Context-Aware Clustering for SDN Enabled Network

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CONTENT

Motivation

Highly dynamic network topology and limited network resources

Clustered VANETs improve the network efficiency in vehicular environments

Introduction

Different types of applications could have different requirements for network quality

- Vehicular sensor data collections
- Deliver safety messages or control messages
- Vehicle camera data analysis

SDN-enabled context-aware clustering

Related wok

	Research name	Category	Metrics
MANET (Mobile Ad Hoc Network) clustering	Lowest ID [7]	Non	ID
	Highest Degree [8]	Connectivity based	connectivity
	MOBIC [9]	Mobility based	signal power
VANET clustering	CDS-SVB [10]	Mobility based	speed, moving direction, relative location
	HCA [11]	Connectivity based	connectivity status
	Dong et al. [12]	Connectivity based	connectivity status
	Duan et al. [13]	SDN based	signal strength, velocity
	Qi et al. [14]	SDN based	social attributes, inter-vehicle, distance, relative speed

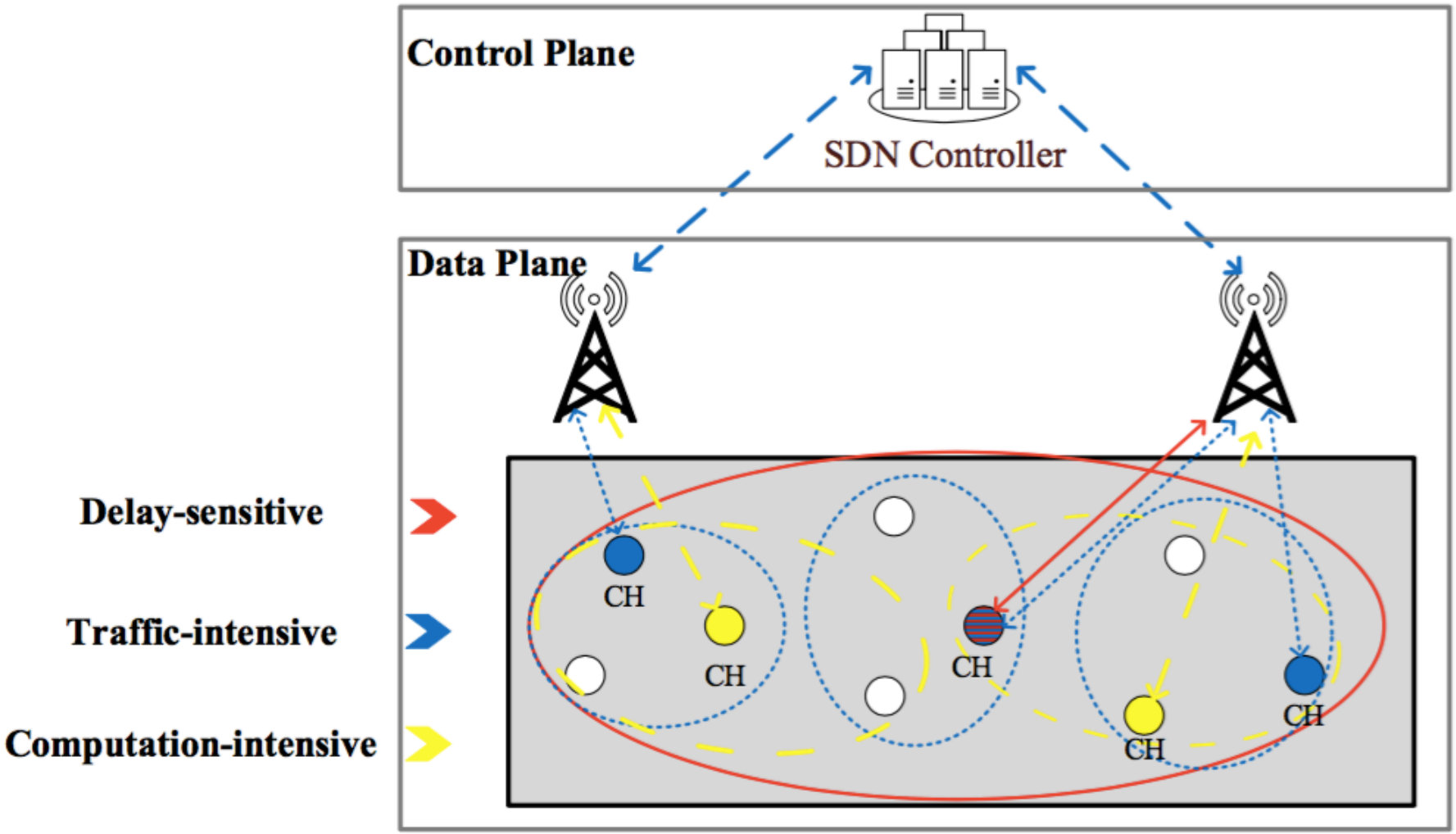
SDN-ENABLED CONTEX-AWARE CLUSTERING

SDN-enabled VANET architecture

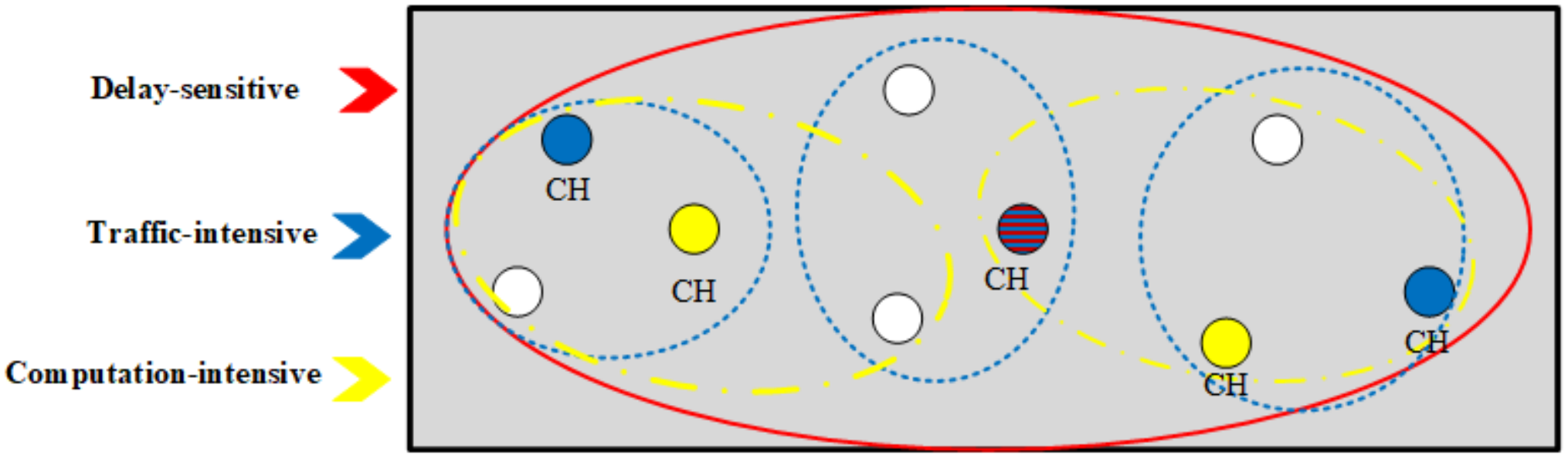
Cluster algorithm

SDN-enabled context-aware clustering

- SDN-enabled VANET architecture



SDN-enabled context-aware clustering
- SDN-enabled VANET architecture



Identify an application: use IP address and port number pairs

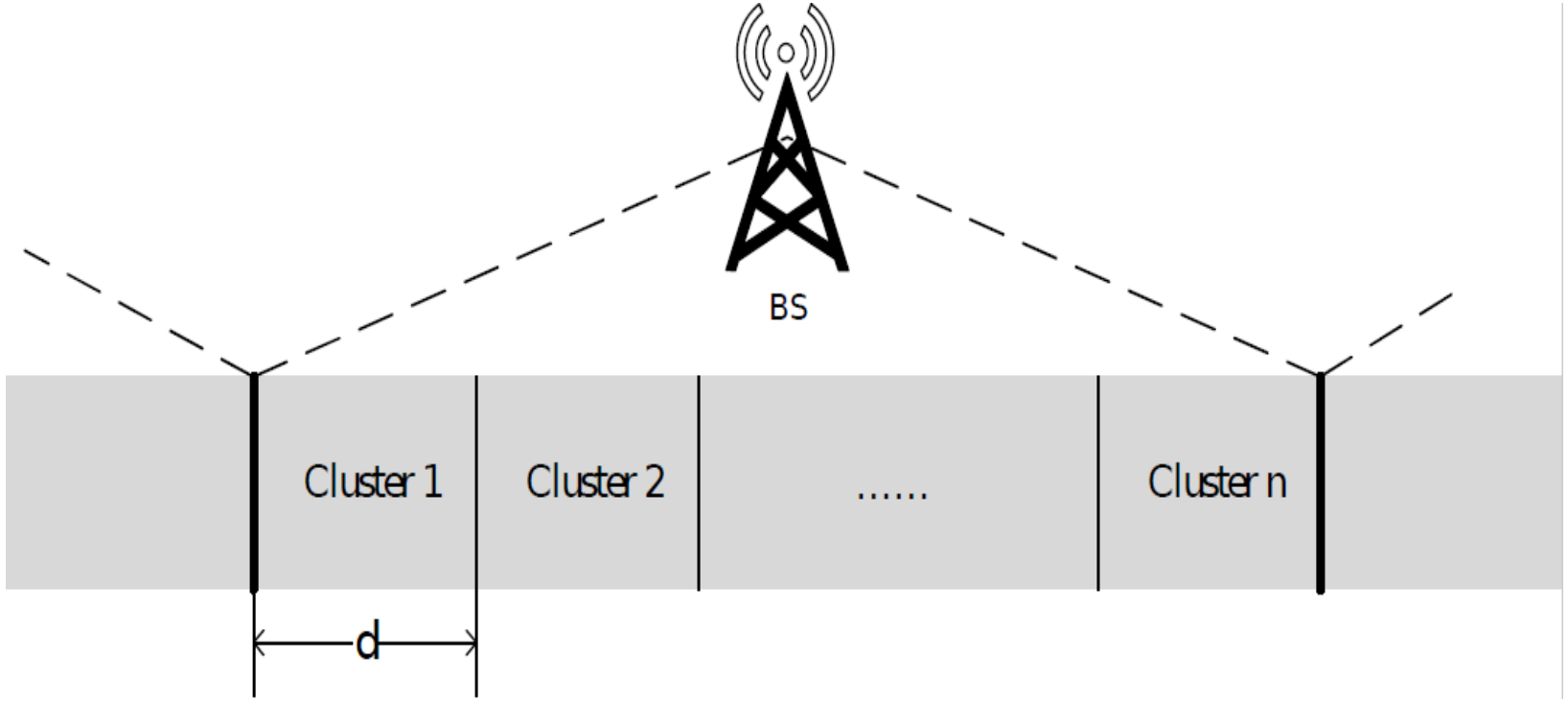
- **Delay-sensitive applications:**
  Higher priority
- **Traffic-intensive applications:**
  Large amounts of forwarding bytes
- **Computation-intensive applications:**
  With few forwarding bytes at the road side but having unique port number

