Dynamic Network Slice Assignment in Software-Defined IoT Networks

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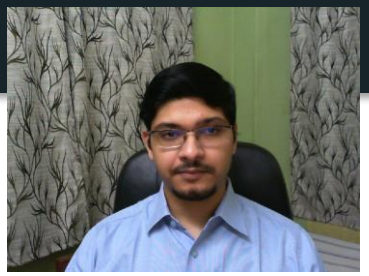
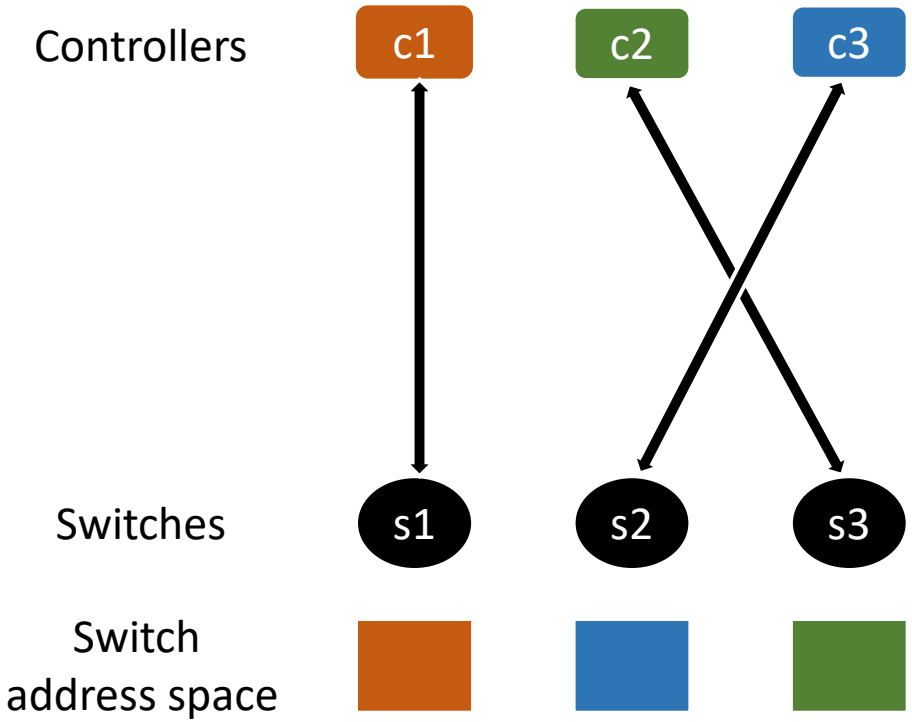
IEEE GLOBECOM 2020

