Secure Vehicular Communications – An Architectural View

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Problem

- Vehicular Communications (VC) / Vehicular Ad Hoc Networks (VANET)
  - Technology in the making
  - Wide (eventually) yet gradual deployment
  - Interoperability
  - Standardization
- Security and Privacy
  - Basic requirements/prerequisites
  - No retrofitting

Security and Privacy - Why?

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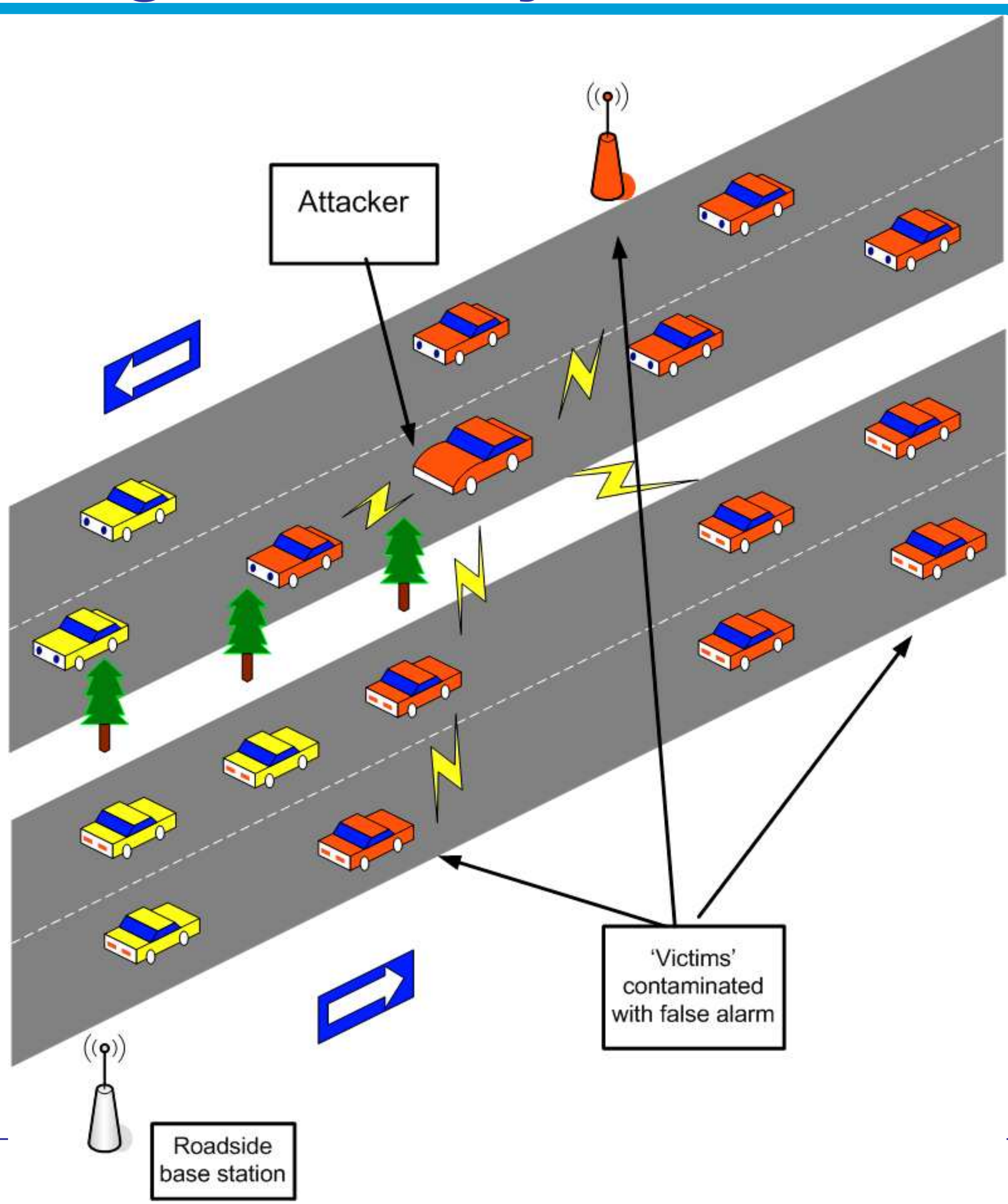
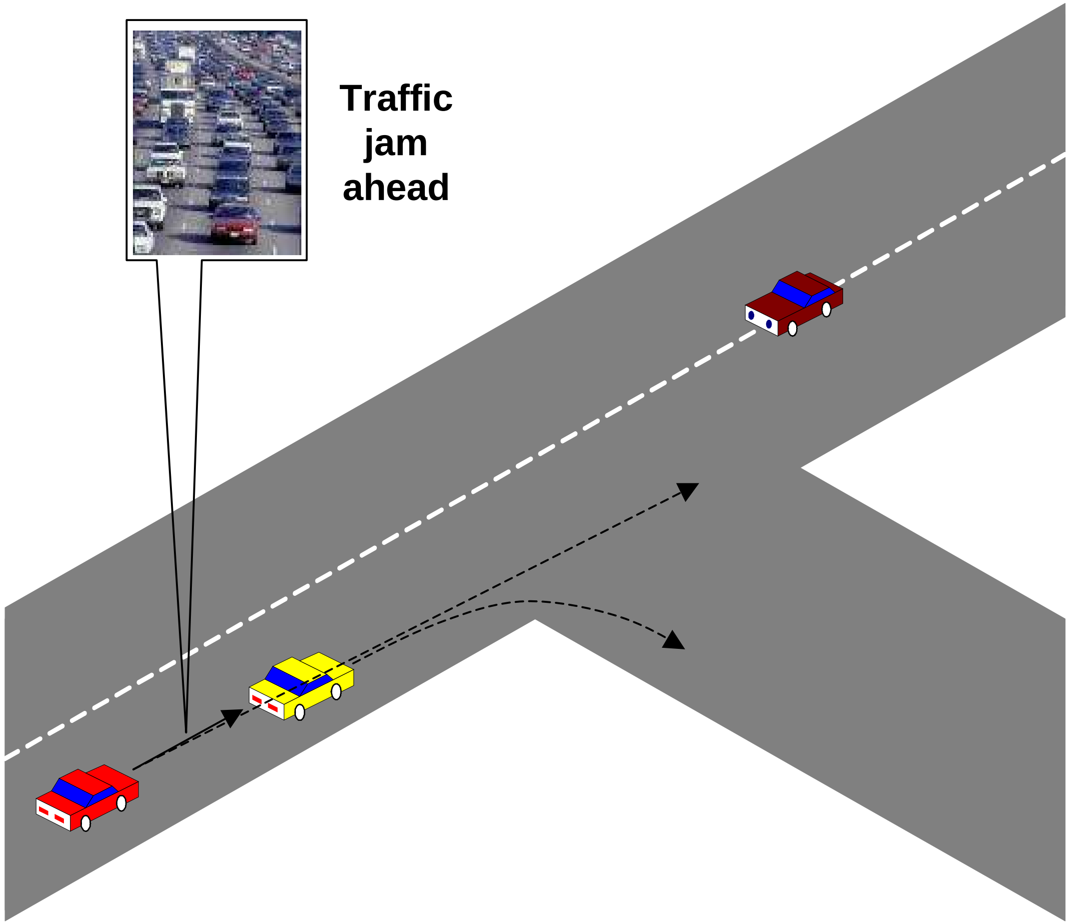
- Without robust designs, VC systems may facilitate antisocial behavior
- The deployment of vulnerable VC systems may cancel out their envisioned benefits
- Abused, poorly defended VC systems can cause damages and high cost
- Attackers and adversaries will always be present