SDN-enabled context-aware clustering - cluster algorithm

Cluster initialization:

Divide vehicles into groups and satisfy the group scale: $d \leq \lambda \times R$

- R denotes the value of largest IEEE 802.11p communication range.
- λ is a coefficient to control the scale of clusters in different applications.



SDN-enabled context-aware clustering - cluster algorithm

By collecting vehicle' s mobility context, obtain clustering algorithm metrics: $\{D, S, Q\}$

Primary context	Processed parameters
Vehicle velocity	Parameter D for estimating the duration time in the cluster.
Vehicle location	
Vehicle received signal quality	Parameter S for measuring the received signal quality of vehicle.
Computing capability	Parameter Q for measuring the computational capability of vehicle.

SDN-enabled context-aware clustering - cluster algorithm

$$D_k = \sqrt{\frac{\sum_{i=1}^{N} (d_k^i)^2}{N}}$$

d_k^i represents connection stability between V_k and vehicle V_i, N is number of vehicles in the cluster

$$S_k = \sum_{i=1}^{N} s_k^i$$

s_k^i means, the received signal power of V_k from V_i

$$Q_k = q_k(1 - \delta)$$

q_k represents the CPU performance of V_k and δ is CPU usage

SDN-enabled context-aware clustering - cluster algorithm

Normalize $\{D, S, Q\}$ into a value ranging between 0 and 1:

$$D_k^n = \frac{D_k - min(D_i)}{\max(D_i) - \min(D_i)}, i \in (o, N)$$

$$S_k^n = \frac{S_k - min(S_i)}{\max(S_i) - \min(S_i)}, i \in (o, N)$$

$$Q_k^n = \frac{Q_k - min(Q_i)}{\max(Q_i) - \min(Q_i)}, i \in (o, N)$$

SDN-enabled context-aware clustering - cluster algorithm

Cluster head selection:

- **Delay-sensitive applications:**
  - ✓ Max number of connection and Max D_i^n
- **Traffic-intensive applications:**
  - ✓ Max $para_i = \mu_1 D_i^n + \mu_2 S_i^n \;\; where \;\; \mu_1 + \mu_2 = 1$
- **Computation-intensive applications :**
  - ✓ Satisfy the application computation requirement and select Max D_i^n

