Security in connected autonomous vehiculars

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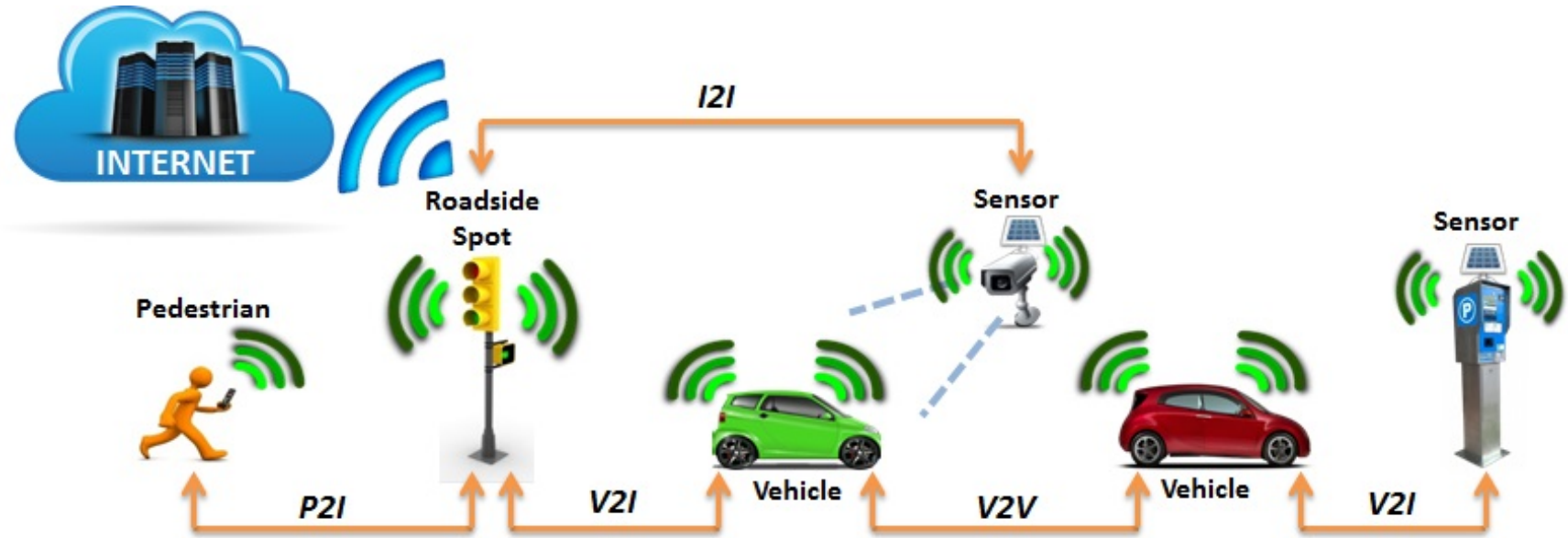
7 January 2019

LABORATOIRE D'INFORMATIQUE,
DE MODÉLISATION ET D'OPTIMISATION DES SYSTÈMES

VANET : Vehicular Ad-hoc NETworks



Communications

- V2V: Vehicular to Vehicular
- V2I: Vehicular to Infrastructure
- I2I: Infrastructure to Infrastructure
- P2I: Pedestrian to Infrastructure

Challenges in VANETs

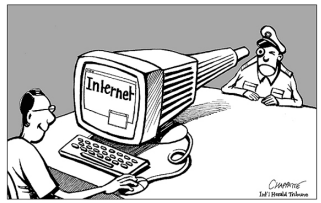
- Mobility
- Connection volatility
- Privacy vs Authentication
- Network scalability
- Bootstrap
- Security

Security Requirements in VANETs

Data exchanged play a VITAL role in traffic safety.

