Decentralized Probe vehicle system using 700MHz band wireless communication system

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Introduction

- Probe vehicle system (Floating car data) became a popular service in ITS area.
  - In Japan, Honda, Nissan, Toyota and other companies started the services in these 10 years.
- Almost all of systems use cellular phone as the communication devices.
- Probe vehicle system is useful to produce traffic information.
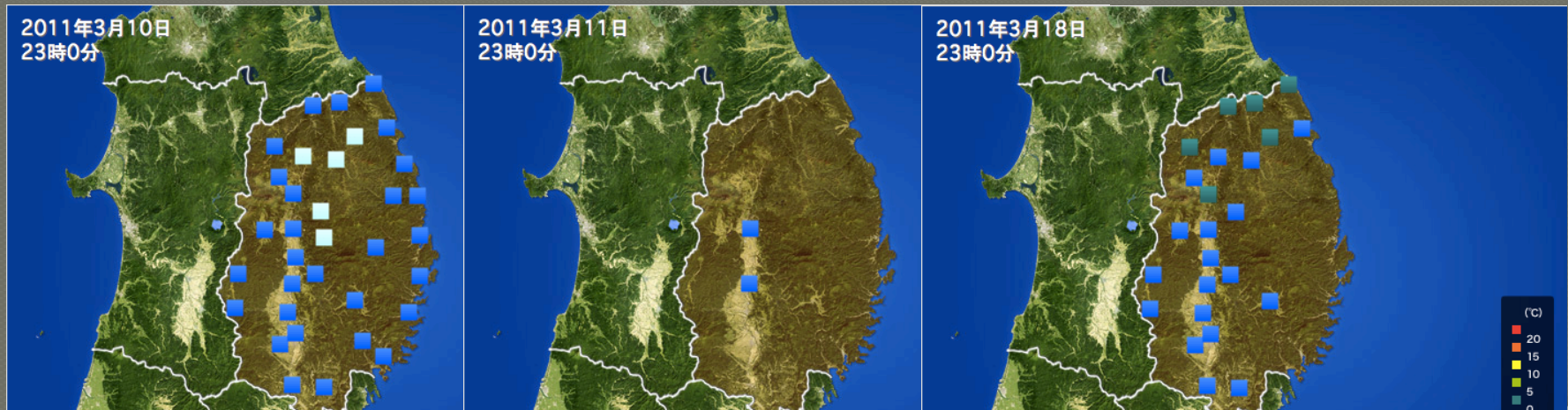- But it has both of more big potential and several problems.

Sensor Networks on 11th March

Traffic information on 11th Mar 20011

No Traffic jam??
=> No, traffic sensors didn't work because of blackout.

Data from AMEDAS before and after Earthquak

Sensor might be able to work with battery but communication is...

Problem statement

- Communication traffic of probe vehicle system is increasing.
- Computational power of the probe vehicle center must be more higher.
- Who should pay for communication cost? The driver of the vehicle is not user in some case.
- Too many number of stakeholders are necessary to start service.
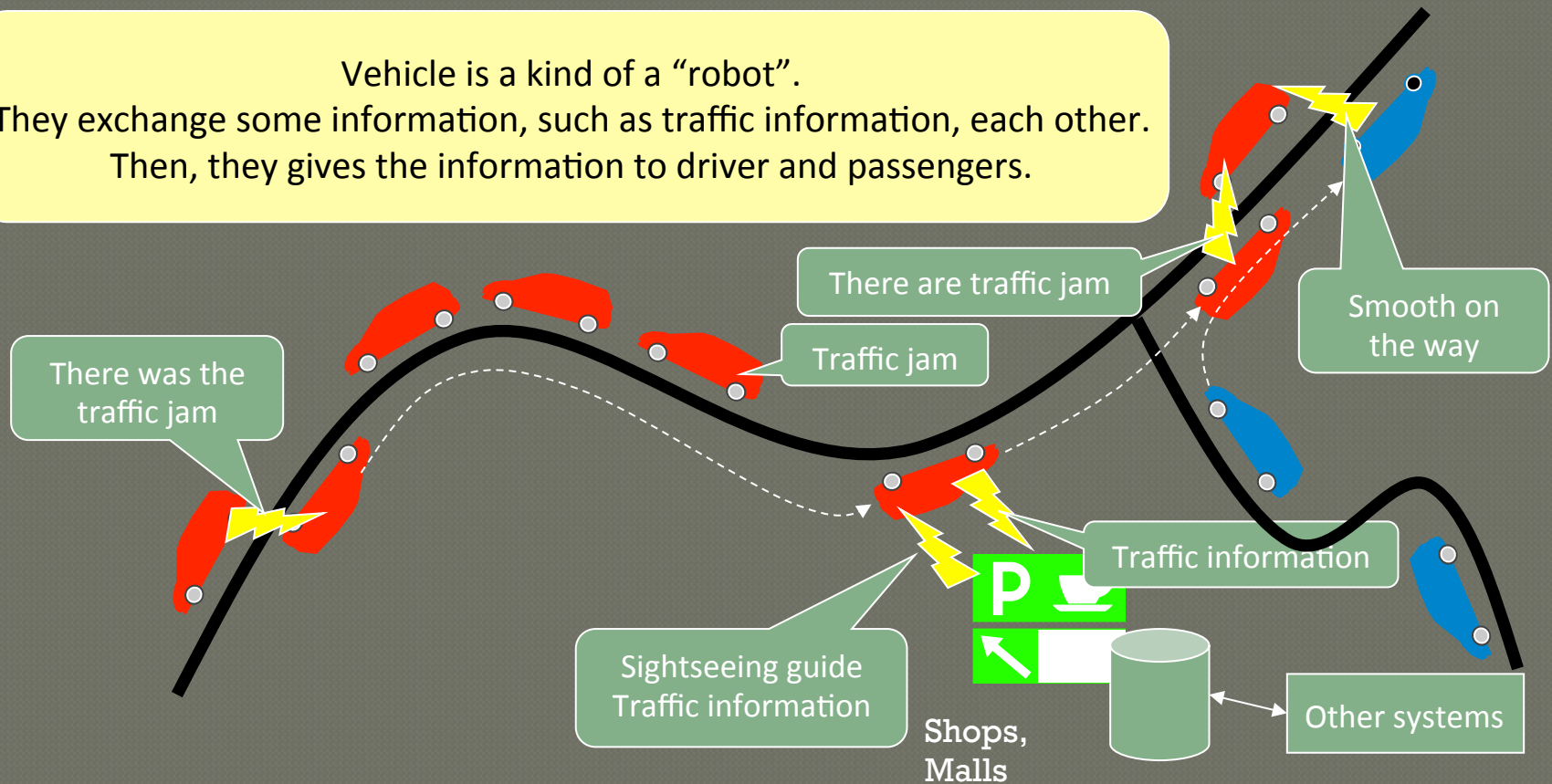- It needs infrastructure now to use 3G communication.