Simulation

Simulation tools: OMNET+5.0 simulator with INET open-source model

Mobility tools: SUMO mobility simulator

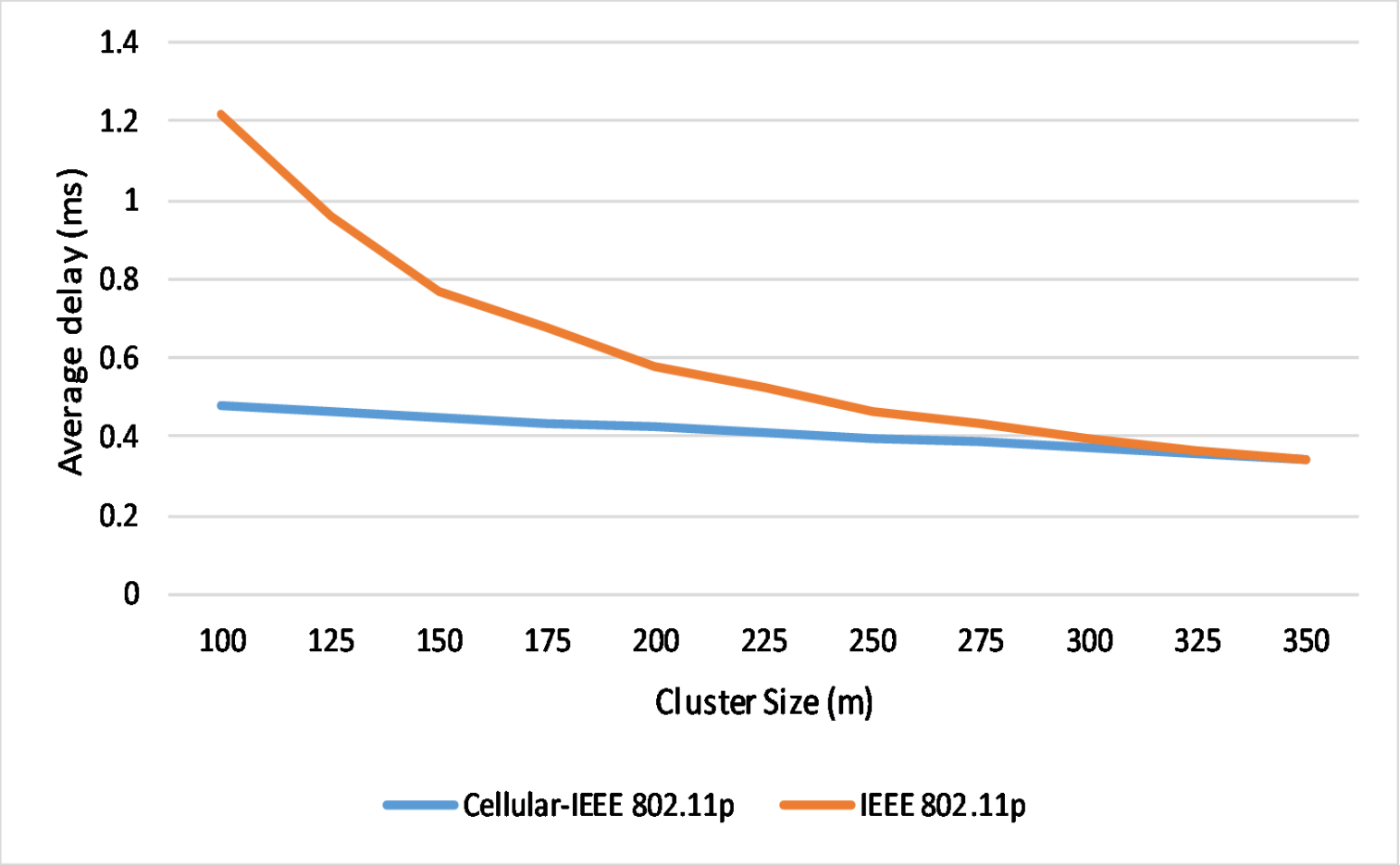
Parameters	Values
Transport Layer	TCP (RENO)/UDP
Interface	IEEE 802.11p/cellular
Data Rate	6Mbps
Beacon Interval	0.1s
Simulation Topology	Straight road
Topology Size	2000m with 4 lanes

Simulation

For delay-sensitive application

Running UDP application to simulate network alarm in case of emergency

- **Cellular-IEEE 802.11p:**
  - Two hops intra-cluster communication
  - Up to four hops of wireless propagation to reach all vehicles
- **IEEE 802.11p :**
  - Flood to n hops

