

SDN Dependability: Assessment, Techniques, and Tools

SDN RG

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Motivation

- **Dependability** of a system can be understood as the **ability to deliver a set of services that can be justifiably trusted**
 - It is also related to fault tolerance, availability, and reliability disciplines
- Undependable systems/infrastructure may cause business disruption with a high recovery cost and economic losses
- Infrastructure downtime is costly to organizations (in the order of \$Bi)
- Risk is a crucial factor to the establishment of Service Level Agreements (SLA)

http://www.emersonnetworkpower.com/en-US/Solutions/infographics/Pages/Cost_Implications_of_Outages.aspx

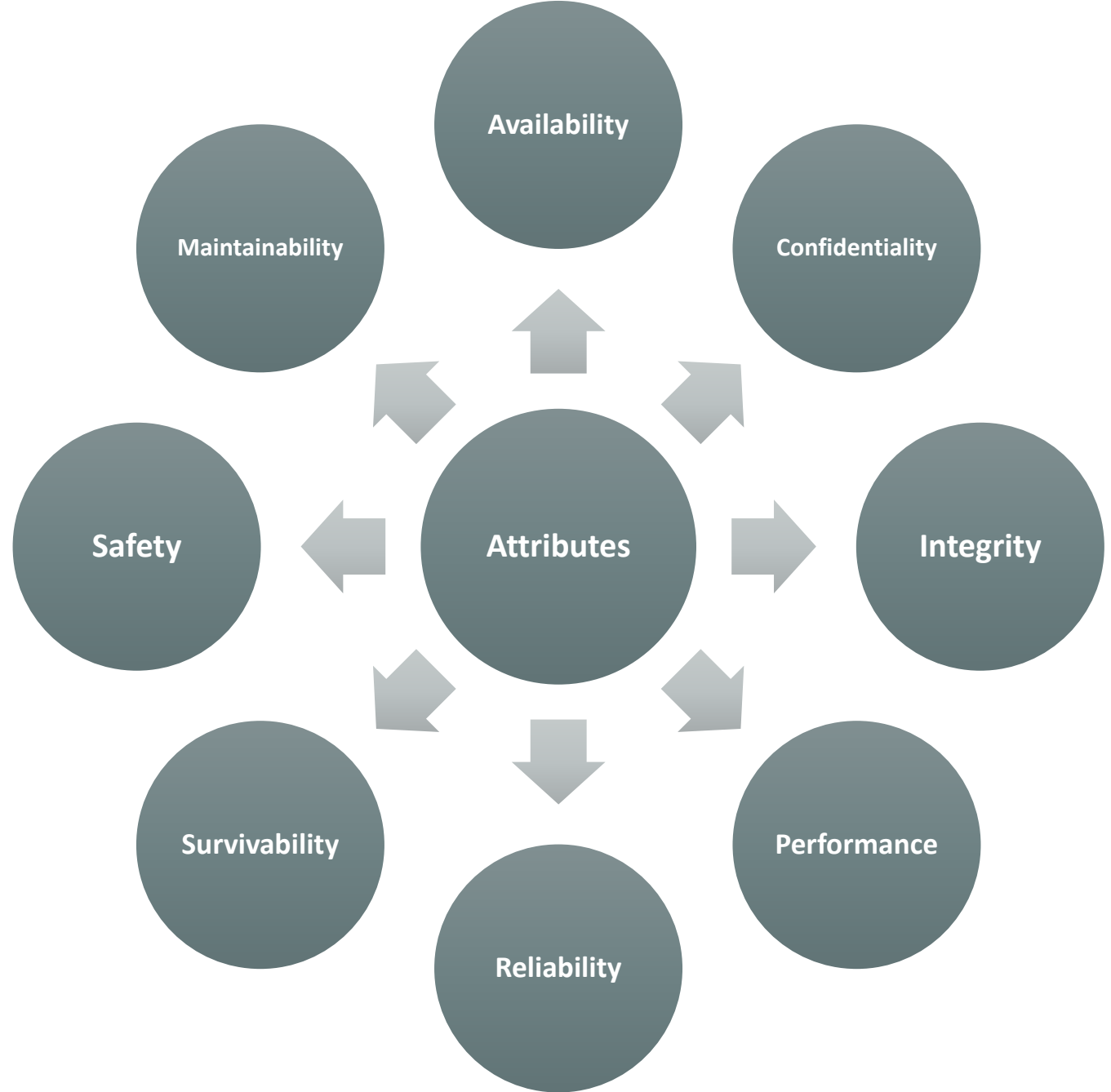
http://www.emersonnetworkpower.com/documentation/en-us/brands/liebert/documents/white%20papers/2013_emerson_data_center_cost_downtime_sl-24680.pdf