Attacking the VC system



Attacking the VC system (cont'd)



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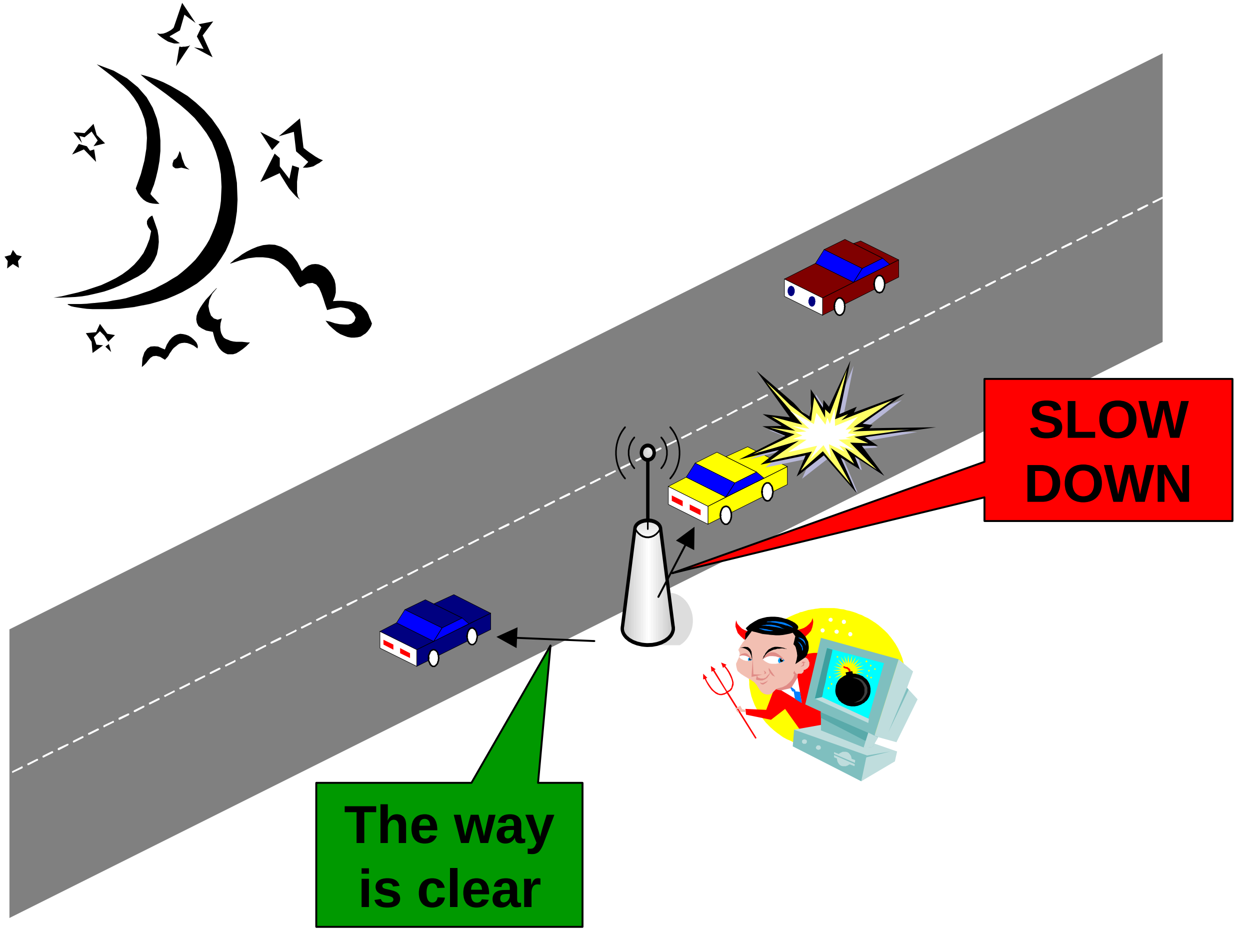