Decentralized probe vehicle system

- Omit "probe vehicle center" which collects probe data, processes them and produce traffic information.
- Vehicles communicate each other to exchange collected data.
- All vehicle process data to produce traffic information as distributed computing.
- This mechanisms is not only for traffic information but also it can be applied to the other application such as weather information.
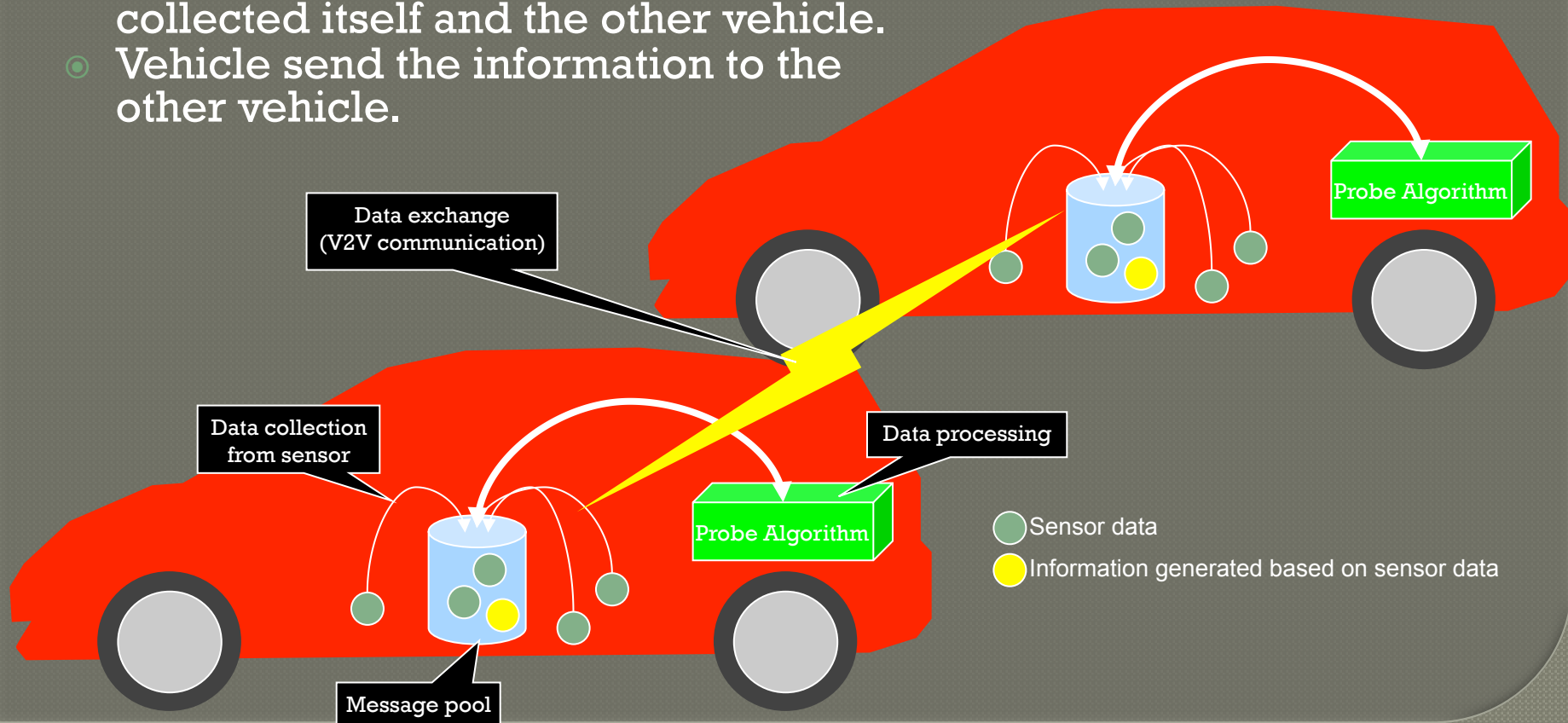
Decentralized probe vehicle system

Vehicle is a kind of a "robot".
They exchange some information, such as traffic information, each other.
Then, they gives the information to driver and passengers.

There are traffic jam

Smooth on the way

There was the traffic jam

Traffic jam

Traffic information

Sightseeing guide
Traffic information

Shops, Malls

Other systems

System overview

- Each vehicle collect probe data from its sensor and store them to message pool.
- The sensor data is exchanged each other.
- Each vehicle produce probe information using both of data which collected itself and the other vehicle.
- Vehicle send the information to the other vehicle.

