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Evaluation of A Multi-Cannel MAC Protocol for Multi-hop InterVehicle Communications in Road Traffic Environment

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Background

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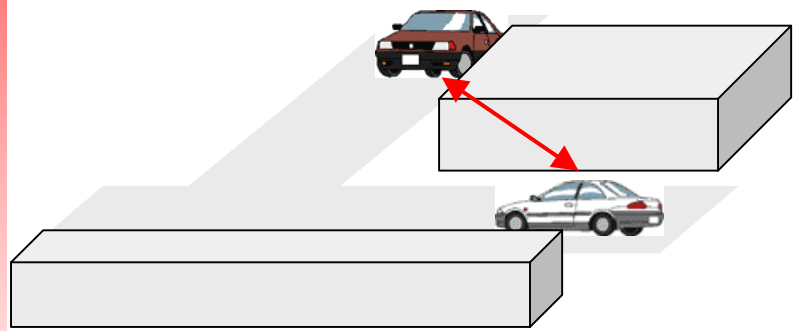
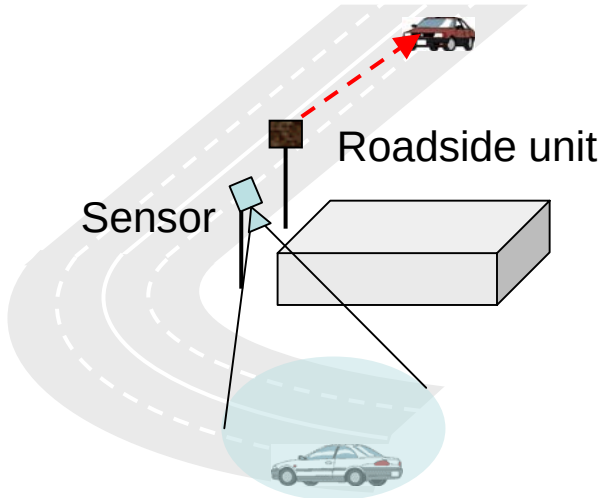
Vehicle to vehicle communication



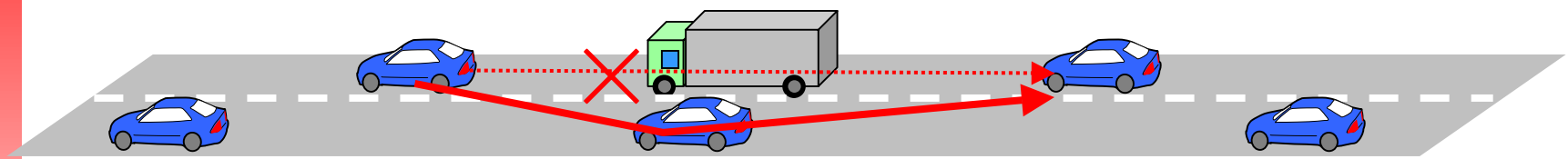
Roadside to vehicle communication



Vehicular communication is expected to enable safety assistance and several other ITS applications.

In vehicular environment, communication is not stable due to shadowing, blocking and multi-path fading.