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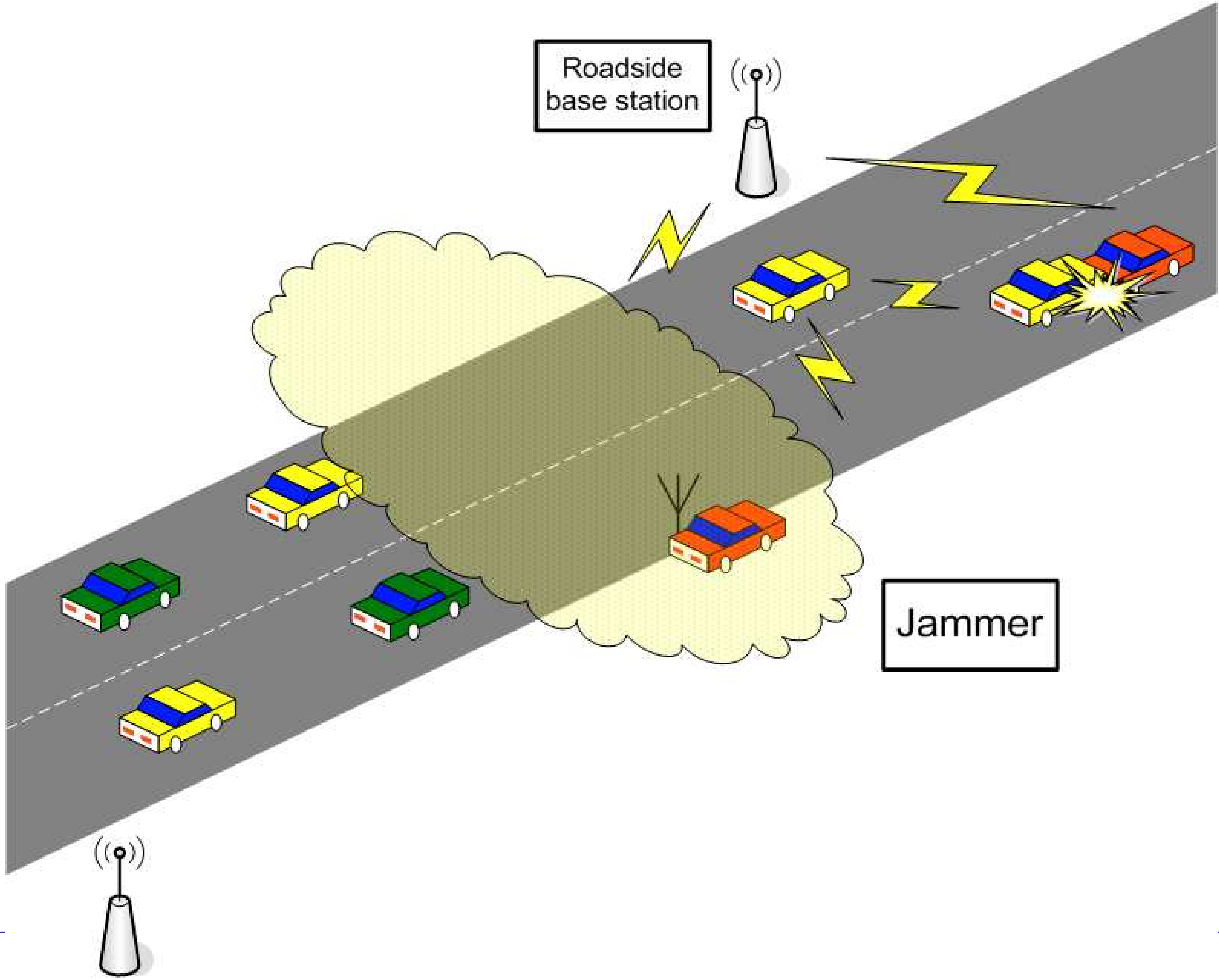

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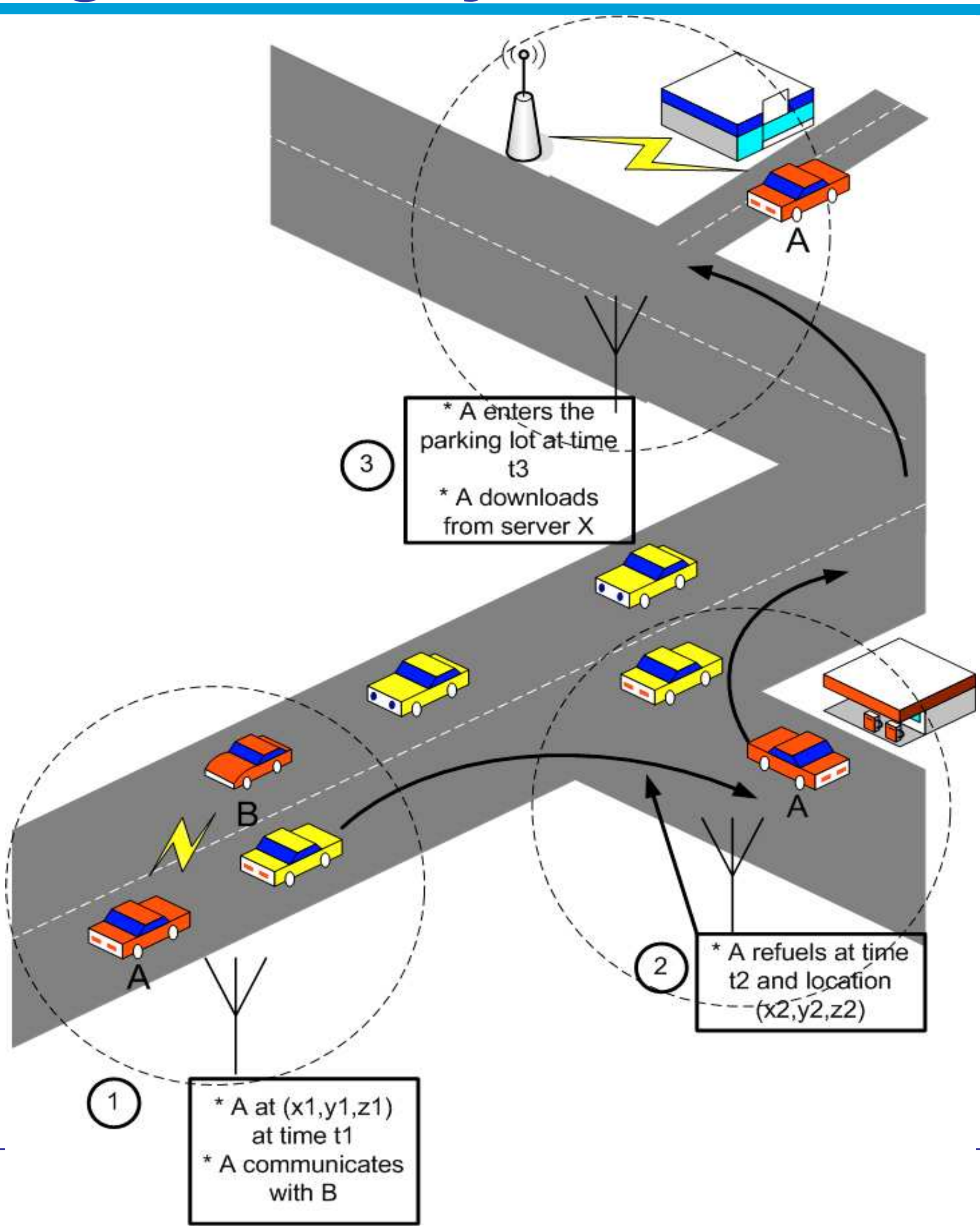

