Migrating to SDN for Mobile Core Networks : A Dynamic and Global Perspective

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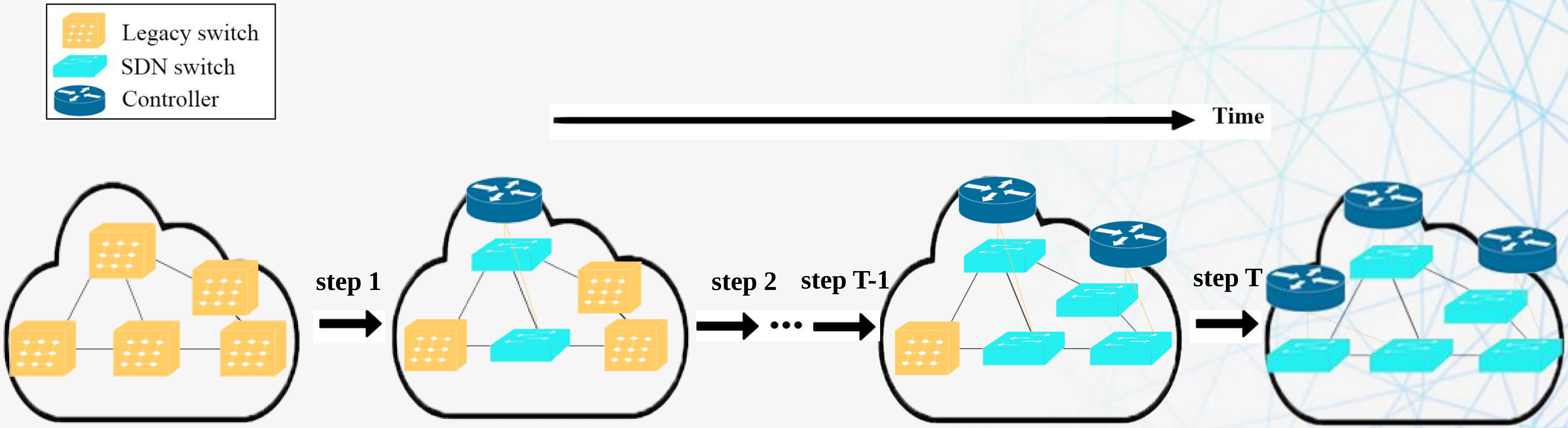
Background

- Software-Defined Networking SDN

- Hybrid SDN

Migrating to SDN



(a) IP network

(b)

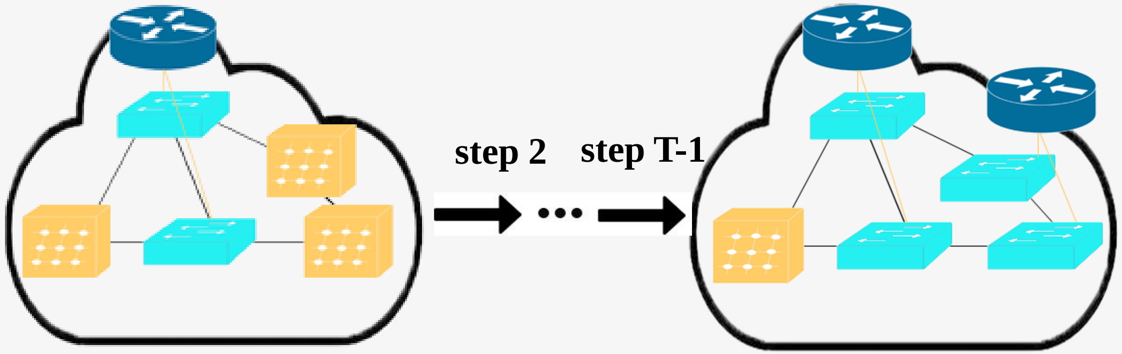
Hybrid SDN

(c)

(d) Pure SDN

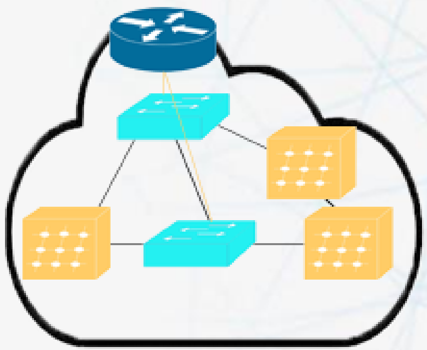
Dynamic

- Considering the entire migration trajectory as a whole
- Only considered switches upgrade