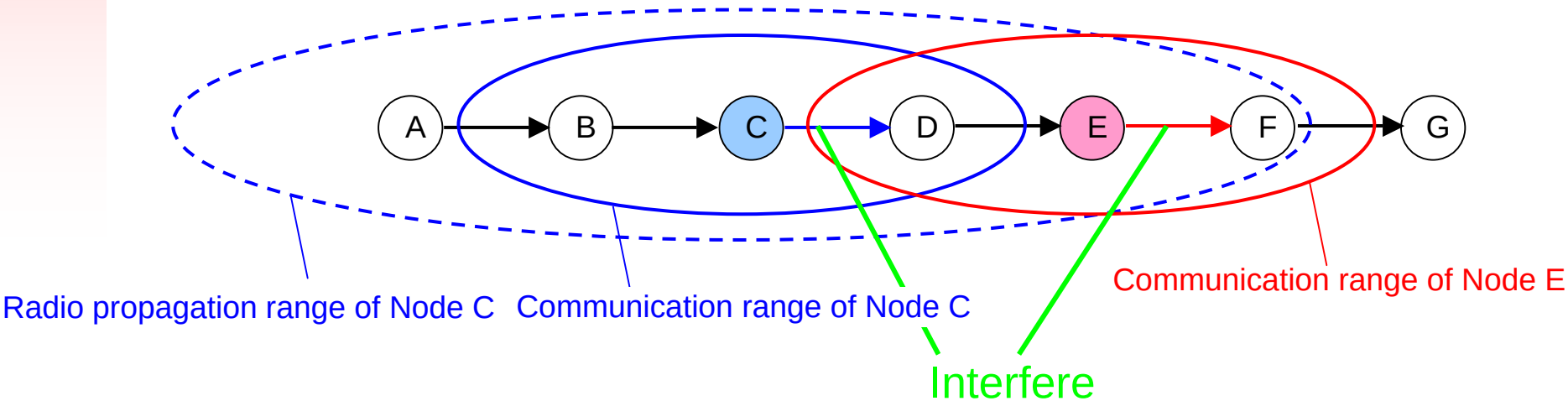
Multi-hop communication



Extension of communication area

Major problem

Degradation of throughput ⟹ Channel sharing issue



Solutions to channel sharing issue

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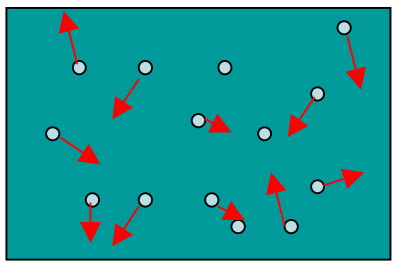
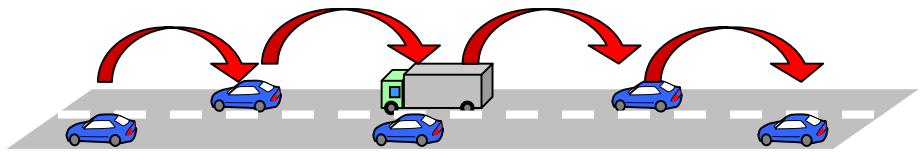
Approaches

- Directional antenna
- Transmission power control
- Multiple channels(frequency, time, code ・・・)



Random simulation model



Multi-hop vehicular communication

Performance evaluation in vehicular environment is needed.

Multi-channel MAC protocol

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Related works

N. Jain et al., RBCS (Receiver-Based Channel Selection) in [9]

S.-L. Wu et al., DCA (Dynamic Channel Assignment) in [10]

J. So et al., MMAC (Multi-channel MAC) in [13]

DCA (Dynamic Channel Assignment)