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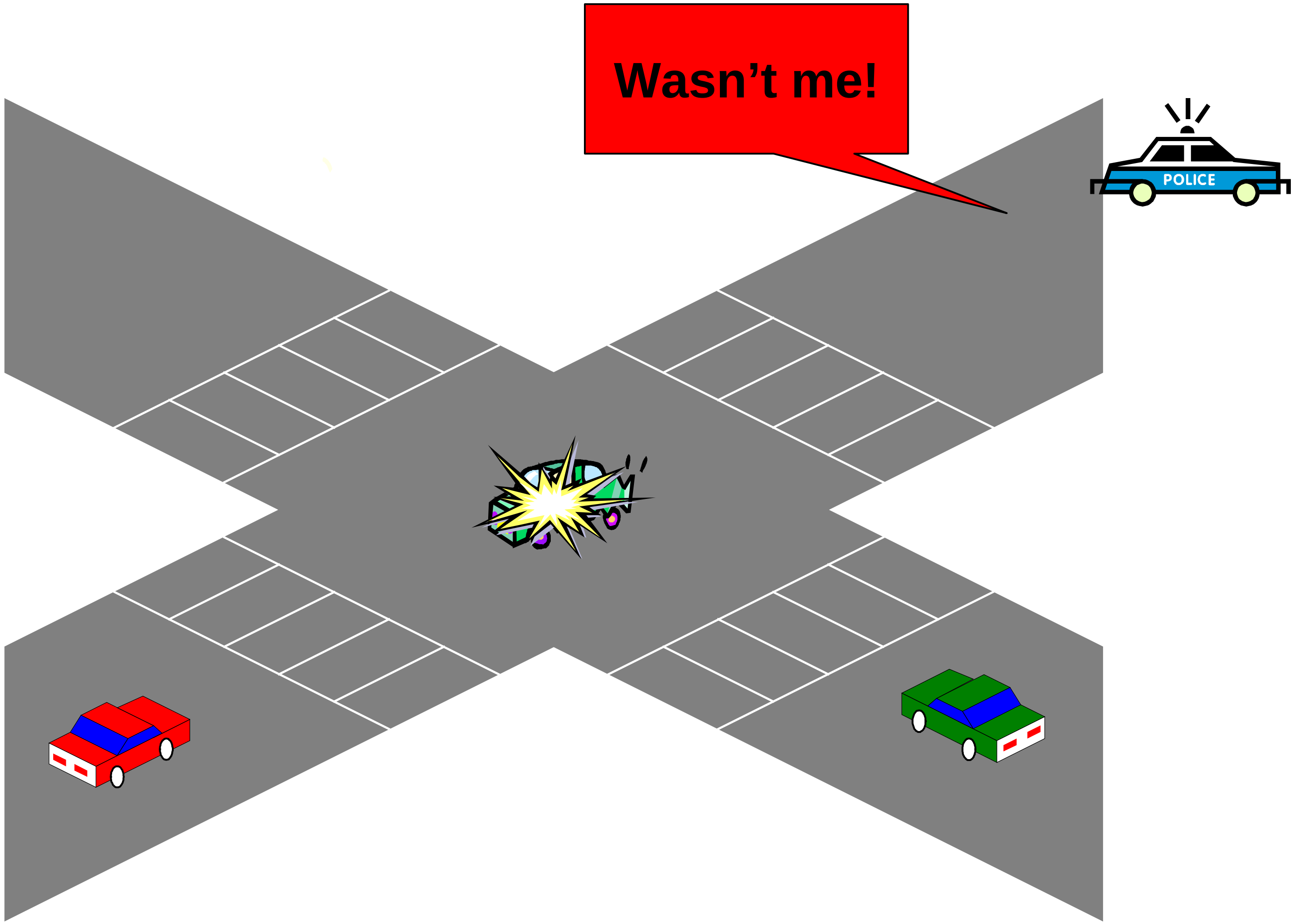


Requirements

- Point of caution
  - Not all requirements listed here are relevant to all applications and scenarios

- (1) Message Authentication and Integrity
  - Messages must be protected from any alteration and the receiver of a message must corroborate the sender of the message

Requirements (cont'd)

- (2) Entity authentication
  - The receiver is ensured that the sender generated a message *recently*
- (3) Message Non-Repudiation
  - The sender of a message cannot deny having sent a message
- (4) Access control
  - Distinct roles for different types of network entities
  - Regulate access to information/services
  - *Authorization:* Establish what each network entity is allowed to do (e.g., protocols to run, messages to send)

Requirements (cont'd)

- (6) Message Confidentiality
  - The content of a message is kept secret from those nodes that are not authorized to access it