Static

- At a fixed point of time
- Jointly deploy controllers and upgrade switches

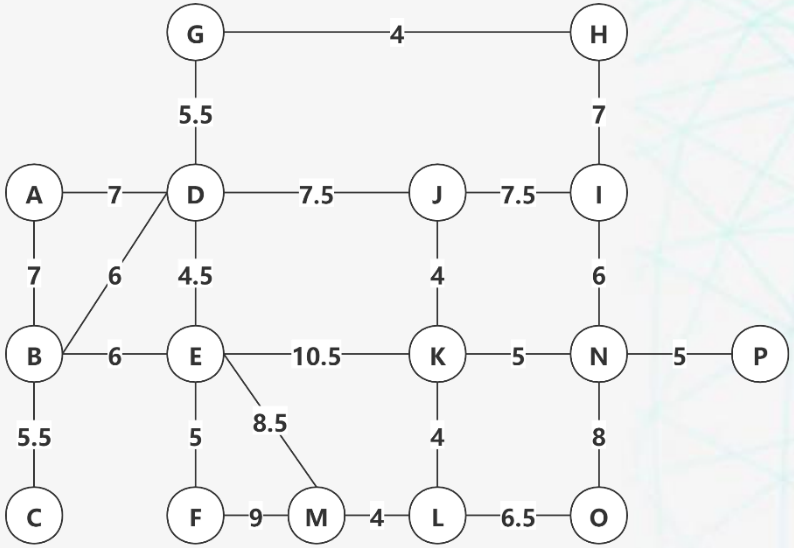


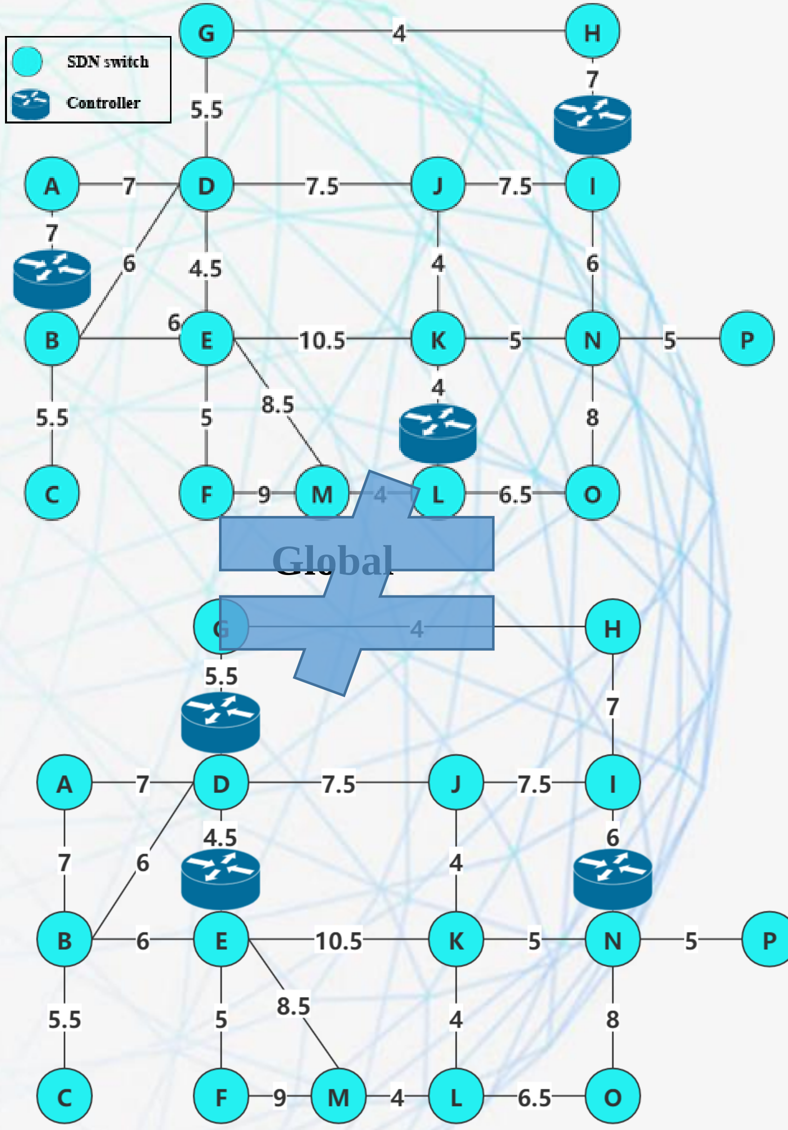
Problem

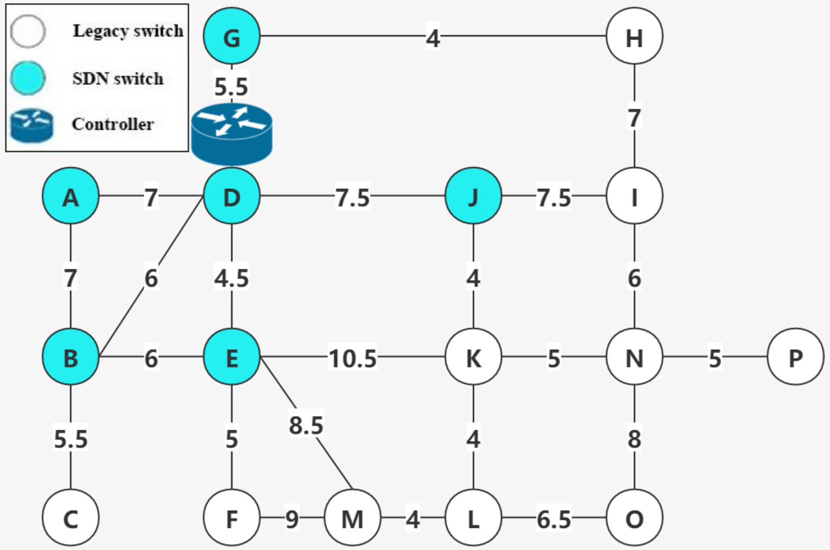
- Which
  - Which legacy devices should upgrade at each step
- When
  - Which legacy devices should upgrade first, and which subsequently
- How
  - Where to deploy controllers
  - Which controller controls which SDN switches

Motivation

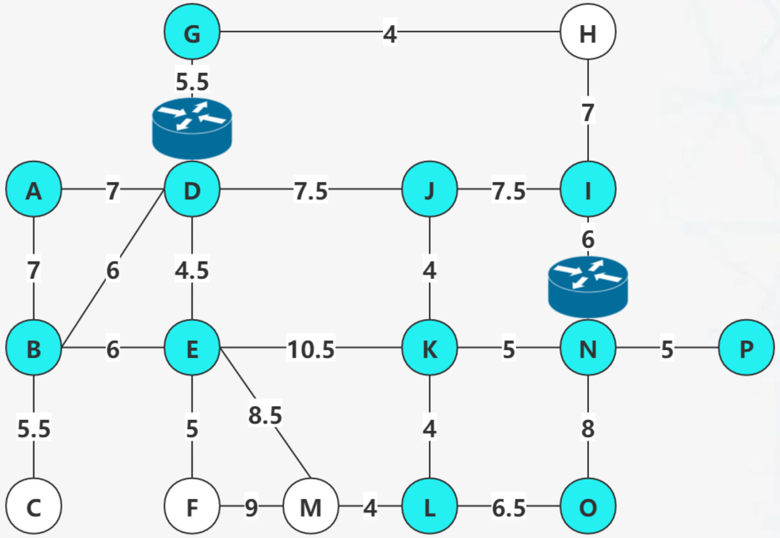
Global controllers are on node B, I, L, with the total delay of 83.5ms.
Migration controllers are on node D, E, N, with the total delay of 93.5ms.