Data exchange
(V2V communication)

Probe Algorithm

Data collection
from sensor

Data processing

Probe Algorithm

Sensor data

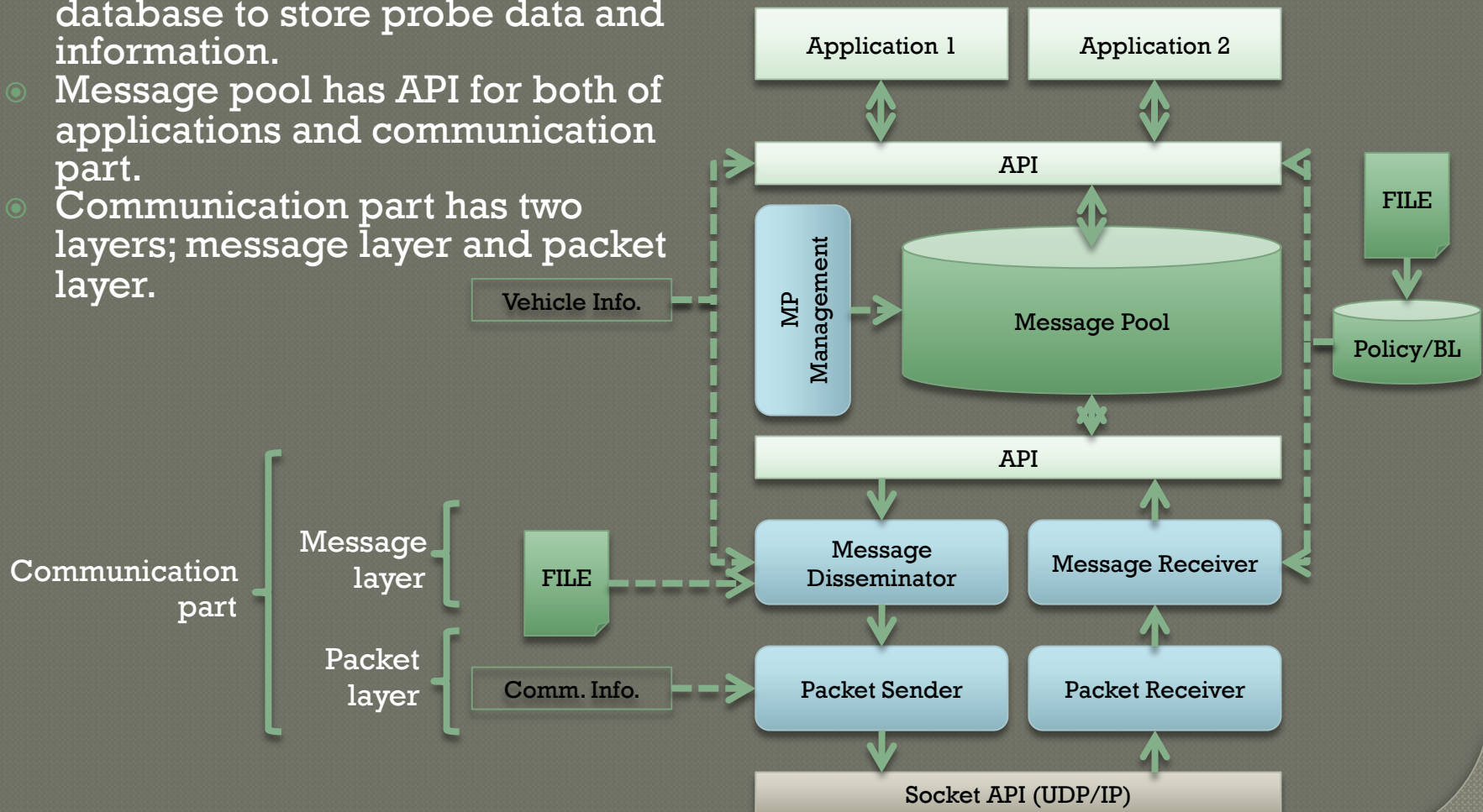Information generated based on sensor data

Message pool

System structure (hardware)