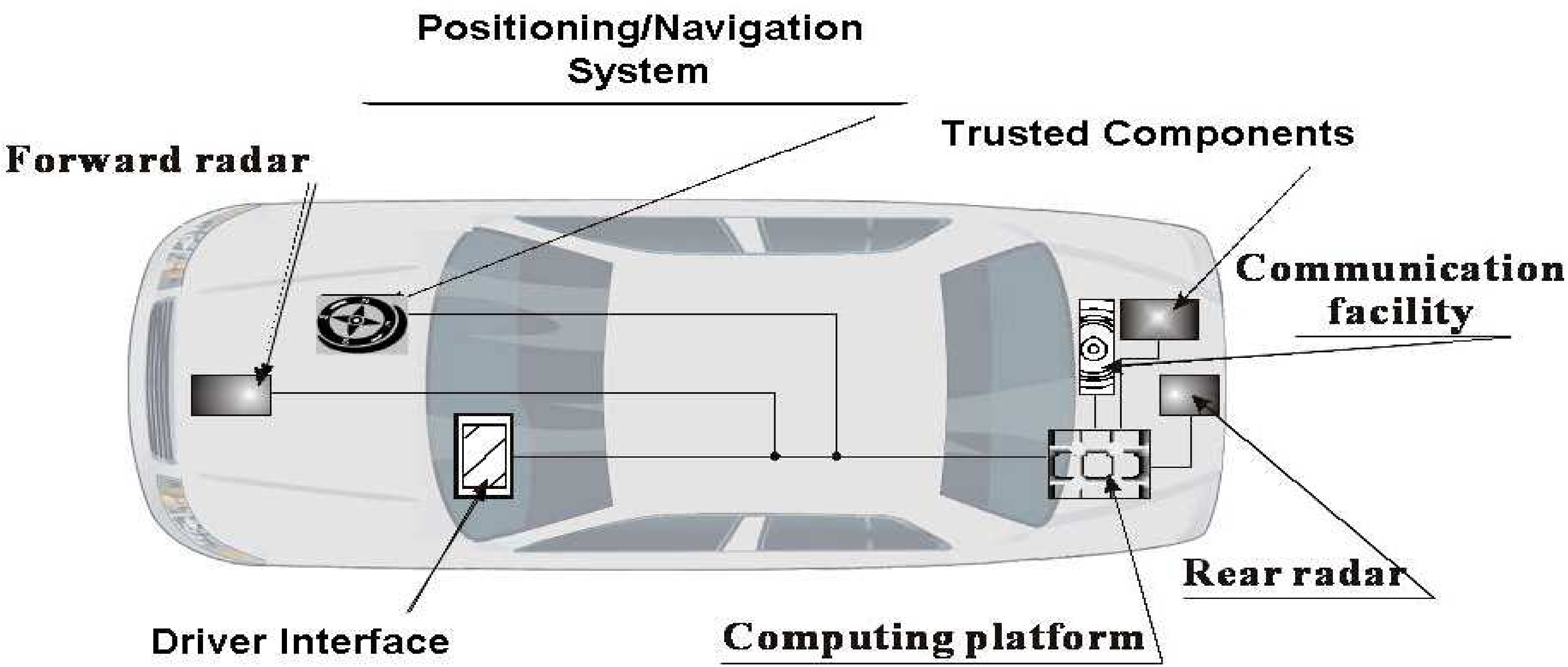
- (7) Privacy - Anonymity
  - *VC* systems should not disclose or allow inferences on the personal and private information of the users
  - At *minimum*, an observer can*not* learn if a node performed, or will perform in the future, a specific action, assuming that the node performs the action

Requirements (cont'd)

- (8) Availability
  - Protocols and services should remain operational even in the presence of faults, malicious or benign
  - Secure and fault-tolerant designs
  - Resilience to resource depletion attacks
  - Self-stable protocols
- (9) Liability
  - Users of vehicles are liable for their deliberate or accidental actions that disrupt the operation of other nodes, or the transportation system
  - The VC system should provide information that assists the attribution of liability
  - Auditing

Security architecture

- Smart vehicle



Security architecture (cont'd)

- Node *V*
  - Unique identity
  - Public / private key pair
    - K_V, k_V
  - Certificate
    - $Cert_X\{K_V,A_V\}$
  - Central processing and communication module
- Additionally (optionally)
  - Set of additional credentials/certificates and cryptographic keys

Security architecture (cont'd)

- Trusted components
  - Tamper-resistant
  - Storage
    - Cryptographic material
    - Data
  - Processing
    - Cryptographic operations
  - Motivation
    - Current state; Event Data Recorders (EDRs)
    - Bind physically cryptographic material to the vehicle

Security architecture (cont'd)

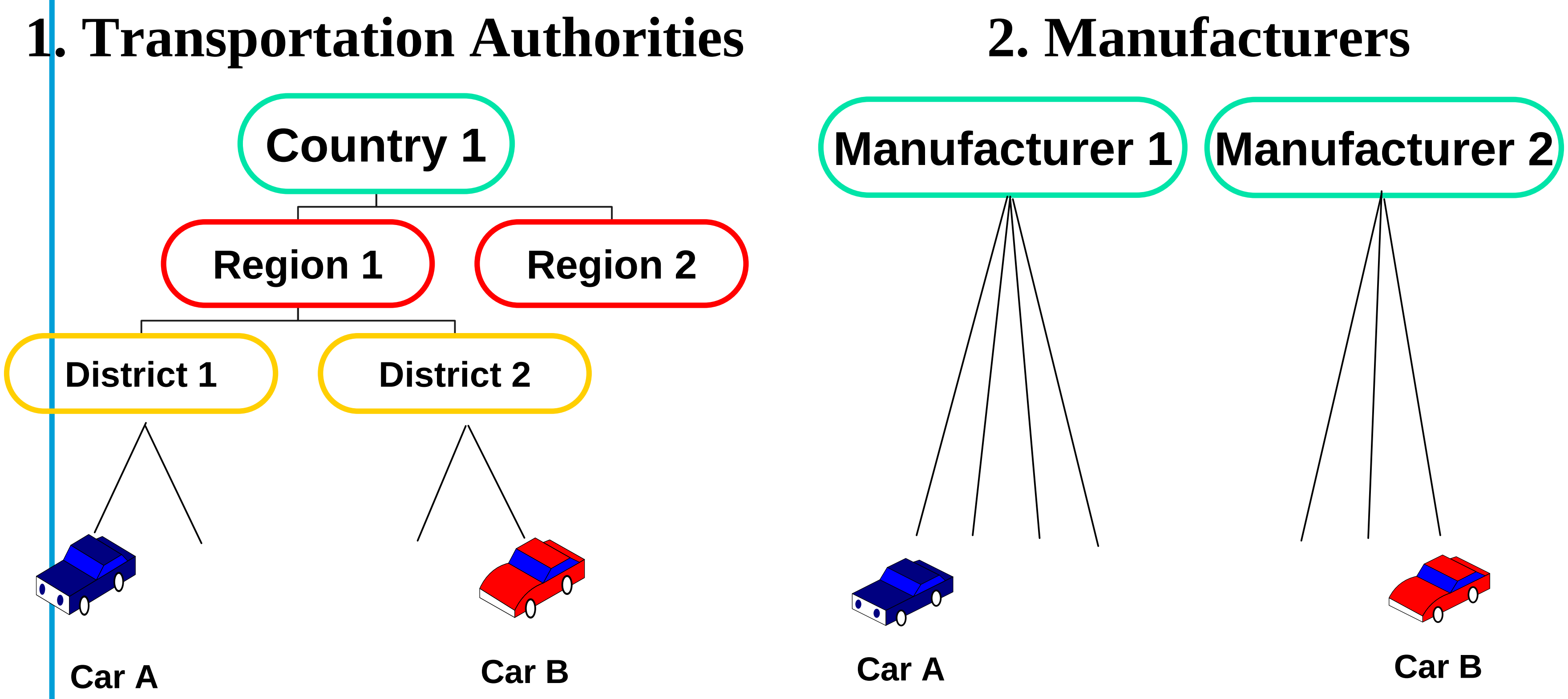
- Public (e.g., emergency, police, buses) vehicles
- Infrastructure (road side units)
- Assigned special roles and attributes
  - Relatively more trustworthy
  - Facilitate security-related operations