step 1

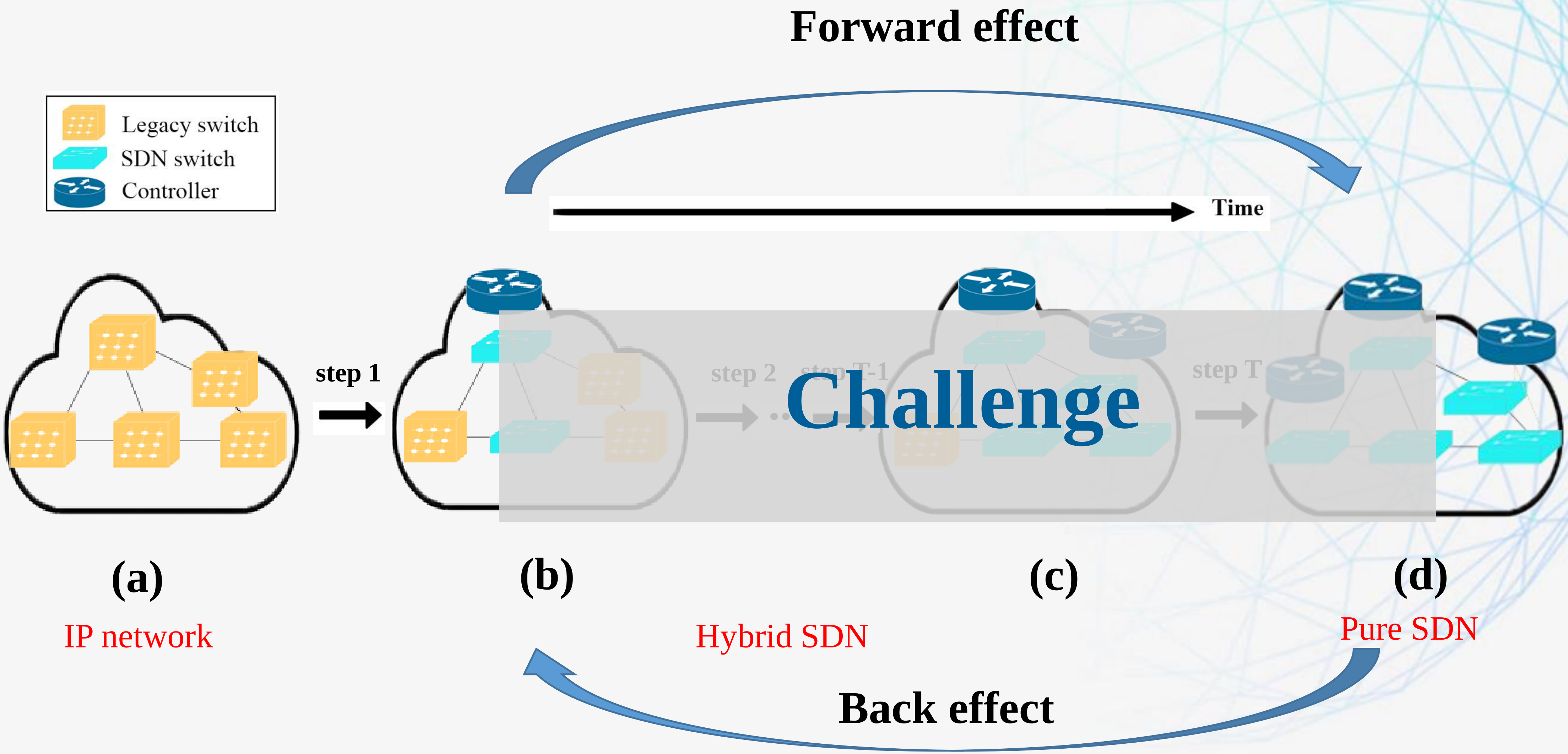


step 2

Local

step 3

Motivation


Forward effect
Legacy switch
SDN switch
Controller
Time
step 1
step 2
step T-1
step T
Challenge
(a)
(b)
(c)
(d)
IP network
Hybrid SDN
Pure SDN
Back effect