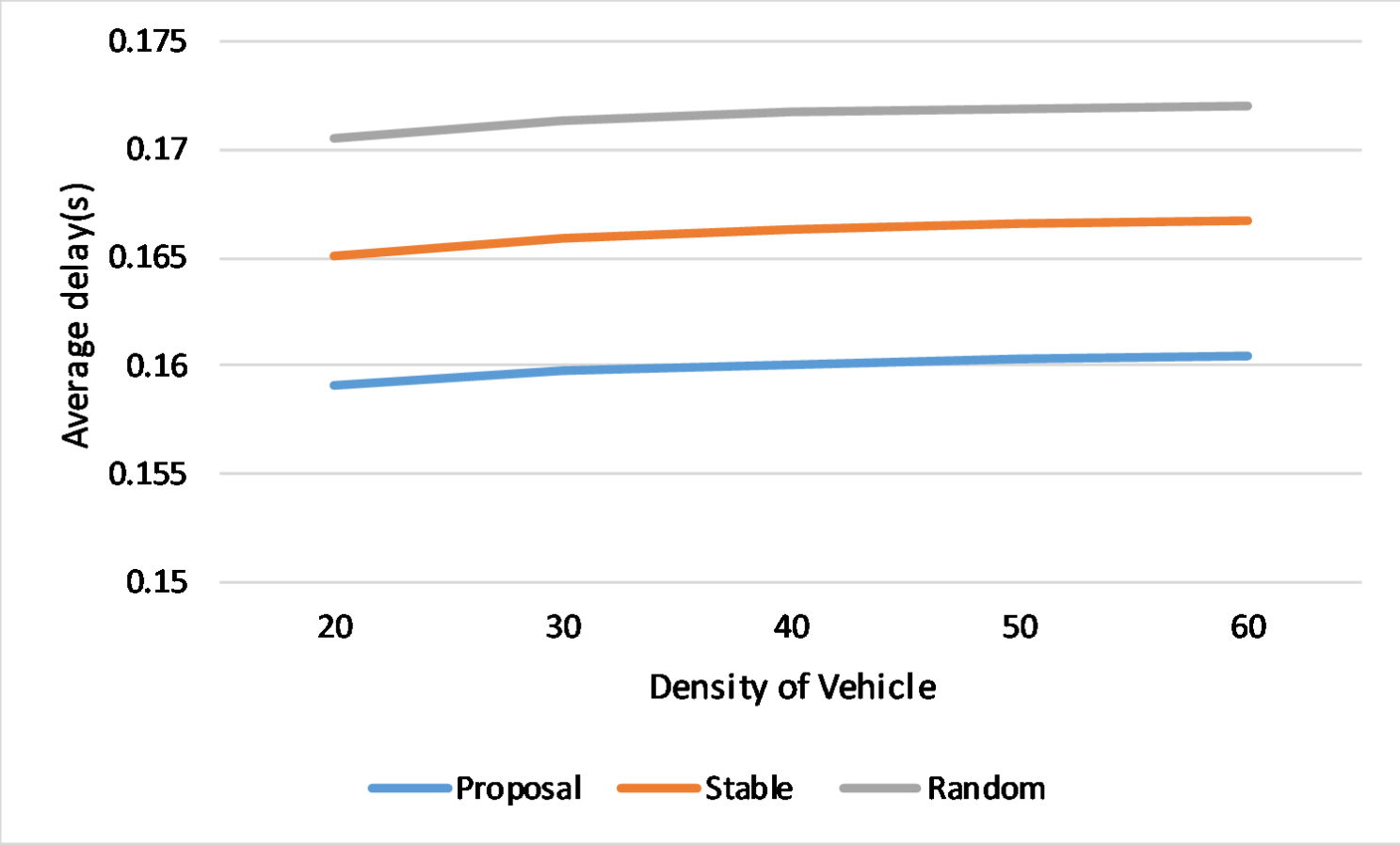


Simulation

For delay-sensitive application

Running UDP application to simulate network alarm in case of emergency

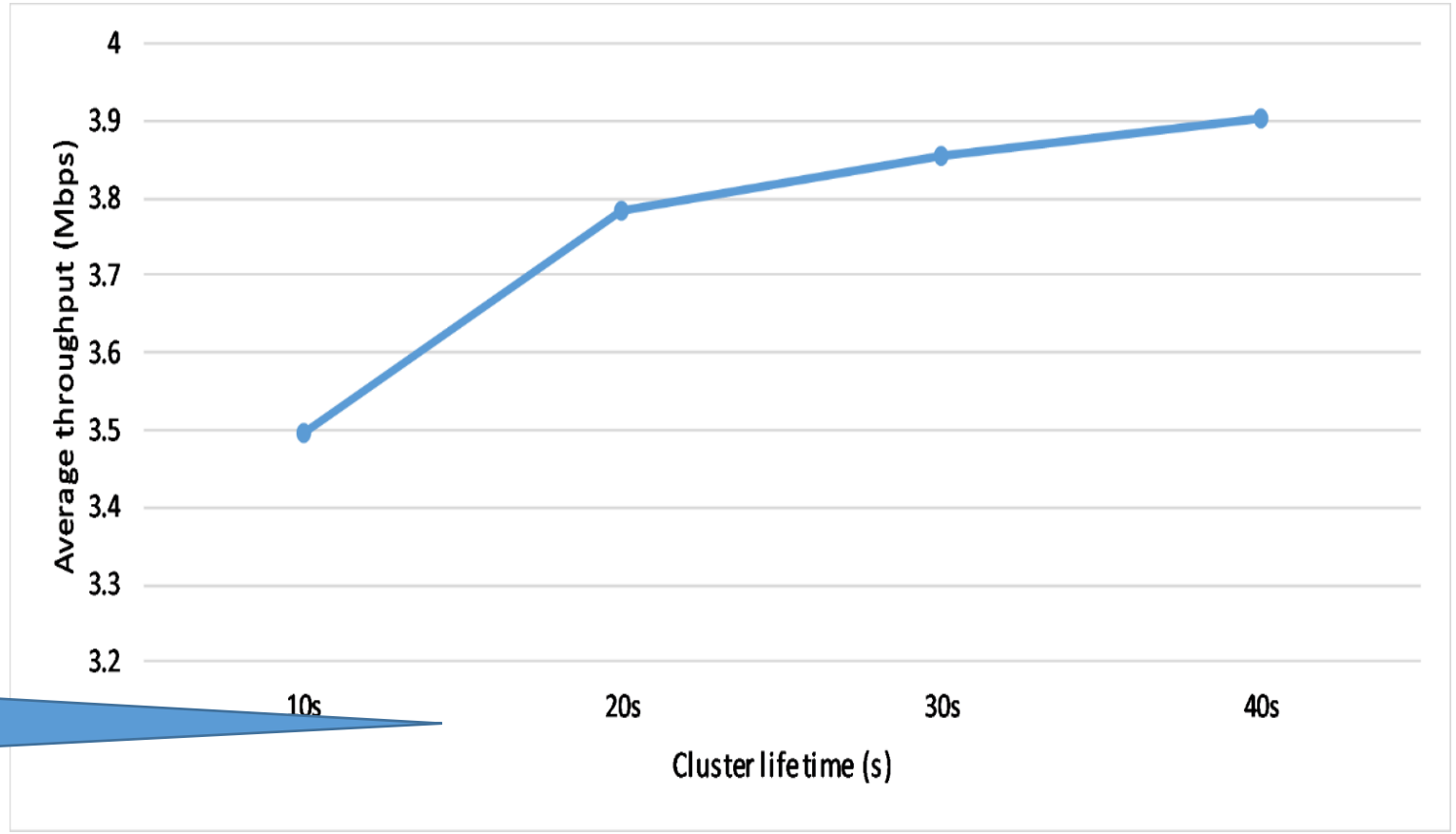
- Proposal
- Stable: longest life time in the cluster
- Random: randomly select CH.