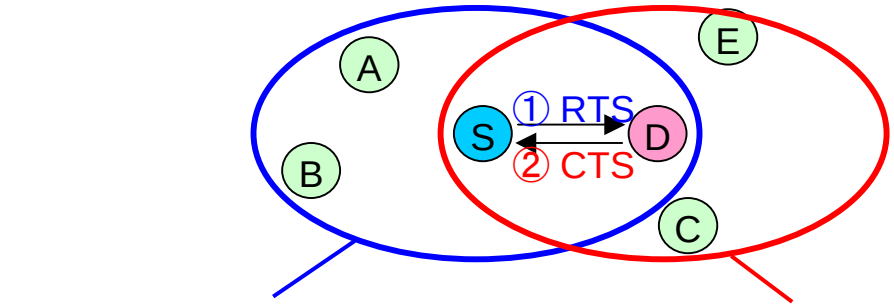
- Approach

  Using RTS/CTS※ messages for channel assignment

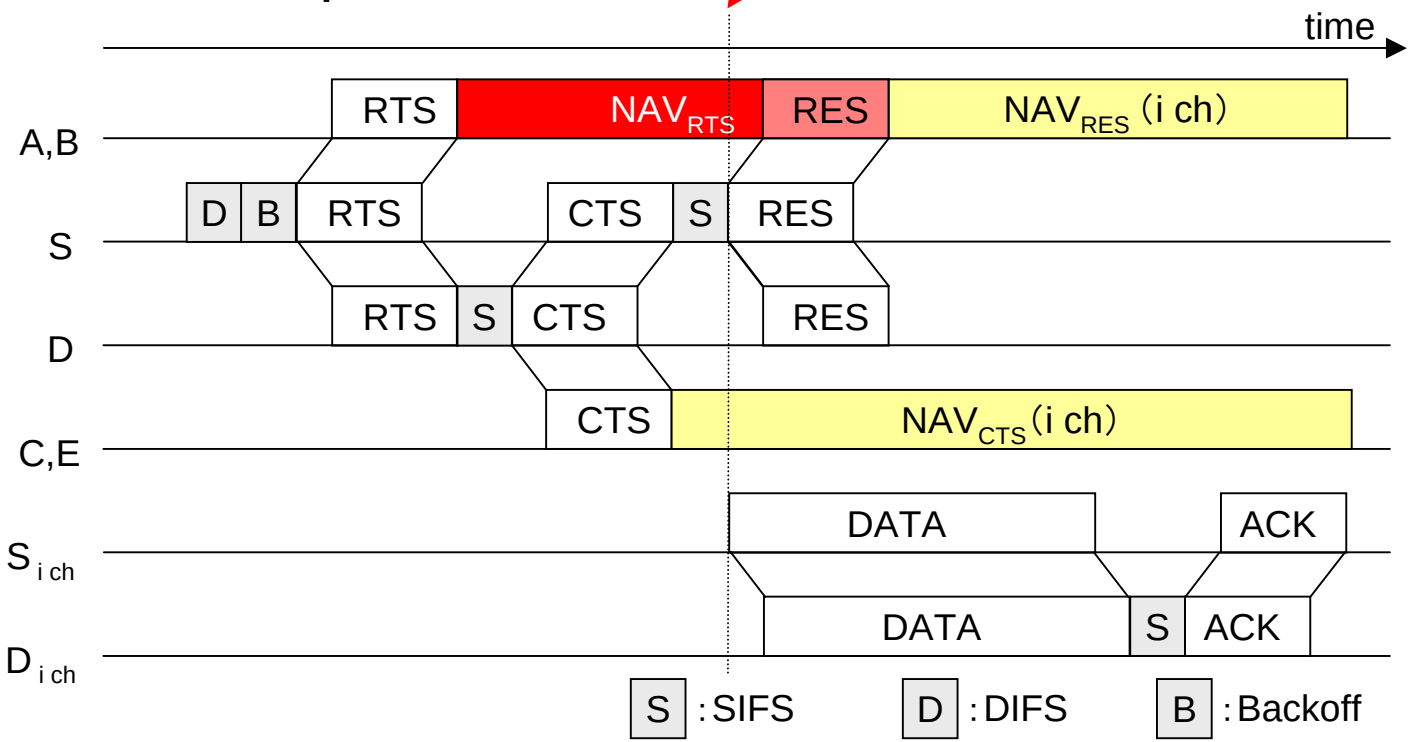
  ※ RTS/CTS messages are defined in IEEE802.11 DCF(Distributed Coordination Function)

- Number of transceivers : 2
  - ✓ For control : 1（Using for channel assignment）
  - ✓ For data : 1（Using for sending data on assigned channel）
- Number of channels :n（n ≧ 2）
  - ✓ For control : 1（Dedicated control channel)
  - ✓ For data : n-1（All channels except control channel）

