



Simulation Evaluation of Distributed Congestion Control -Reactive DCC-

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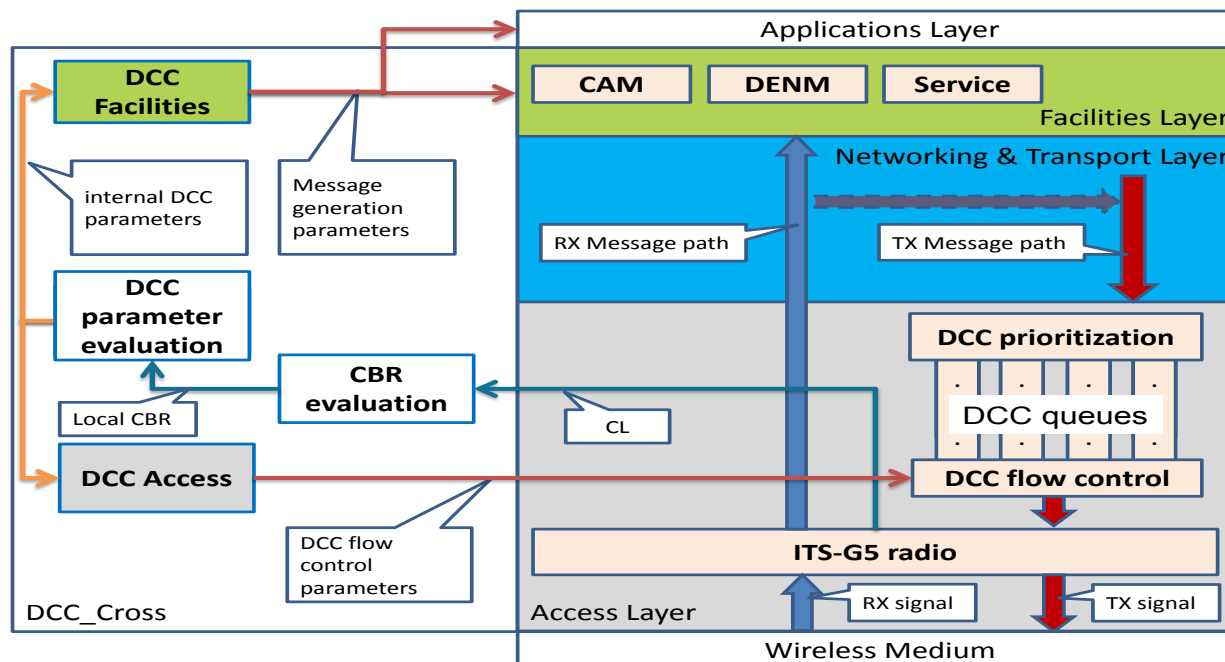
18 December 2014

Report overview

-- Study of different implementations of Reactive DCC --

- Motivation:
 - What is the “optimal” behavior of Reactive DCC?
- Implementation & Simulation setting
- Results & Discussion

DCC Reactive rate control



- DCC Access
 - PHY channel monitoring
- DCC Facilities
 - Rate control

Table A.1: Reactive DCC - DCC states and corresponding CL

States	CL (%)	T_{off} (ms)	R^{rx} (Hz)
<i>relaxed</i>	$0\% \leq CL < 19\%$	60	16,7
<i>active_1</i>	$19\% \leq CL < 27\%$	100	10,0
<i>active_2</i>	$27\% \leq CL < 35\%$	180	5,6
<i>active_3</i>	$35\% \leq CL < 43\%$	260	3,8
<i>active_4</i>	$43\% \leq CL < 51\%$	340	2,9
<i>active_5</i>	$51\% \leq CL < 59\%$	420	2,4
<i>restricted</i>	$CL \geq 59\%$	460	2,2

Controlling the CAM generation interval

- Periodical message transmission
 - Timer triggered message generation → Set Timer and send data when the timer is expired
- Upon being informed with a new CBR value, the CAM generator may
 - Wait the expiration of the ongoing timer then change the parameter table → Wait-and-Go
 - Cancel the ongoing timer and set the timer following the parameter table → Cancel-and-Go
- Considering that the neighbors have the “same” information update, generate a message with a “random” interval before following the parameter table
 - Do not consider: Synchronous
 - Consider: Asynchronous



4 Possible Approaches !

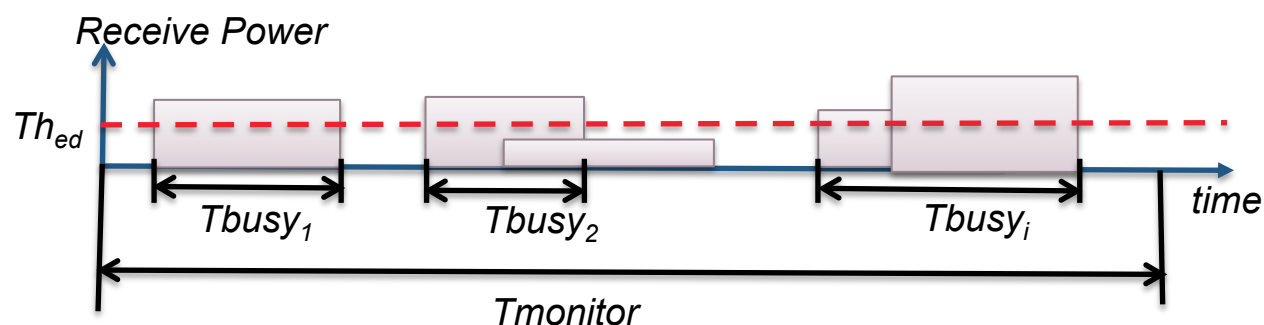
Approaches to “realize” Reactive DCC

- Approach 1: Synchronous & Wait-and-Go
- Approach 2: Synchronous & Cancel-and-Go
- Approach 3: Asynchronous & Wait-and-Go
- Approach 4: Asynchronous & Cancel-and-Go

Implementation and simulation setting details

DCC Implementation Overview

- NS3 version ns-3.21 coupled with SUMO
 - 802.11p module is implemented
- Implementation of channel load measurement on PHY
 - Channel activity monitoring:
 - Monitoring period: 100ms
 - Calculation of CBR (busy period / total period)
 - Notification to the CAM generator (and any other module, which needs the info)



$$CBR = \frac{\sum T_{busy_i}}{T_{monitor}}$$

- Implementation of Transmission Rate Control at CAM
 - Rate adaptation following the provided rule
 - DCC Reactive Control

DCC Reactive Control

- PHY Channel Activity Monitor notifies the channel state (CBR)
- Compares CBR with DCC Reactive parameter table and adjusts the Toff period

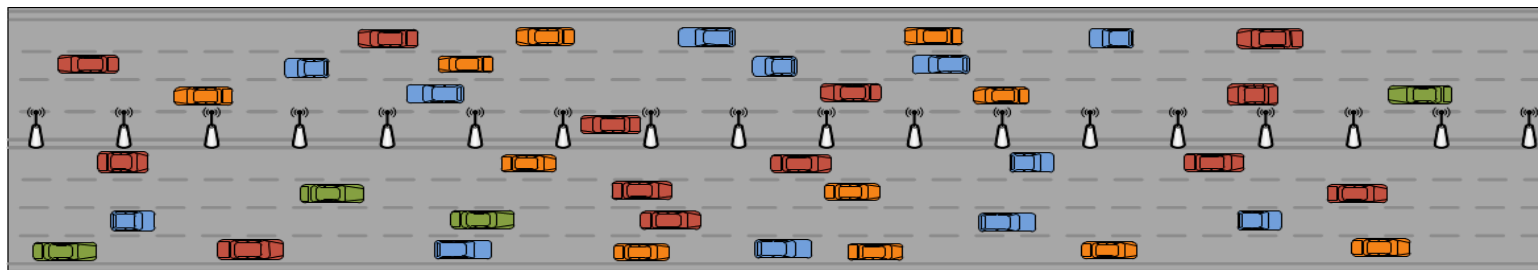
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Simulation Scenario

Table 16: Scenario Descriptions

Category	Testing Objectives	Conditions	Scenarios	Mobility
1	Scalability	Homogeneous ITS-S density	1-D highway 2D Parking Lot	Static
2	Adaptability	Heterogeneous ITS-S density	Highway, One direction dense, one empty	Exponential Inter-distance (low on direct flow, high on contra-flow)
			Elevated Highway	Exponential Inter-distance (low on elevated highway, high on highway)
3	Resilience	NLOS	Blind Intersection	One vehicle arriving at constant speed at each corner
			Dense Blind Intersection	The East/West direction: platoon of dense static vehicles. On West/East and North/South, two vehicles approach at constant speed.
4	Responsiveness	Variable Traffic	Cluster/Platoon on one direction, single vehicle on the opposite direction	Platoons of dense vehicles, sparse conditions in-between



Topology Setting

Table 18: Scenario Parameter for Scalability Test

Class	Vehicular Density	Corresponding 1D parameters	Corresponding 2D parameters
Sparse	50 vehicle/km ²	100 m inter-distance / 3 lanes / 2 directions	1,5 m inter-distance, 2D
Medium	100 vehicles/km ²	45 m inter-distance / 3 lanes / 2 directions	0 m inter-distance, 2D
Dense	250 vehicles/km ²	20 m inter-distance / 3 lanes / 2 directions	-
Extreme	400 vehicles/km ²	10 m inter-distance / 3 lanes / 2 directions	-

Table 19: Specific highway configurations for scalability tests

Parameter	Value	Default
Highway Length	1 000 m to 50 000 m	10 000 m (1 000 m if static)
RSU Inter-Location	50 m to 500 m	100 m
Vehicle size	2 m × 5 m	2 m × 5 m
Flow density class	Sparse/Medium/Dense	Dense
Contra-flow density class	As Flow	Dense

Communication parameters

Table 22: Default communication parameters for all scenarios

Parameter	Value
CAM transmission ranges (in Time)	[0,6 ms - 0,8 ms - 1 ms]
CAM 'minimum' Tx Rate (R^{tx})	1 Hz
CAM default Tx Rate (R^{tx})	10 Hz
CAM triggering conditions: changes in position - speed - acceleration	5 m - 2 m/s - 1 m/s ²
Default Tx Power (P^{tx})	23 dBm
Tx Power approaching CEN DSRC Toll Booth	10 dBm
CAM Routing	SHB
EDCA Queue / TC	1 DENM / 3 CAM
F_D threshold	-95 dBm
Modulation Schema	QPSK ½ 6 Mbit/s
Antenna Pattern	Omnidirectional, gain = 1 dBi
Access Technology	ITS G5A
ITS G5 Channel	CCH

