SMART TECHNOLOGY
FOR SMARTER CARS

SCALABLE VEHICULAR AD-HOC NETWORKS

DISTRIBUTED SOFTWARE-DEFINED NETWORKING

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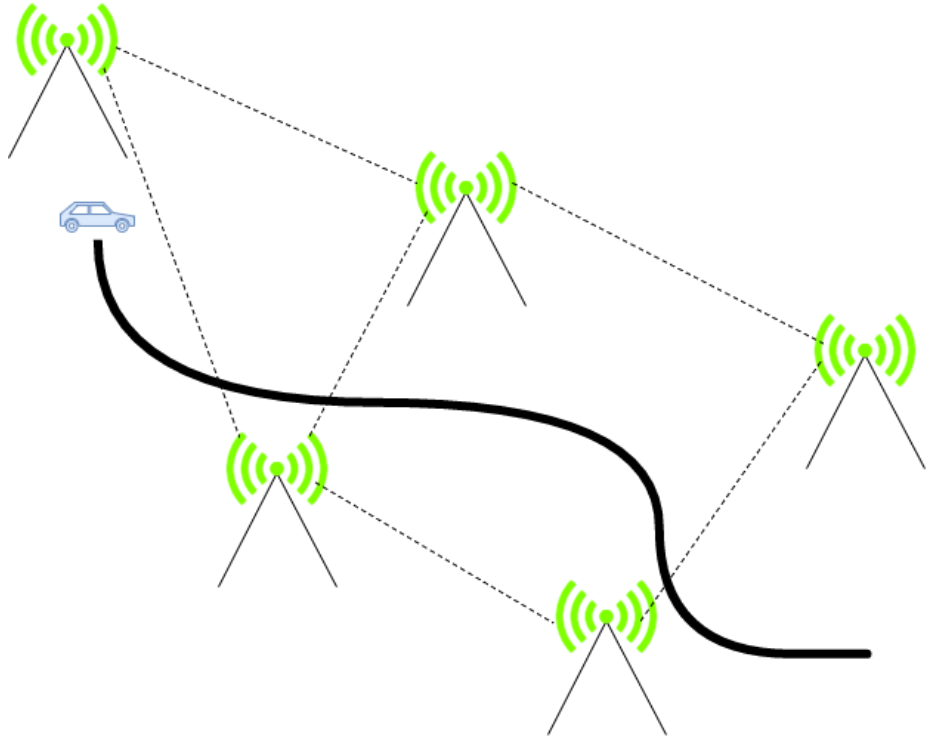
AGENDA

- Current networking solutions for V2X
- Problem definition
- Motivations for a scalabe networking solution
- SDN and DSDN
- Getting SDN in Vehicular networking: VDSDN
- Challenges
- Summary

CURRENT NETWORKING SOLUTIONS FOR V2X

Centralized Network Access

- The key components of this infrastructure are the Backhaul RSU, the Datacenter, and the Vehicle
  - Backhaul RSU is the radio tower connecting the vehicle with the datacenter wirelessly
- Relevant options for backhauling:
  - WiMAX
  - LTE
  - WMN
  - HiperLAN