<http://blogs.gartner.com/andrew-lerner/2014/07/16/the-cost-of-downtime/>

Motivation

- Virtualization in general introduces a number of risk/dependability challenges
 - E.g, an approach based on several virtualized components may imply in a less reliable system
- **What are the risks associated to the SDN/NFV paradigm?**
 - Shift from reliability and availability per network element to end-to-end service
 - For example: How to predict the availability of an e2e service?
- Recent concern for data centers and cloud computing infrastructure
 - Policy-driven automatic network fault remediation (Google Patent, 2015)
 - Tamura, Motoshi, et al. "A study to achieve high reliability and availability on core networks with network virtualization." NTT Docomo Tech. J 15.1 (2013): 42-50.
 - Fault tolerant routing in a non-hot-standby configuration of a network routing system (Google Patent, 2014)
 - Xia, Ming, et al. "Risk-aware provisioning for optical WDM mesh networks." IEEE/ACM Transactions on Networking (TON) 19.3 (2011): 921-931.

Dependability



Dependability Attributes Definitions

Availability

- readiness for correct service

Confidentiality

- absence of unauthorized disclosure of information

Integrity

- absence of improper system state alterations

Performance

- The degree to which it accomplishes its designated functions within given constraints

Reliability

- continuity of correct service

Survivability

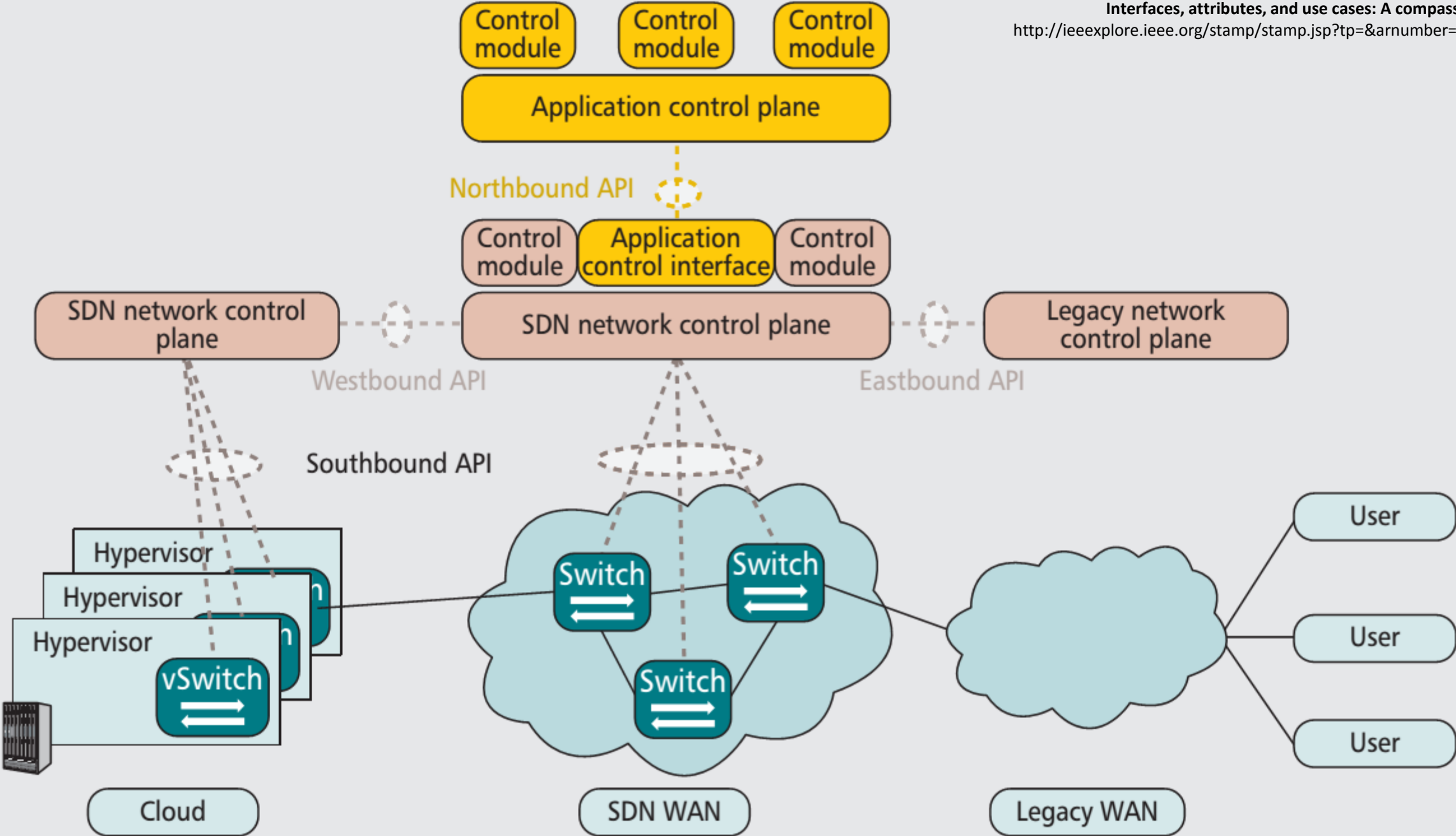
- capability to fulfill its mission, in the presence of failures