- Vehicle has ECU to get data from vehicle sensor, GPS, 700MHz communication system and in-vehicle PC.
- 700MHz band is basically allocated for safety application. It shouldn't be disturbed.
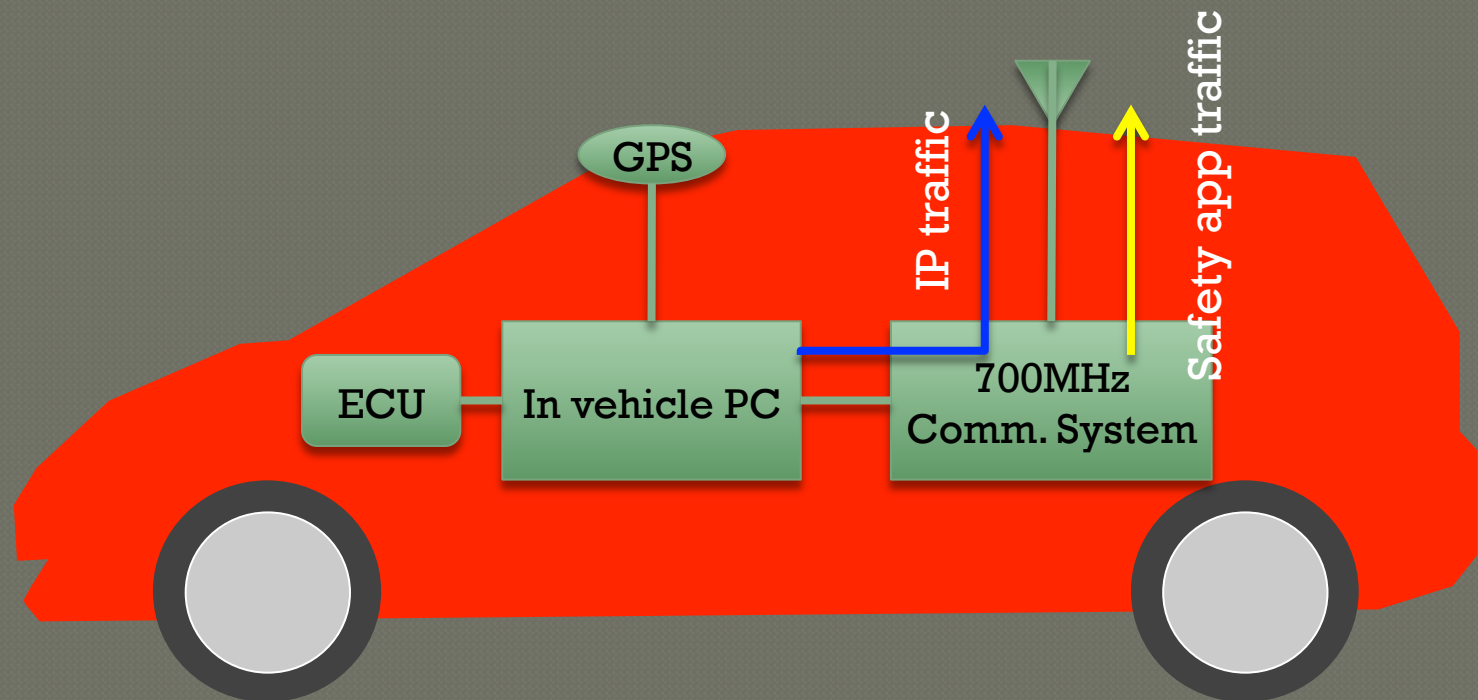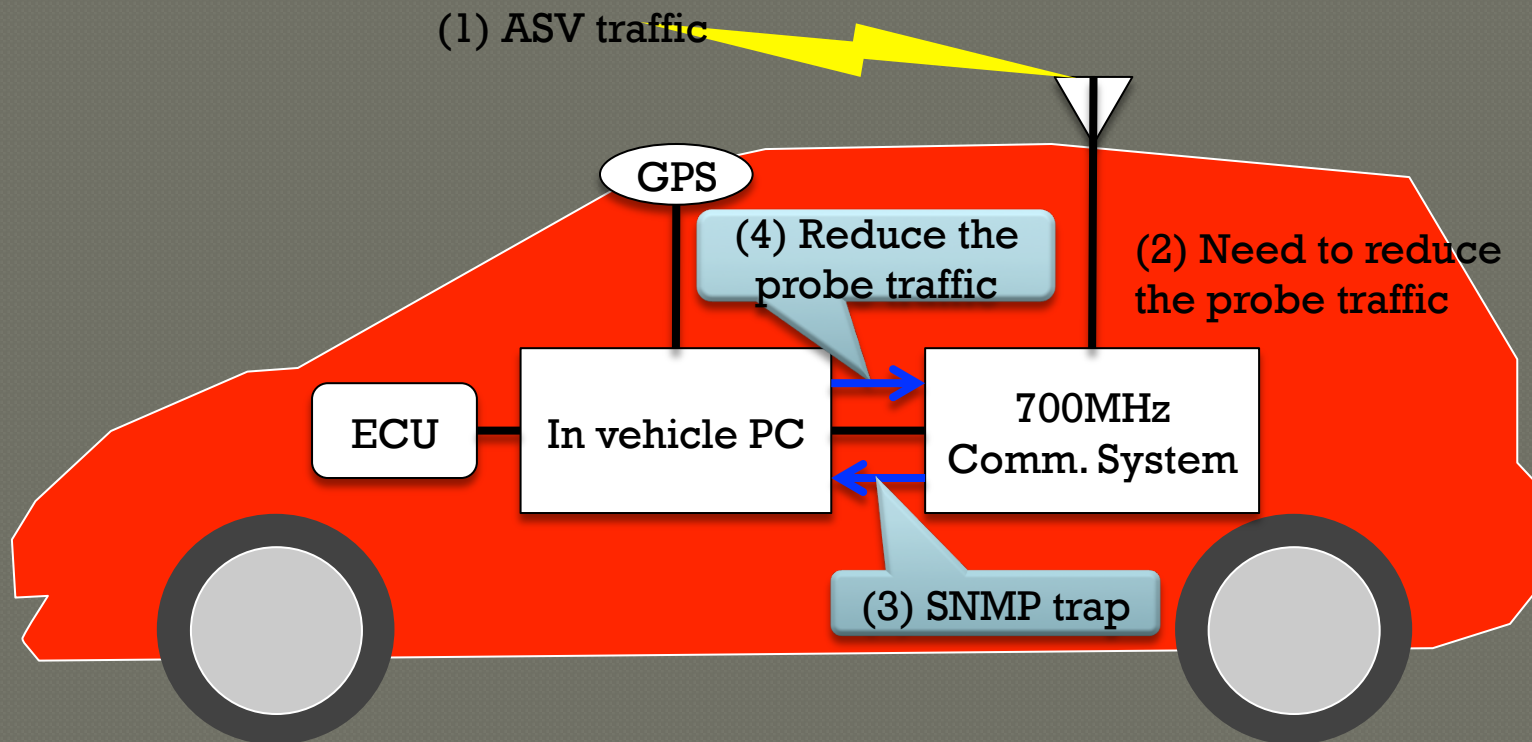
System structure (software)

- Message pool is a kind of database to store probe data and information.
- Message pool has API for both of applications and communication part.
- Communication part has two layers; message layer and packet layer.

Communication part

Message layer

Packet layer

Application 1

Application 2

API

MP Management

Message Pool

Vehicle Info.

FILE

Policy/BL

API

FILE

Message Disseminator

Message Receiver

Comm. Info.