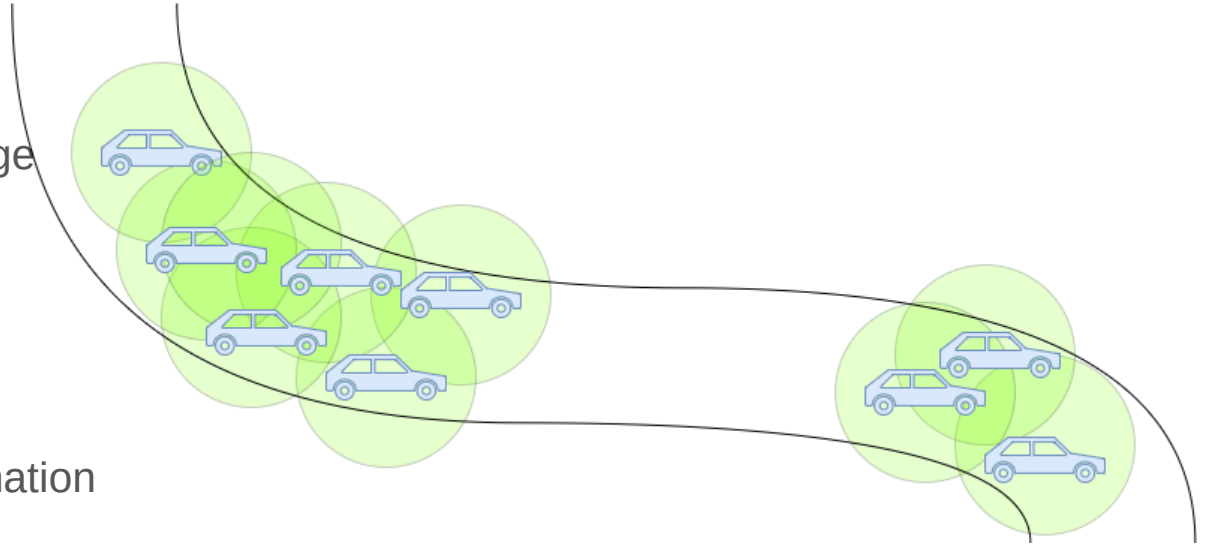


Typical centralized network for V2V and V2X, where the radio towers cover large areas and communicate with each other. The Vehicles communicate with the towers using the relevant protocols.

CURRENT NETWORKING SOLUTIONS FOR V2X

Ad Hoc Network

- Used mainly for Geocast, and is based on flooding
  - Geocast is a broadcast going through the network coverage area
- Basic advantage is it does not require preinstalled infrastructure
- Can create hybrid system
  - RSUs and other vehicles can relay traffic to reach a destination not in the original network reach



An example of Ad Hoc V2V/V2X. Vehicles communicate with other vehicles and RSU that happen to be within the network coverage area.

PROBLEM DEFINITION

Network Scalability

- Current V2X network technologies doesn't provide scalable solutions

Datacenter-based V2X network	Ad Hoc-based V2X network
Require pre-installed infrastructure	Has small network coverage area, not exceeding geo neighbors
Communication quality is sensitive to mobility	Basic mechanisms of traffic flooding and relaying are not scalable in dense network
Costs of deployment and operation are high	No standard way of managing the network

MOTIVATIONS

V2X needs a scalable networking solution

- Ideally it should be infrastructure-less, and goes beyond geo neighbors vehicles
- Covering the V2X communication demands, from small vehicle stats dissemination to media and content sharing
- Also it should provide private and secure environment for safe networking

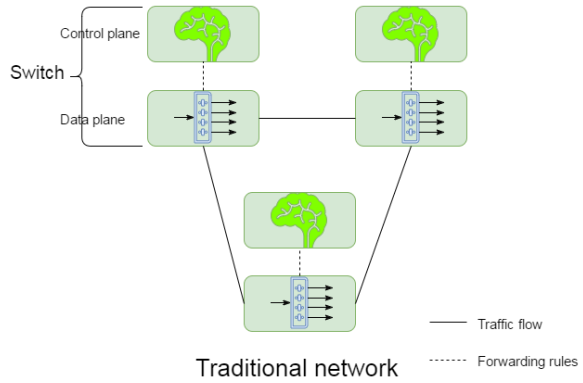
In this presentation, we will introduce Software-defined Networking

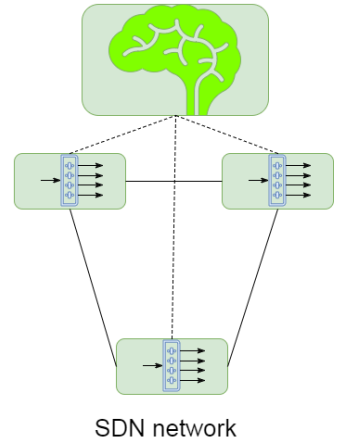
- This new technology is used in the IT domain
- Potential solution for V2X that addresses the scalability limitations of current solutions