Safety

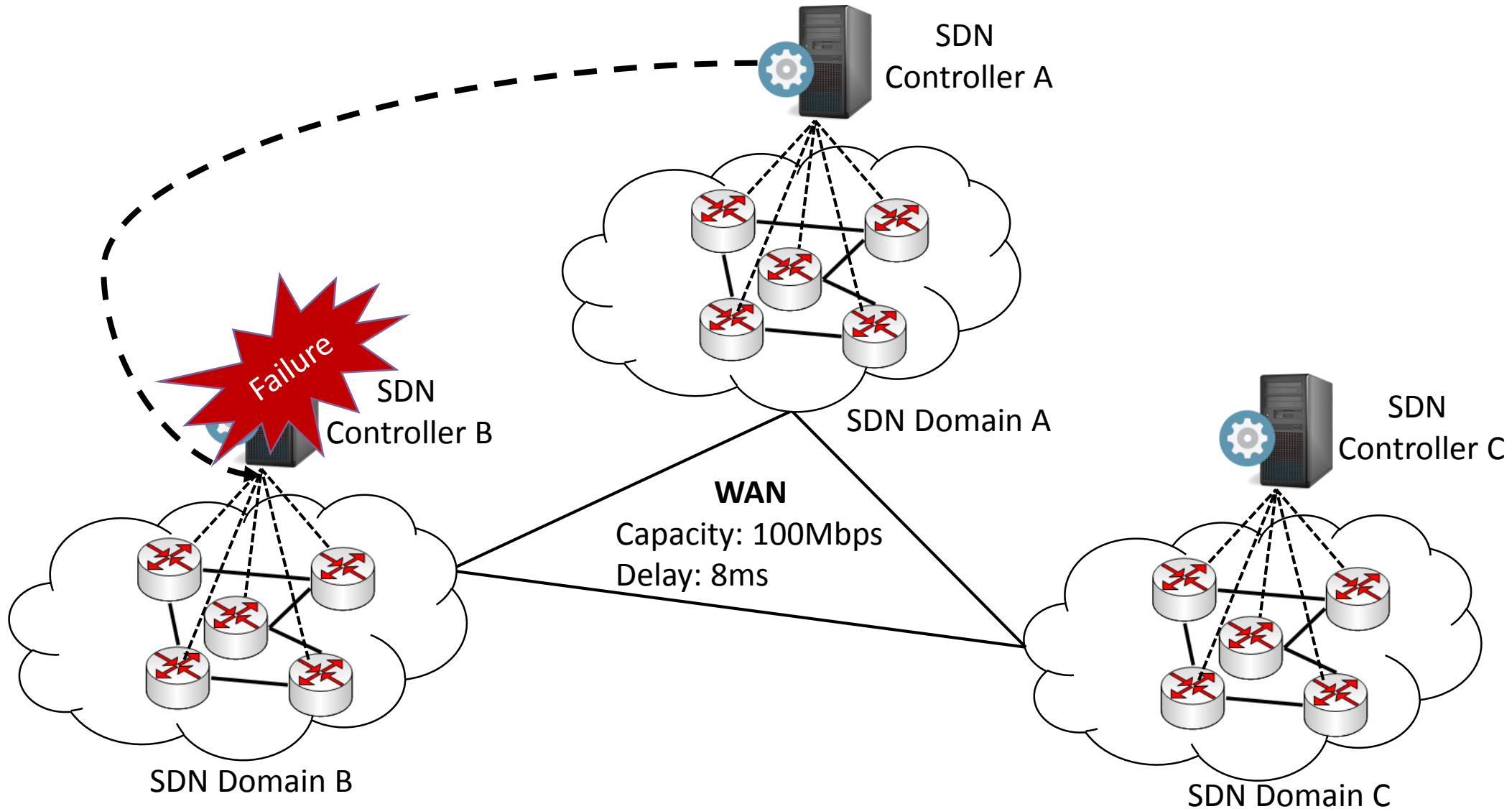
- absence of catastrophic consequences

Maintainability