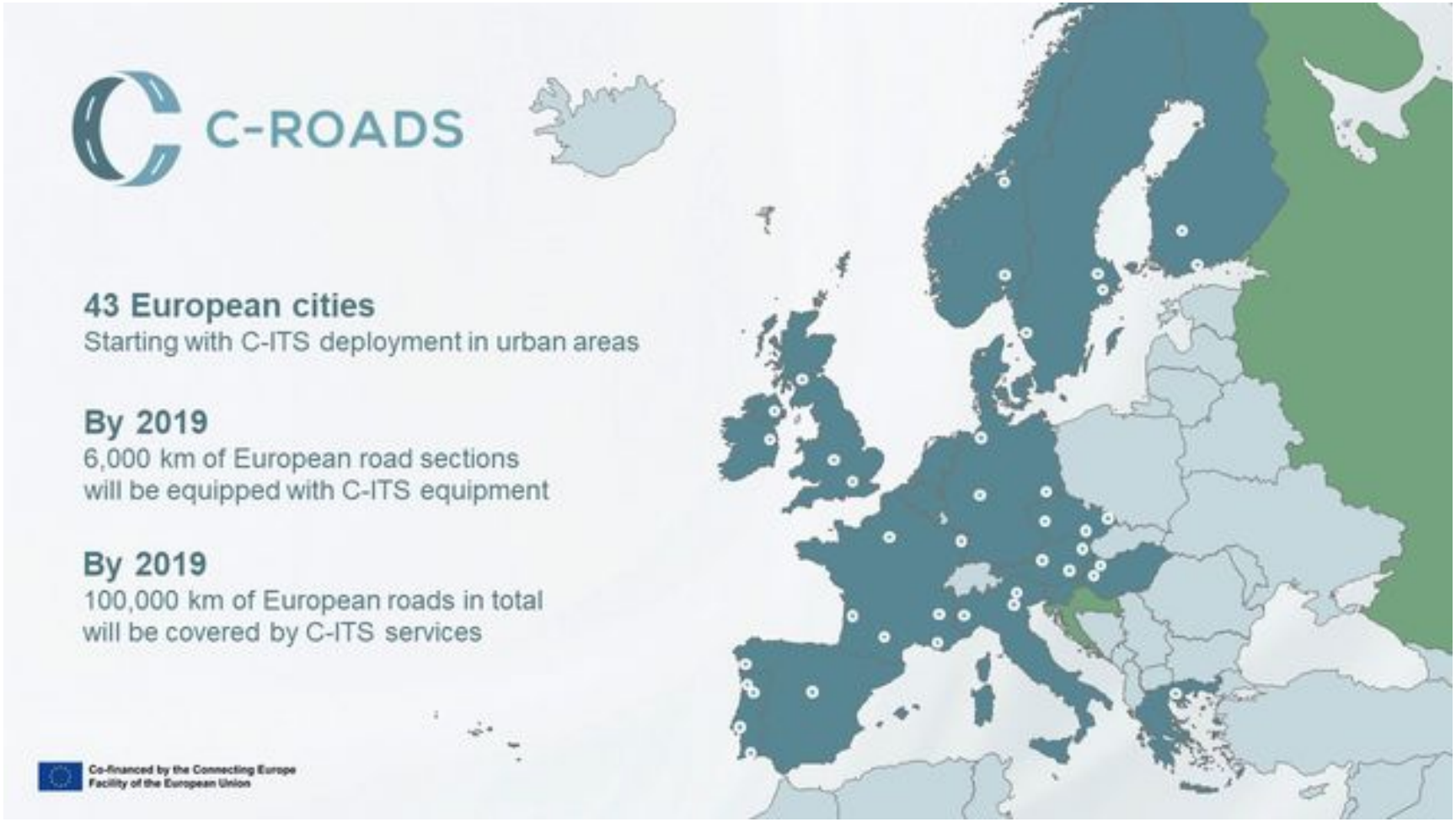
Properties

- Data Integrity
- Data Confidentiality
- Data Privacy
- Authentication
- Non-repudiation
- Avaibility
- Realtime constraints