Simulation

For traffic-intensive application

Long cluster life time performs better to the traffic-intensive application !

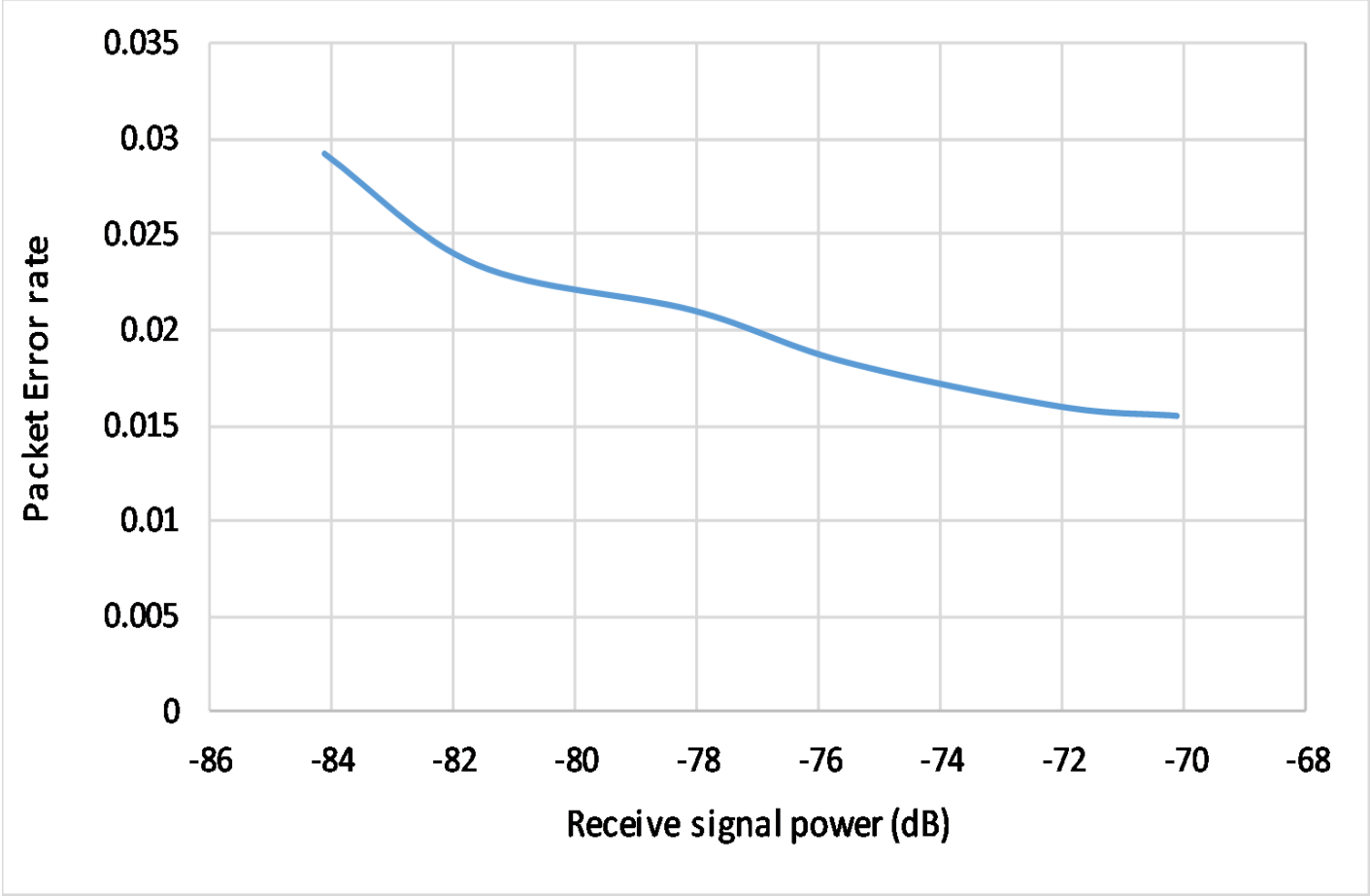


Cluster life time increases, the cluster handover frequency decreases