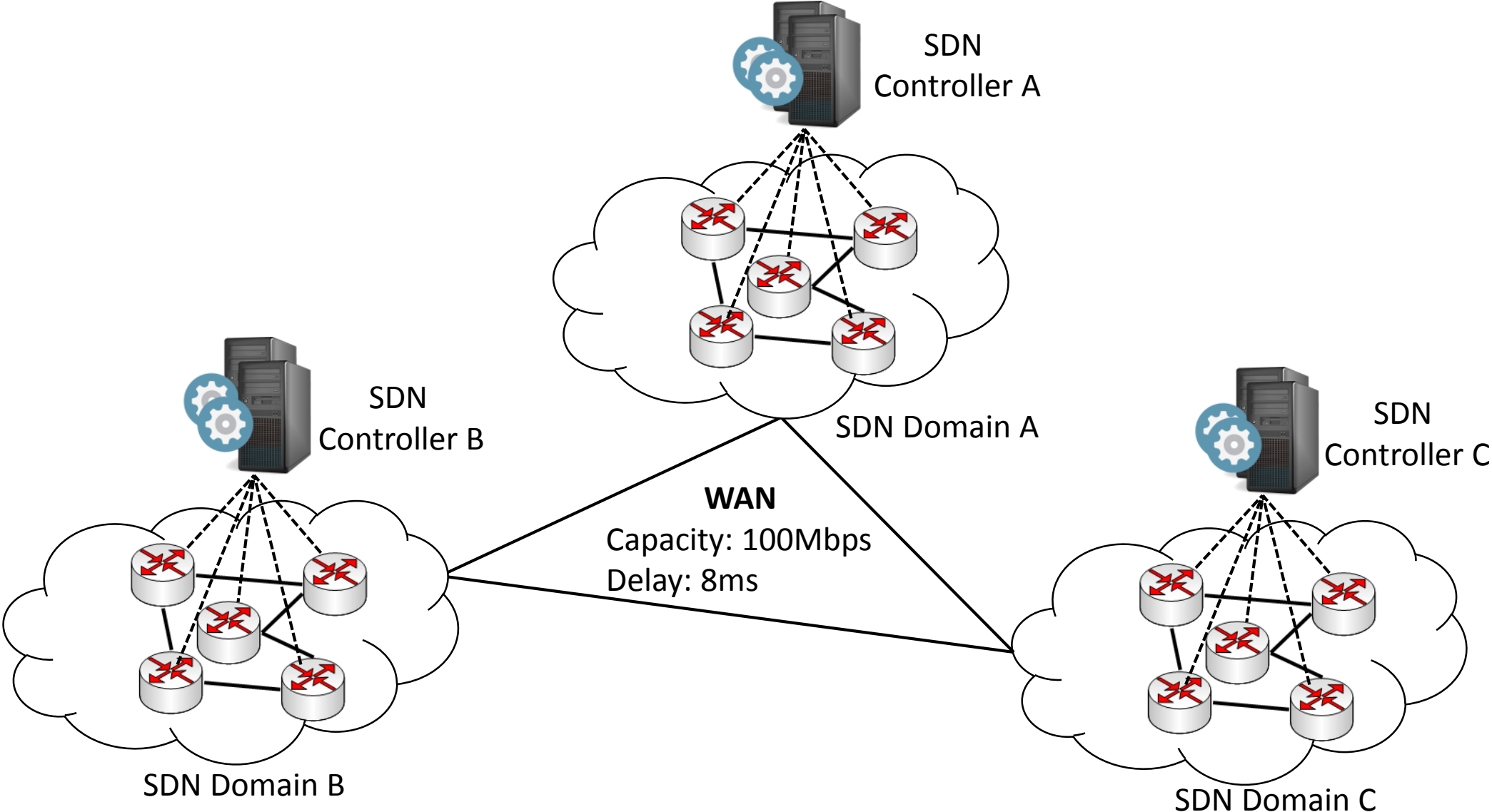
- ability to undergo repairs and modifications



