# A Survivability-based Backup Approach in Multi-controller SDN against Failures

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# Outline

## 1. Introduction

- 1.1 Controller Backup Problem
- 1.2 Current approaches

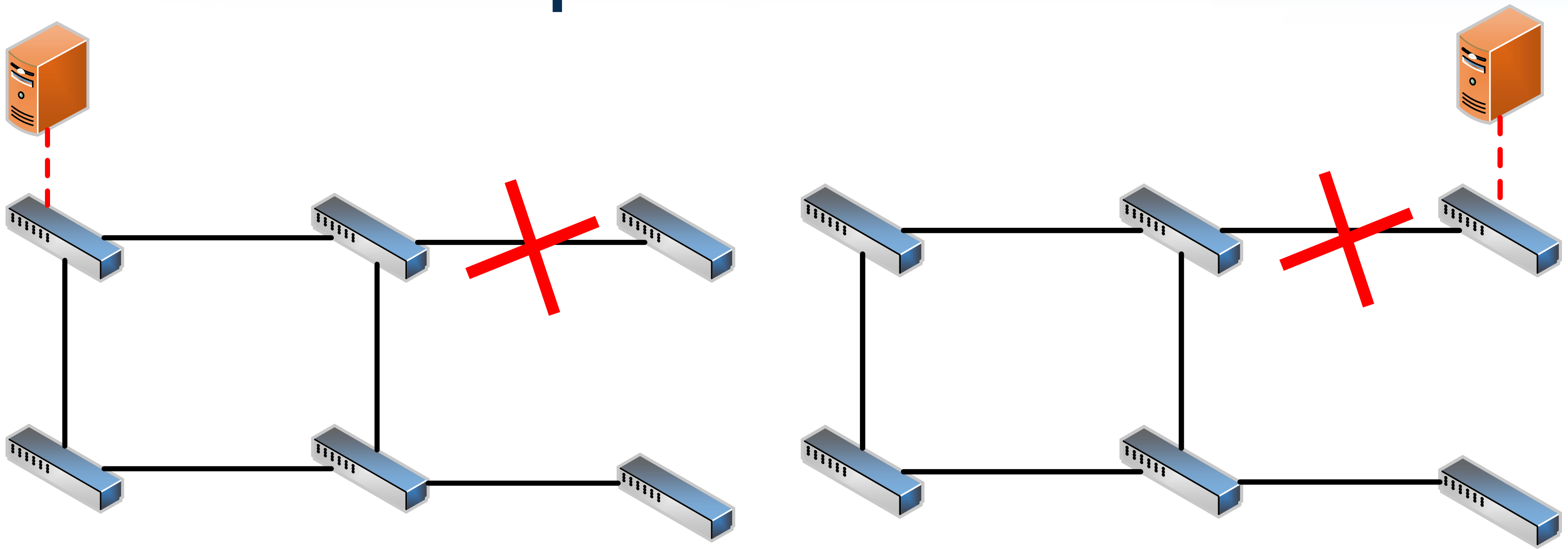
## 2. Survivability-based Controller Backup Approach

- 2.1 definition of public link
- 2.2 survivability metric
- 2.3 controller backup approach

## 3. Performance Evaluation

# 1. Introduction

## 1.1 Controller Backup Problem



Question:

- Where to place the backup controller?

Main Goal:

- Improve the survivability

# 1. Introduction

## 1.2 Current approaches

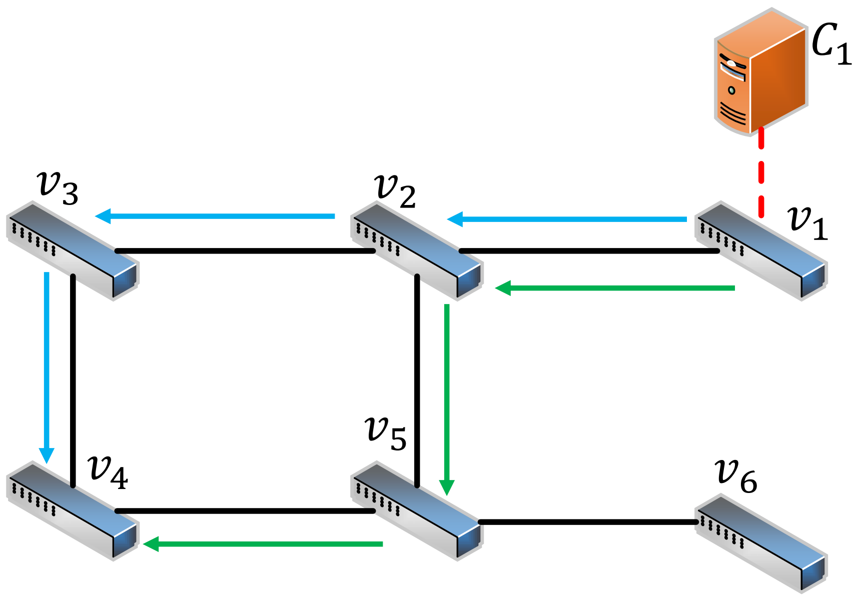
- **Stage 1: select locations to place the backup controllers**
  - ✓ Guarantee the network can recover from the controller failures
  - ✓ Improve the survivability of the control plane in SDN