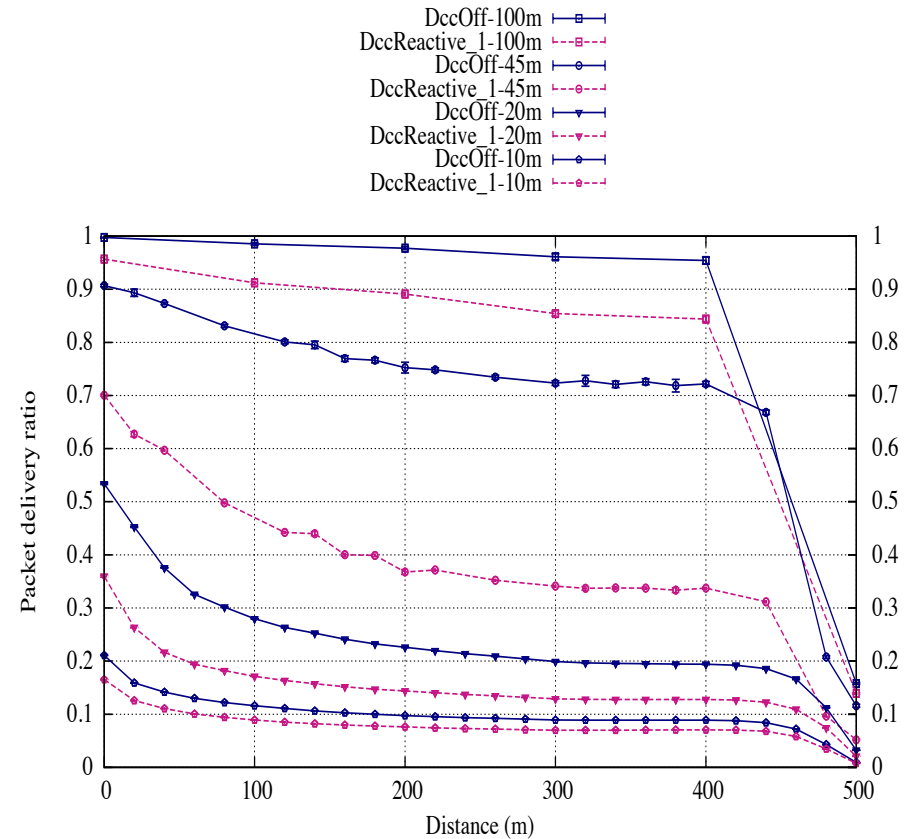
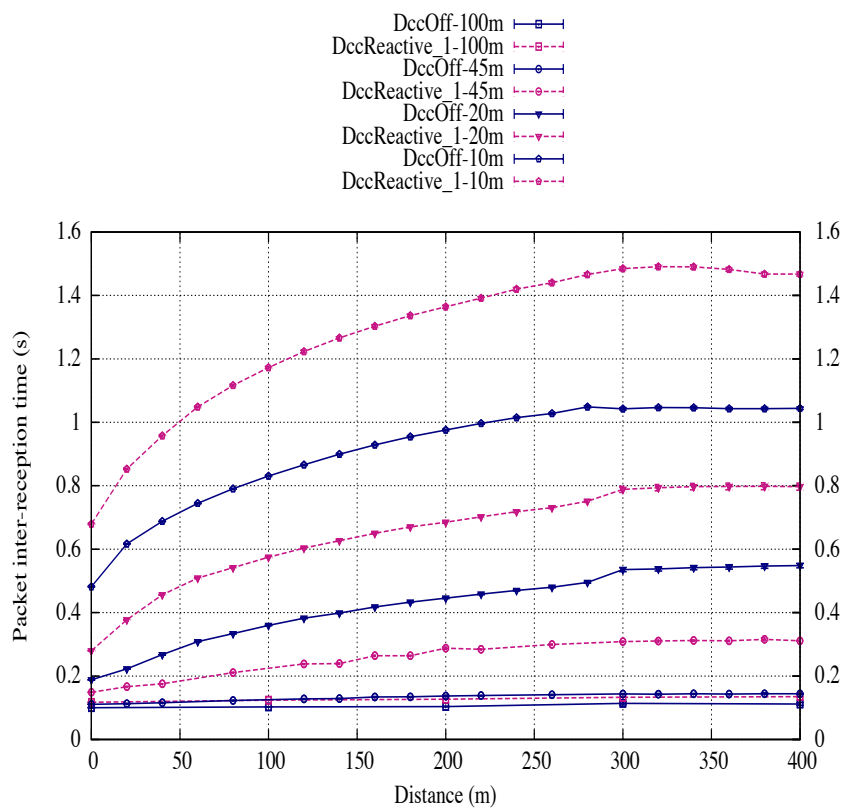
Table 23: Scenario 1 and scenario 2 - communication scenario - no-hidden node

Parameter	Value
Tx Power	Fixed 23 dBm
Fading	LogDistance, Exponent: 2
Target CL	65 %

Results: Packet delivery ratio and Packet Inter-Reception Time

- Approach 1: Synchronous & Wait-and-Go
- Approach 2: Synchronous & Cancel-and-Go
- Approach 3: Asynchronous & Wait-and-Go
- Approach 4: Asynchronous & Cancel-and-Go

Packet inter-reception time and Delivery Ratio -- Approach1: Synchronous & Wait-And-Go --

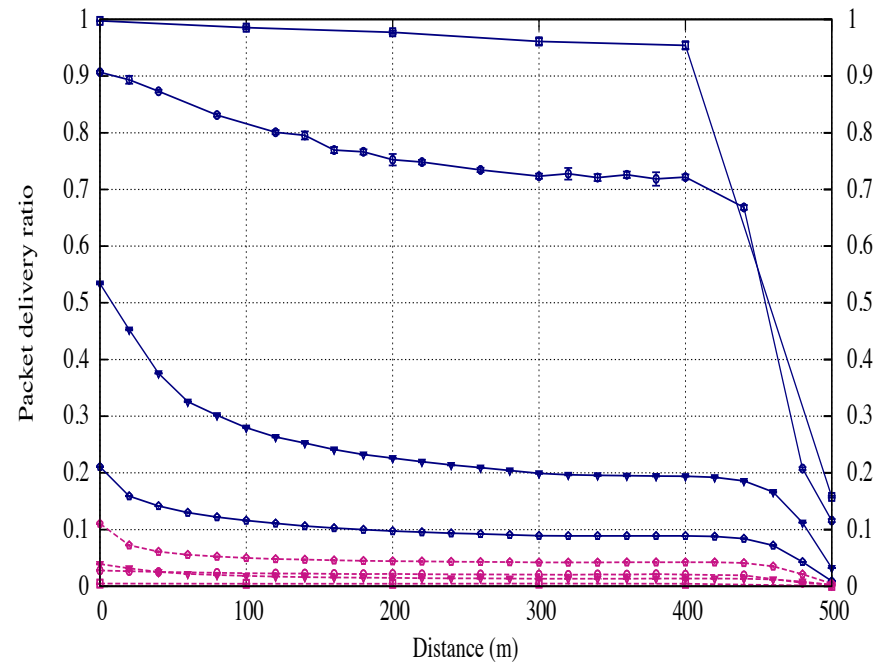
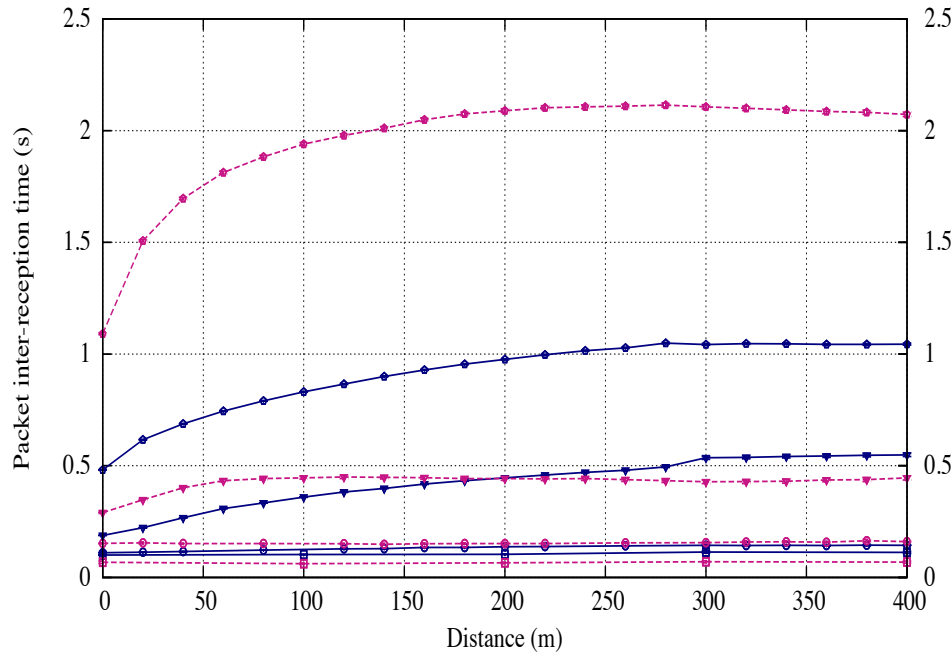


Packet inter-reception time and Delivery Ratio

-- Approach2: Synchronous & Cancel-And-Go --

DccOff-100m —■—
 DccReactive_2-100m - - - ■ - - -
 DccOff-45m —●—
 DccReactive_2-45m - - - ● - - -
 DccOff-20m —▼—
 DccReactive_2-20m - - - ▼ - - -
 DccOff-10m —◆—
 DccReactive_2-10m - - - ◆ - - -

DccOff-100m —■—
 DccReactive_2-100m - - - ■ - - -
 DccOff-45m —●—
 DccReactive_2-45m - - - ● - - -
 DccOff-20m —▼—
 DccReactive_2-20m - - - ▼ - - -
 DccOff-10m —◆—
 DccReactive_2-10m - - - ◆ - - -

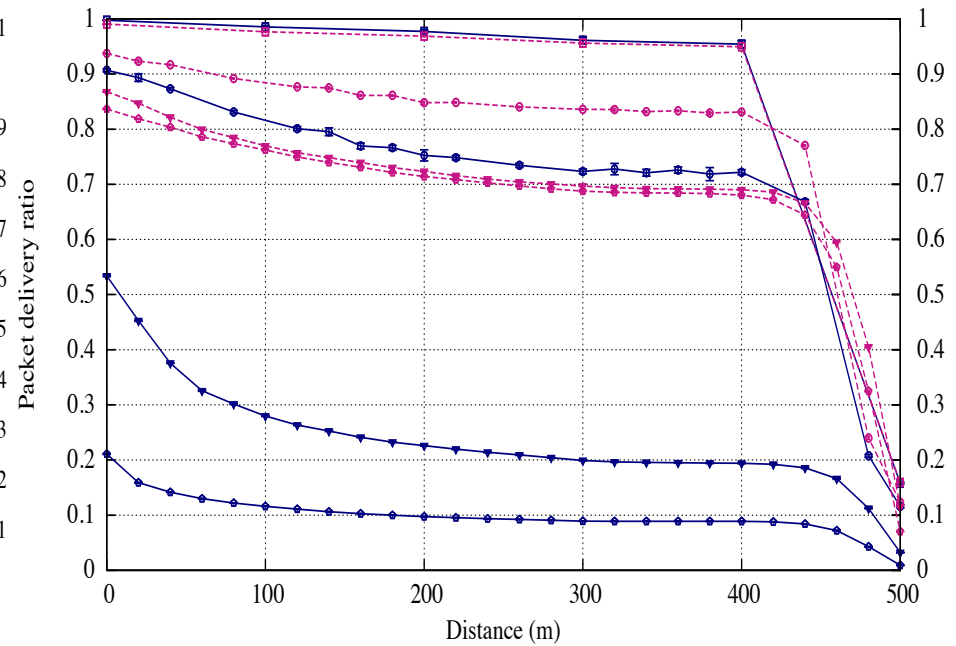
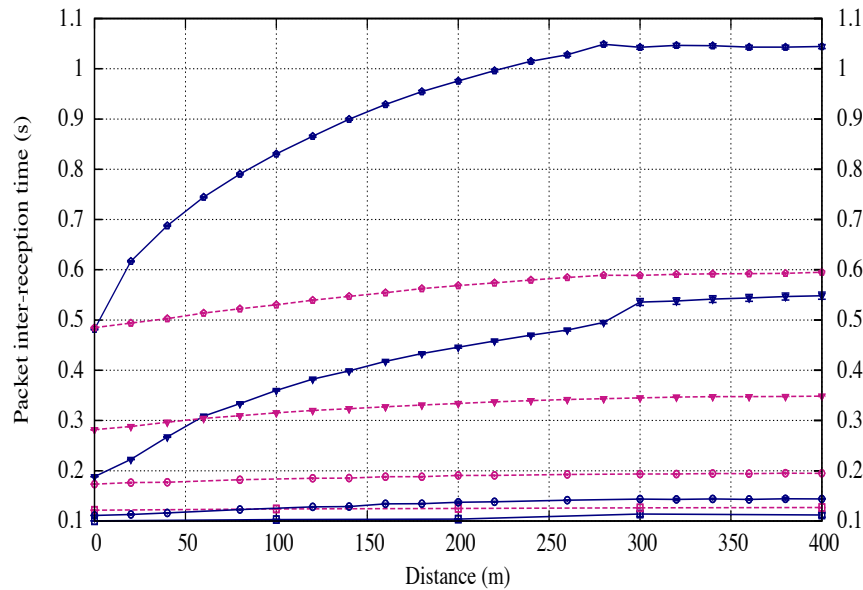