Design: Controller placement problem




Design: Controller placement problem



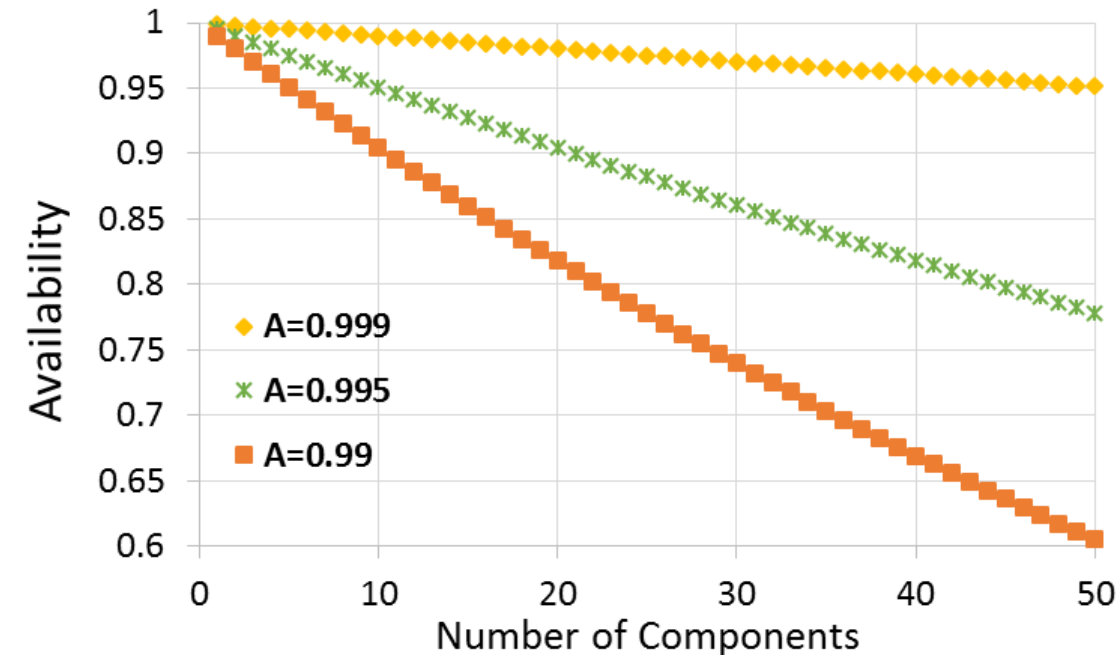
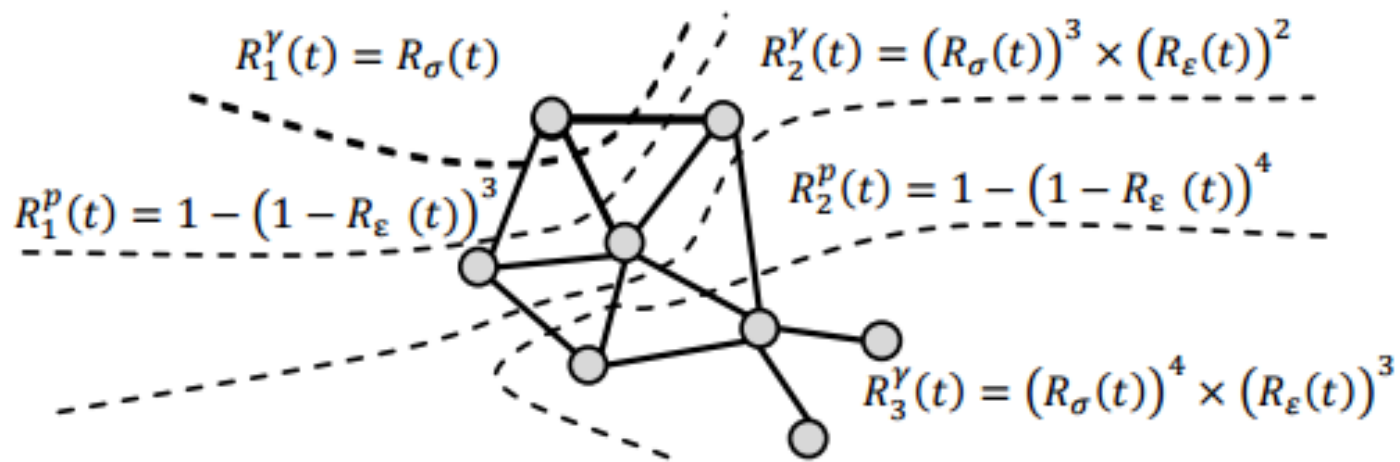
Dependability Assessment

- Mean Time To Failure (**MTTF**)
Average time to a failure
- Mean Time To Repair (**MTTR**)
Average time under repair
- Mean time between failures (**MTBF**)
Average time between failures