- **Stage 2: design a synchronization mechanism between the backup and the primary controller**
  - ✓ Reduce the delay of controller failure recovery
  - ✓ Reduce the traffic load in the network caused by communication between the primary and backup controllers

⇒ **Survivability-based Controller Backup Approach**

# 2. Survivability-based Backup Approach for Controllers

## 2.1 Public link




$$PL^{v_1 \to v_2} = \{link^{v_1 \to v_2}\}$$

$$PL^{v_1 \to v_3} = \{link^{v_1 \to v_2}\}$$

$$PL^{v_1 \to v_4} = \{link^{v_1 \to v_2}\}$$

$$PL^{v_1 \to v_5} = \{link^{v_1 \to v_2}\}$$

$$PL^{v_1 \to v_6} = \{link^{v_1 \to v_2},\ link^{v_5 \to v_6}\}$$

$$PL^{v_i \to v_j} = \left\{ {Link_k}^{v_i \to v_j} \,\middle|\, \begin{array}{l} {Link_k}^{v_i \to v_j} \in {Path_l}^{v_i \to v_j}, \\ \forall k \in q, \forall l \in p \end{array} \right\}$$

# 2. Survivability-based Backup Approach for Controllers

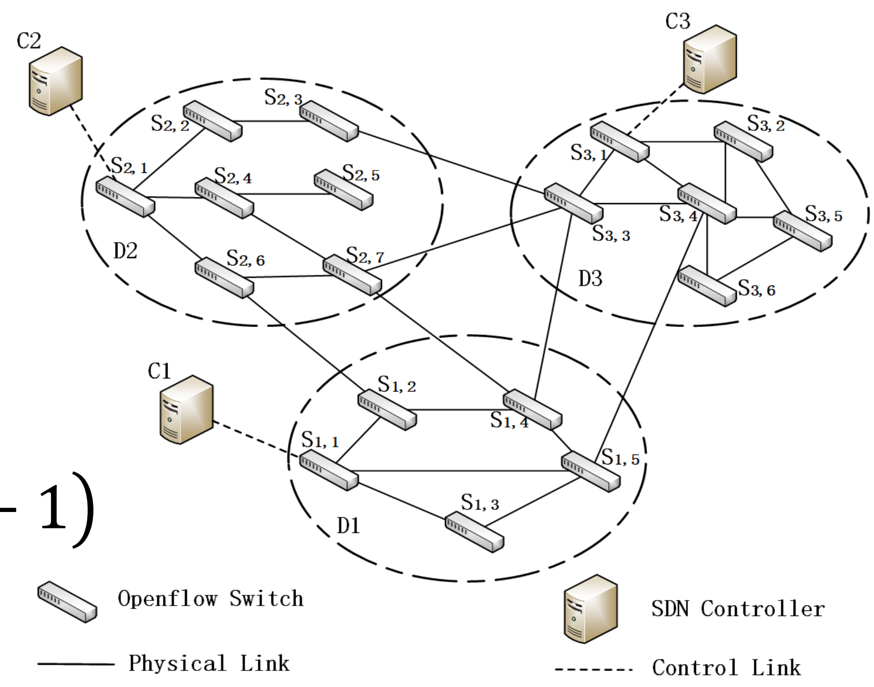
## 2.2 Survivability metric

(1) $GP^{v_c \to v_i} = (1 - P_e)^{|PL^{v_c \to v_i}|}$

(2) $Por^{v_c \to v_i} = \dfrac{|PL^{v_c \to v_i}|}{q}$

(3) $SF^{v_c \to v_i} = GP^{v_c \to v_i} \Big/ (Por^{v_c \to v_i} + 1)$

(4) $Sur(V^c) = \dfrac{\sum_{i=1}^{|D|} \sum_{j=1}^{|D_i|} SF^{{v_i}^c \to v_{i,j}}}{|D| \times |D_i|}$




$P_e$: the probability of single link failure

# 2. Survivability-based Controller Backup Approach

## 2.3 Survivability-based backup approach

**1)** Ensure that backup resources are protected from single-link failure which are available even if there happens a single link failure.