Packet inter-reception time and Delivery Ratio

-- Approach3: Asynchronous & Wait-And-Go --

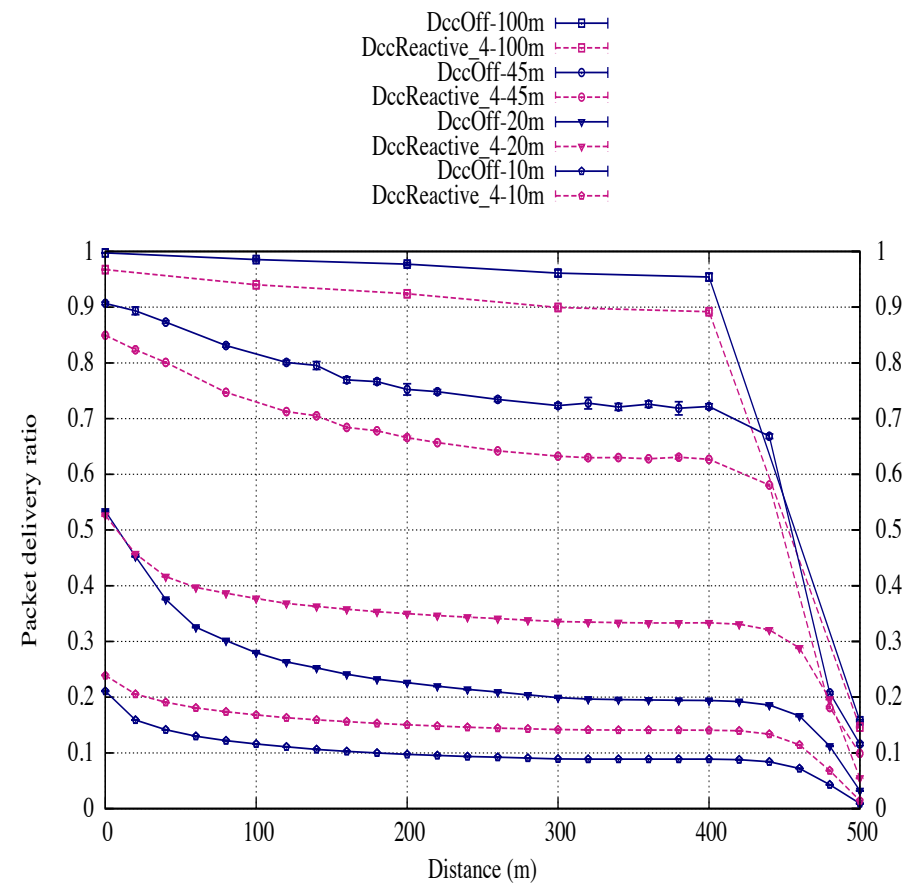
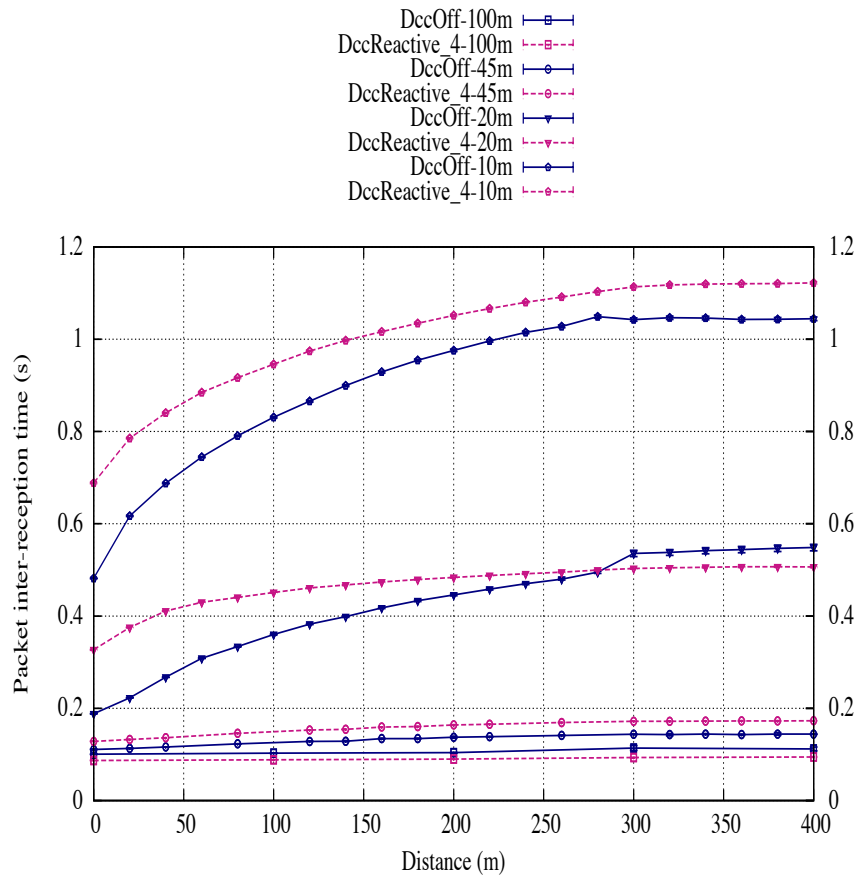
DccOff-100m
 DccReactive_3-100m
 DccOff-45m
 DccReactive_3-45m
 DccOff-20m
 DccReactive_3-20m
 DccOff-10m
 DccReactive_3-10m

DccOff-100m
 DccReactive_3-100m
 DccOff-45m
 DccReactive_3-45m
 DccOff-20m
 DccReactive_3-20m
 DccOff-10m
 DccReactive_3-10m



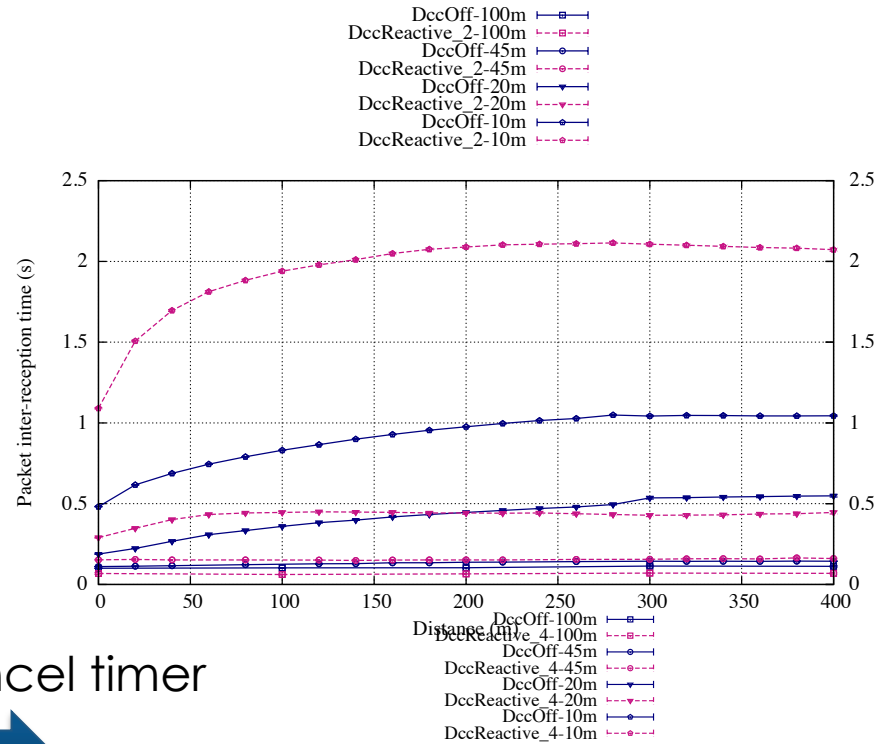
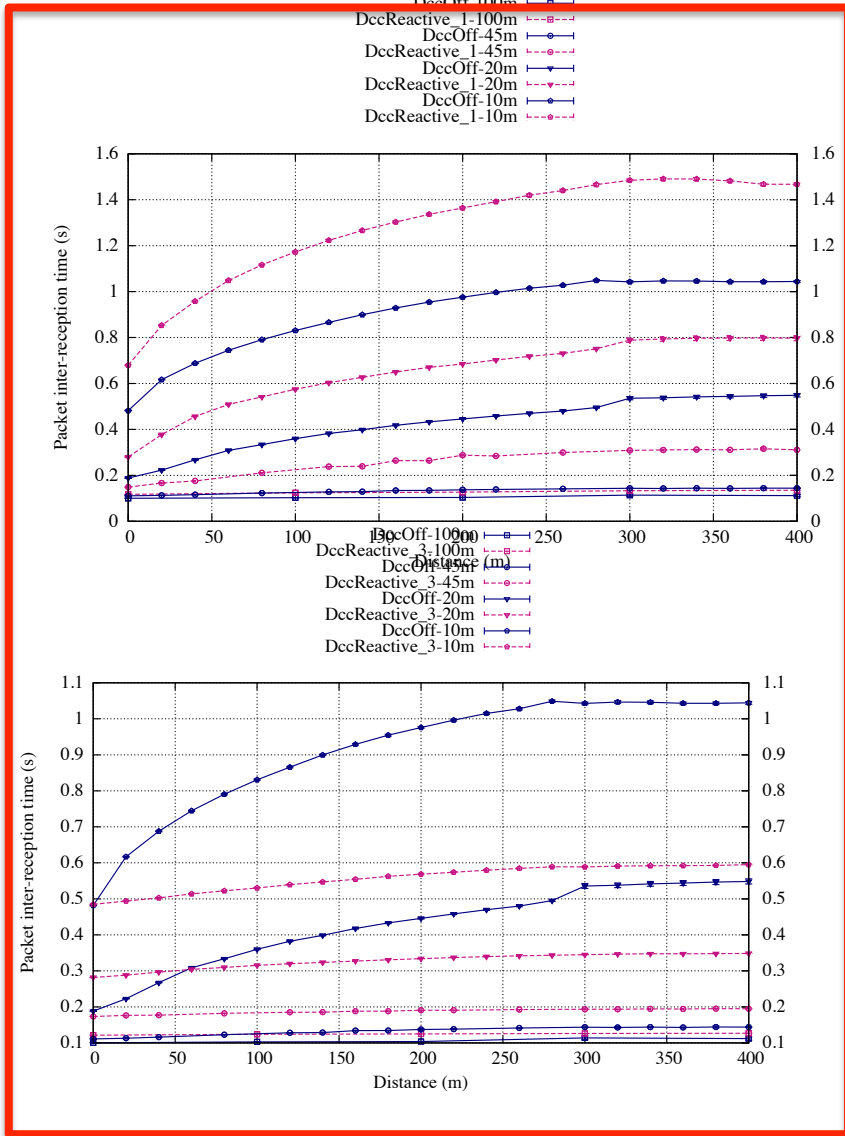
Packet inter-reception time and Delivery Ratio

-- Approach4: Asynchronous & Cancel-And-Go --



Packet inter-reception time

-- Comparing the 4 Approaches --



Cancel timer



- Cancelling the timer seems to be "BAD" idea!!