Model

x_i^t: Upgrade switch i at step t
y_i^t: Deploy controller i at step t
z_{ij}^t: Controller i controls switch j at step t

obj:	$max \sum_{i \in N} \beta^t * d_i * x_i^t$	Upgrade switches	Maximizing network programmability	(1)
	$min \sum_{i,j \in N} \omega_{ij} * z_{ij}^t$	Deploy controllers	Minimizing the delay	(2)
s.t.	$\sum_{i \in N} x_i^t = s^t, \sum_t s^t = n,$		$\forall t \in [1, T]$	(3)
	$\sum_{i \in N} y_i^t = r^t, \sum_t r^t = m,$		$\forall t \in [1, T]$	(4)
	$\sum_{j \in N} z_{ij}^t \leq c * y_i^t,$		$\forall i, \forall t \in [1, T]$	(5)
	$\sum_{i \in N} z_{ij}^t = x_j^t \,,$		$\forall j, \forall t \in [1, T]$	(6)
	$y_i^t \leq x_i^t \,,$		$\forall i, \forall t \in [1, T]$	(7)
	$x_i^{t-1} \leq x_i^t \,,$		$\forall t \in [2, T]$	(8)
	$y_i^{t-1} \leq y_i^t,$		$\forall t \in [2, T]$	(9)
	$x_i^t, y_i^t, z_{ij}^t \in \{0,1\},$		$i, j \in N$	(P_1)