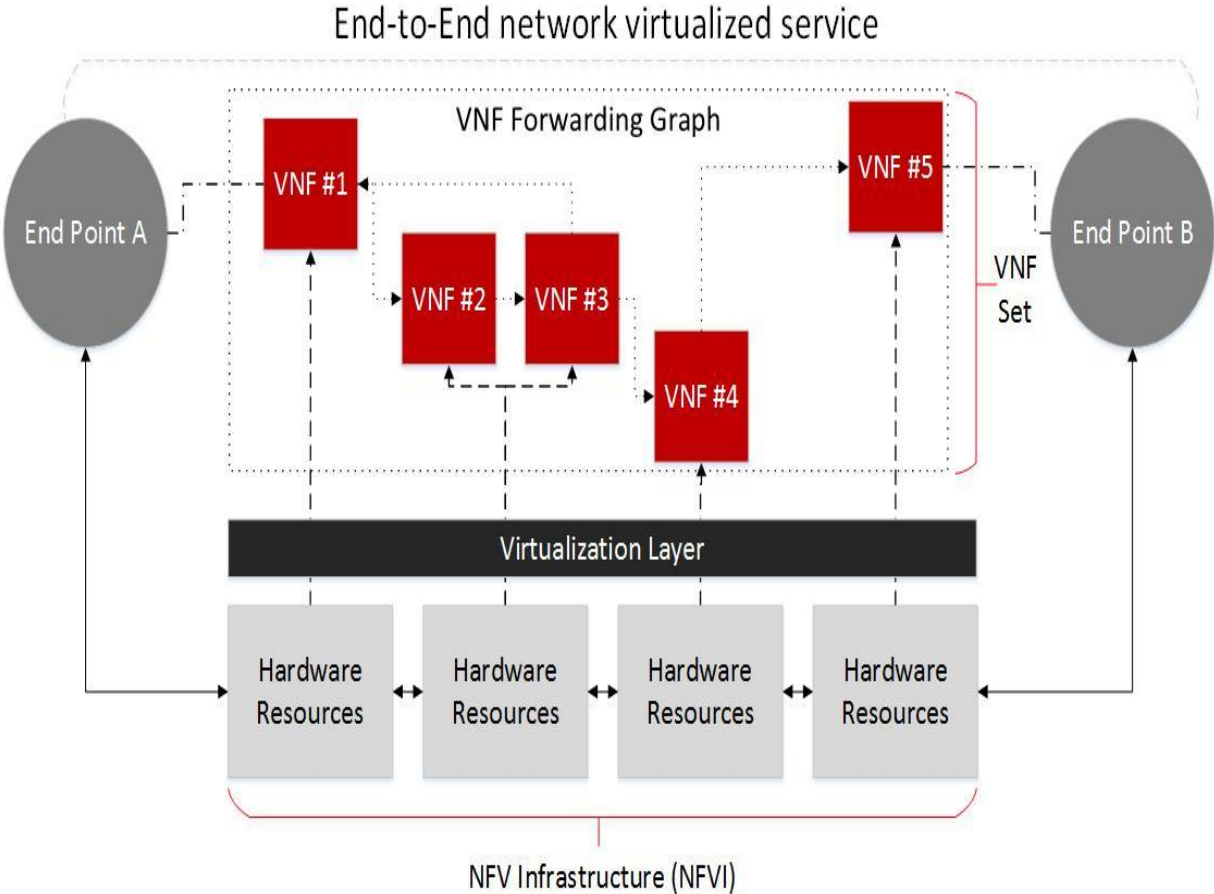
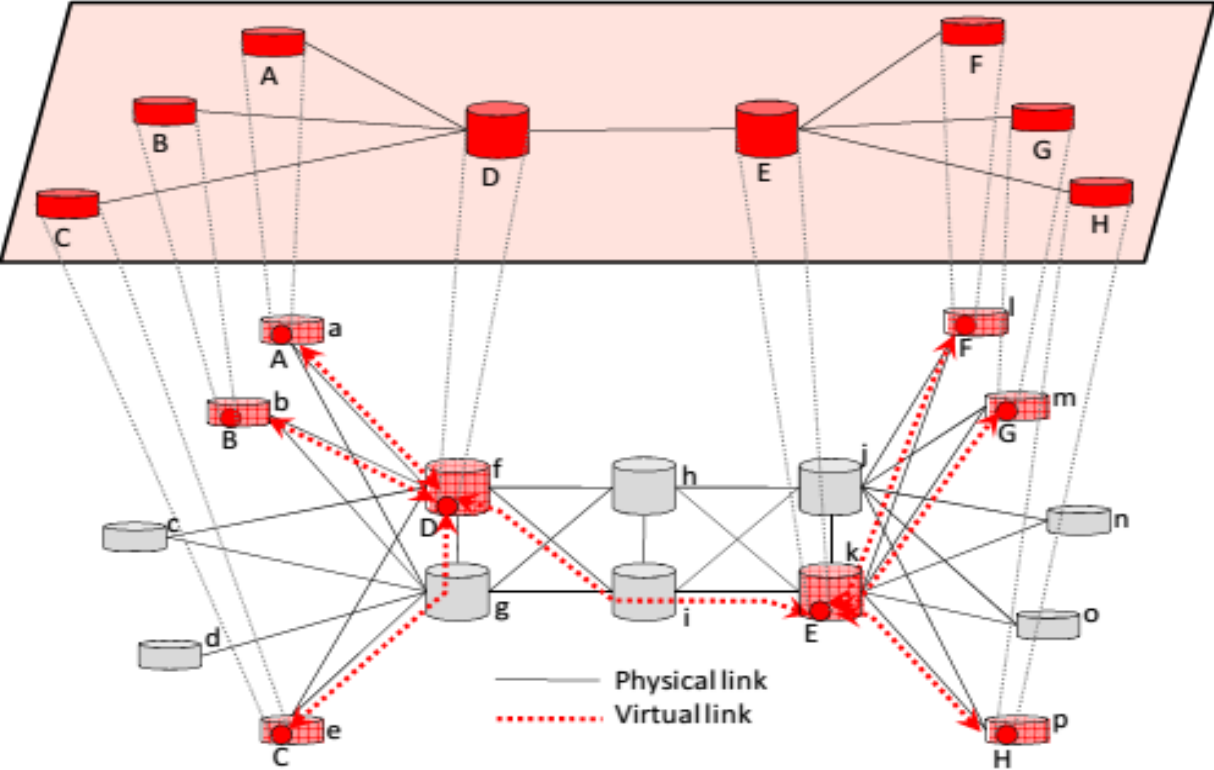
• **Availability (A)** = % time correct  $A = \frac{MTTF}{MTTF + MTTR}$ or $A = \frac{MTBF}{MTBF + MTTR}$

