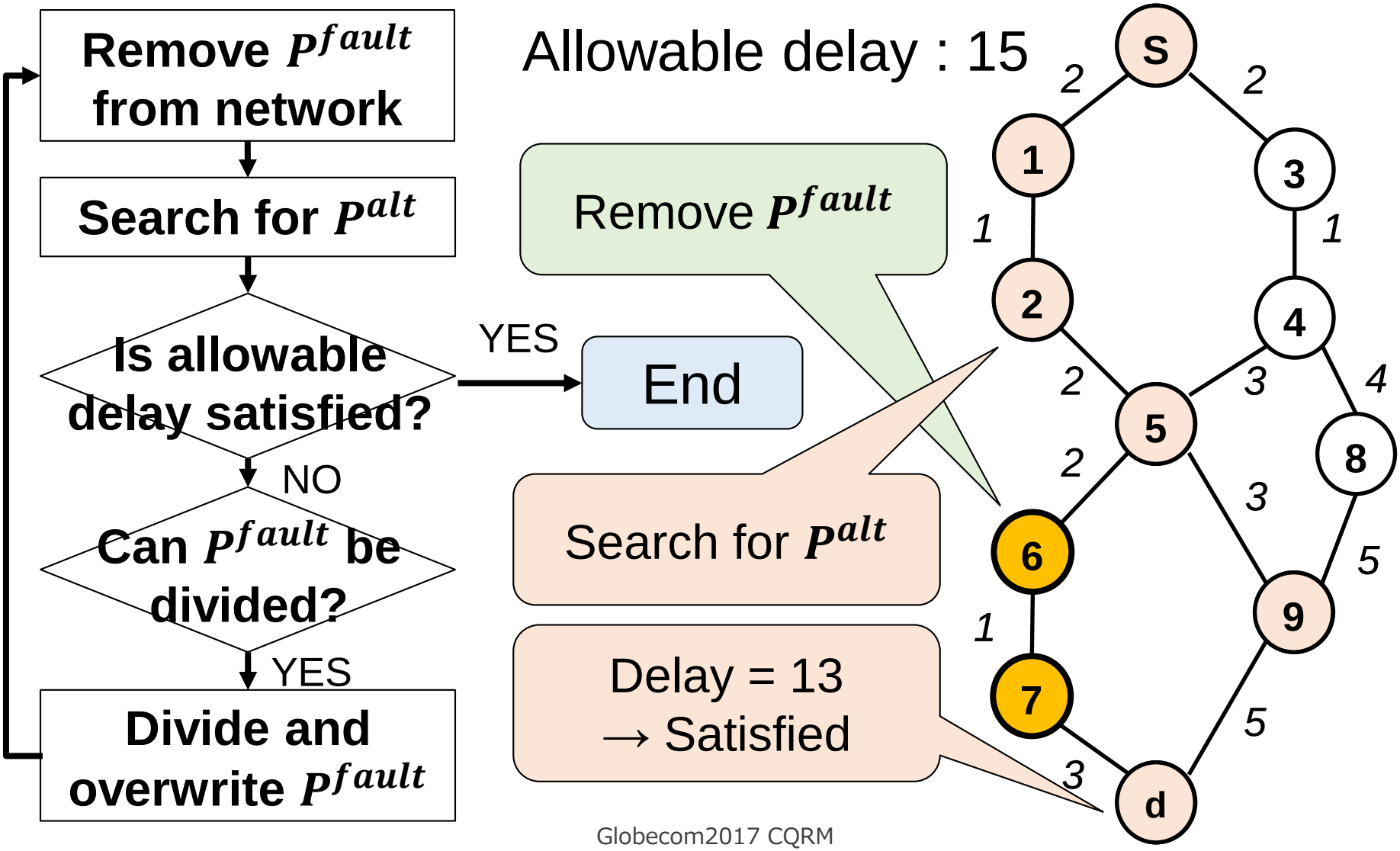
Example(2/4)


Remove P^{fault} from network
Search for P^{alt}
Is allowable delay satisfied?
NO
Can P^{fault} be divided?
YES
Divide and overwrite P^{fault}
Allowable delay : 15
Remove P^{fault}
Search for alternative route P^{alt}
Delay = 17
→ Not satisfied
S
1
2
3
4
5
6
7
8
9
d
2
2
1
1
2
3
4
2
3
5
1
5
3