Security architecture (cont'd)

- Authorities
  - Trusted entities issuing and managing identities and credentials for all *VC* system entities
  - Multiple and distinct
  - S_X set of *VC* system entities registered with an authority *X*
- Also known as:
  - Certification Authorities (CAs)
  - (Vehicular) Public Key Infrastructure

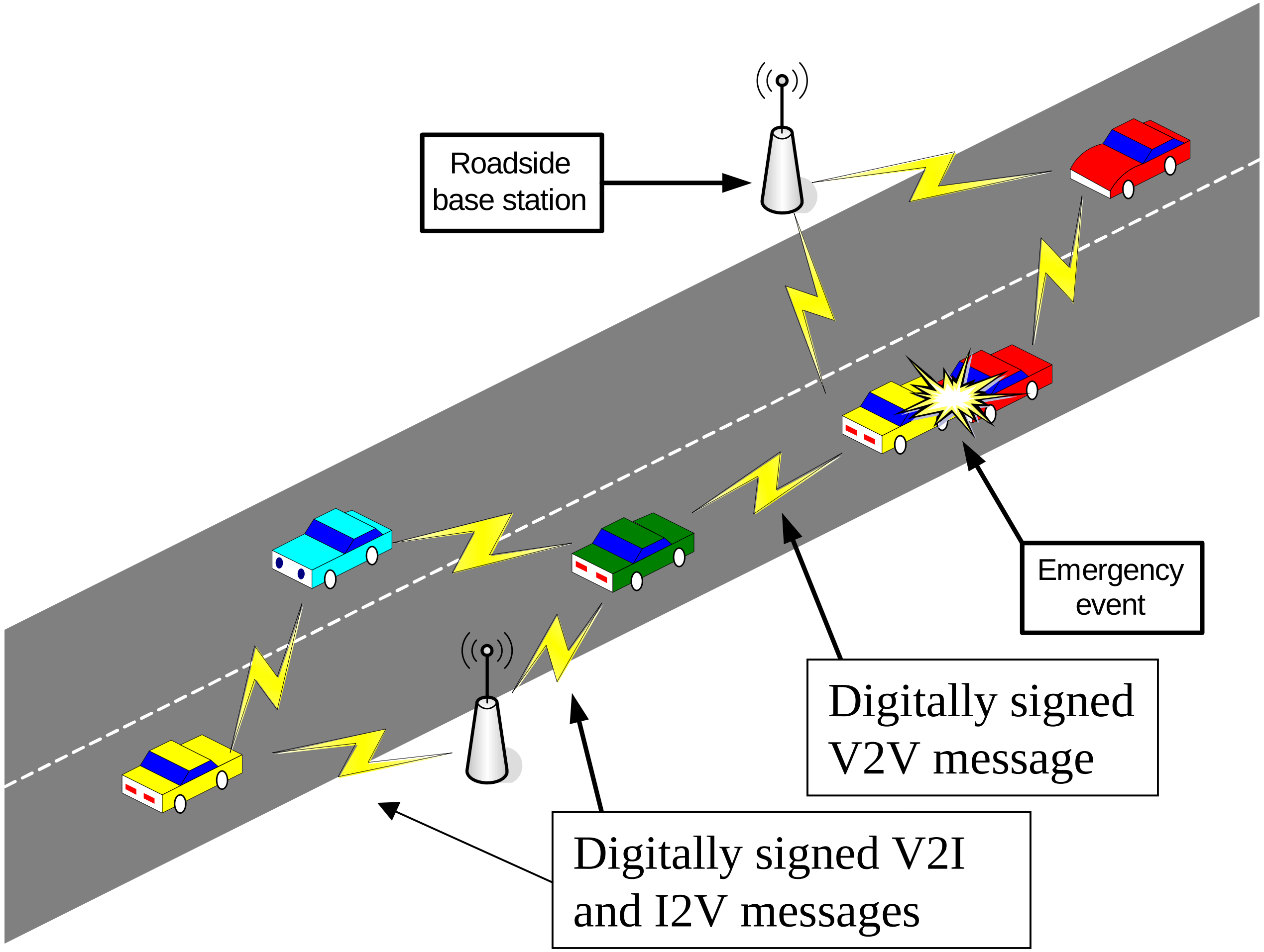
Security architecture (cont'd)