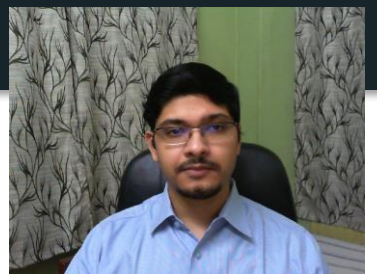
Controller mapping in SDN

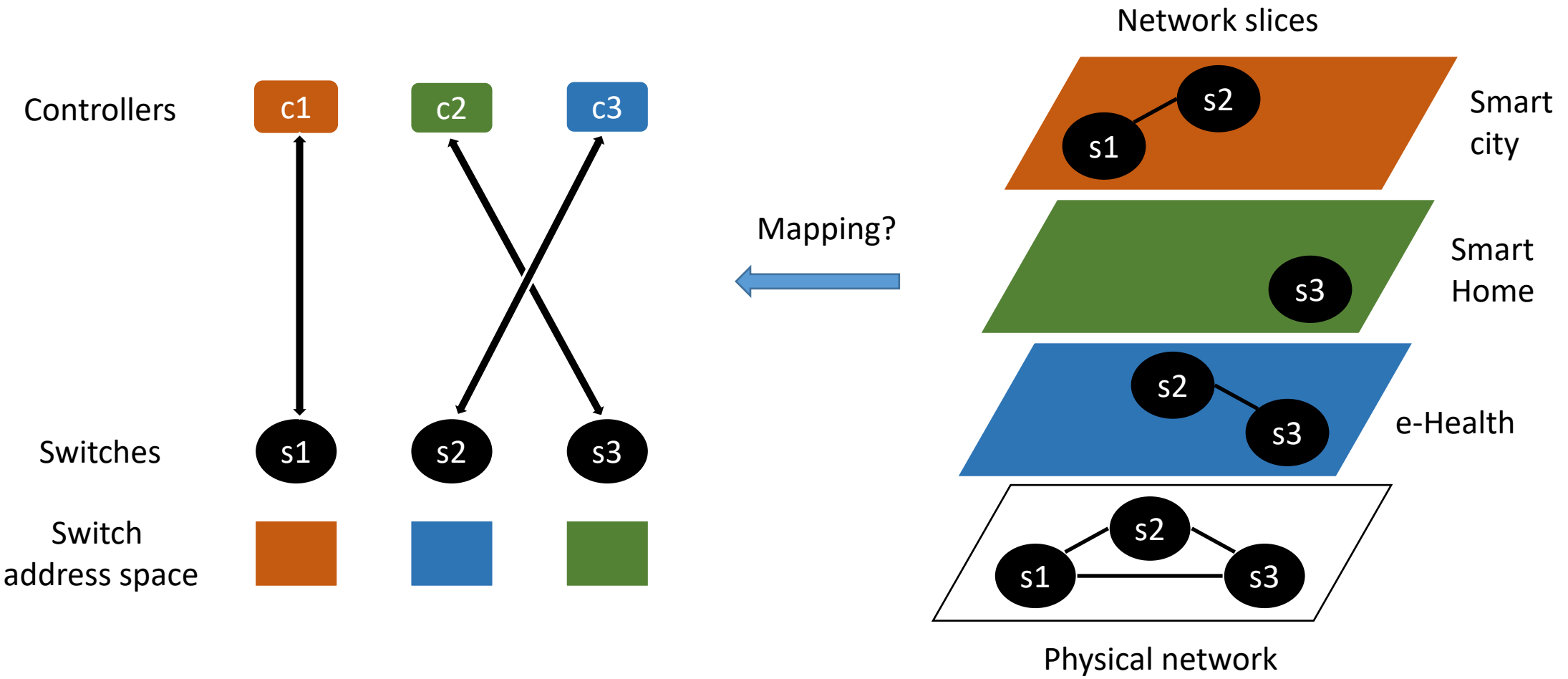




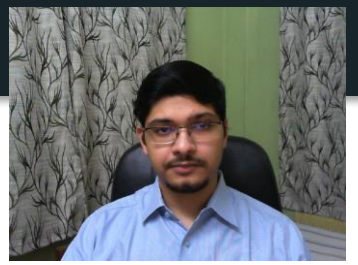
Controller to switch mapping