Example(3/4)


Remove P^{fault} from network
Search for P^{alt}
Is allowable delay satisfied?
NO
Can P^{fault} be divided?
YES
Divide and overwrite P^{fault}
Allowable delay : 15
OK
Divide the region
Fault
S
1
2
3
4
5
6
7
8
9
d
2
2
1
1
2
3
4
3
5
1
5
3

Example(4/4)


Remove P^{fault} from network
Search for P^{alt}
Is allowable delay satisfied?
YES
End
NO
Can P^{fault} be divided?
YES
Divide and overwrite P^{fault}
Allowable delay : 15
Remove P^{fault}
Search for P^{alt}
Delay = 13
→ Satisfied
S
1
2
3
4
5
6
7
8
9
d
2
2
1
1
2
3
4
2
3
5
1
5
3

Evaluation Model

- Network: SDN architecture
  - Partial network measurement
  - Traffic management per flow
- Link bandwidth: sufficient
  - The transmission delay is included in the link delay
- SDN controller's resources: sufficient
  - The computation time for Dijkstra's algorithm and route configuration is omitted
- The number of faults: one
  - The silent failure happens at ONLY one node/link

Parameter

■ Default setting

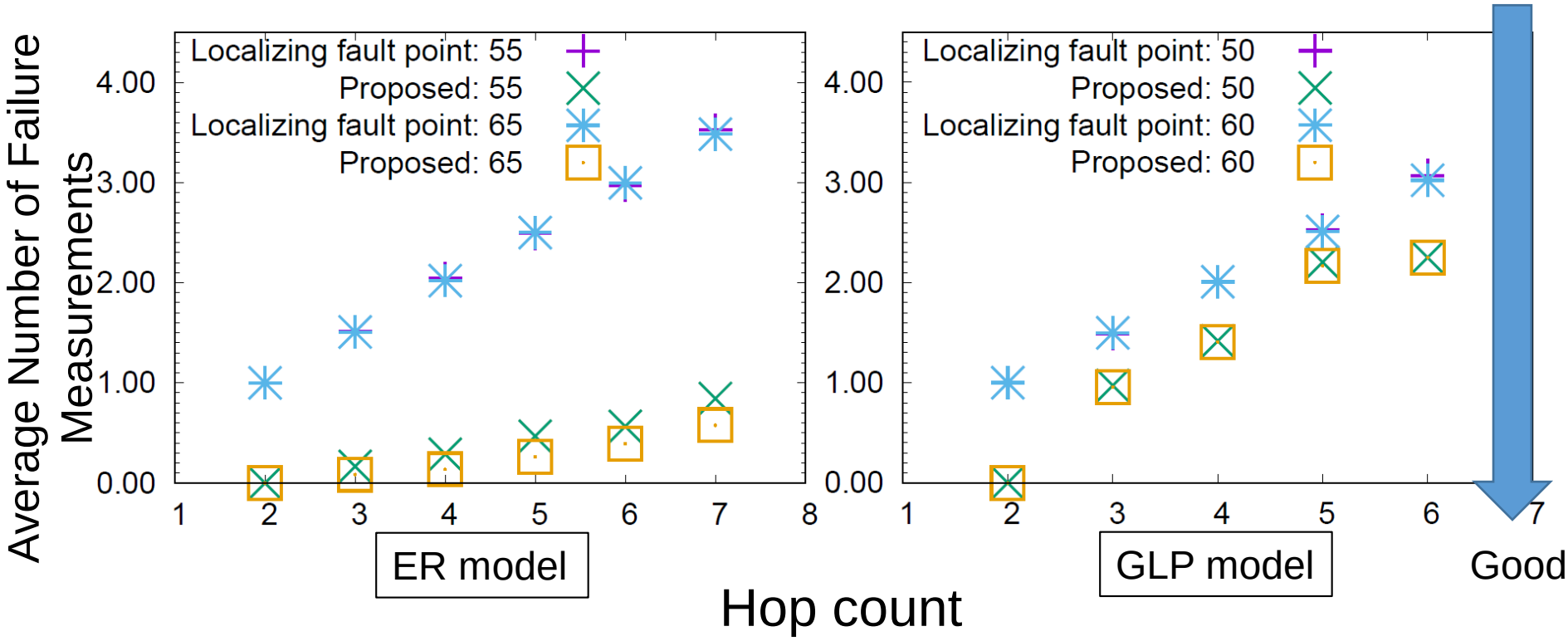
	Random graph (ER model)	Scale-free graph (GLP model)	Data center graph (Fat tree model)
Number of nodes	3000		2500
Average degree	3.98	4.03	4.8
Link cost	5~15[ms] (Uniform distribution)		10[ms](constant)
Allowable delay	60[ms]		