Packet Sender

Packet Receiver

Socket API (UDP/IP)

Traffic control mechanism 1

- Condition of radio can be detected only by communication system: radio strength, interference and so on.
- It notify the condition using SNMP to in-vehicle PC
- Thus the in-vehicle PC can control the IP traffic

(1) ASV traffic

GPS

(4) Reduce the probe traffic

(2) Need to reduce the probe traffic

ECU

In vehicle PC

700MHz Comm. System

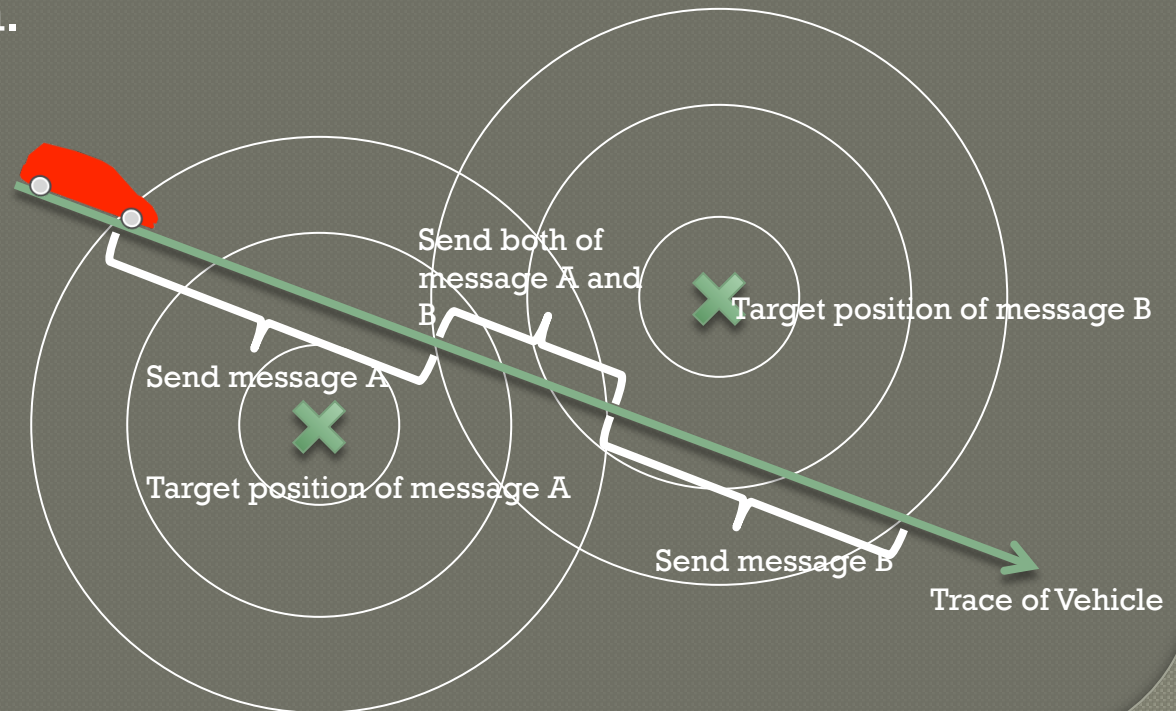(3) SNMP trap

Traffic control mechanism 2

- Packet layer has traffic control mechanism.
- For fairness of applications, a kin of class based queuing mechanism is adopted.
- If vehicle is alone, it uses half of bandwidth. Otherwise it uses $B/(n+1)$.
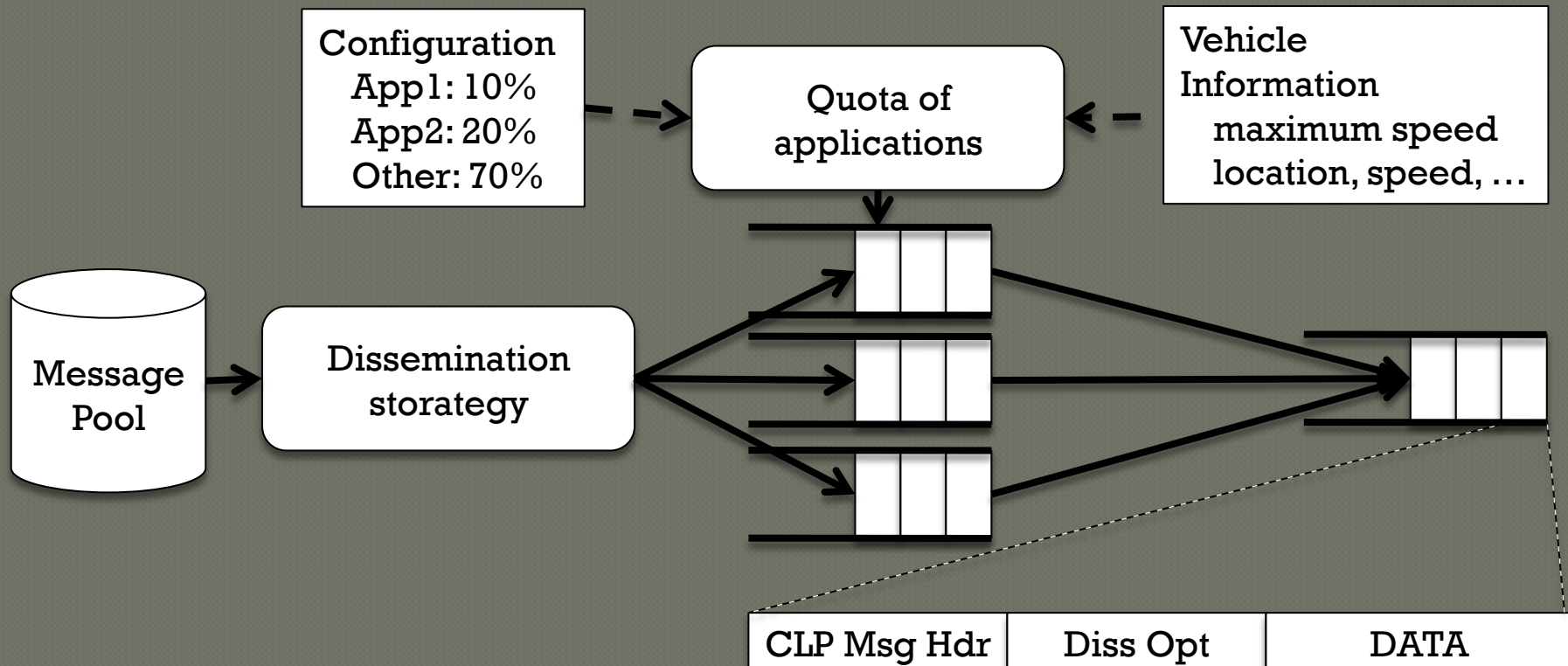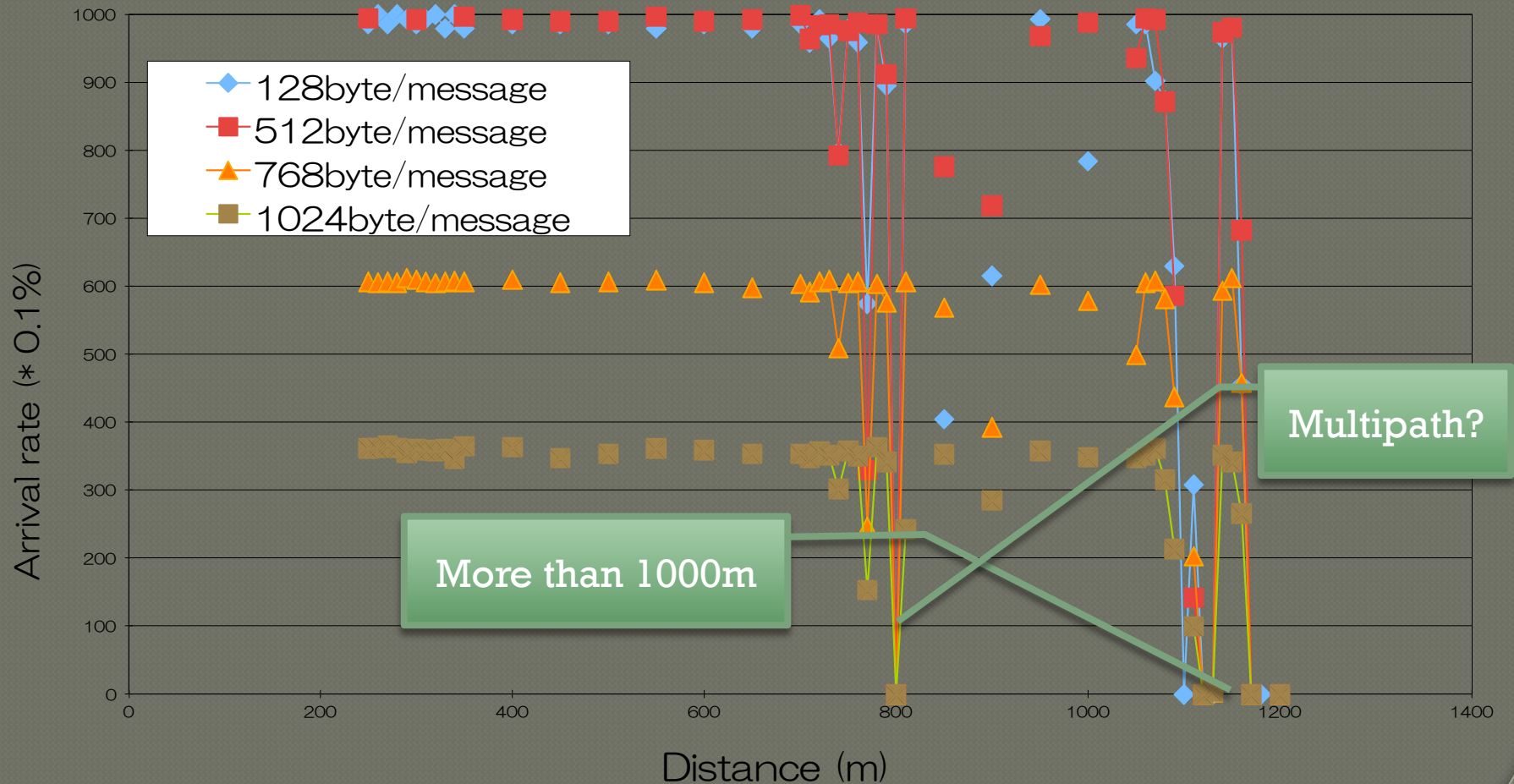