- Options for instantiating an Authority

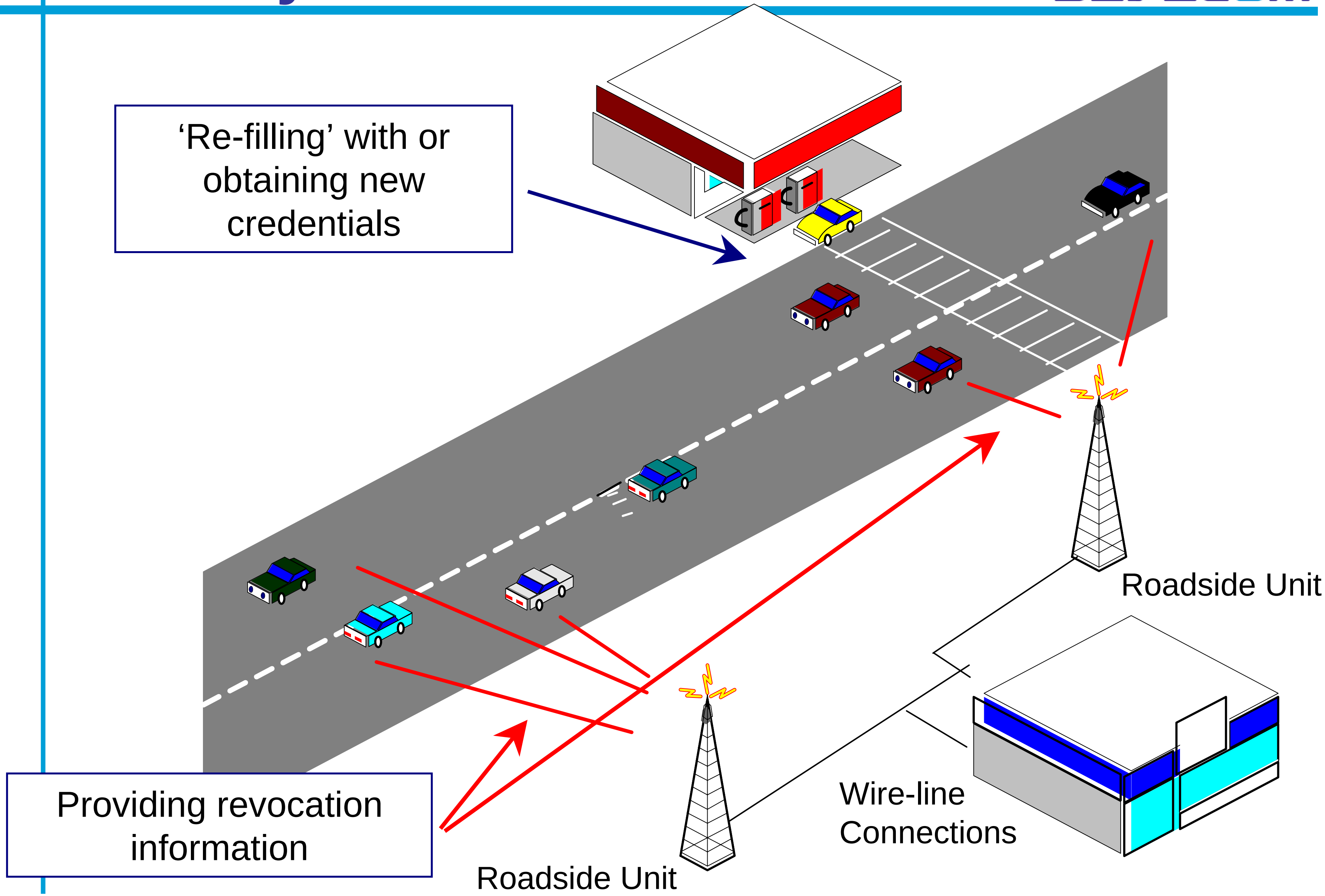


Security architecture (cont'd)

- Vehicle-to-vehicle (V2V) and Vehicle-to-Infrastructure (V2I) secure communication