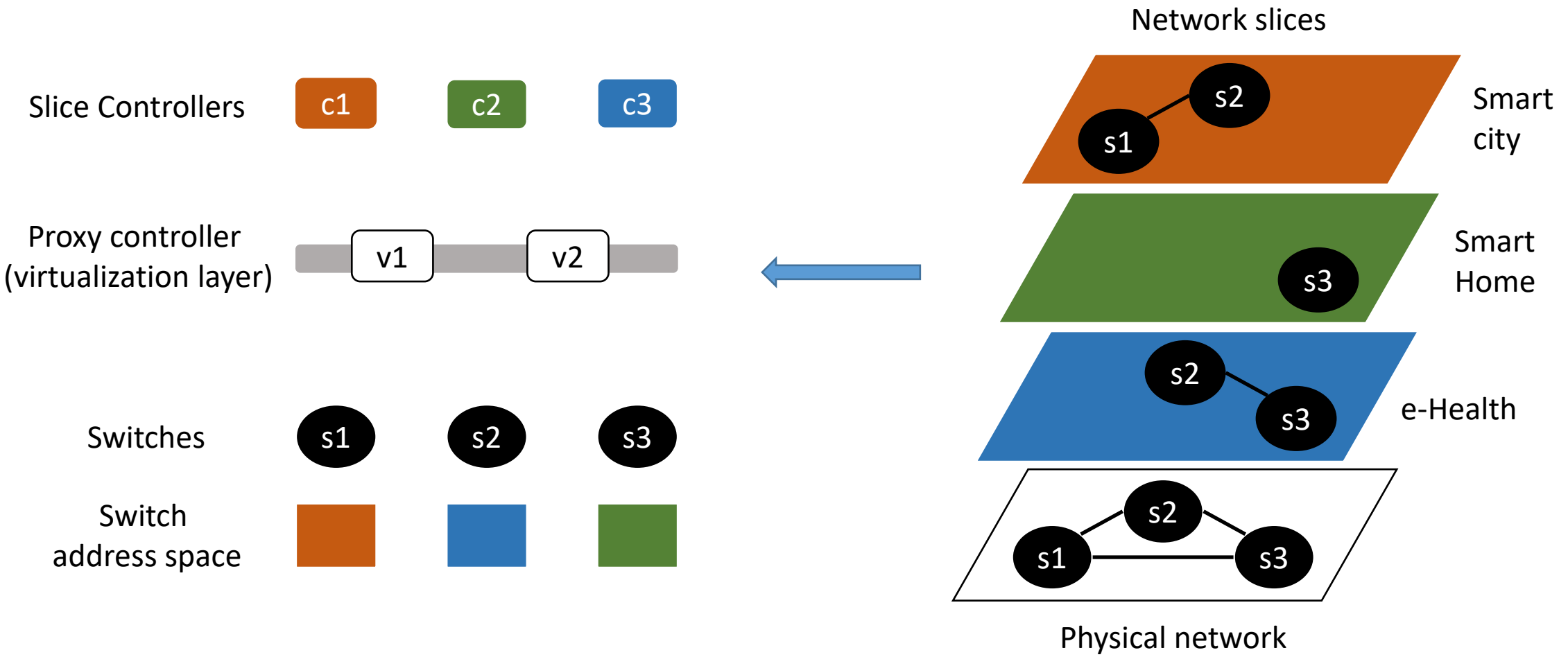
Network slicing for IoT



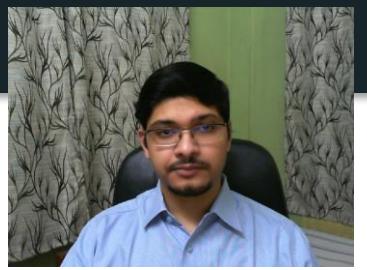


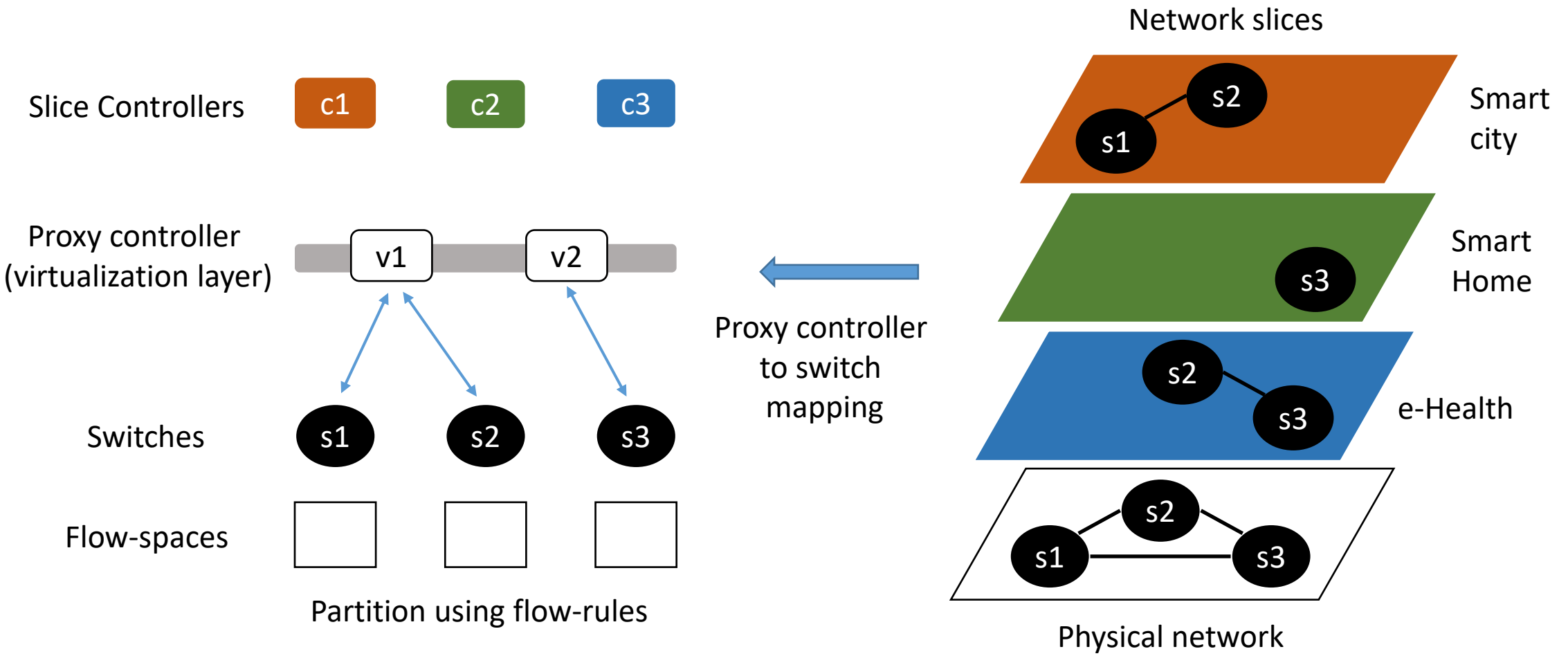
Network slicing for IoT



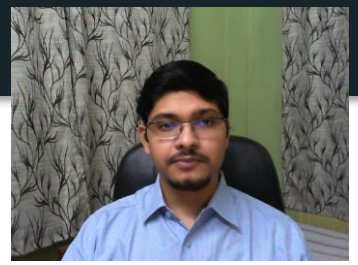