SDN AND DSDN

Software-defined Networking: SDN

- SDN is a new approach in networking, where the data plane is separated from control plane
  - In traditional networks, traffic forwarding rules are configured and executed by the switch HW
  - In SDN, the data plane is abstracted, and standardized APIs are used to control/configure the rules by SW interfaces. The control plane is centralized and implemented in software
- This separation decouples software from hardware, making it possible to control the network through software interface, allowing granular control of traffic without relying on hardware-specific firmware



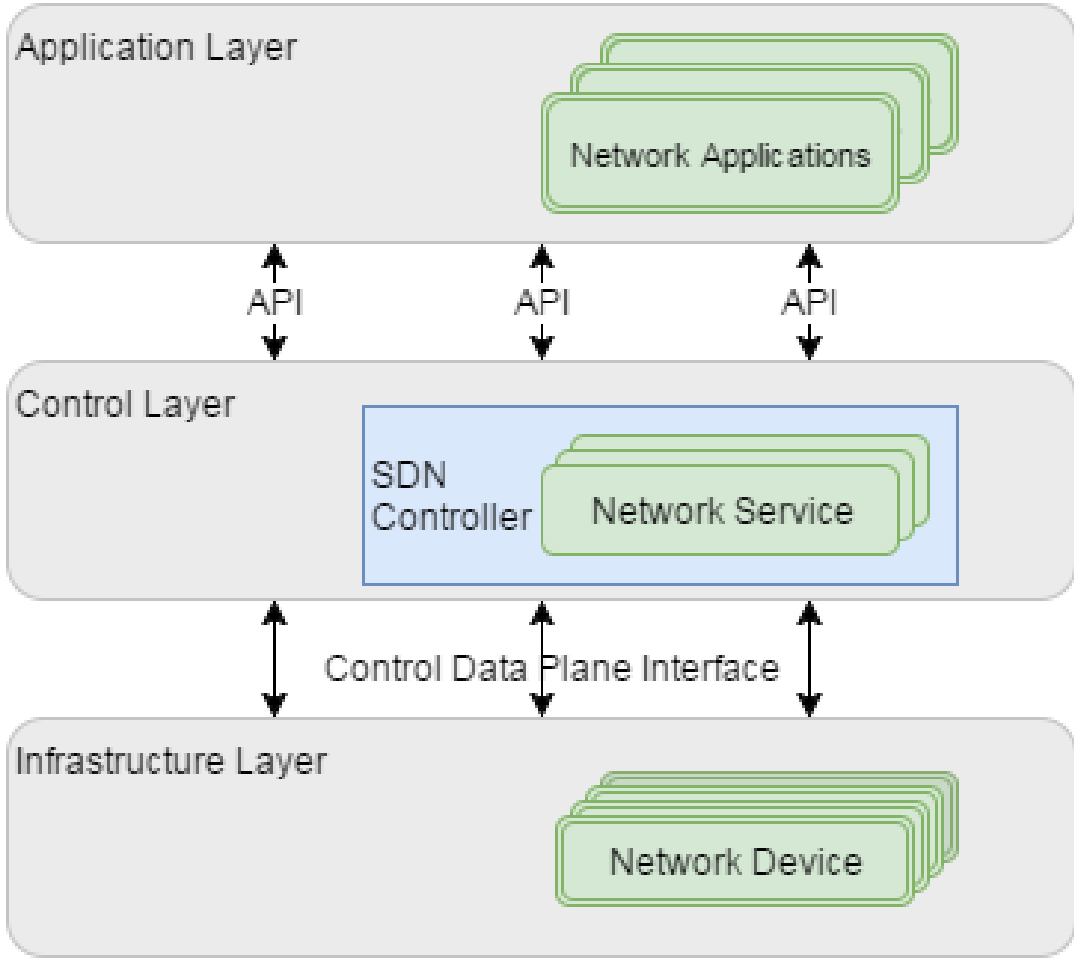


SDN separating and centralizing the control plane.