Closer look to

- Approach 1: Synchronous & Wait-and-Go
- ~~Approach 2: Synchronous & Cancel-and-Go~~
- Approach 3: Asynchronous & Wait-and-Go
- ~~Approach 4: Asynchronous & Cancel-and-Go~~

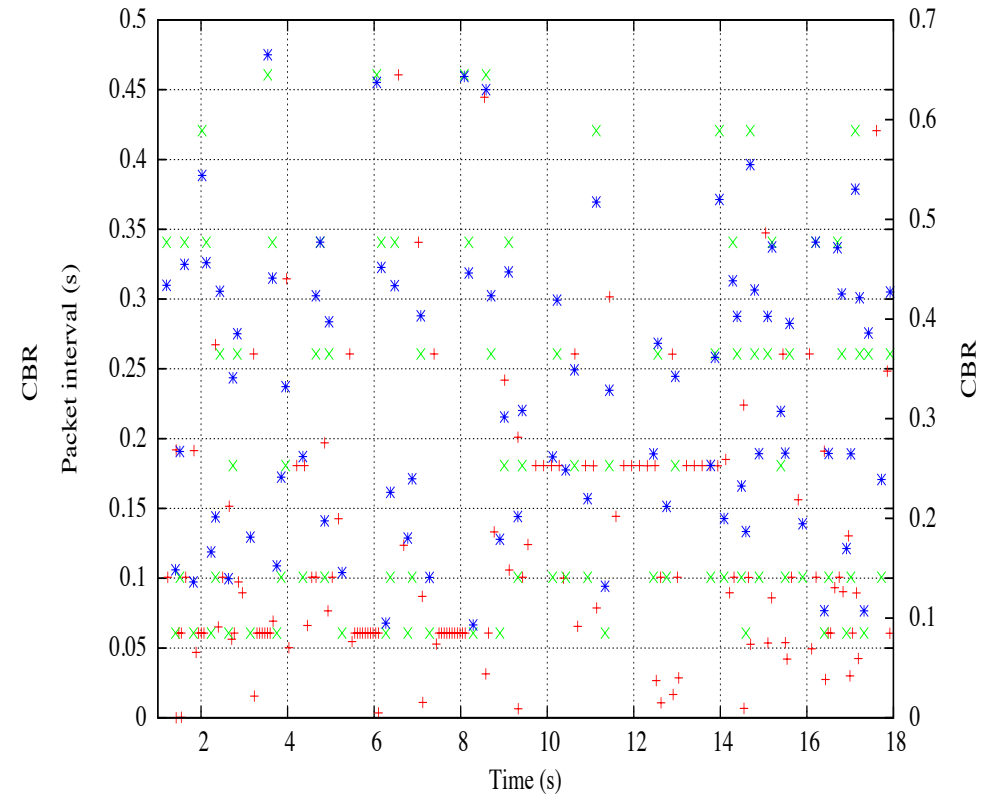
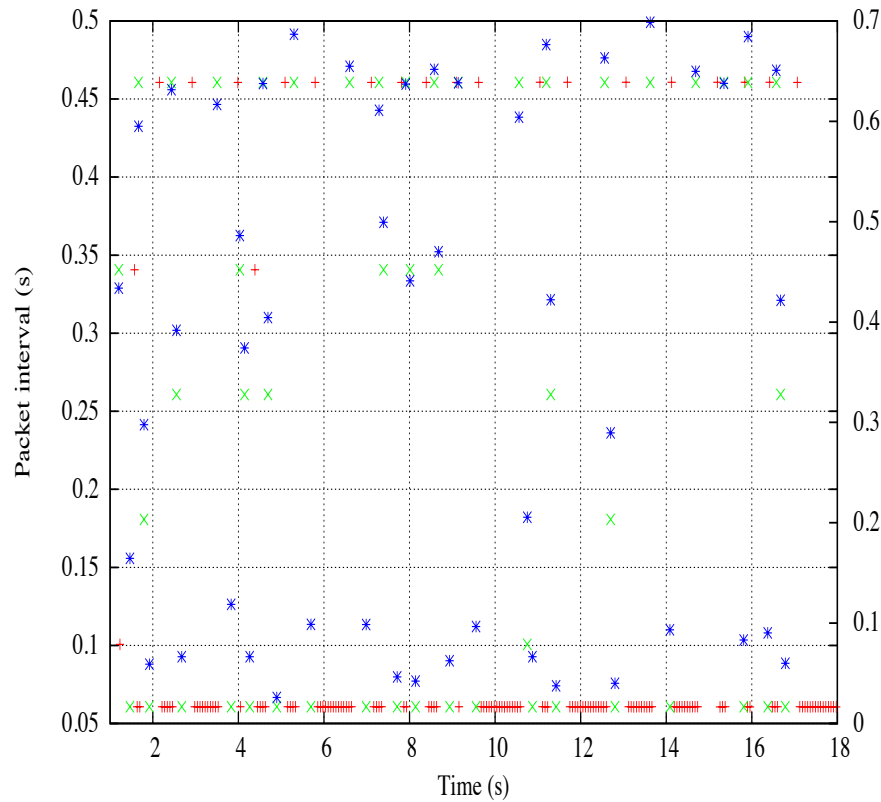
Message generation behaviour at a node

Message generation behavior

- Scenario: 100m inter-vehicle distance-

MsgGenInterval +
intervalSetting x
Cbr *

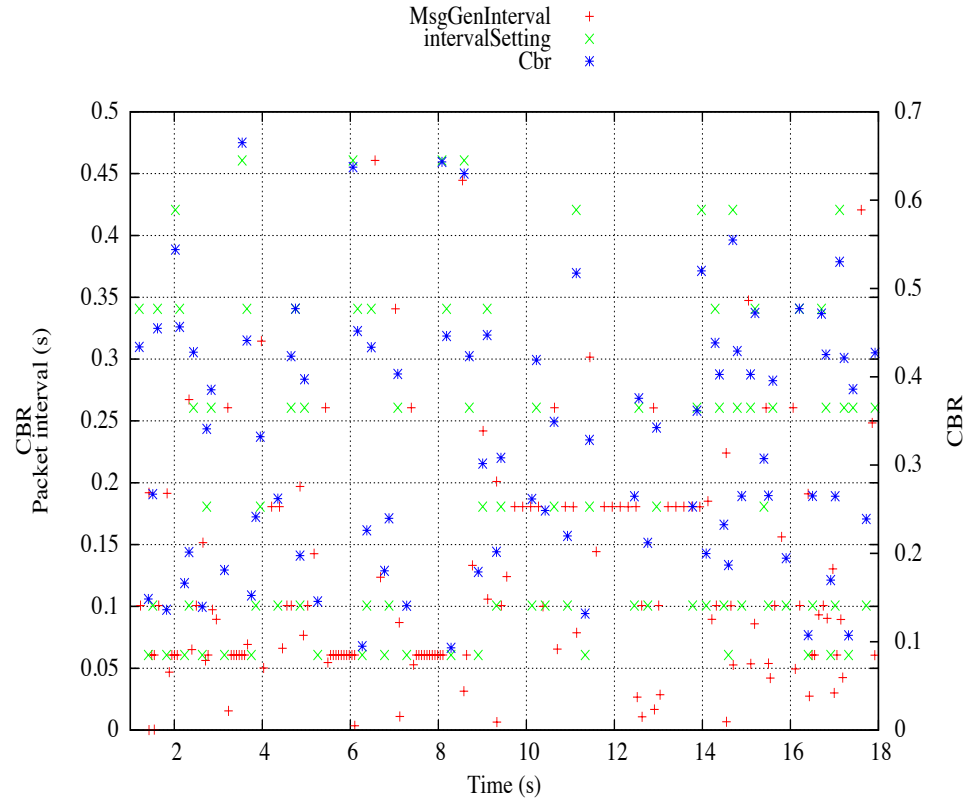
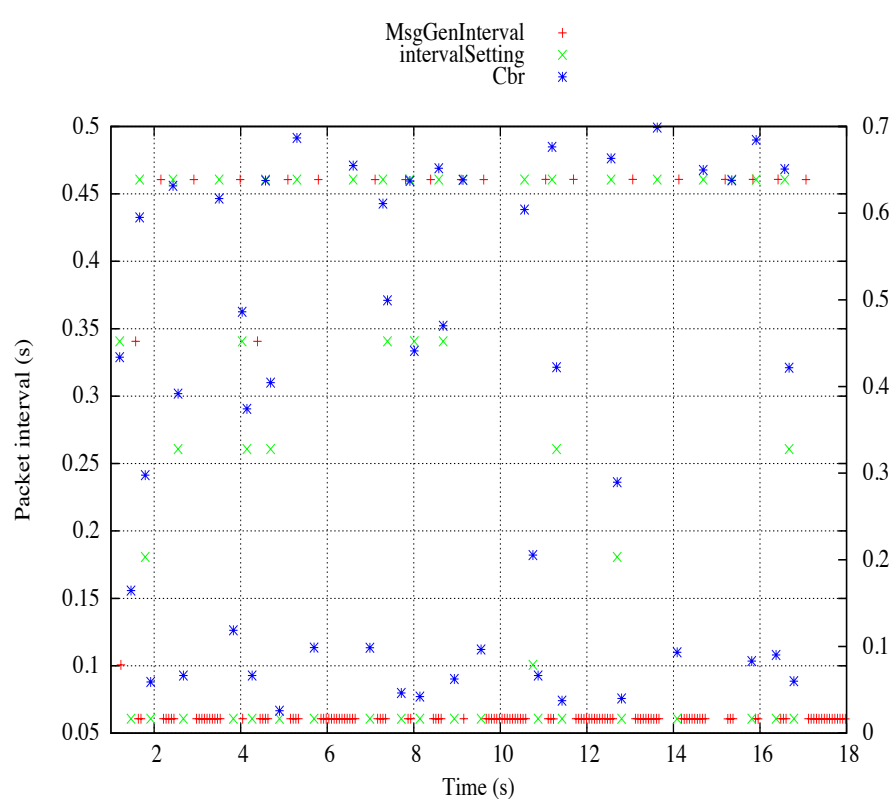
MsgGenInterval +
intervalSetting x
Cbr *



- Synchronous approach:
 - Message generation interval switches between high or low values

Message generation behavior

- Scenario: 20m inter-vehicle distance-

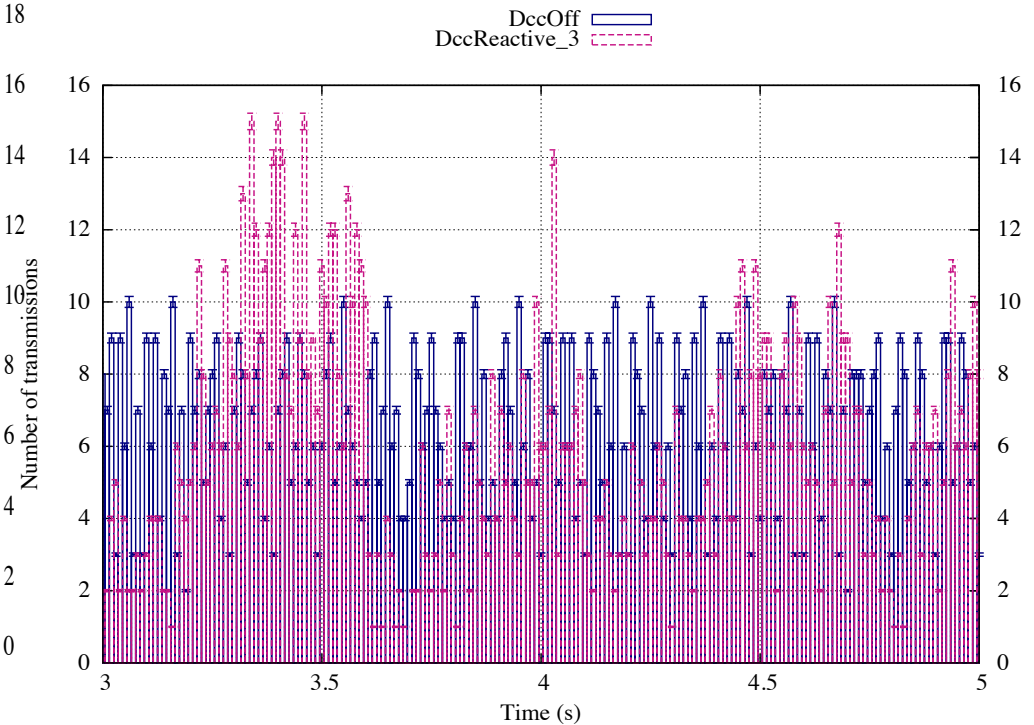
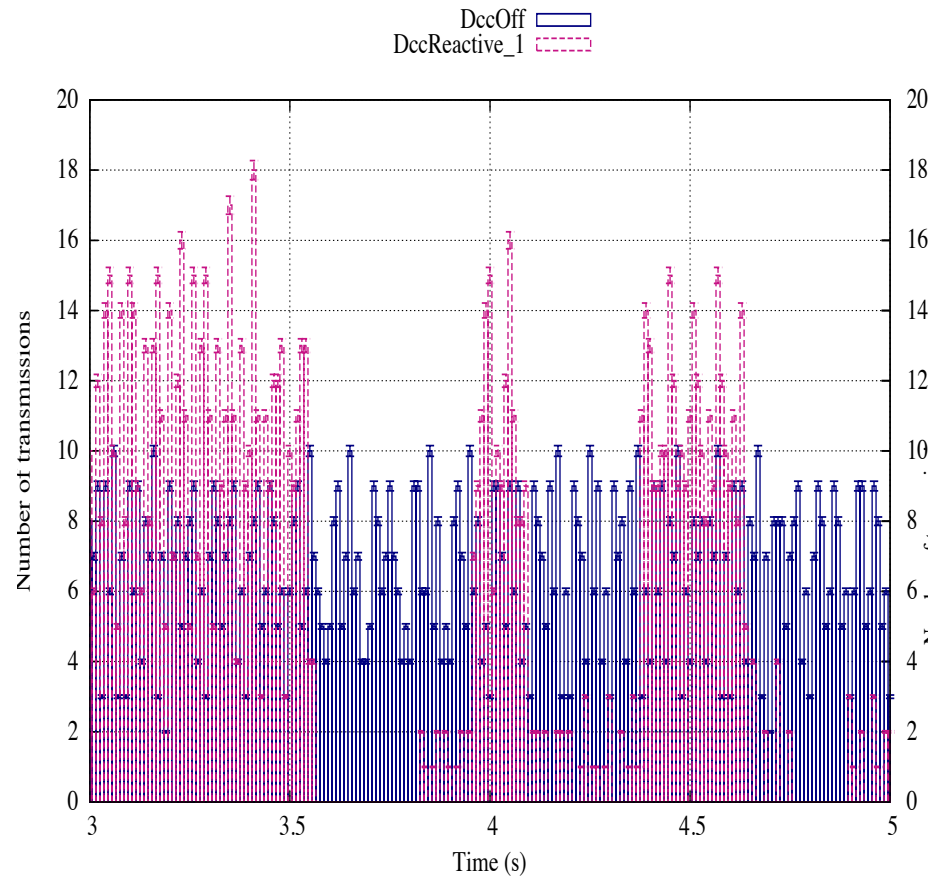