Model

Middle steps Hybrid SDN

- Maximizing network programmability
- Minimizing the delay

Hybrid SDN

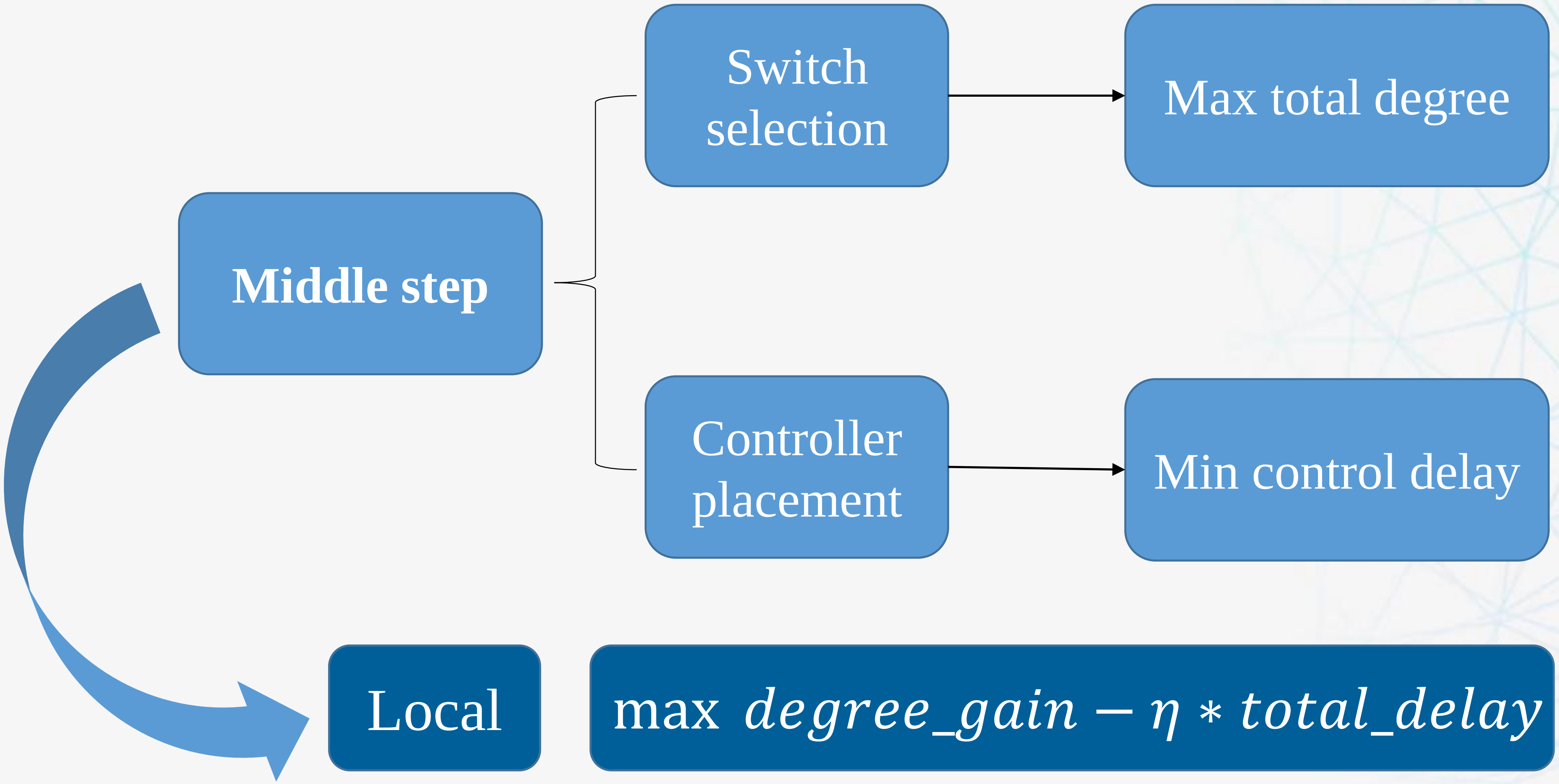
Last step Pure SDN

- Minimizing the delay

Pure SDN

Accumulation of local optimum may not get the global optimum.

Solution


Switch selection
Max total degree
Middle step
Controller placement
Min control delay
Local
$\max \ degree\_gain - \eta * total\_delay$

Solution

Last step: min total delay

Global optimal position for controllers in pure SDN

Punish the non-global optimal position

Global

min total punishment

Solution

Local:
max degree gain
min total delay

Global:
min total delay

max $degree\_gain - \eta * total\_delay$

min total punishment