SDN AND DSDN

Software-defined Networking: SDN

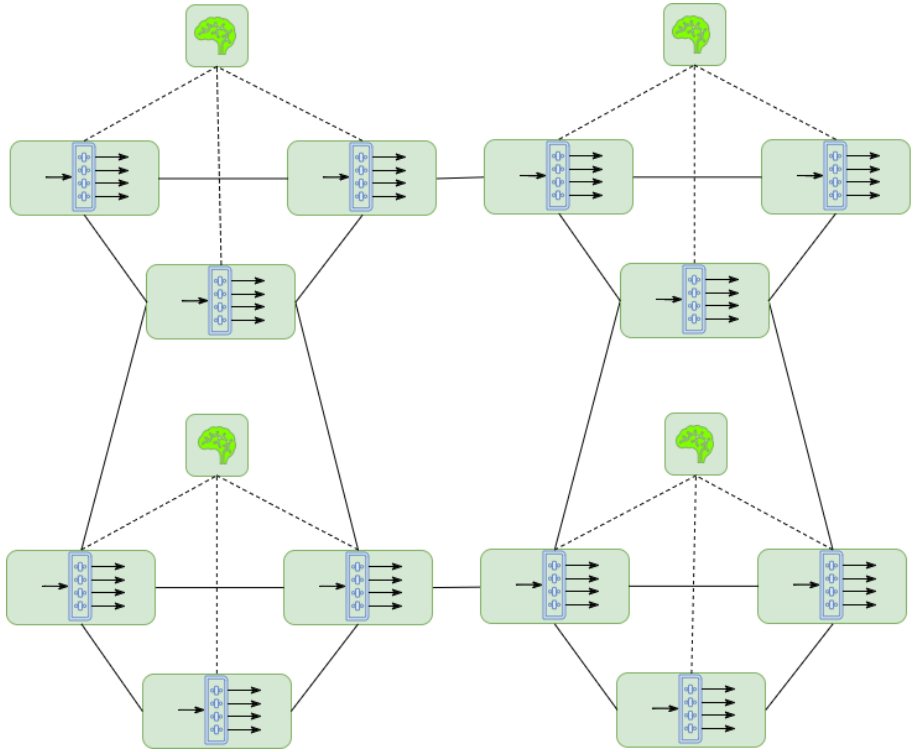
- SDN controller is consisted of three layers
  - Application, Control, and Infrastructure layers.
- Infrastructure layer:
  - Implements the data plane, and is consisted of multiple physical and virtual network devices.
- Control layer:
  - The centralized control for the underlying network devices in the infrastructure layer.
  - Implements the programmable logic for controlling and configuring traffic forwarding rules, and provides APIs for the application layer.
- Application layer
  - Runs the actual applications that controls the traffic, through the API interface provided by the SDN controller.



SDN AND DSDN

Distributed Software-defined Networking

- SDN is about centralizing the control plane, so wouldn't it be pointless to 'distribute' it again?!
  - Not exactly. Think of it as micromanagement
  - Network state is not maintained in a centralized storage



A collection of SDN controllers, where each one is micromanaging a small network. Together, SDN controllers are forming larger network.

GETTING SDN IN VEHICULAR NETWORKING: VDSDN

Vehicular Distributed Software-Defined Networking

- A hybrid architecture between Ad Hoc networking and centralized datacenters
  - A group of vehicles act as Mobile Routers, orchestrating the network-on-the-run
  - Mobile Routers still directly communicate to their geo neighbors, just like Ad Hoc
  - Mobile Routers keep info and data about a network that goes beyond direct geo neighbors