- Synchronous approach:
 - Message generation interval switches between high or low values

Number of total transmissions during
samples of time period

Number of transmissions

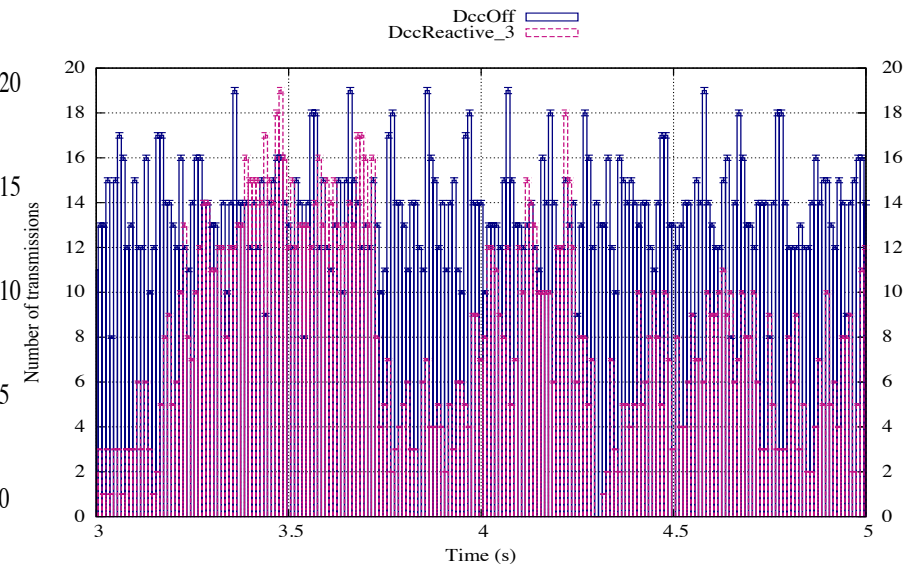
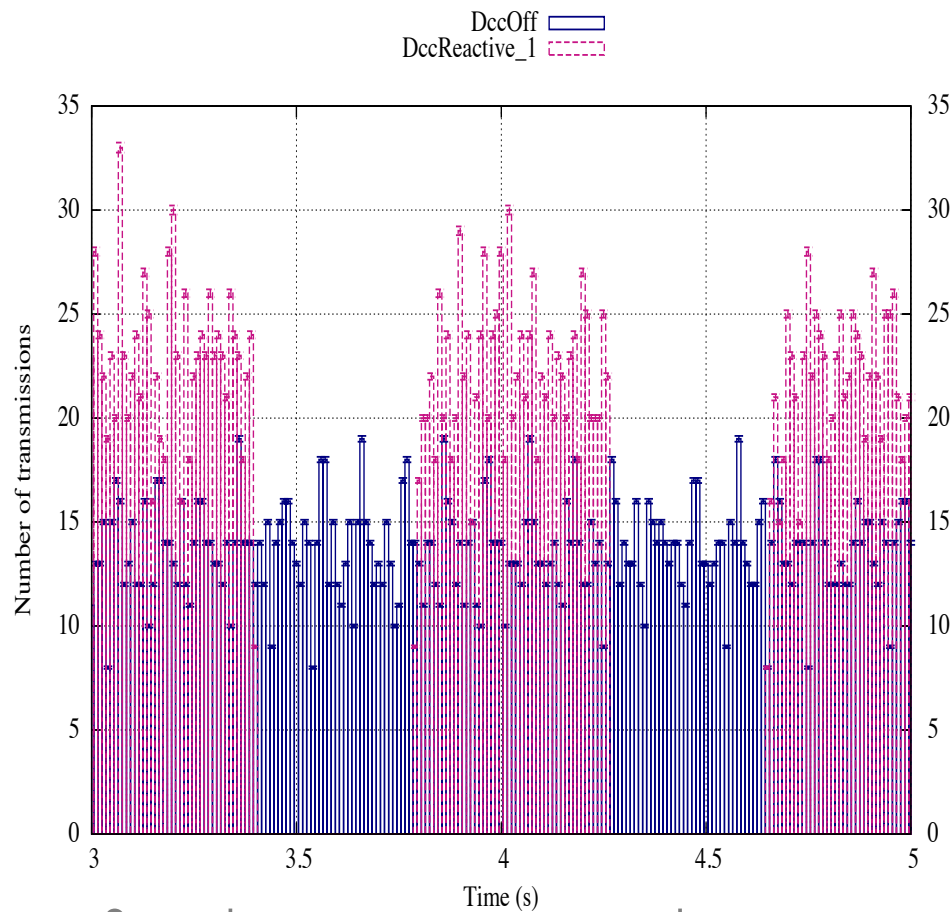
- Scenario: 100m inter-vehicle distance-