Dissemination strategy
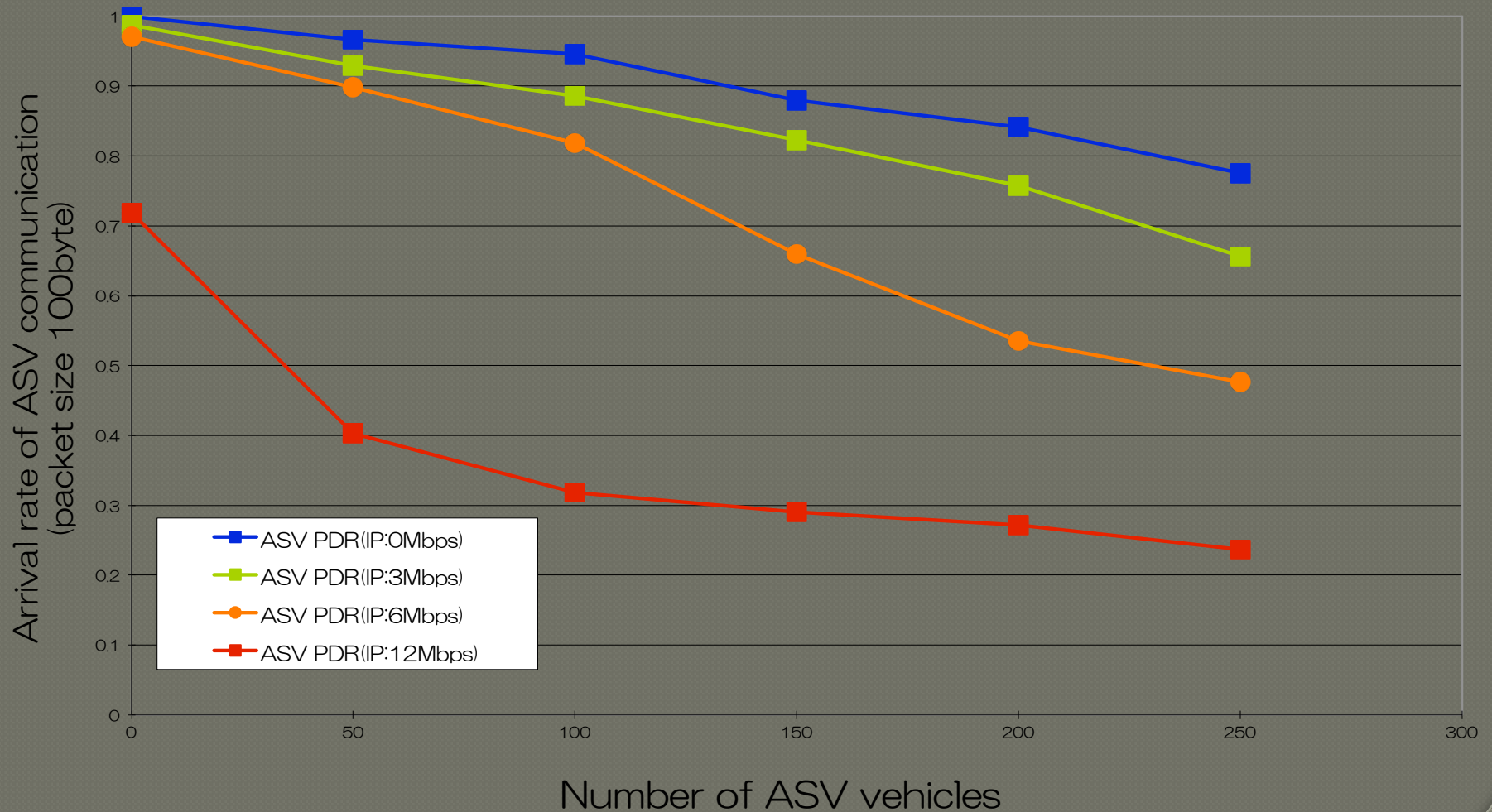
- Circle dissemination strategy
  - Every message has the target position for dissemination.
  - When vehicle is located near the target position of information A, the vehicle sends the message A.
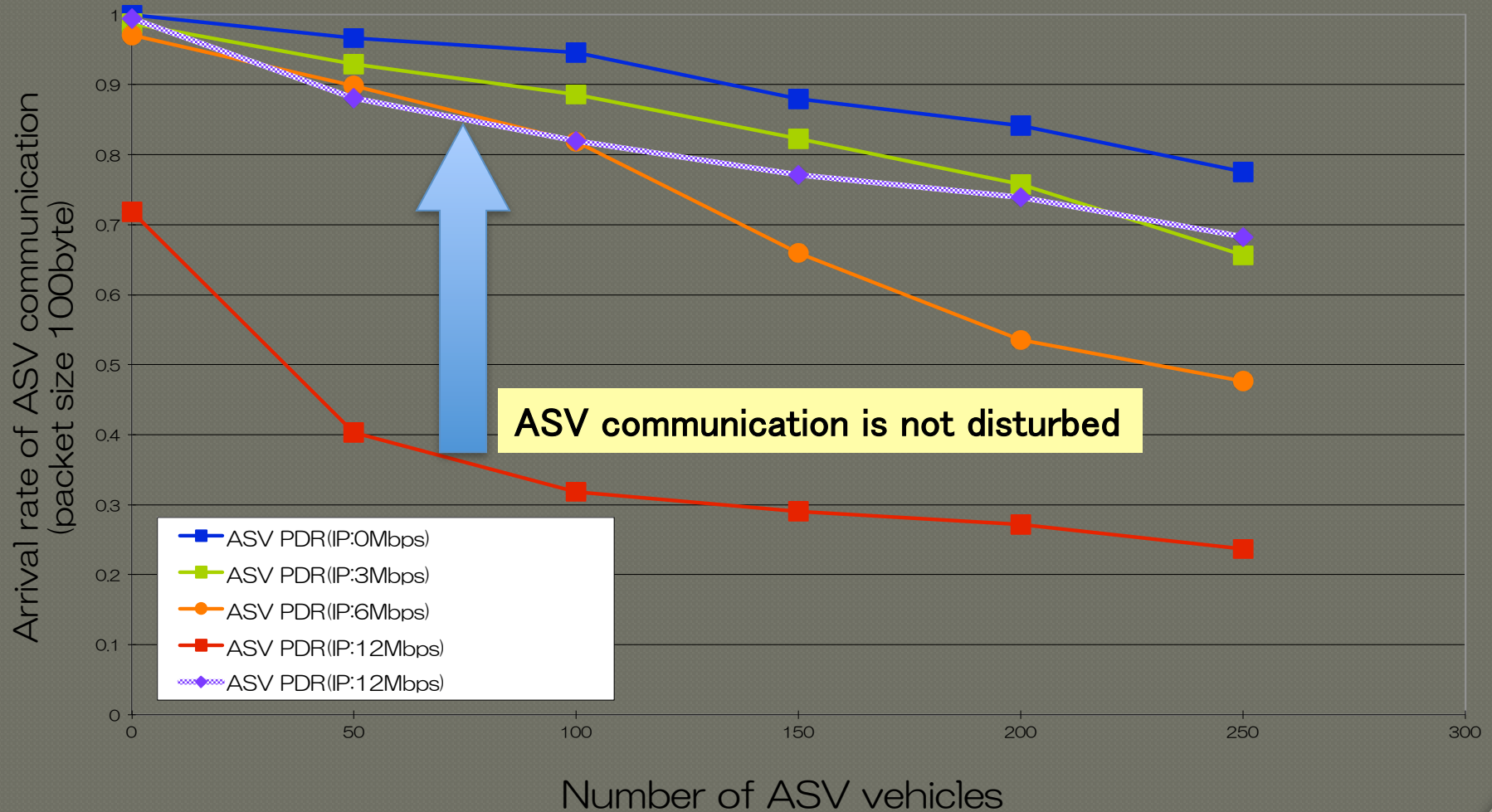 - Using this strategy, vehicle can get many data which addressed to current location.