max $degree\_gain - \eta * total\_delay - \gamma * punishment$

$$max \sum_{i \in N} \beta^t * d_i * x_i^t - \eta * \sum_{i,j \in N} \omega_{ij} * z_{ij}^t - \sum_{i \in N} \gamma^t * q_i * y_i^t$$

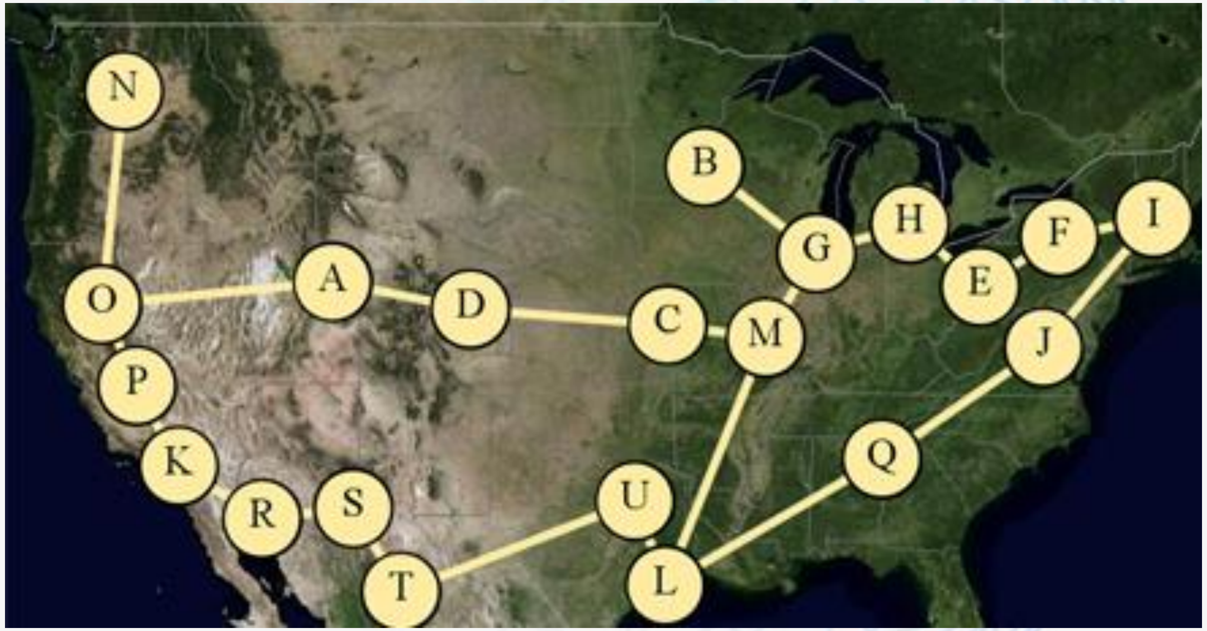
Evaluation

- Dataset
  - Atmnet –Topology Zoo
  - 21 nodes and 22 edges
- Compared methods
  - Naive deployment:

  First pick the switches in the degree descending order, then deploy the controllers in the sub SDN network to minimize control delay.
  - Joint deployment:

  To maximize the degree gain and minimize the control delay simultaneously in each step.
  - Global deployment:

  To maximize the degree gain, minimize control delay, and minimize the penalty simultaneously in each step.