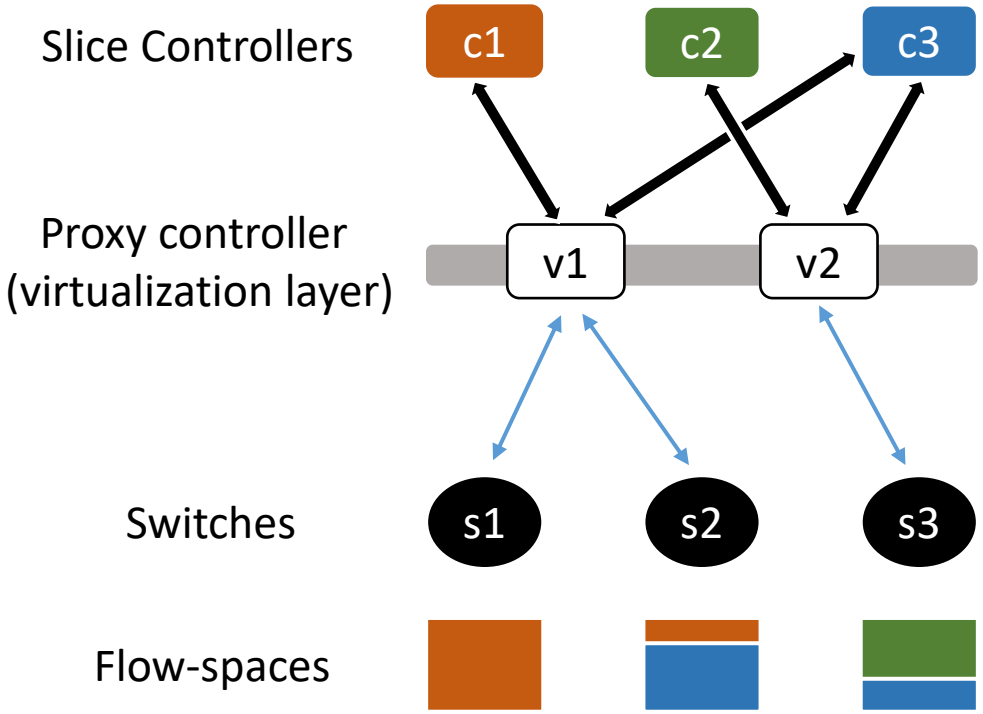
Network slicing for IoT





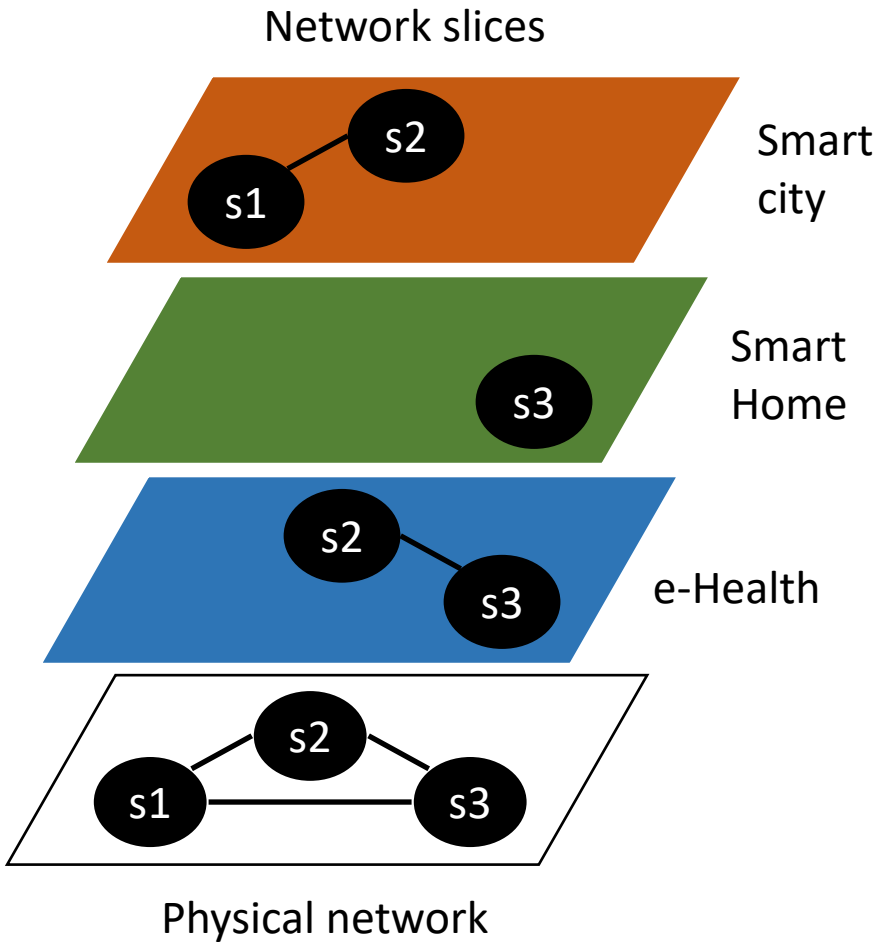
Problem scenario





Slice controller to proxy controller mapping