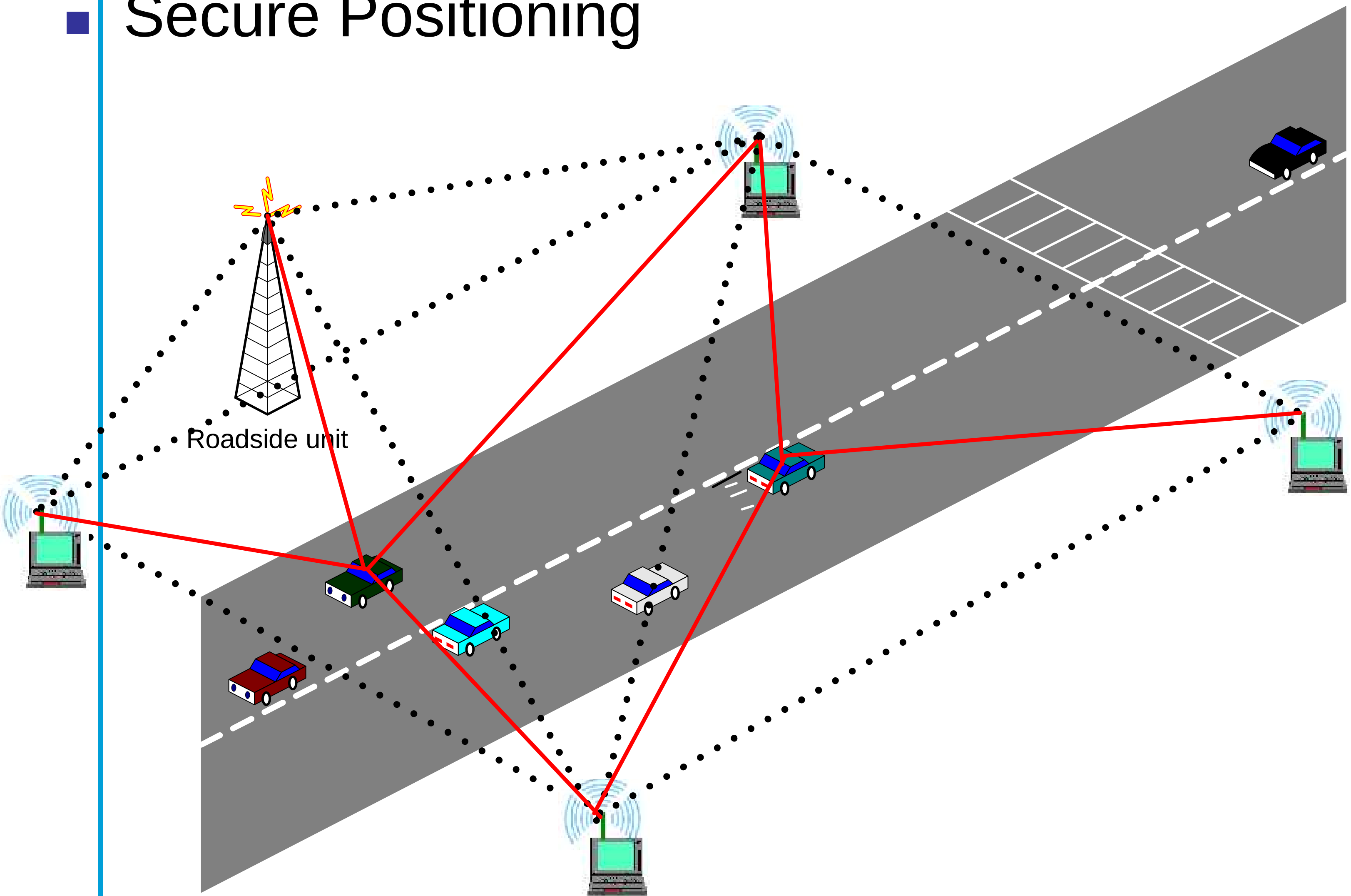


Security architecture (cont'd)



Security architecture (cont'd)

- Secure Positioning

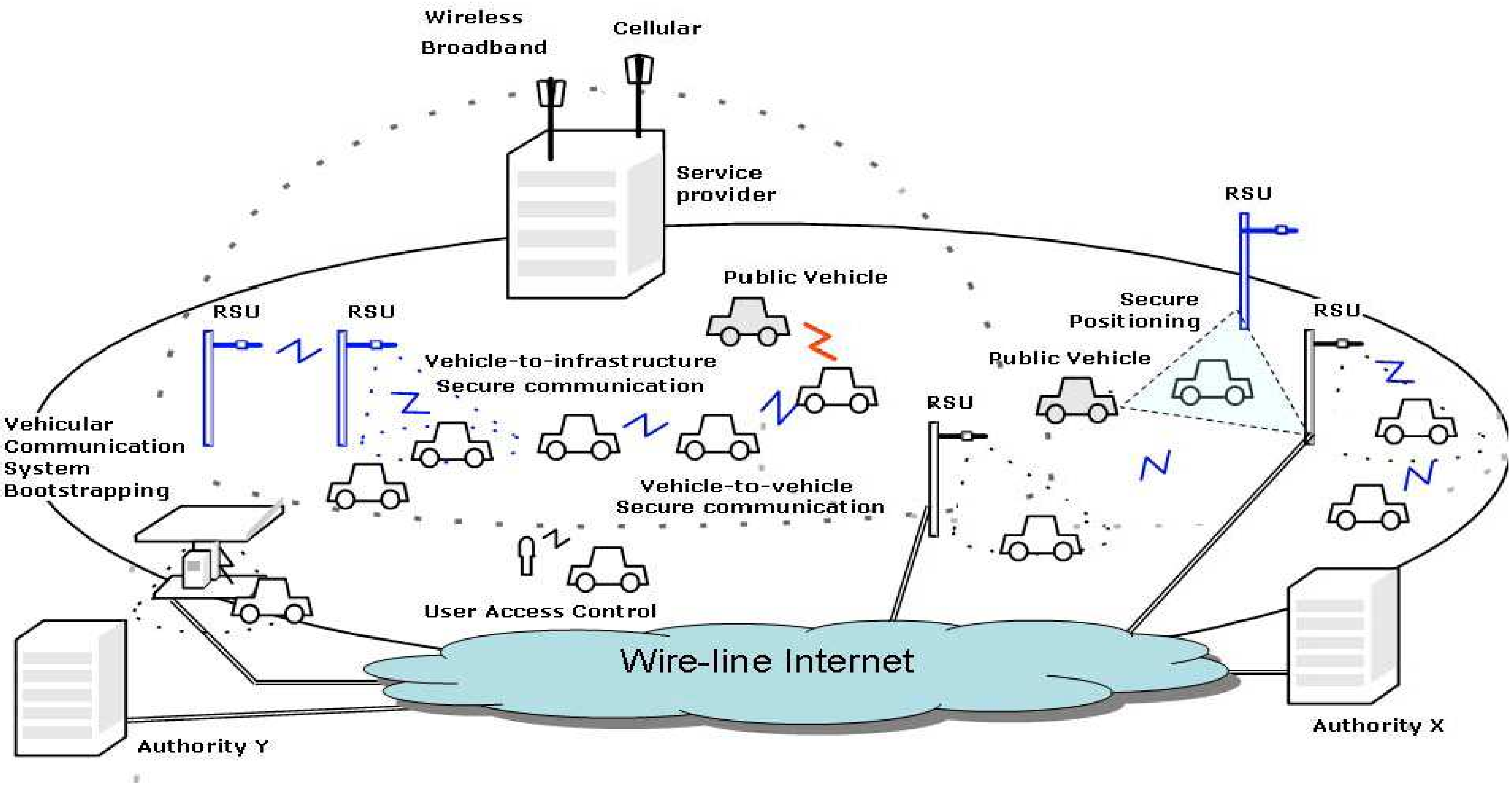


Security architecture (cont'd)

- Other aspects
  - In-car security
  - User identification
  - User-vehicle association
  - Resilience to false measurements/data
  - Resilience to resource-depletion Denial of Service (DoS) attacks
  - …

Security architecture (cont'd)

- Overall System View



Conclusion

- Security and privacy-enhancing mechanisms for vehicular communication systems are a prerequisite for their deployment
- Securing VC systems is a complex problem
- On the positive side
  - Real problem
  - Constrained problem space
- Opportunity
  - Awareness
  - Joint efforts in industry and academia
  - Standardization

Questions?

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