Details of Dynamic Channel Assignment



Frame time sequence



Evaluation method

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Performance evaluation in multi-hop vehicular communication

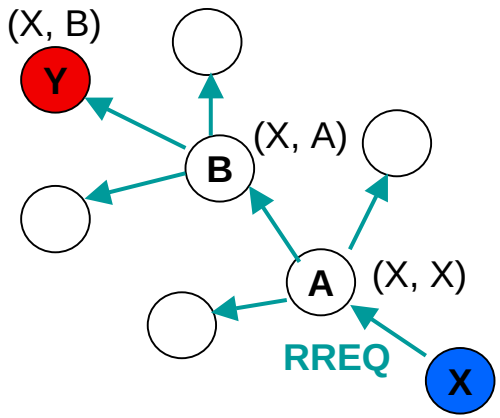
- ✓ Throughput on application layer
- ✓ Effect of a number of hops and channels
- ✓ Effect of a transport layer protocol

Protocol stack

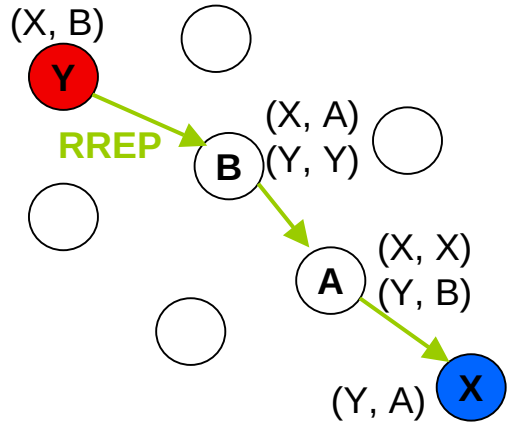
- ✓ Application　FTP（File Transfer Protocol）: TCP
  CBR（Constant Bit Rate）　: UDP
- ✓ Routing protocol
  AODV（Ad hoc On-demand Distance Vector）
  - ➢ RFC3561
  - ➢ Most popular protocol in reactive type

FTP	CBR
TCP	UDP
IP + AODV	
IEEE802.11b MAC／Multi Channel	
IEEE802.11b PHY	

Ad-hoc routing protocol



Route request



Route reply

To establish a route toward a multi-hop destination …

Network layer (Layer 3)

Flooding messages using broadcast packet

MAC layer (Layer 2)

Using broadcast frames

Modification to DCA

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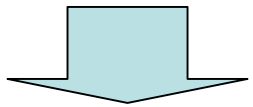
DCA does not define broadcast packet

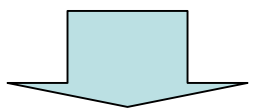


Definition of broadcast packet

Which channel is used for broadcast ?

Requirements for broadcasting messages

- Channel is free for all nodes
- All nodes within radio range have to be able to listen on the channel



In our simulation

Sending broadcast packet on control channel after DIFS and backoff without sending RTS.