- Synchronous approach:
 - Nodes transmit in synchronized way

Number of transmissions

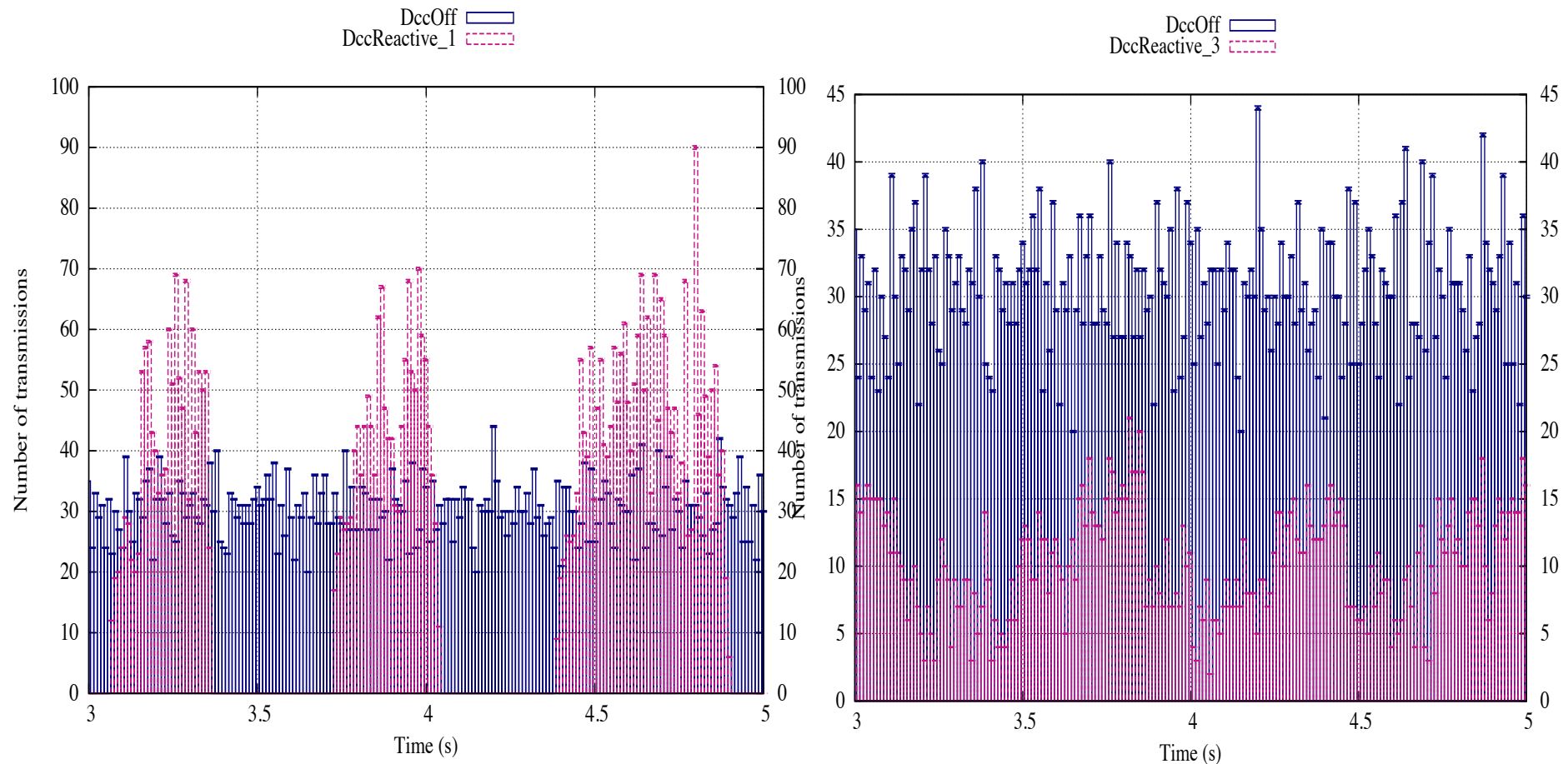
- Scenario: 45m inter-vehicle distance-



- Synchronous approach:
 - Nodes transmit in synchronized way

Number of transmissions

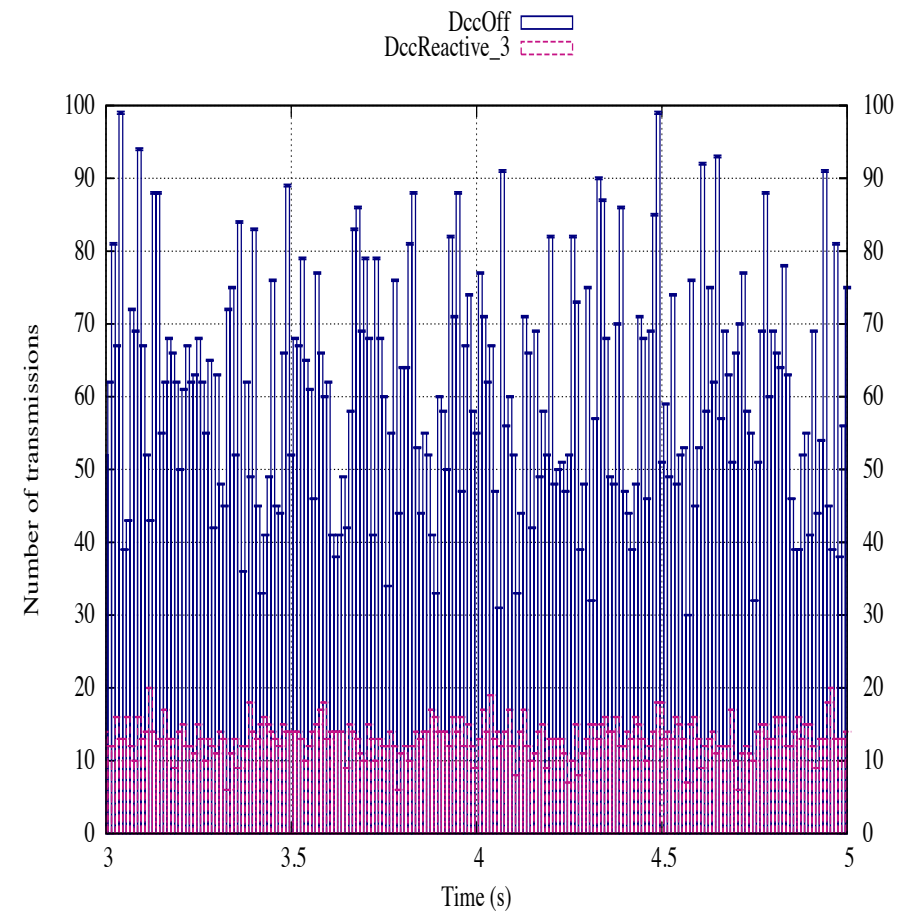
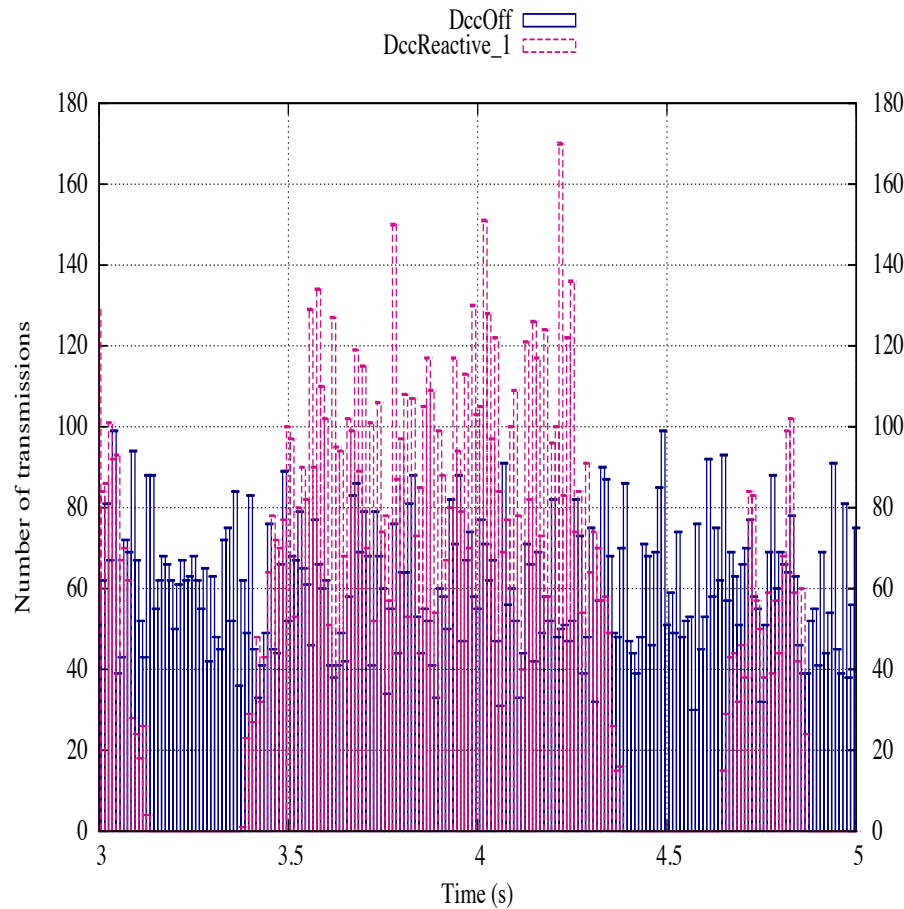
- Scenario: 20m inter-vehicle distance-



- Synchronous approach:
 - Nodes transmit in synchronized way

Number of transmissions

- Scenario: 10m inter-vehicle distance-

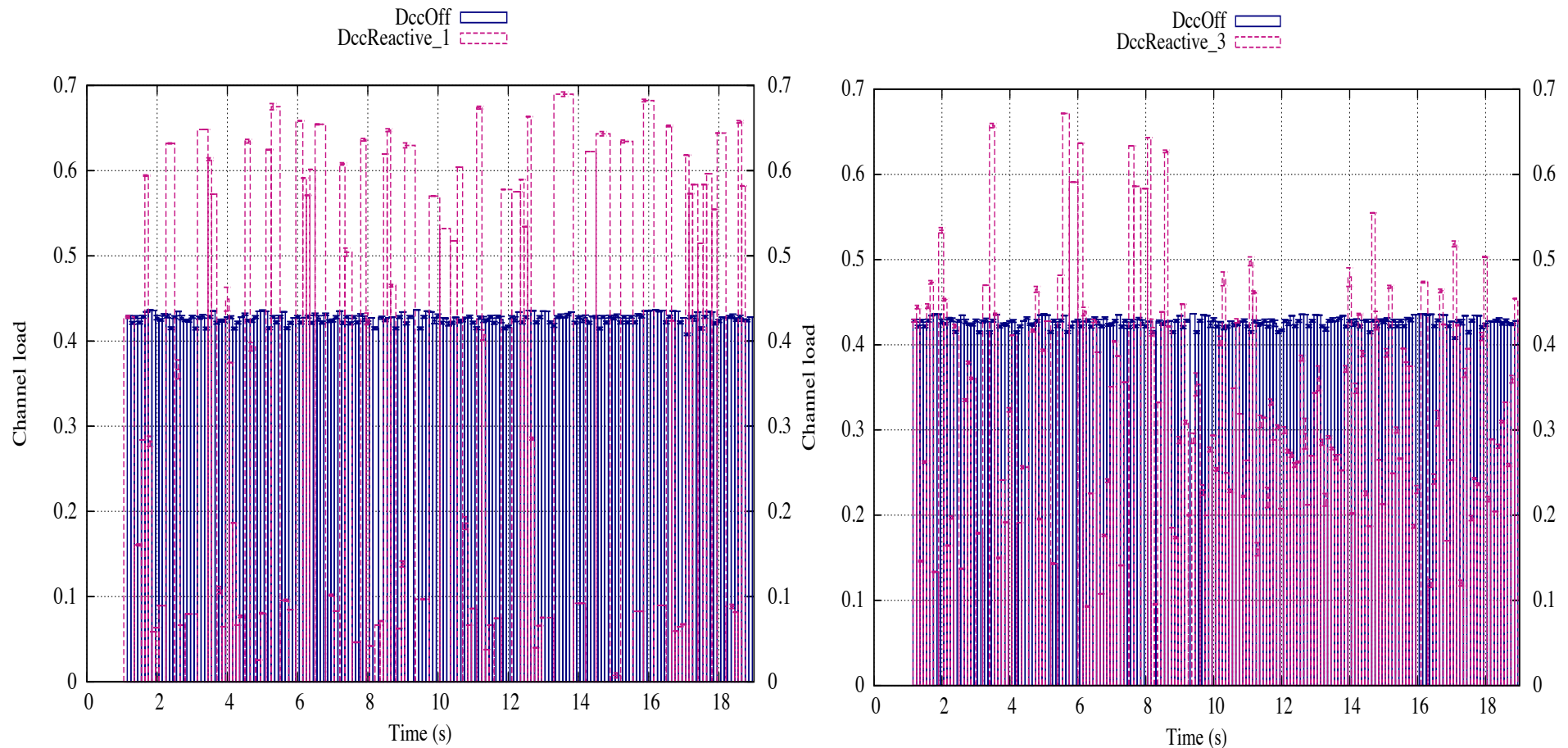


- Synchronous approach:
 - Nodes transmit in synchronized way

Average CBR during samples of time period

CBR vs Time

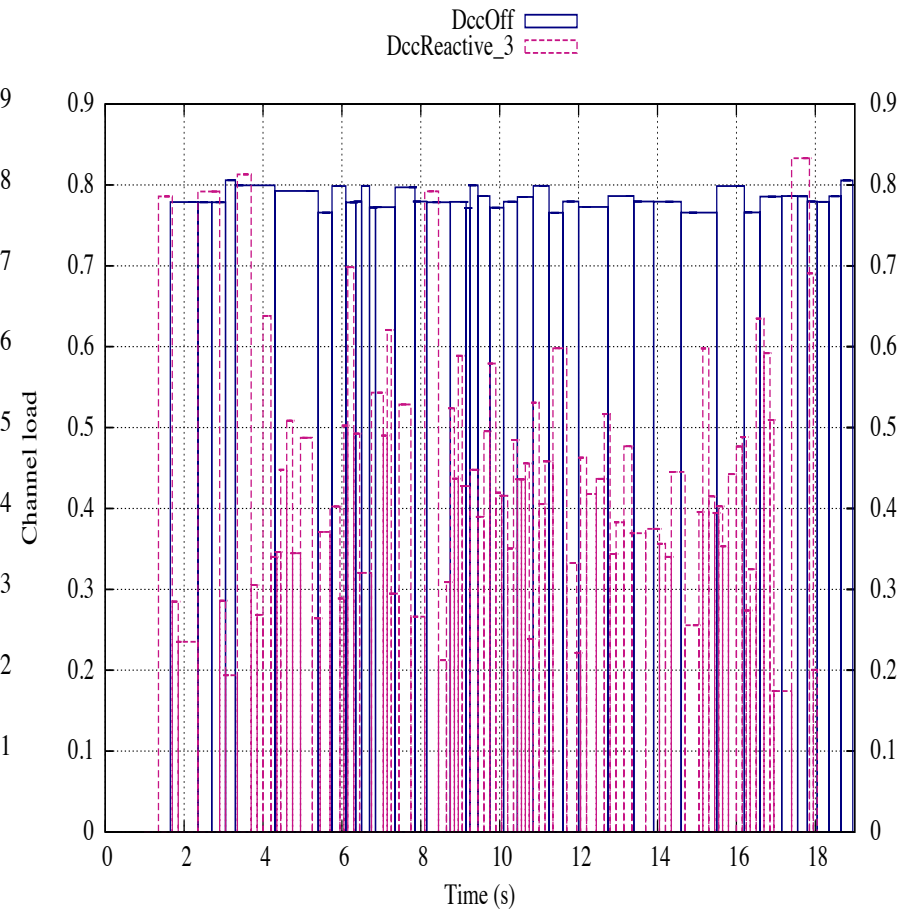
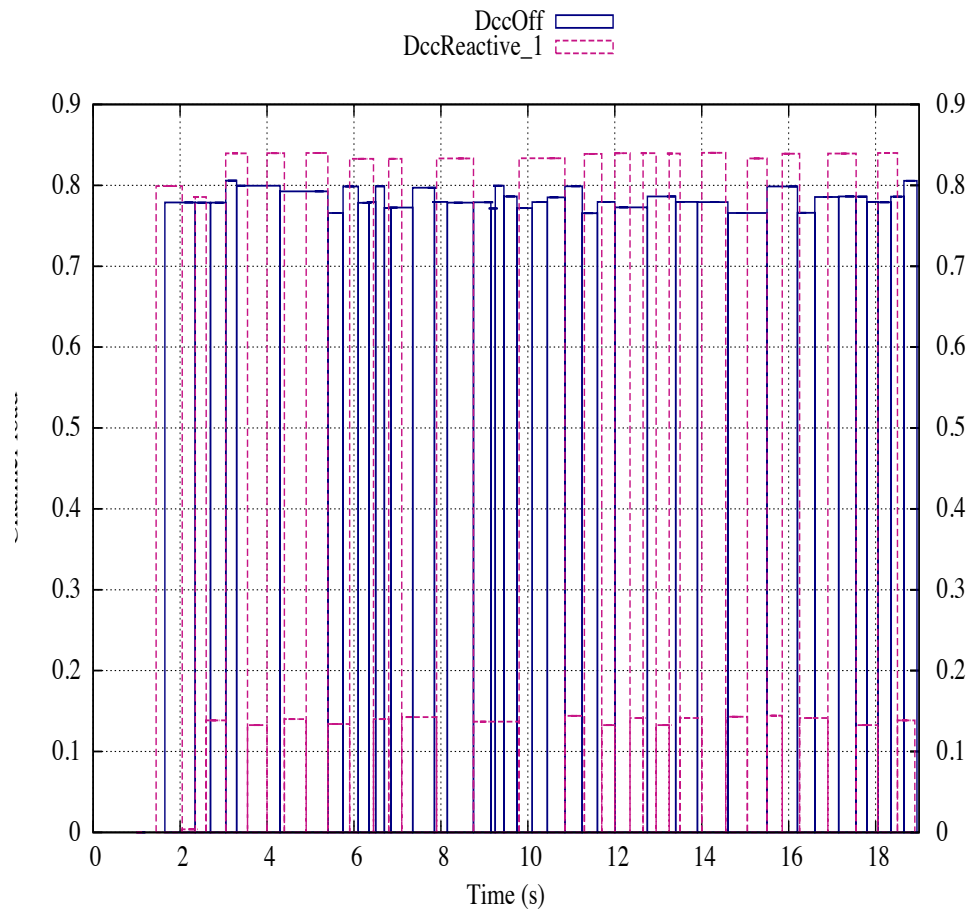
- Scenario: 100m inter-vehicle distance-