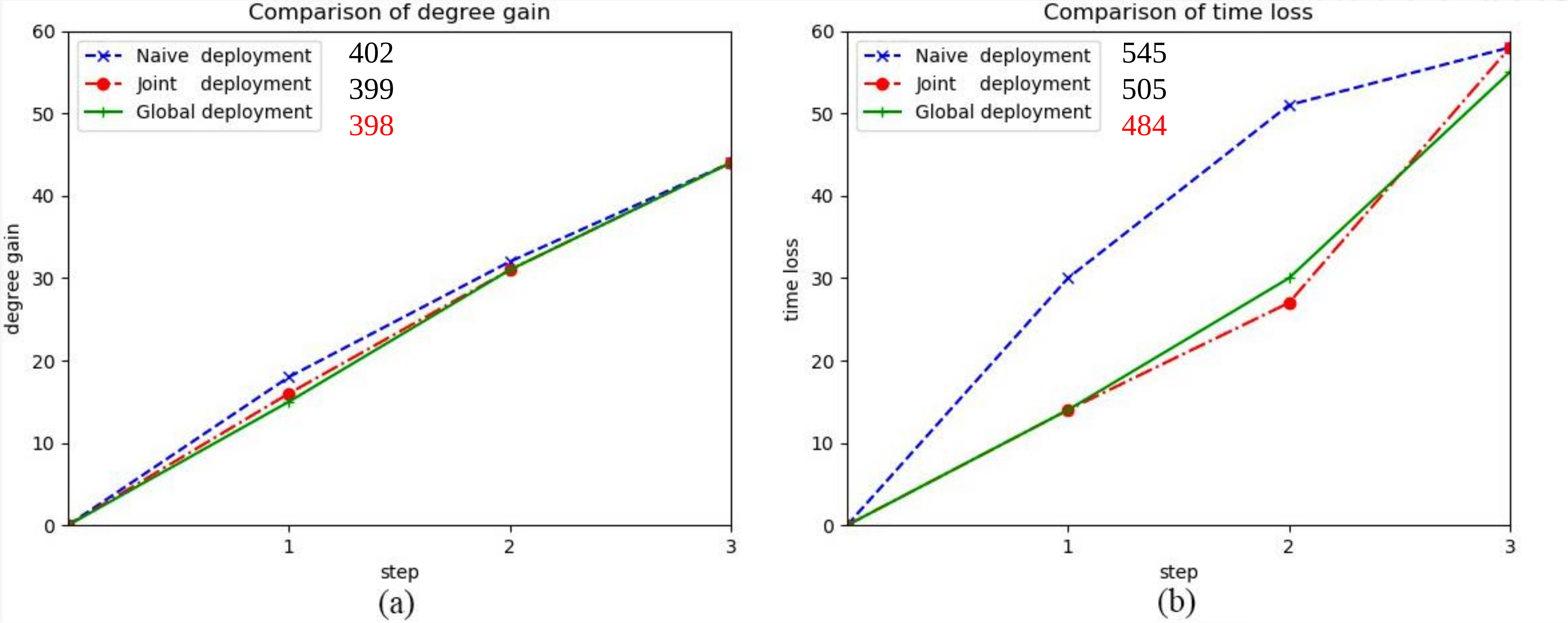
Evaluation

$\text{degree\_gain} = \sum_{i \in N} d_i * x_i^t$

$total\_degree\_gain = \sum_{\mathrm{t}=1}^{\mathrm{T}} \text{degree\_}gain$

$\text{time\_loss} = \sum_{i,j \in N} \omega_{ij} * z_{ij}^t$

$\text{total\_}time\_loss = \sum_{\mathrm{t}=1}^{\mathrm{T}} time\_loss$



(a) (b)

Conclusion

- Contribution
  - Jointly deploy controllers and upgrade switches at each time step in the whole migration process.
  - Considers the inconsistence of middle steps and final step.
  - By introducing the penalty item, the optimization problem is transformed into solvable single-objective linear programming problem.

- Results
  - Our method could get a tradeoff between the local and global goals.

Thanks for your listening