- ✓ Ensure that the connection between the backup controller and the master will not be affected by a single link failure
- ✓ Ensure that the connections between the backup controller and its neighbor controllers will not be affected by a single link failure

**2)** Ensure that the connections between the backup controller and its switches in each domain will not affected by a single link failure

- ✓ make the value of survivability metric maximum

# 2. Survivability-based Backup Approach for Controllers

## 2.3 Survivability based backup approach

**Objectives:**

**1）** make the survivability of the network maximum:

$$\max\ Sur(V^{bc})$$

**2）** make the number of public links between ${v_i}^c$ and ${v_i}^{bc}$ minimum

$$\min \sum_{x=1}^{q} PublicLink_x^{{v_i}^c \rightarrow {v_i}^{bc}} \ , \forall i \in |D|$$

**3）** make the number of public links between ${v_i}^{bc}$ and ${v_j}^c$ minimum

$$\min \sum_{x=1}^{q} PublicLink_x^{{v_i}^{bc} \rightarrow {v_j}^c}, \forall i \in |D|, \forall j \in |{D_i}^{nei}|$$

**4）** make the number of public links between ${v_i}^{bc}$ and ${v_j}^{bc}$ minimum

$$\min \sum_{x=1}^{q} PublicLink_x^{{v_i}^{bc} \rightarrow {v_j}^{bc}}, \forall i \in |D|, \forall j \in |{D_i}^{nei}|$$

# 2. Survivability-based Backup Approach for Controllers

## 2.3 Survivability based backup approach

**Location Constraints：**

**1)** each switch can be placed on one backup controller at most

$$x_{i,j} \leq 1, \forall i \in |D|, \forall j \in |D_i|$$

**2)** the backup controller in each domain can be placed on exactly one switch node

$$\sum_{j=1}^{|D_i|} x_{i,j} = 1, \forall i \in |D|$$

**3)** the backup controller is not placed on the primary controller node

$$x_{i,j} = 0, if\ v_{i,j} = v_i^c, \forall i \in |D|, \forall j \in |D_i|$$

# 2. Survivability-based Backup Approach for Controllers

## 2.3 Survivability based backup approach

**Delay Constraints:**

**1)** The average delay between the backup controller and switches meets the average delay requirement

$$AvgDelay_i \leq T_{avg}, \forall i \in |D|$$

**2)** The delay between the backup controller and its switches meets the worst delay requirement

$$WstDelay_i \leq T_{wst}, \forall i \in |D|$$

# 3. Performance Evaluation

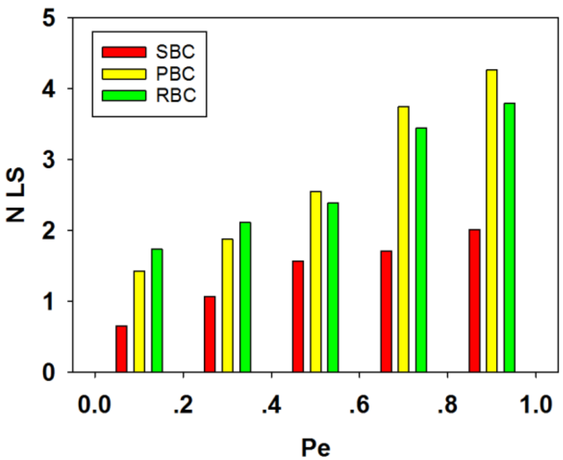
- **Comparison of PBC, RBC and SBC**

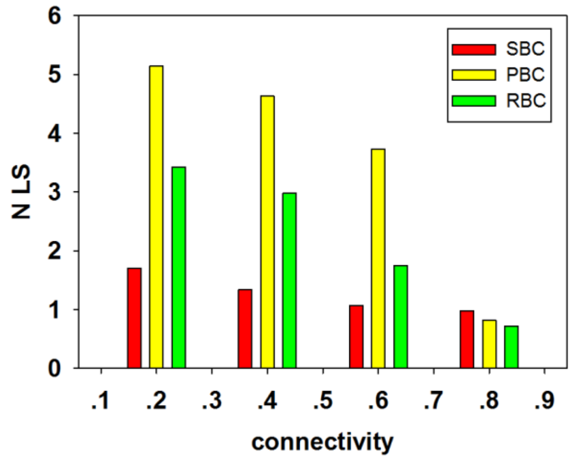
| Approach | Failure Recovery Strategy |
|---|---|
| PBC | The proximity-based controller backup approach [8] |
| RBC | The residual capacity-based controller backup approach [8] |
| SBC | The survivability-based controller backup approach |