- Synchronous approach:
 - CBR fluctuates more

CBR vs Time

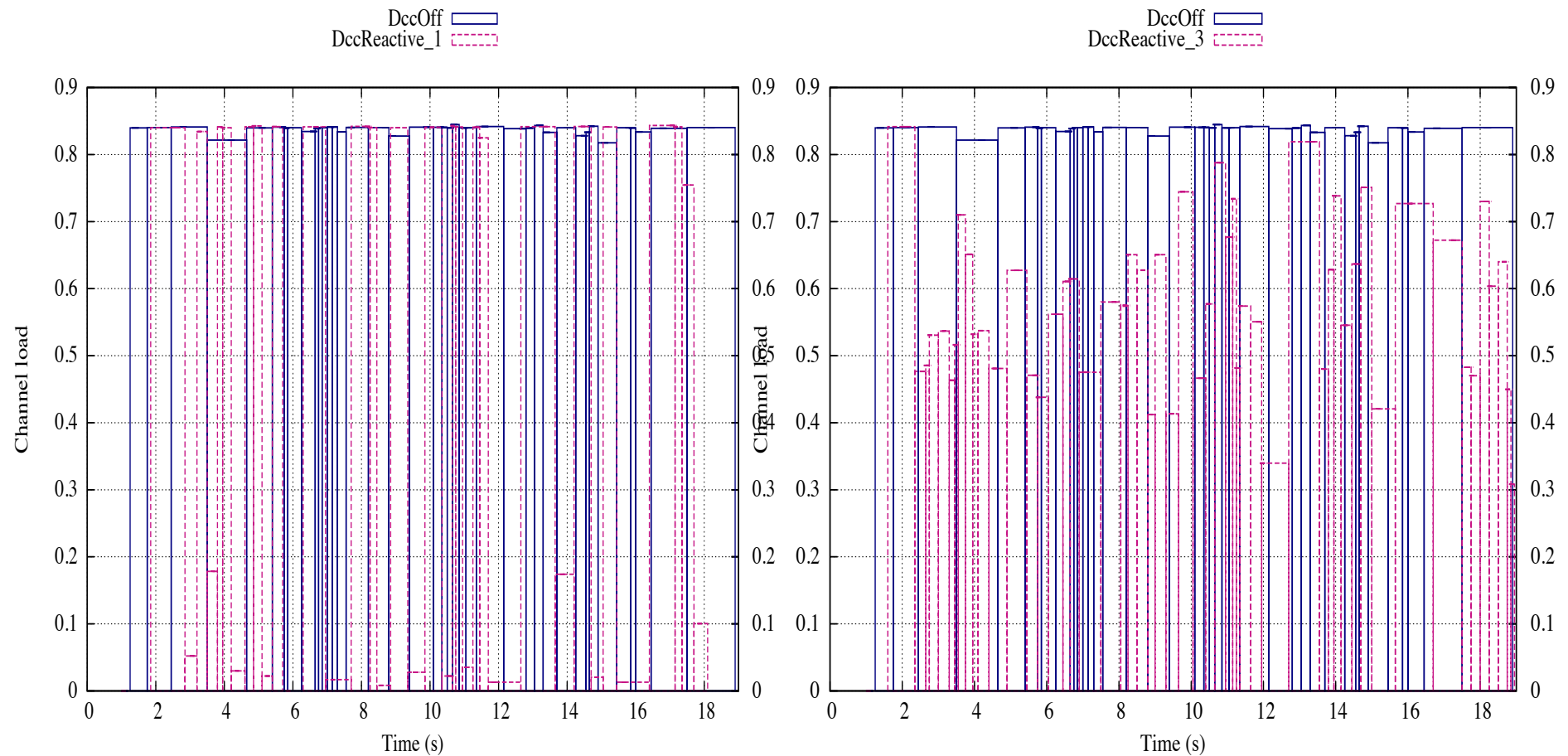
- Scenario: 45m inter-vehicle distance-



- Synchronous approach:
 - CBR fluctuates more

CBR vs Time

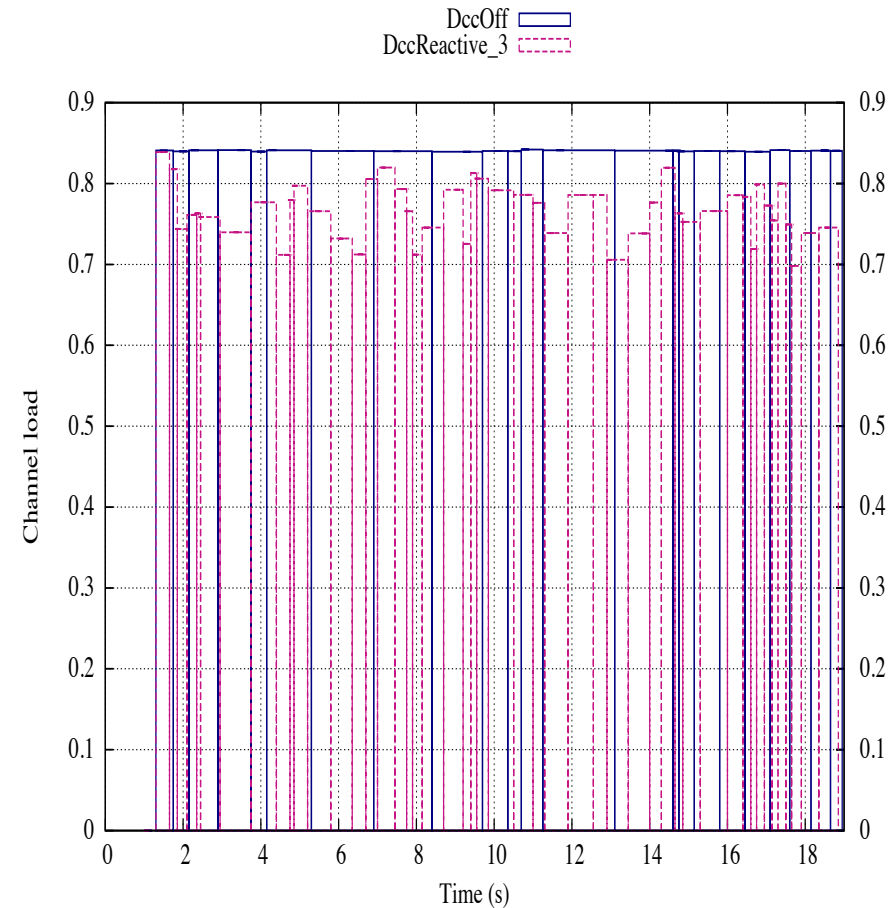
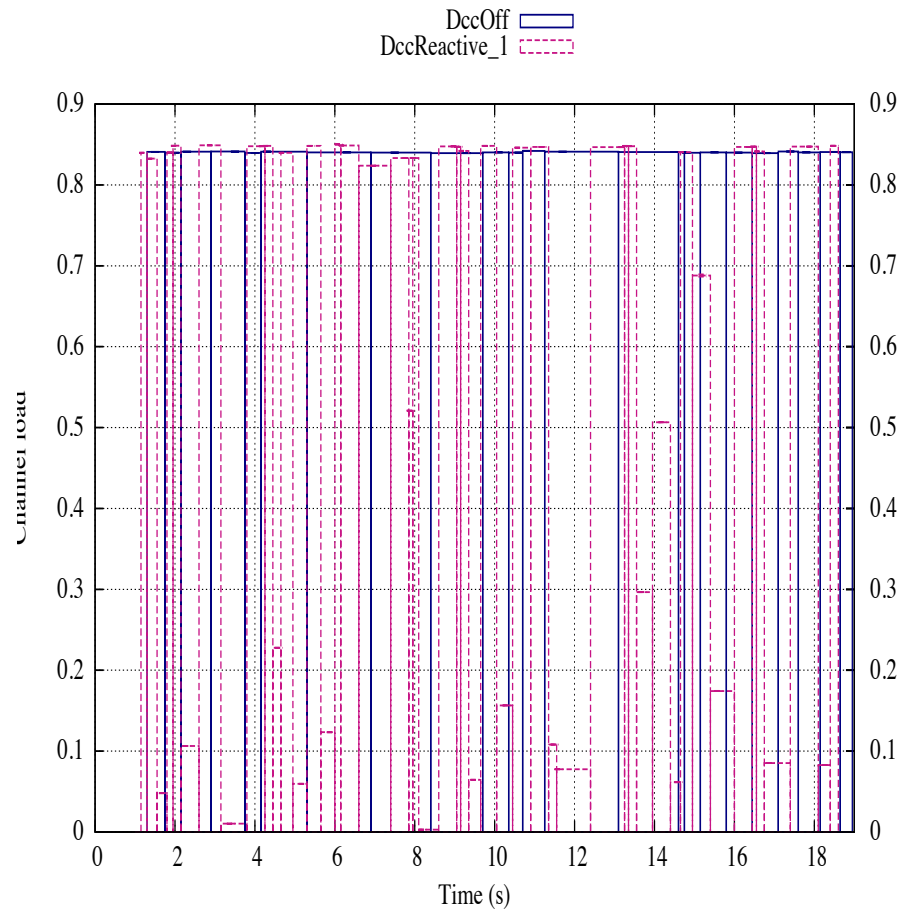
- Scenario: 20m inter-vehicle distance-