Proxy controller to switch mapping



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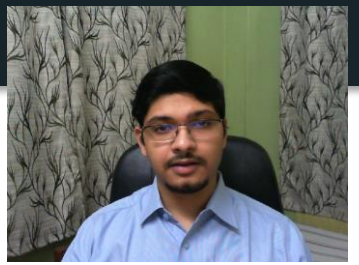
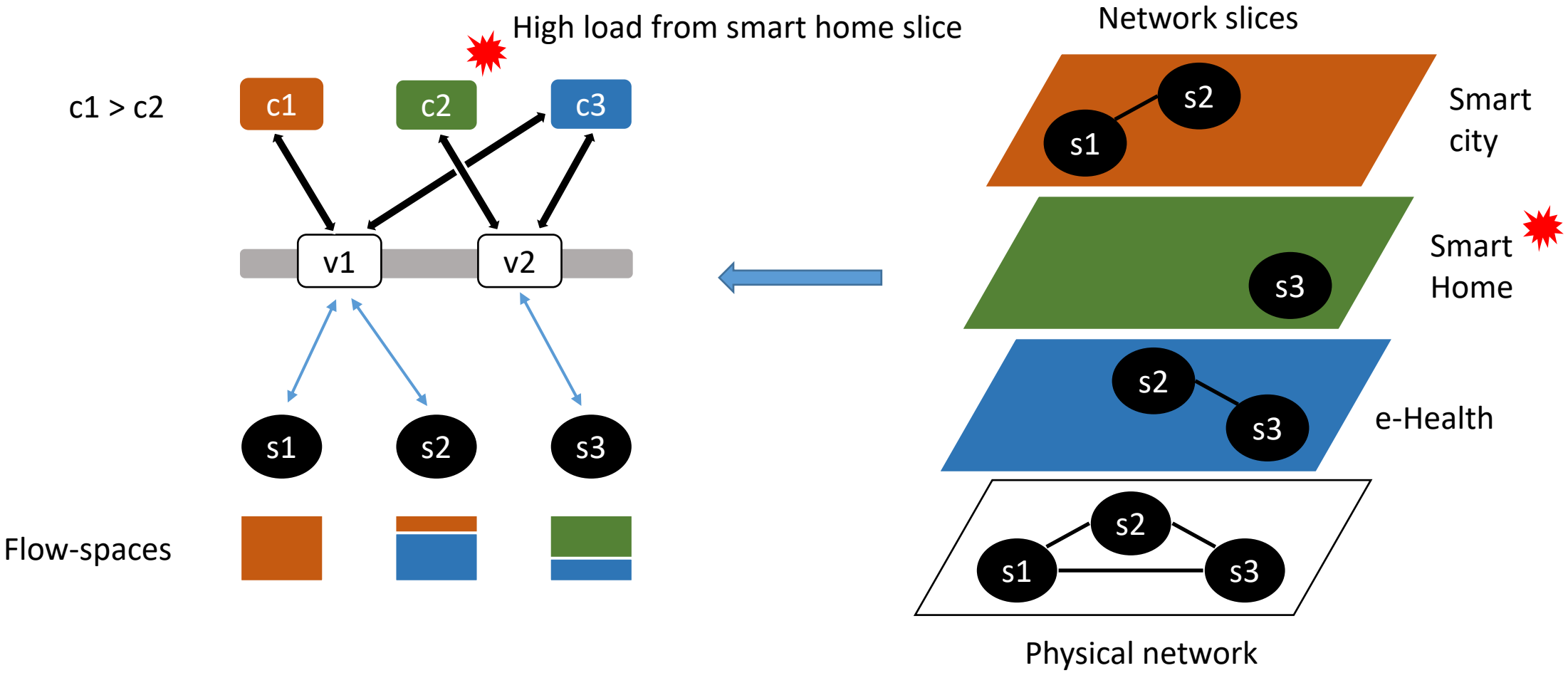
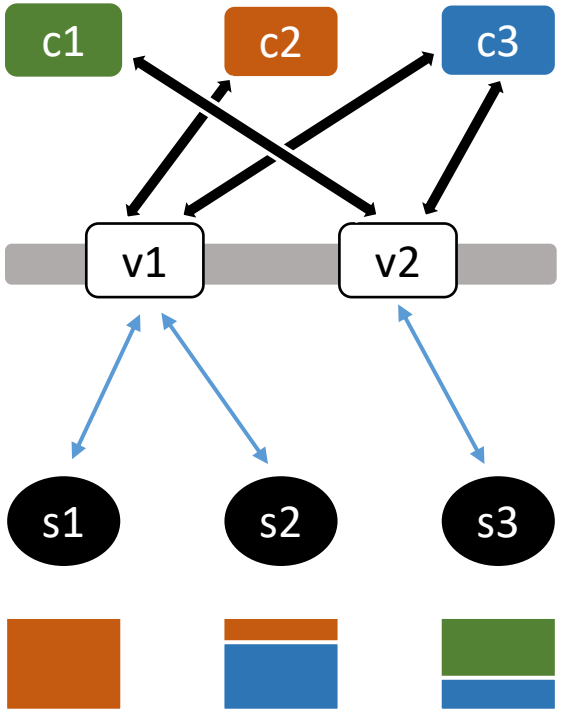