Measured items

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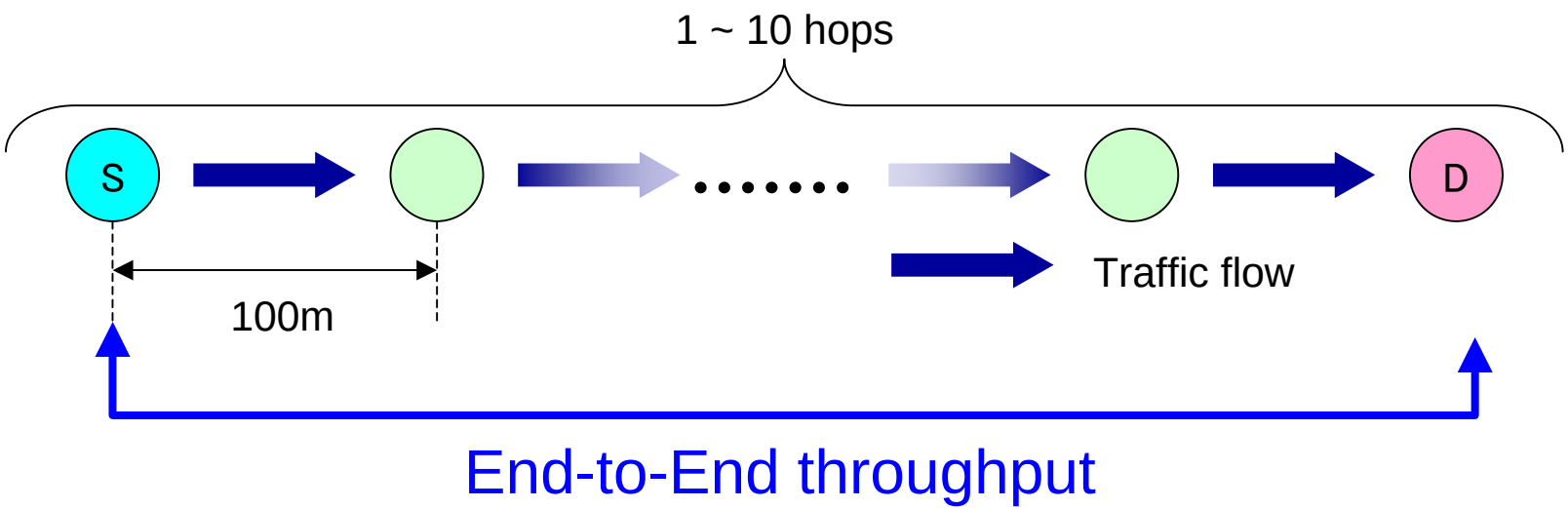
1. Throughput in multi-hop communication
   - ✓ The number of hops
   - ✓ The number of channels

2. Throughput in mobility environment
   - ✓ Vehicle speed
   - ✓ Transport layer protocol

Simulation scenario : Multi-hop communication



End-to-End throughput

Parameters

Parameter	Value	Parameter	Value
Node mobility	none	Bandwidth	11Mbps (fix)
Gap between nodes	100m	Number of data channels	1 ～ 10
Communication pattern	P2P	Applications	FTP（TCP）,CBR（UDP）
Number of hops	1 ～ 10	Duration	30 sec
Routing protocol	AODV		

Simulation results : Multi-hop communication

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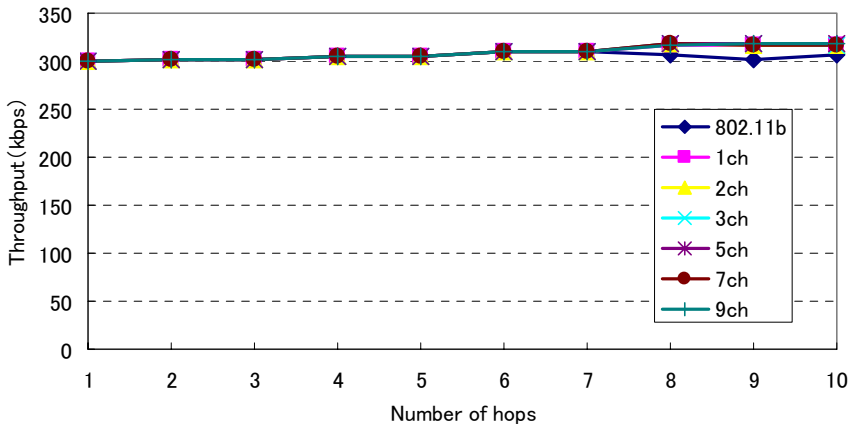
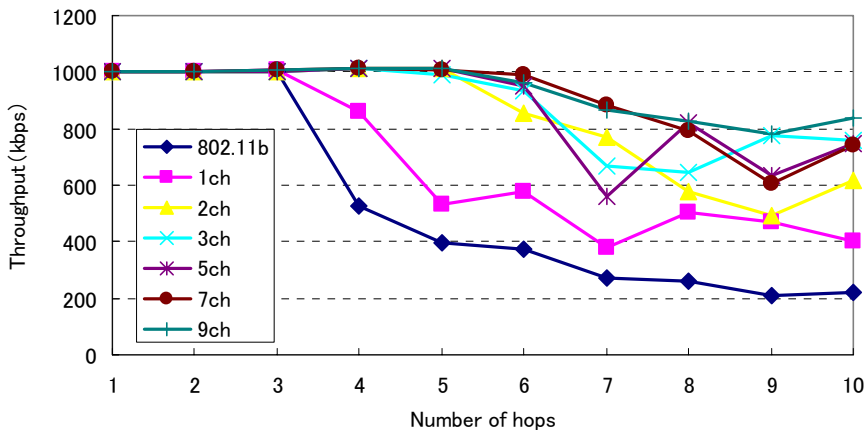