Simulation

For traffic-intensive application

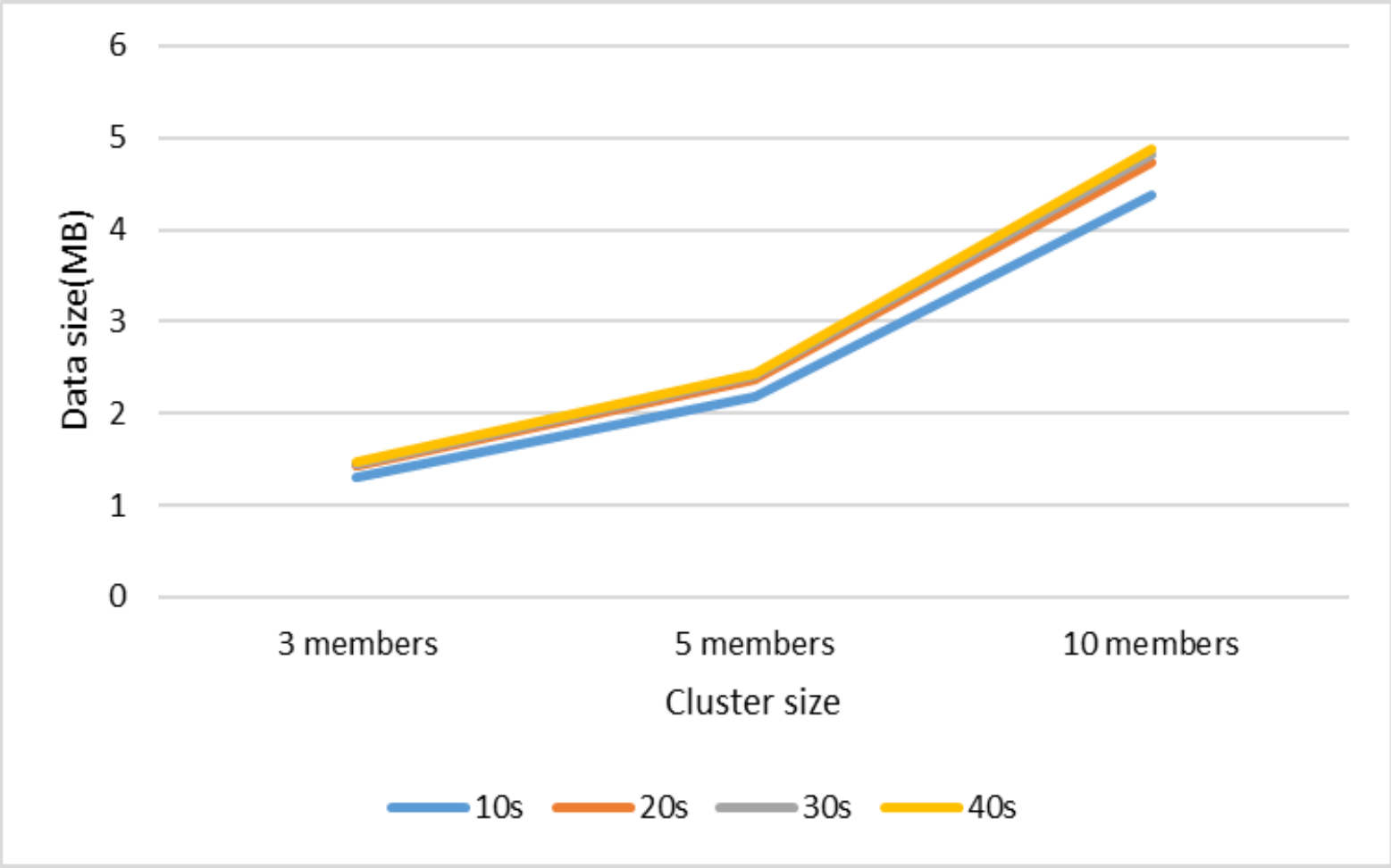
Received signal quality is important in improving transmission capability for traffic-intensive application.