Problem scenario

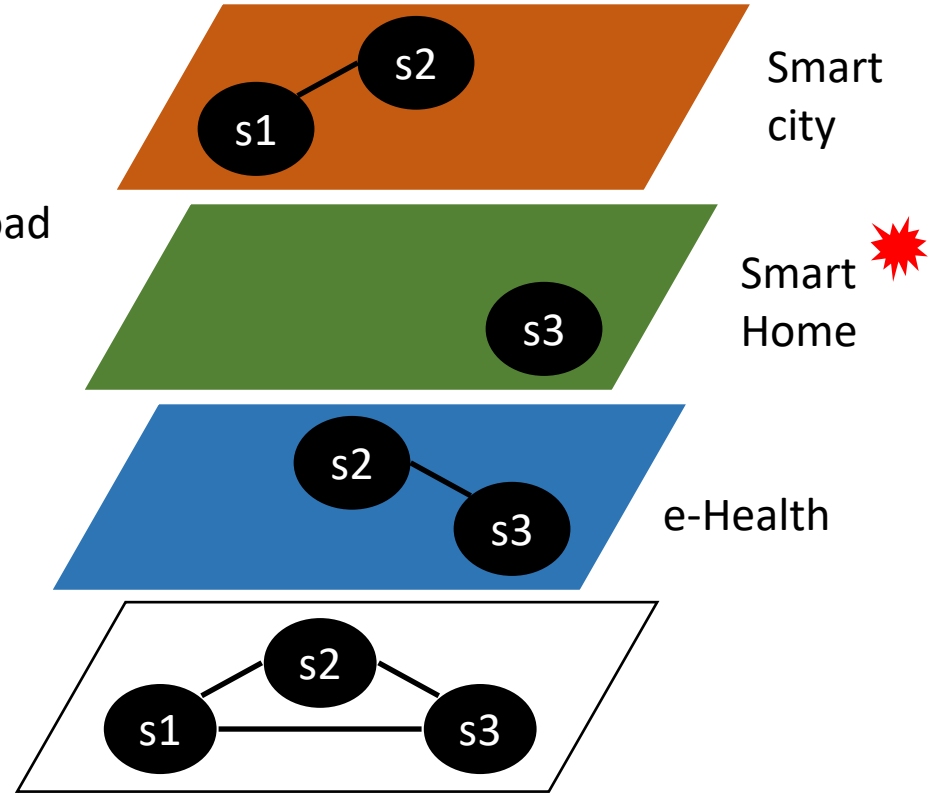
High load from smart home slice

c1 > c2

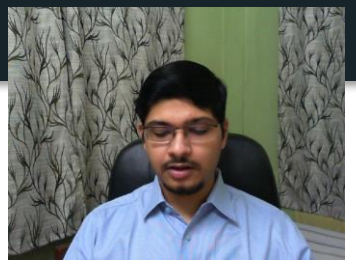


Re-mapping to handle increased load

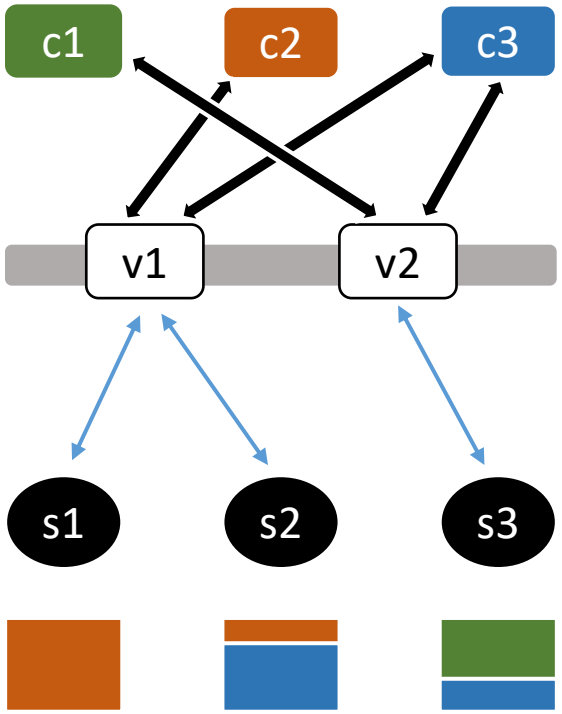
Network slices



Our work in a nutshell



c1 > c2



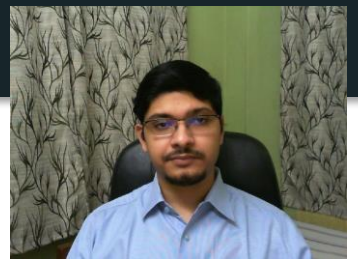
Re-mapping to handle increased load

Flow-spaces

Mapping between network slices and network slice controllers.

- How to map?
- When to re-map?

How to map?



Objective

$$\phi(t) = \sum_{c \in C} \phi_c^{ctrl}(t) + \sum_{c \in C} \phi_c^{serv}(t)$$

← control overhead + operating expenses

Constraints

$$\sum_{f \in F} g_c^f = 1 \quad \forall c \in C, \quad \sum_{c \in C} g_c^f = 1 \quad \forall f \in F$$

← One-to-one mapping between slice controllers and flow-spaces

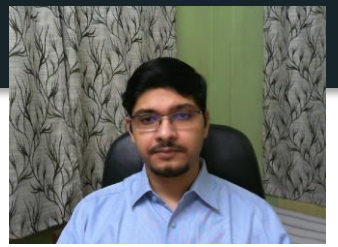
$$\theta_c(t) \leq \beta \mu_c \quad \forall c \in C$$