Send both of message A and B

Target position of message B

Send message A

Target position of message A

Send message B

Trace of Vehicle

Coverage of 700MHz band wireless communication system

Arrival rate (* 0.1%)

- 128byte/message
- 512byte/message
- 768byte/message
- 1024byte/message

More than 1000m

Multipath?

Distance (m)

Result of effectiveness of Traffic control using SNMP

Result of effectiveness of Traffic control using SNMP

ASV communication is not disturbed

Arrival rate of ASV comunication (packet size 100byte)

Number of ASV vehicles

- ASV PDR(IP:0Mbps)
- ASV PDR(IP:3Mbps)
- ASV PDR(IP:6Mbps)
- ASV PDR(IP:12Mbps)
- ASV PDR(IP:12Mbps)

Result of Fairness test

◉ Senario:

• Two vehicles locate very closely. One other vehicle come to the next of vehicles

Bandwidth (bps)

Two communications are balanced

Three communications including new communications are balanced

New communication

Duration (s)
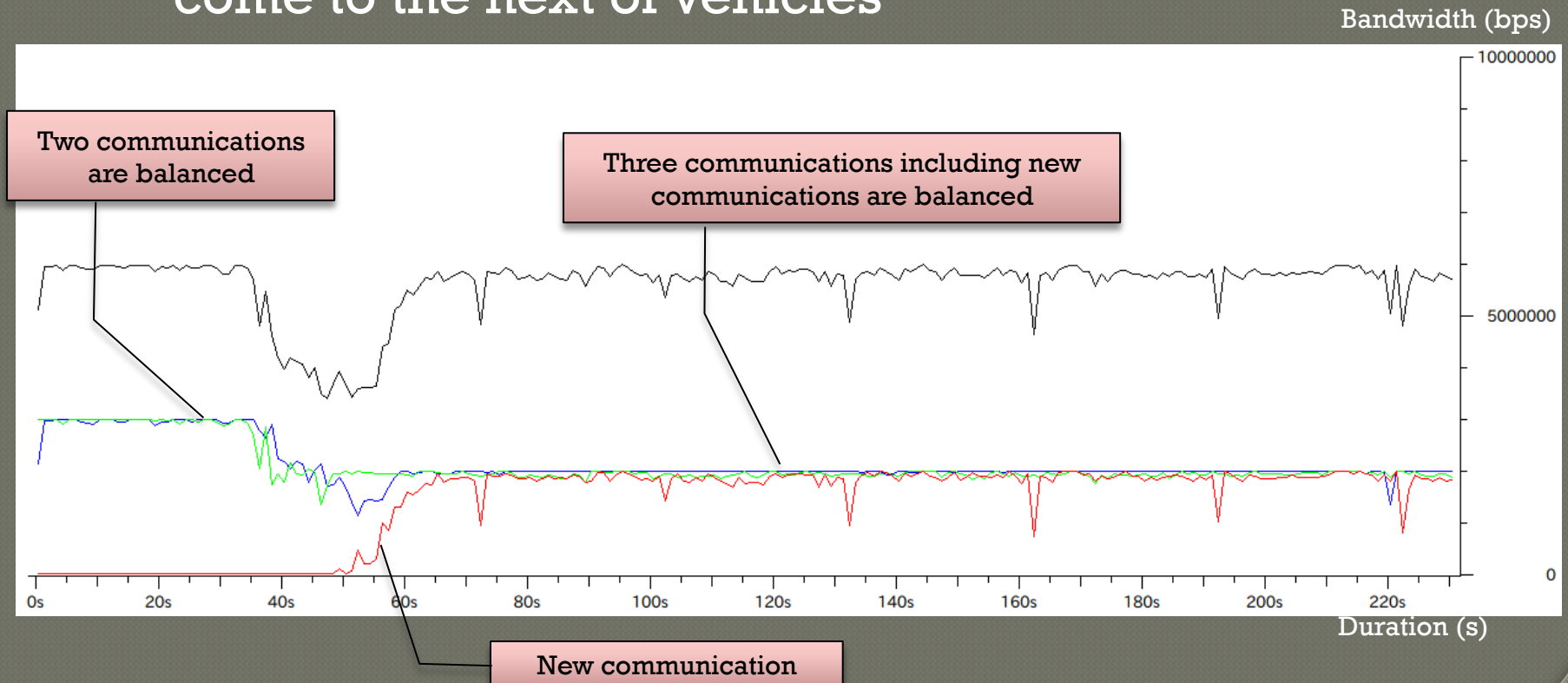
Test in real environment

Conclusion

- Introduced the system architecture of Decentralized probe vehicle system.
- Using Vehicle-to-Vehicle communication, probe vehicle system can be implemented.
- Several types of communication control system is necessary.
- Dissemination strategy is really important.
- Hope this kind of system can be work in disaster situation.