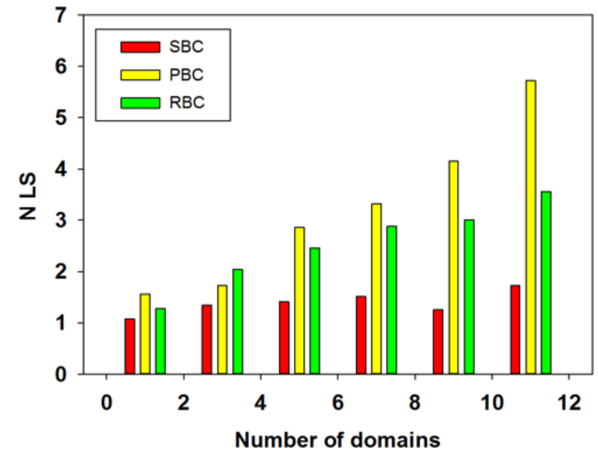
- ***Evaluation metrics***
  1) ***NLS: number of lost switches***
  2) ***NLCP: number of lost connections between the backup controller and its primary controller***
  3) ***NLCN: number of lost connections between the backup controller and its neighbor backup controllers***
  4) ***Average Delay: the average propagation delay of whole multi-controller network***

# 3. Performance Evaluation

- *The results of the experiments:*

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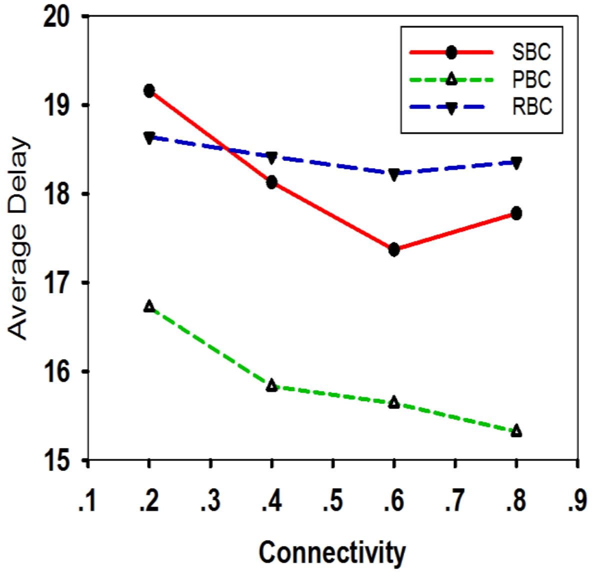
When the number of domains increases, the value of NLS in three approaches all gets larger. However, the value of NLS in SBC is always smaller than that in PBC and RBC

NLS: number of lost switches

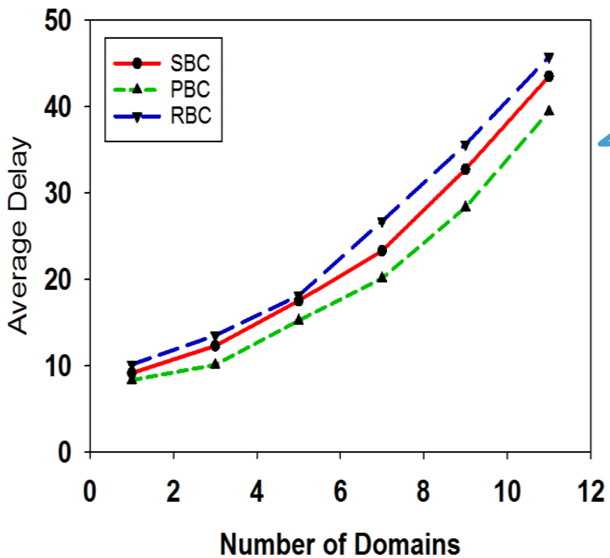
Pe: probability of single link failure

# 3. Performance Evaluation

- *The results of the experiments:*




When the connectivity increases, the average delay in three approaches all gets smaller slightly. The average delay in PBC is much smaller than that in SBC and RBC.




When the number of domains increases, the average delay in three approaches all gets larger. The average delay in SBC is overall between that in PBC and RBC.

# Thanks for listening!
# Q&A

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