For computation-intensive application

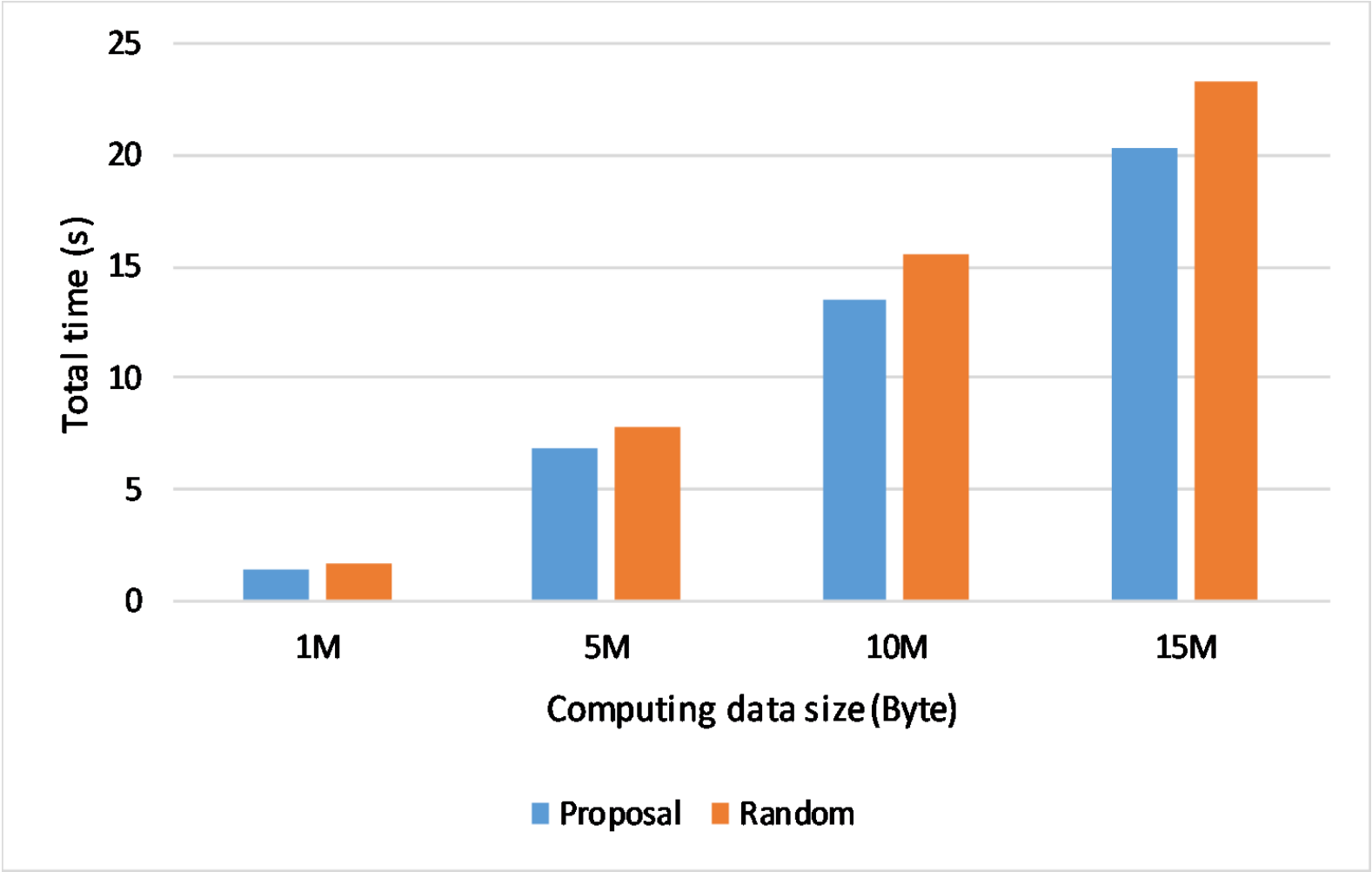
Vehicles are set to run TCP applications communicating with cluster head continuously.

- Computing data size is influenced by the number of cluster members and cluster' s life time
- When more vehicles join, computational capability of the cluster head should be considered



For computation-intensive application

- The total required time for the application in computing different size of data.
- The total time is mainly affected by data transmission delay and computation delay.



Conclusion

- ✓ SDN-enabled VANET architecture
- ✓ Clustering algorithm
  - ➢ Large cluster size better support delay-sensitive applications.
  - ➢ Make connection life time longer for traffic-intensive applications.
  - ➢ Offer large computation capability in case of too many cluster members.

Thanks !

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