GETTING SDN IN VEHICULAR NETWORKING: VDSDN

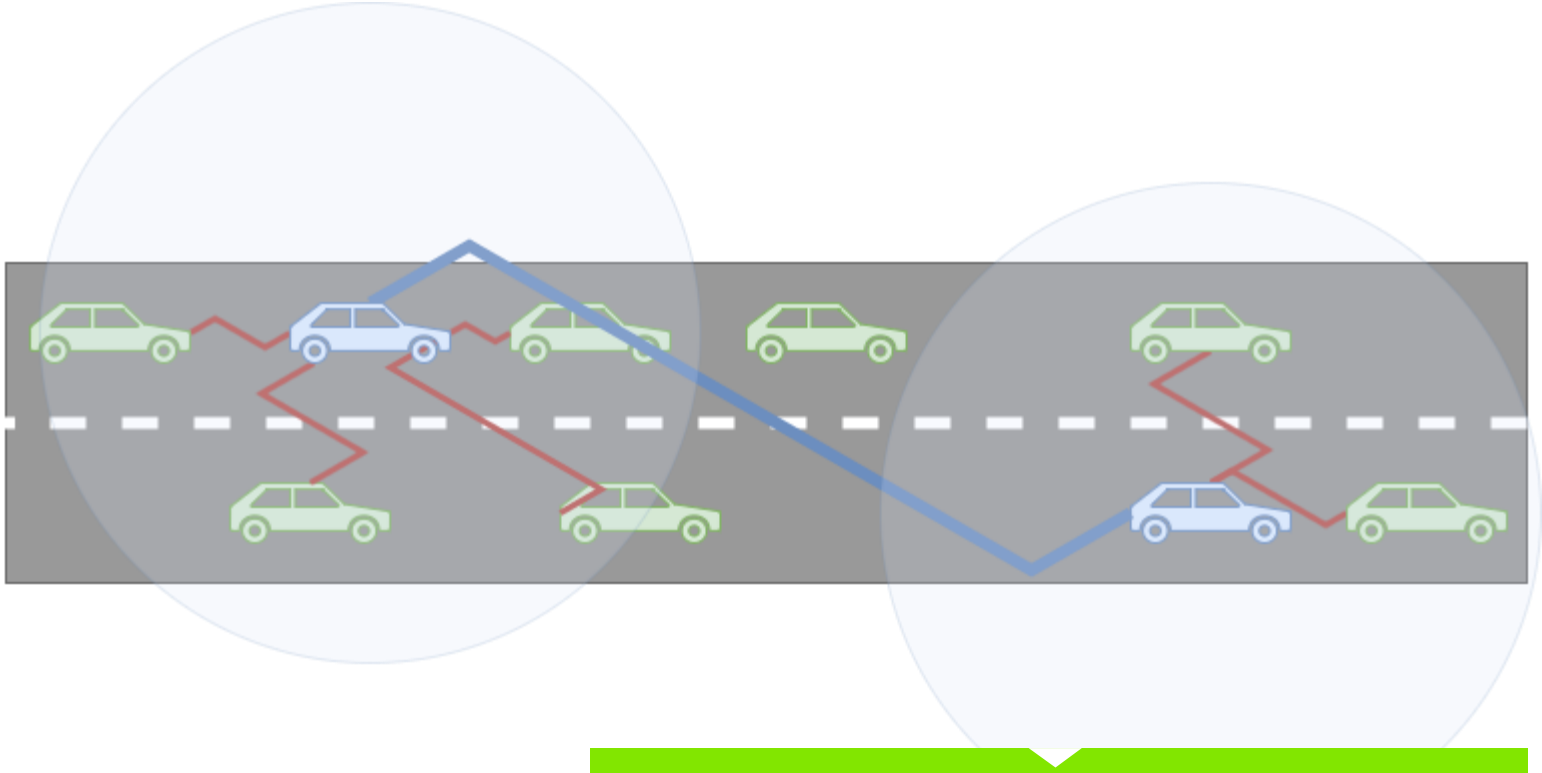
Automotive use-cases for SDN

- SDN can provide infrastructure-less, LAN-like network for vehicles
  - Optimal path finding
  - Area-aware targeted communication
- Road-specific and journey-specific network
  - From Safety to gaming
  - Self-organizing convoys
  - Autonomous vehicles
- Vehicular IoT and Fog Computing
  - In Cloud computing, the required functionality is implemented on a server on the internet, and it adopts client-server approach
  - Fog computing adopts peer-to-peer approach, and has the functionality implemented on the peers
  - For vehicular environment, this allows vehicles to share services among other vehicles