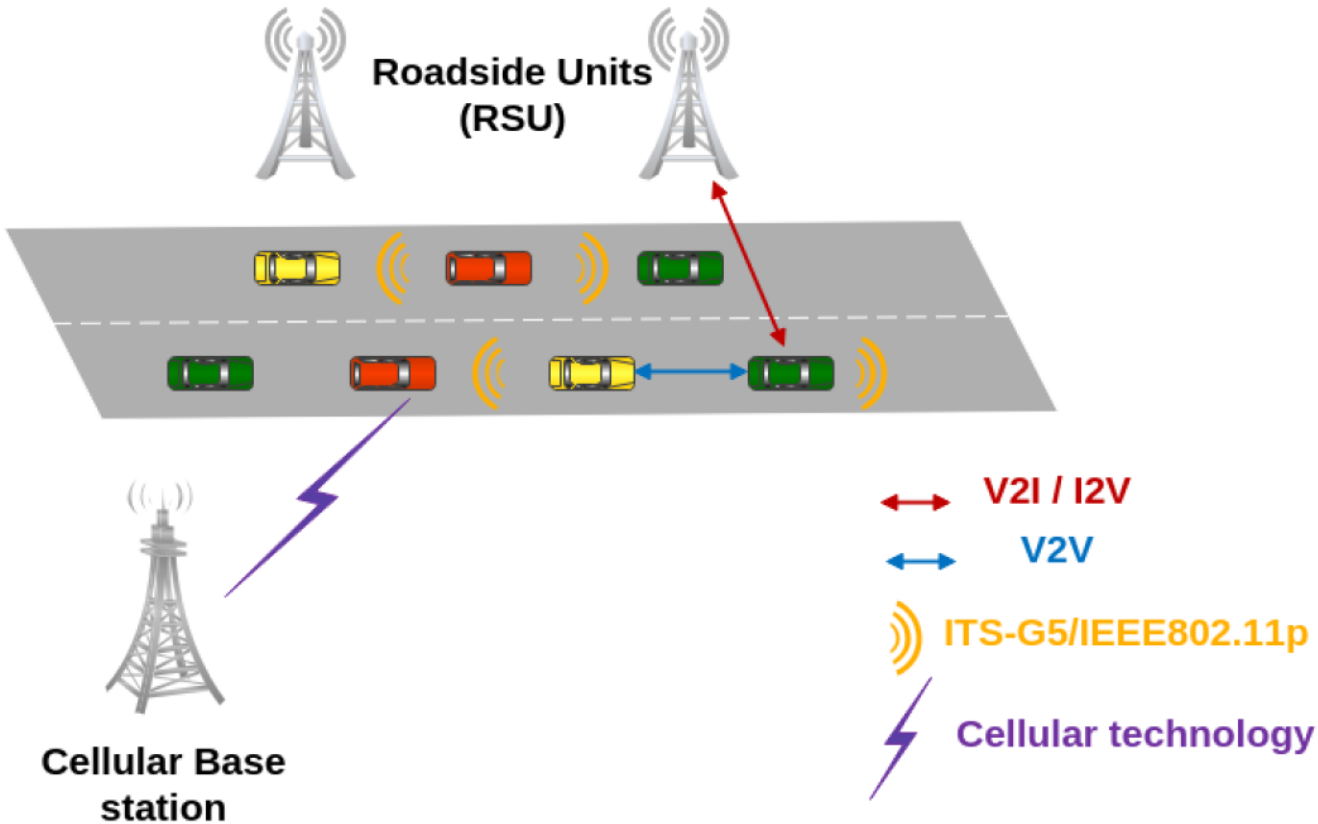
Outline

Outline

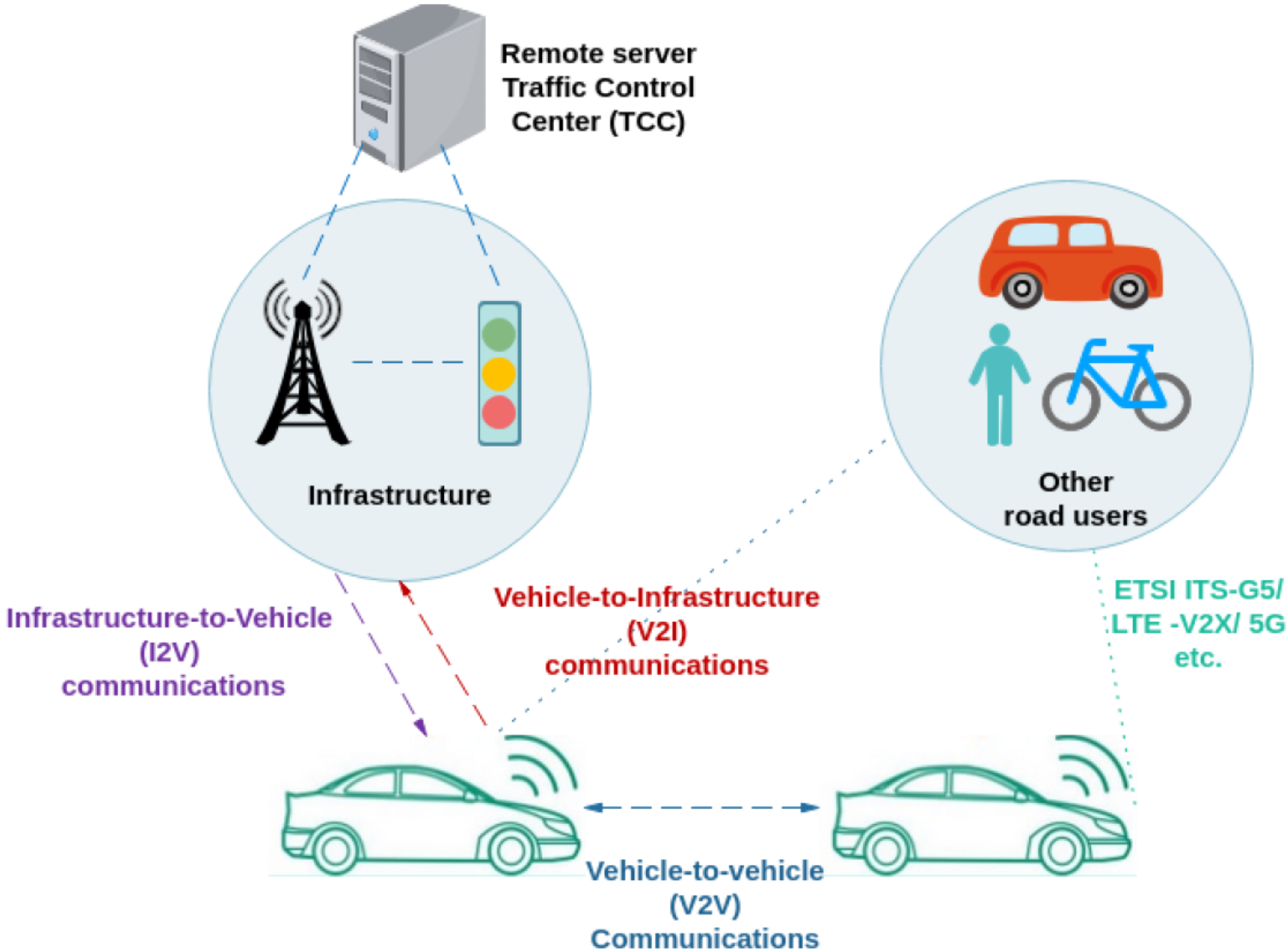

C-ROADS
43 European cities
Starting with C-ITS deployment in urban areas
By 2019
6,000 km of European road sections
will be equipped with C-ITS equipment
By 2019
100,000 km of European roads in total