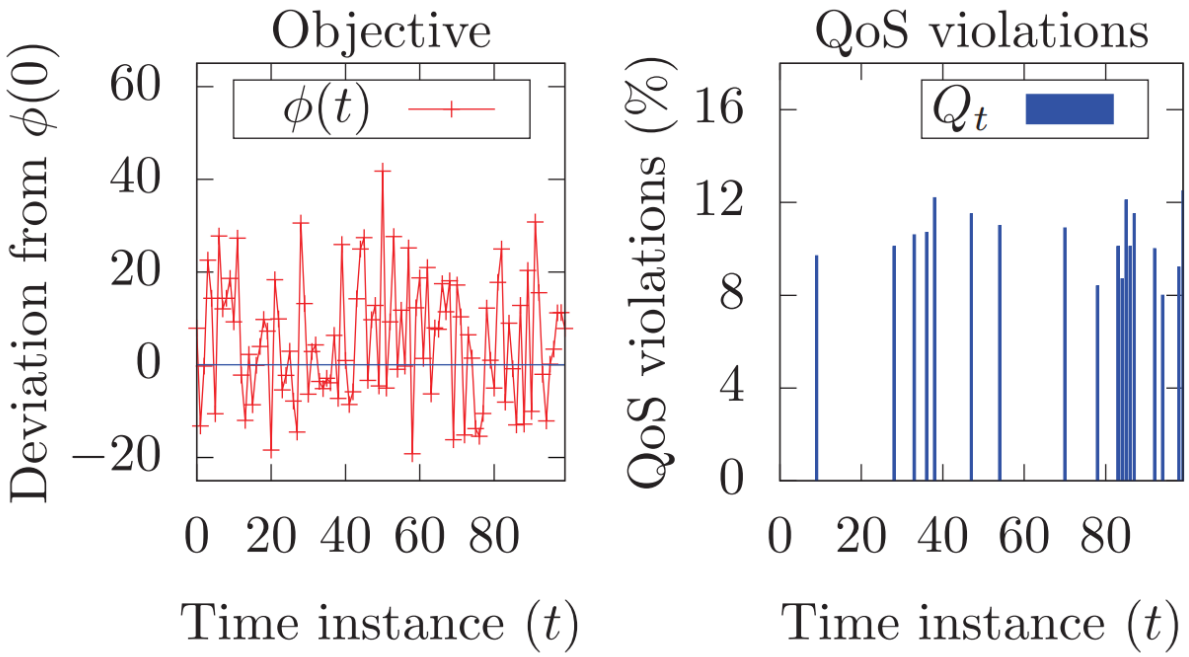
← Load should not exceed service rate

$$\Delta_c^f \leq \Delta_{max}^f \quad \forall c \in C, \forall f \in F$$

← Delay experienced at slice controller should not exceed delay requirements

When to map?





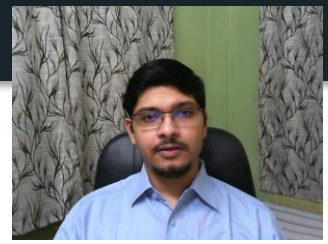
Trade-off

Expected cost of migration in terms of communication overhead

Key idea

- ✓ Keep track of the development of QoS violations and determine optimal time t* to minimize expected cost
- ✓ **One step look ahead (OSLA) rule:** trigger re-mapping at the first step in which the expected reward is as high as continuing to next time step and then re-computing

Evaluation



Benchmarks

Controller Mapping

- Fractional mapping scheme (SFM)[1]

Scheduling strategies for controller mapping

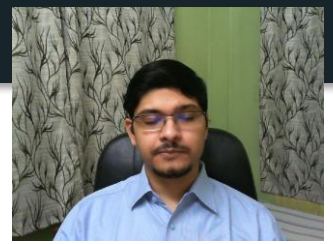
- Threshold-based strategy
- Periodic re-mapping strategy

Simulation settings

Parameter	Value
Switches	20
Slice controllers	10
Proxy controllers	2
Flow-spaces	10
Controller capacity	100 – 200
Max. controller utilization	0.9

1. V. Sridharan, M. Gurusamy and T. Truong-Huu, "On Multiple Controller Mapping in Software Defined Networks With Resilience Constraints," in *IEEE Communications Letters*, vol. 21, no. 8, pp. 1763-1766, Aug. 2017

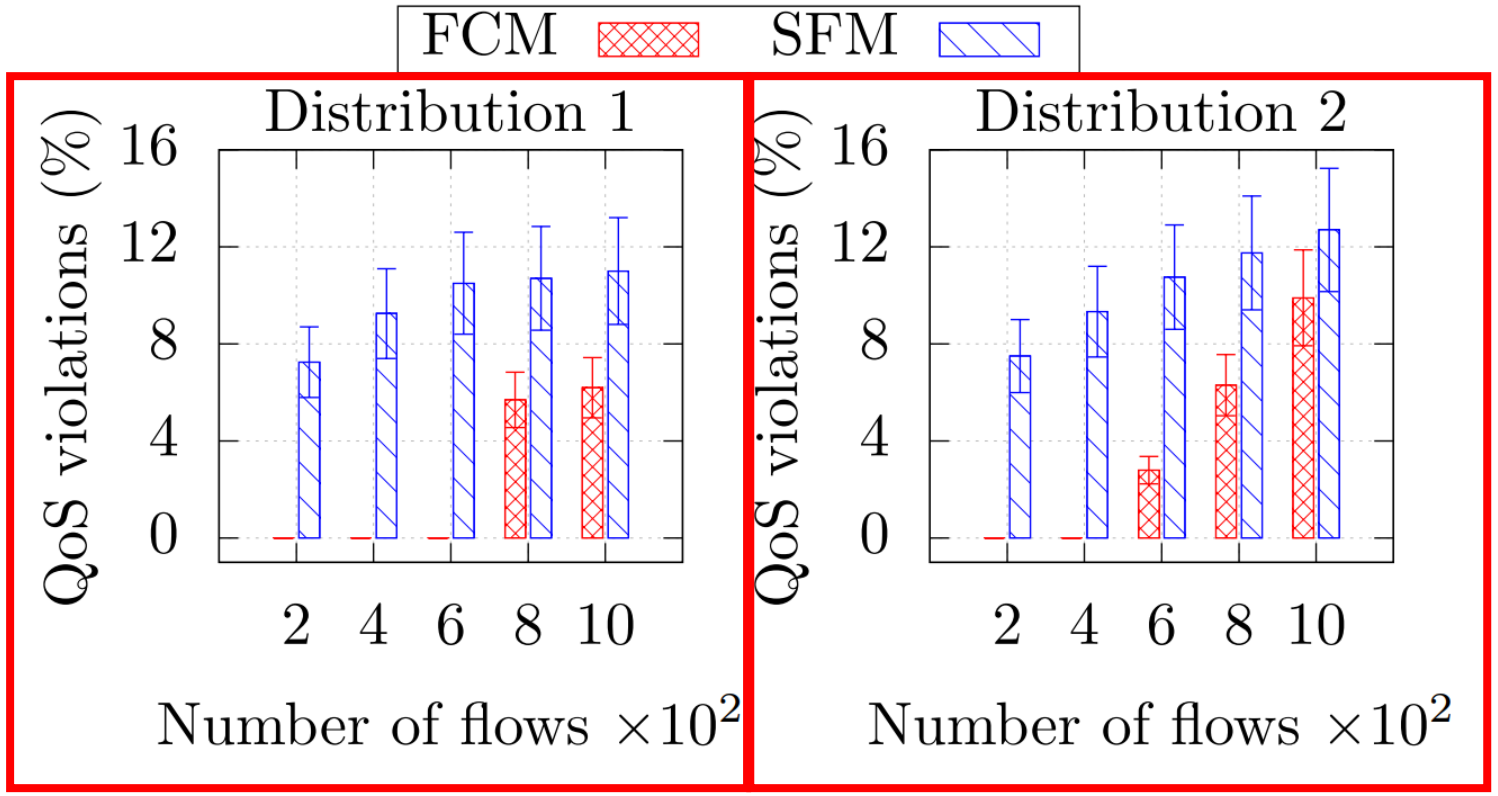
Comparison of controller mapping schemes