Dependability in Virtualized Environments

- Series components reduce availability
- parallel (redundant) components increase availability



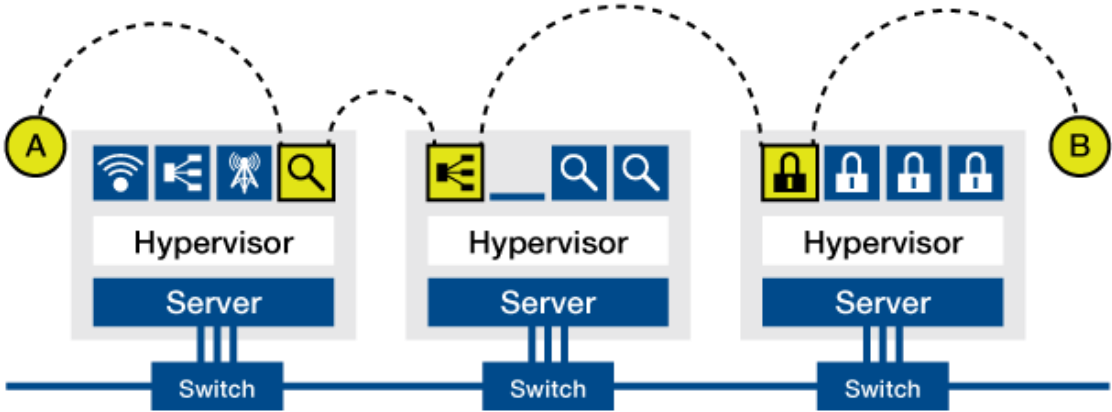
Dependability in Virtualized Environments



Dependability in Virtualized Environments

Component	MTTF (h)	MTTR (h)
Link	19996	12
Router	320000	1

*MMTF and MTTR for physical nodes and links components



- 5 VNFs (A=99.5%)
- 4 Routers
- 5 Links



Availability (A) = **97.2316%**
 Downtime per Month = **20.44 hours**

*S. Fernandes, et al., "Dependability assessment of virtualized networks." Communications (ICC), 2012 IEEE International Conference on. IEEE, 2012.

Dependability in Virtualized Environments

Availability	Downtime per Year	Downtime per Month	Downtime per week
90%	36.5 days	72 hours	16.8 hours
95%	18.25 days	36 hours	8.4 hours
98%	7.3 days	14.4 hours	3.36 hours
99%	3.65 days	7.20 hours	1.68 hours
99.5%	1.83 days	3.6 hours	50.4 min
99.9%	8.76 hours	43.2	10.1
99.95%	4.38 hours	21.56	5.04
99.99% (four)	52.6 min	4.32 min	1.01 min
99.999% (five)	5.26 min	25.9 s	6.05 s
99.9999% (six)	31.5 s	2.59 s	0.605 s

Dependability Tools and Techniques

- Reliability Block Diagram (RBD)
- Markov Chains
- Reliability Graphs
- Fault Trees (FT)
- Stochastic Petri Networks (SPN)

How to calculate dependability



- Software Aging / Rejuvenation
- Efficient placement of virtualized components
- Accurate Monitoring and Management