■ Conventional method

➢ Localizing method by the sequential search

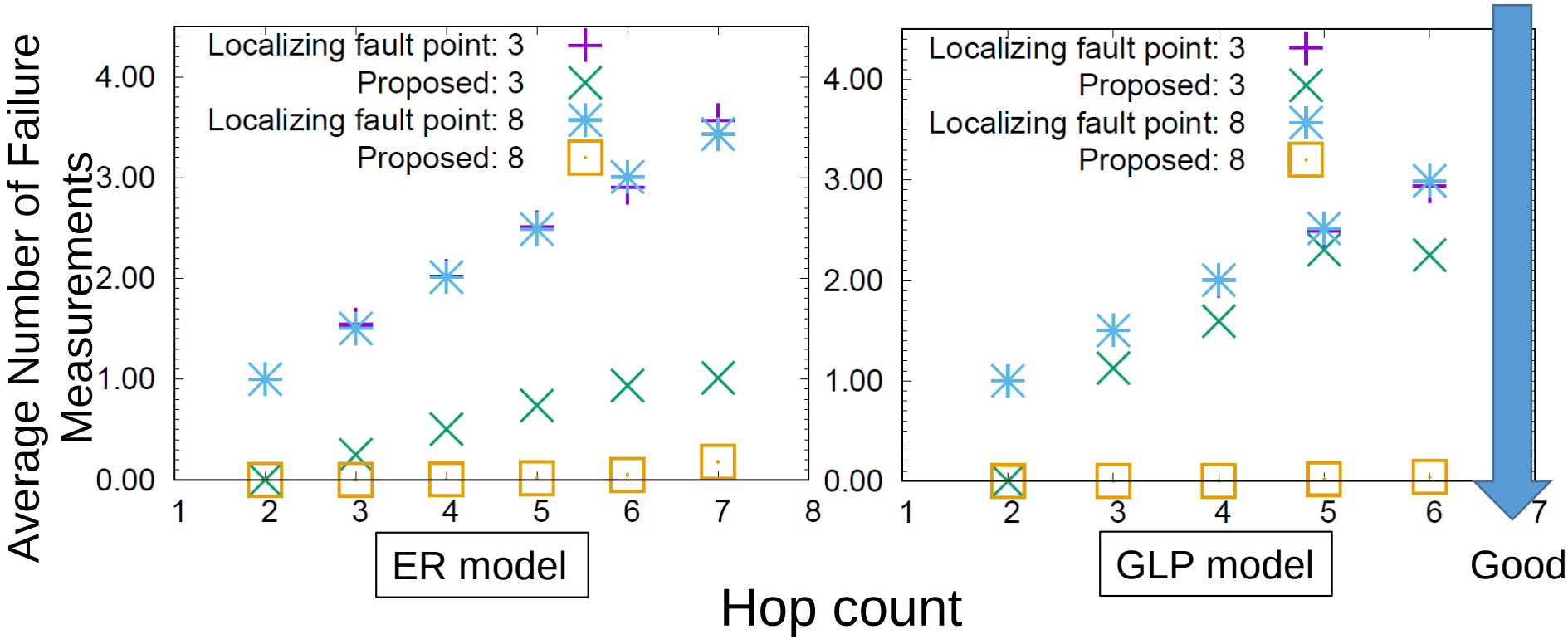
Evaluation(1/3)