- Synchronous approach:
 - CBR fluctuates more

CBR vs Time

- Scenario: 10m inter-vehicle distance-

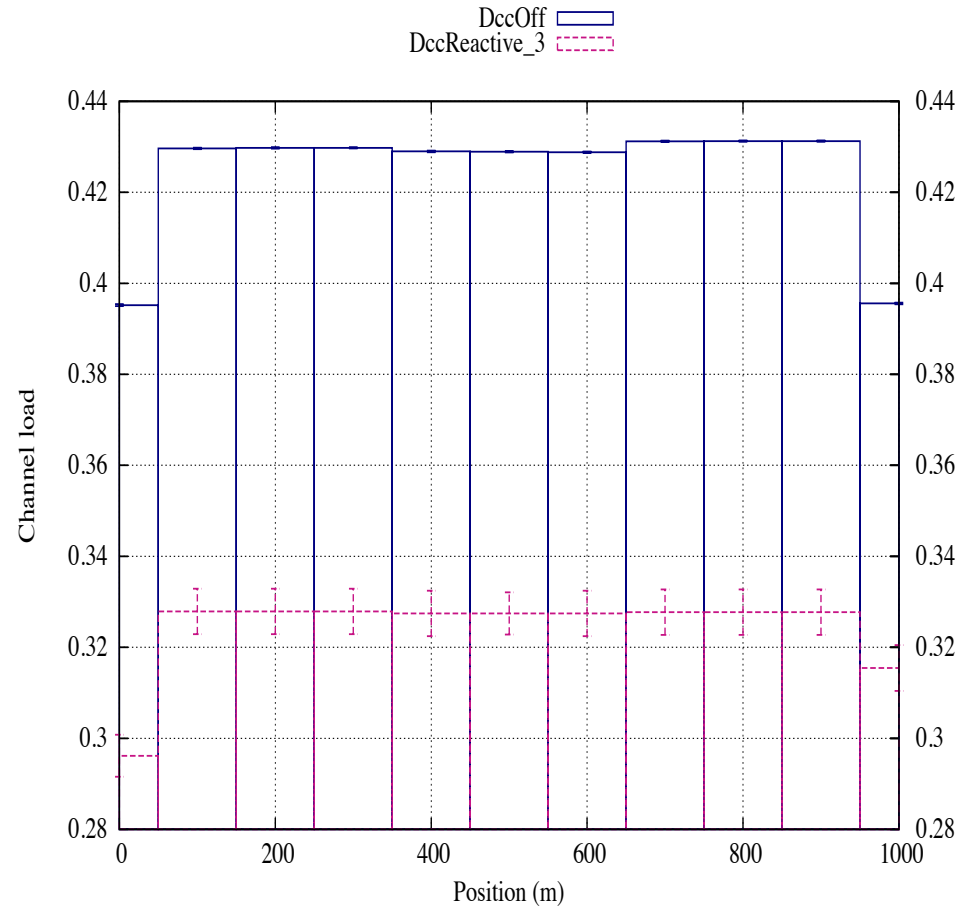
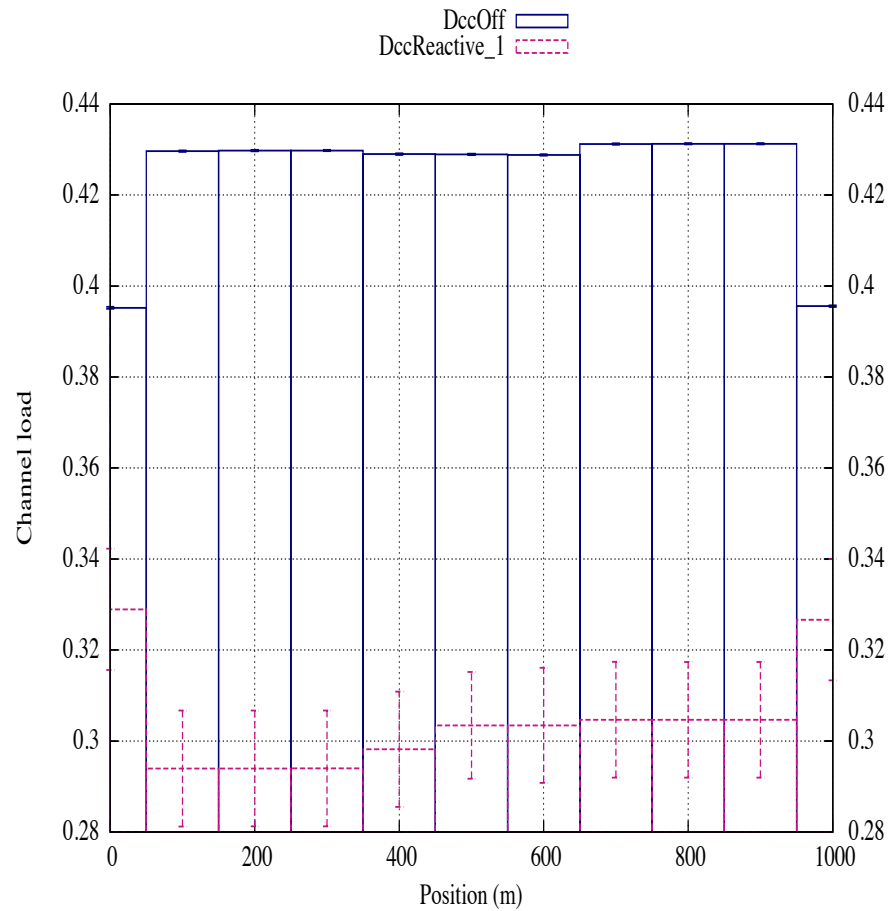


- Synchronous approach:
 - CBR fluctuates more

CBR at vehicles' positions

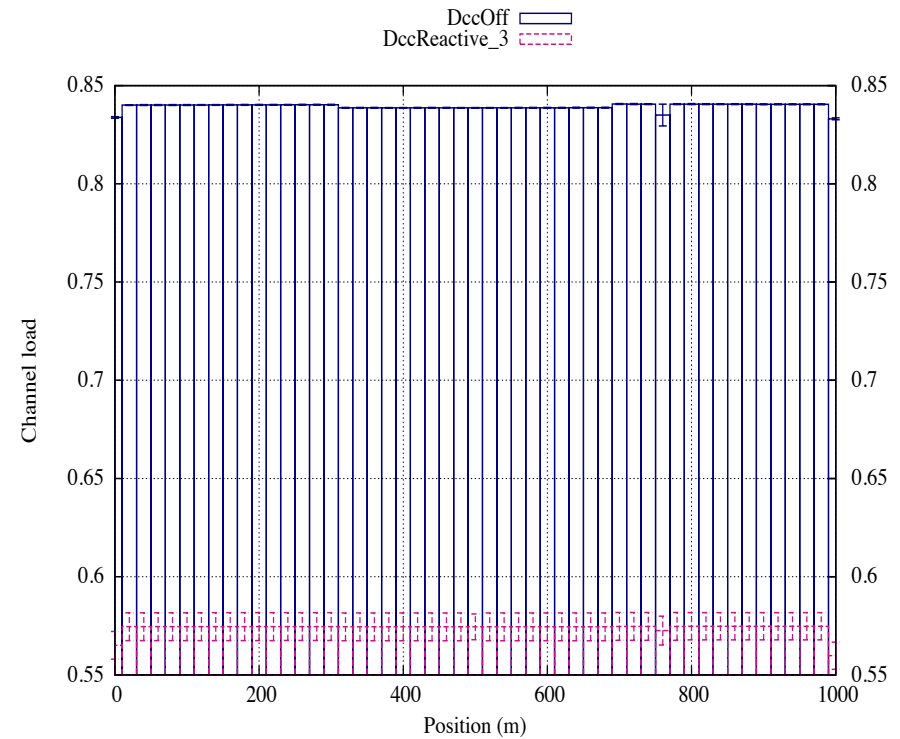
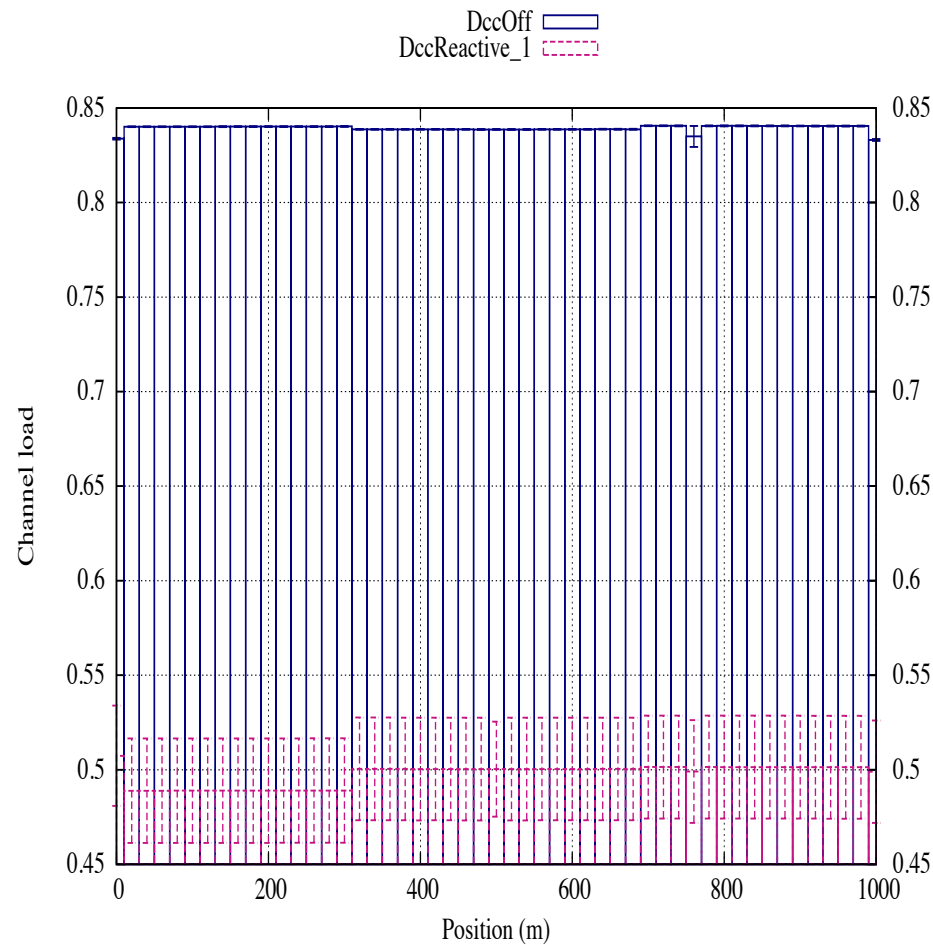
CBR vs Position

- Scenario: 100m inter-vehicle distance-



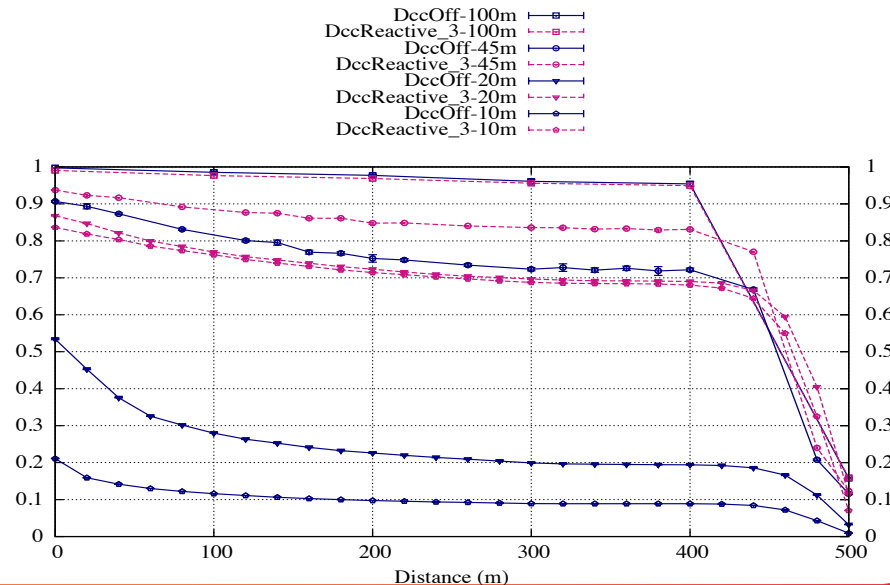
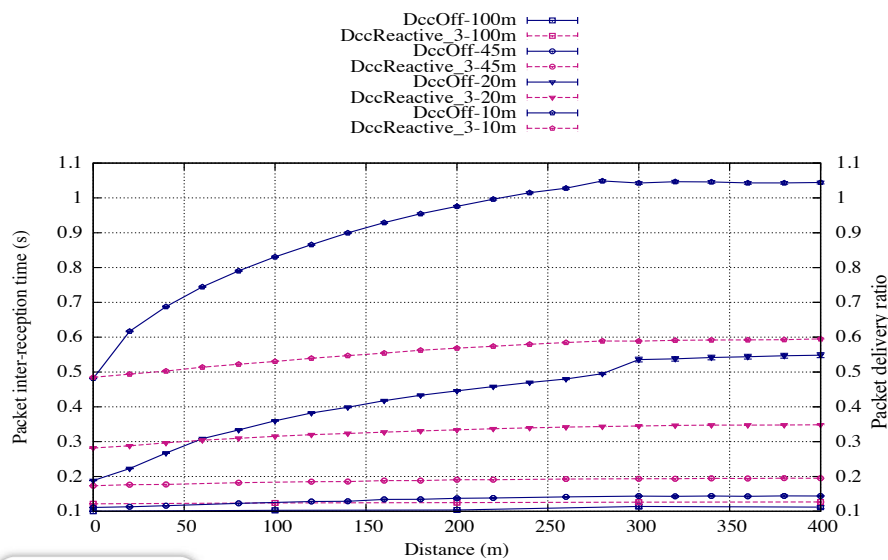
CBR vs Position

- Scenario: 20m inter-vehicle distance-



Conclusion

- Depending on the behaviour of the Reactive DCC, the algorithm can or cannot perform better than non-DCC system
- Because the control is based on a measurement of « common » channel, asynchronous control seems to be necessary
 - Transmit first with a “random” interval before following the table parameter



Thank you!

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