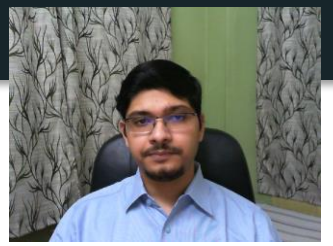
Traffic types

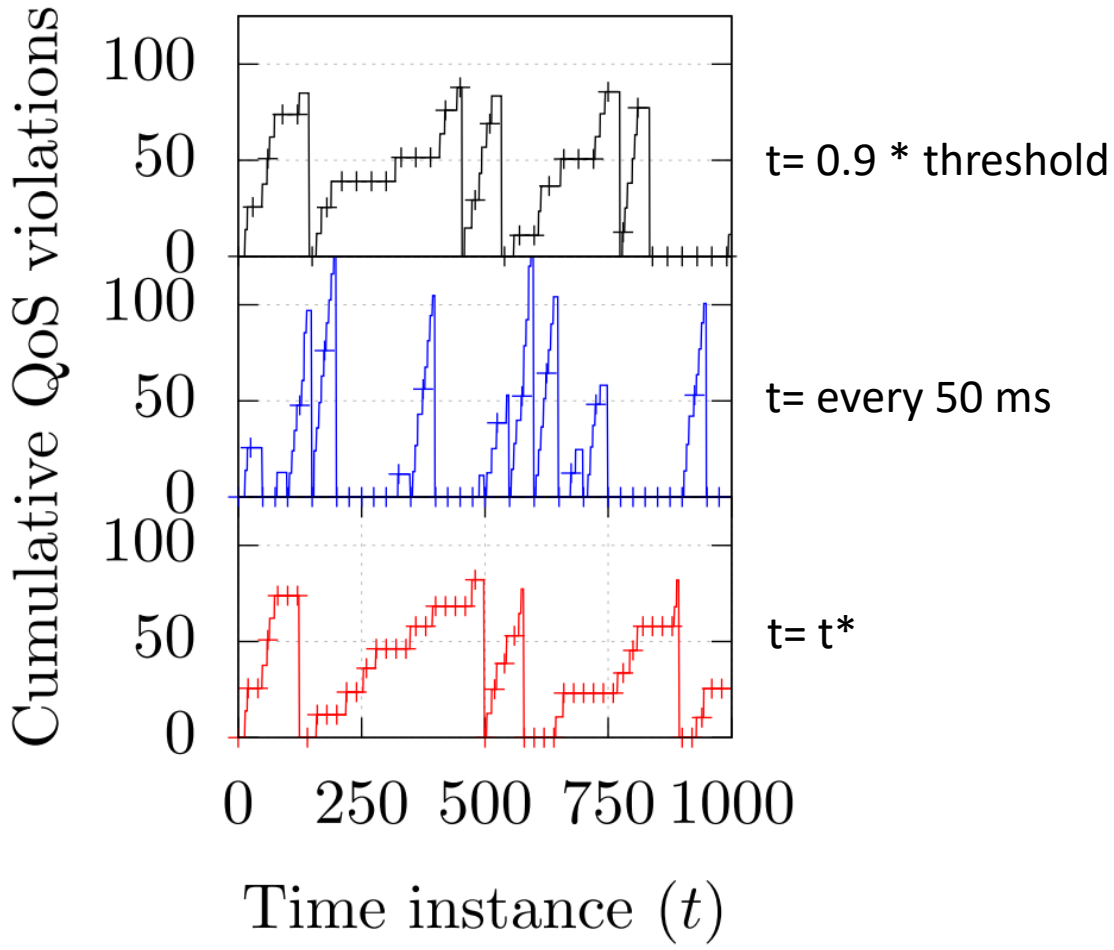
Type	Delay	Dist. 1	Dist. 2
RT	10 - 15	0.1	0.3
NRT	30 - 50	0.3	0.3
DT	> 100	0.6	0.4

70% reduction in QoS violations in Distribution 1



Scheduling strategies for re-mapping





- Both proposed and threshold-based schemes maintain the QoS level
- 20% reduction (on average) over the threshold-based scheme
- 34% reduction in the expected cost of re-computation

Conclusion

- Dynamic network slice assignment scheme for software-defined IoT networks
- Up to 70% reduction in QoS violations while considering IoT traffic
- Dynamic scheduler reduces number and cost of re-computation by 20% and 34%, respectively compared to threshold-based strategies

Our work on SDN for IoT
https://cse.iitkgp.ac.in/~smisra/theme_pages/sdn/