CBR300kbps



CBR1000kbps

Low traffic case

- ✓ Single-channel communication could keep the throughput even in multi-hop.

High traffic case

- ✓ Single-channel
  Throughput degrades from 4 hops.
- ✓ Multi-channel with 2 data channels or more
  Throughput is kept within 6 hops.

Simulation scenario : Mobility environment

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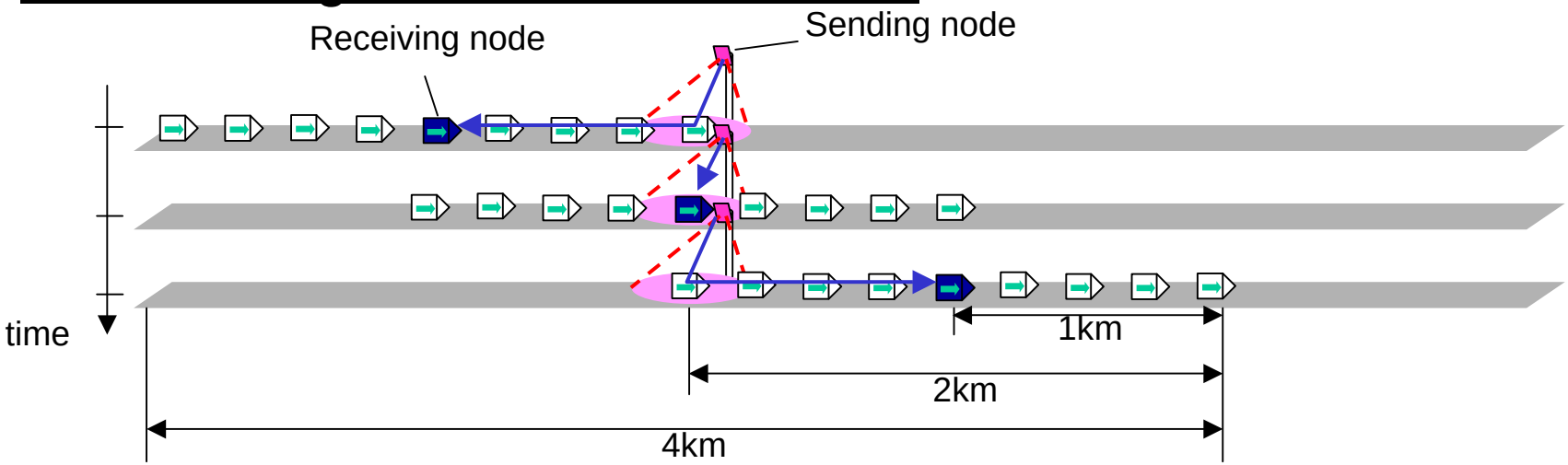
Node arrangement and movement