Improving Dependability

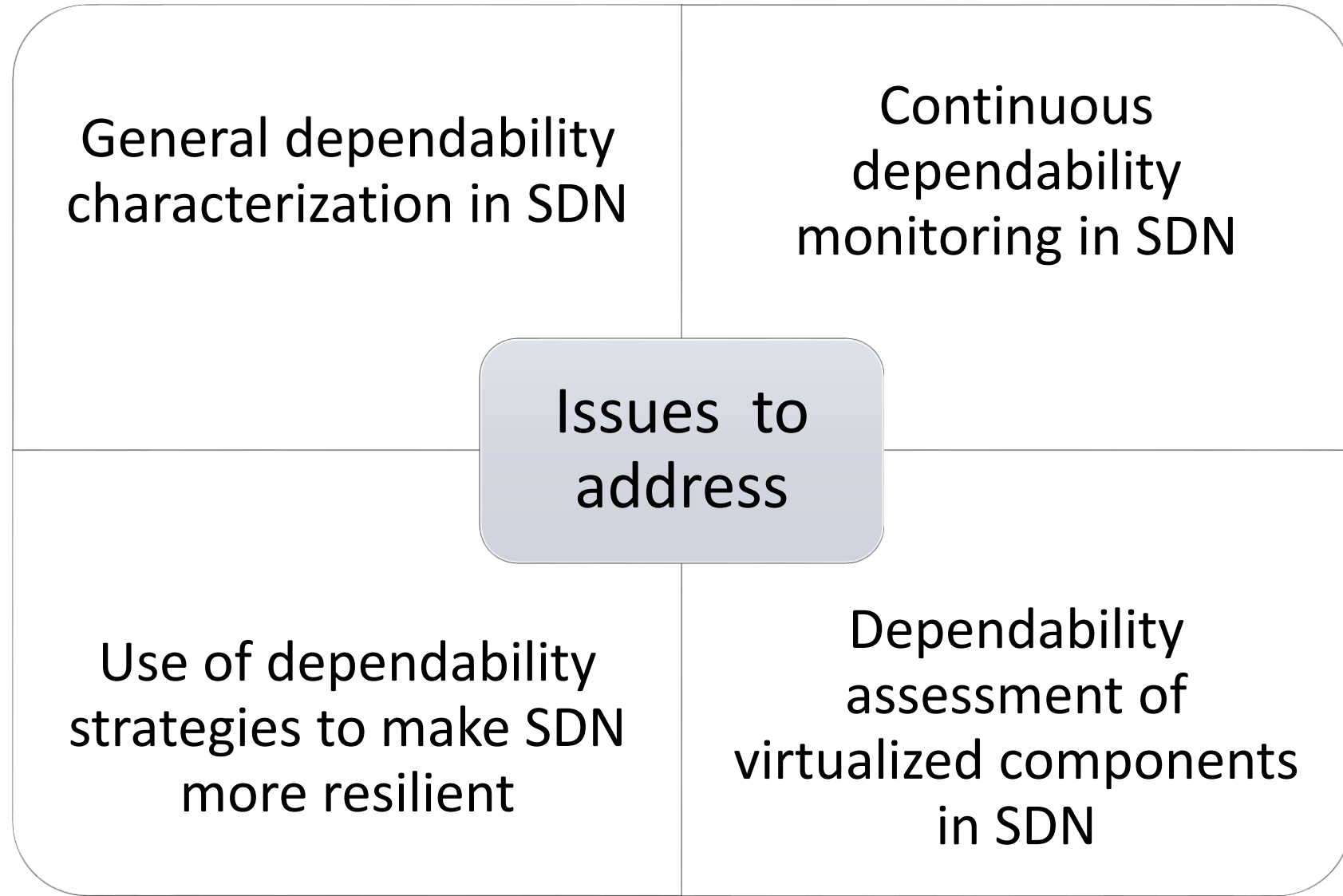


Dependability Concerns in SDN

- How to assess dependability in the network?
- What should we monitor dependability?
- What is the overhead cost?



Dependability Concerns in SDN



Next steps: Prospective approaches

Raise awareness
in the SDN
community

- Informational Draft

Discuss strategies
for dependability
information
dissemination

Discuss strategies
for dependability
assessment

Discuss strategies
to improve
dependability
attributes

Concluding remarks

- Virtualized networking environments need proper design
 - It should include dependability assessment of all physical and virtualized elements
- Lack of strategies to assess and improve dependability in SDN environments
 - An e2e service may present low availability/reliability due to the number of components involved
- Accurate dependability assessment, and effective tools, and techniques should be discussed in order to increase the dependability in SDN

Some references

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Q&A