■ Effect of allowable delay



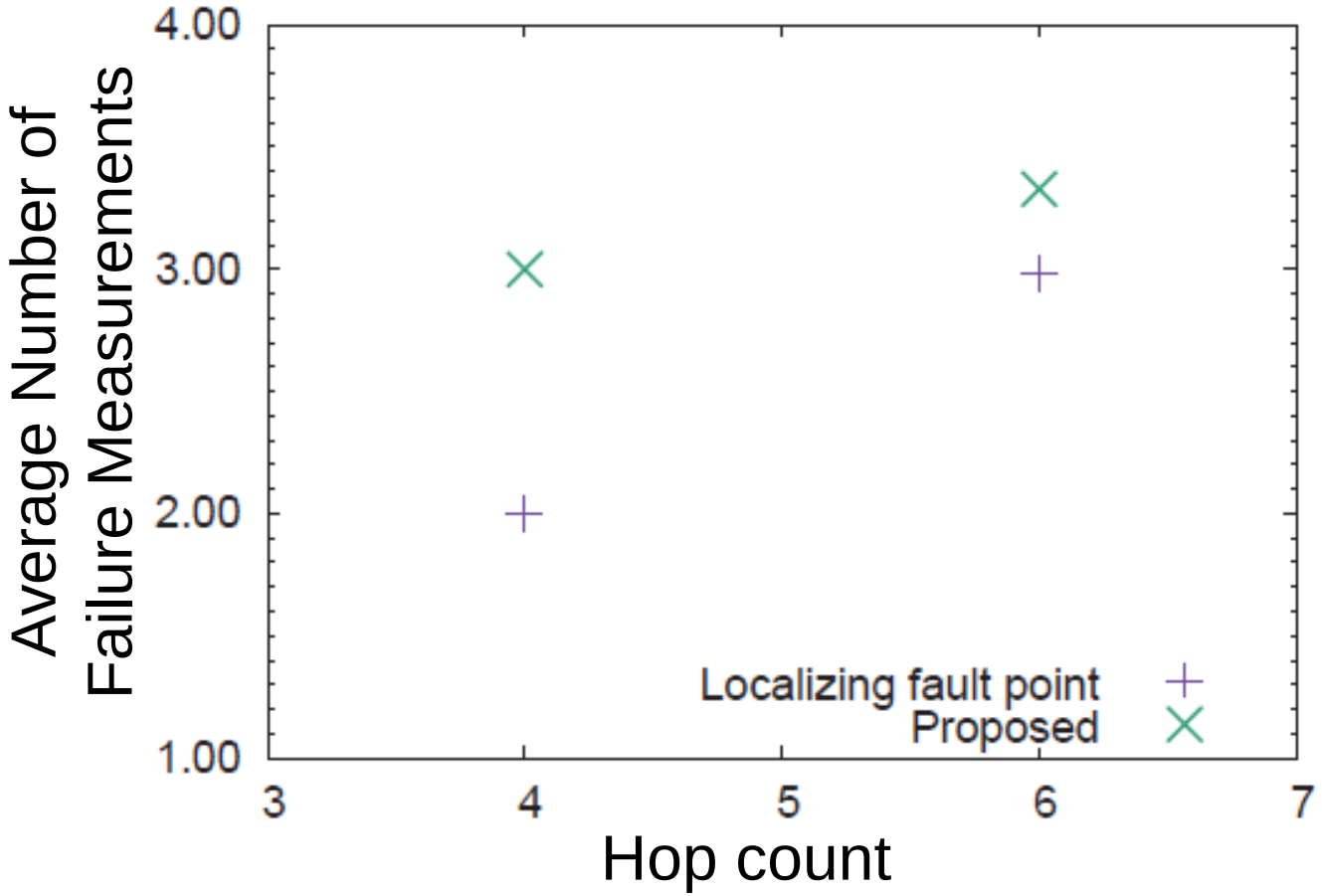
Evaluation(2/3)

■ Effect of average degree



Evaluation(3/3)

■ Fat tree model



Summary & Future Works

Summary

- A fast configuration method of alternative routes on SDN architecture
- Combination of alternative route detection phase and suspicious-region pruning phase
- The proposed method greatly outperforms the localizing method, especially when the average degree is large

Future works

- Analysis in realistic condition
- Improvement of the algorithm