Parameters

Parameter	Value	Parameter	Value
Node mobility	linear(constant speed)	Bandwidth	11Mbps (fix)
Speed Interval of nodes	5m/s , 10m	Number of data channels	1 ～ 10
	10m/s , 20m	Applications	FTP(TCP),CBR(UDP)
	20m/s , 40m	Duration	5m/s:400 sec
	30m/s , 60m		10m/s:200 sec
communication pattern	P2P		20m/s:100 sec
communication distance	0 ～ 1000m		30m/s:66 sec
Routing protocol	AODV		

Simulation results : Mobility environment

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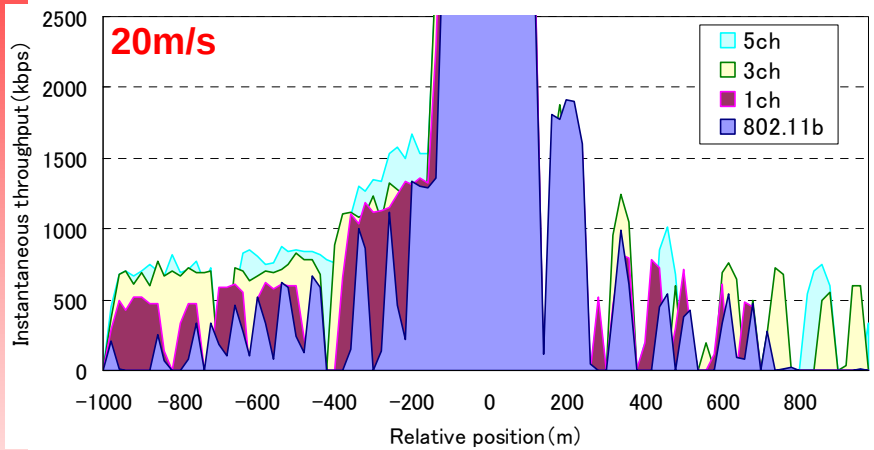
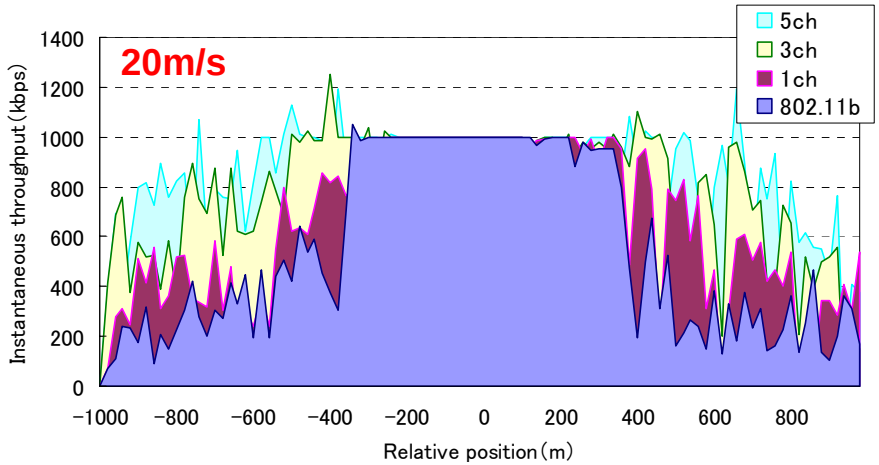


FTP



CBR1000kbps

	FTP	CBR
Throughput in multi-hop area	Low	High
Improvement by multi-channel	Low	High
Transport layer	TCP	UDP

Transport layer protocols affect the performance.

Conclusion

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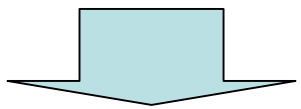
- ✓ Modification of an existing protocol for broadcast packet
- ✓ Performance evaluation in multi-hop vehicular communications
  - ➢ Throughput at application layer
  - ➢ Including network and transport layer



- ✓ Multi-channel MAC protocol is effective enough to realize multi-hop communications.
- ✓ Network and transport layer protocols affect the performance.