GETTING SDN IN VEHICULAR NETWORKING: VDSDN

VDSDN Network Topology

- Predetermined leader

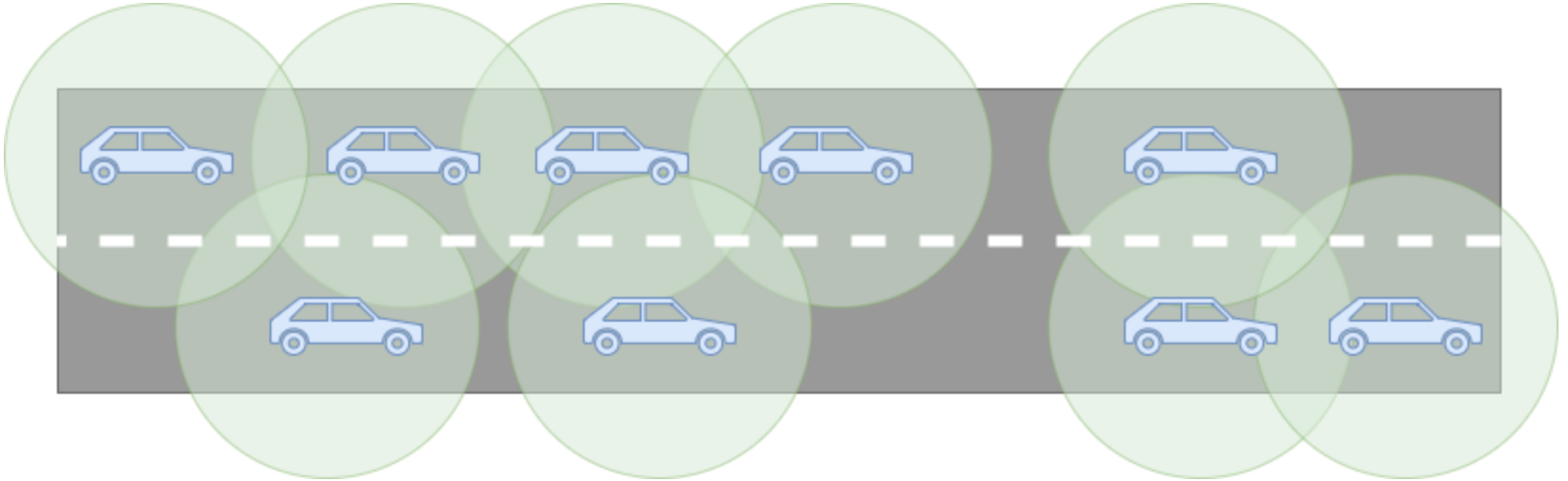


SDN controller installed on the Leader vehicle. The leader controls traffic going through the area of the network, and coordinates with other leaders as well.

GETTING SDN IN VEHICULAR NETWORKING: VDSDN

VDSDN Network Topology

- Fully distributed



Area of effect is rather small, so vehicles form a chain of ‘hops’. One or more coordinators are promoted to manage the network.

CHALLENGES

Deployment

- For a VDSDN-enabled vehicle to work, it has to cooperate with other VDSDN-enabled vehicles to form a network

Privacy

- How to allow only trusted vehicles and RSUs into the network?

Resource sharing

- Under what conditions a vehicle would share its resouces?

SUMMARY

Current V2X networking solutions are not optimal for scalability

- Centralized networking require pre-installed costly assets
- Ad-Hoc networking perform poorly in dense networks

New trend in networking: SDN and DSDN

- SDN separates control plane from data plane and implements centralized control in software
- DSDN takes a different approach of distributing the control instead of centralization in a datacenter

Getting SDN in vehicles: VDSDN

- By using the distributed SDN approach, vehicles can create and manage their own networks
- VDSDN solves the centralized and Ad-Hoc vehicular networking problems
  - Easy scalability, high capacity, and infrastructure-less

Q&A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