will be covered by C-ITS services
Co-financed by the Connecting Europe
Facility of the European Union

Cooperative Intelligent Transport Systems (C-ITS)

- C-ITS communications.
- ETSI ITS-G5/Cellular technology.

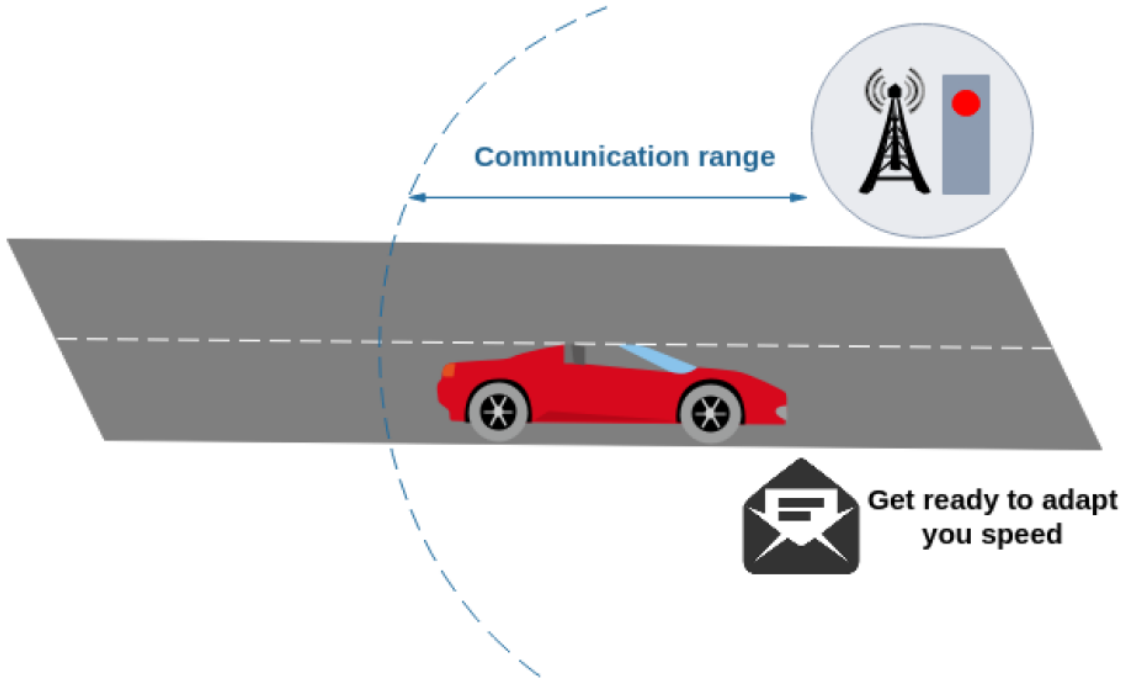


Cooperative Intelligent Transport Systems (C-ITS)

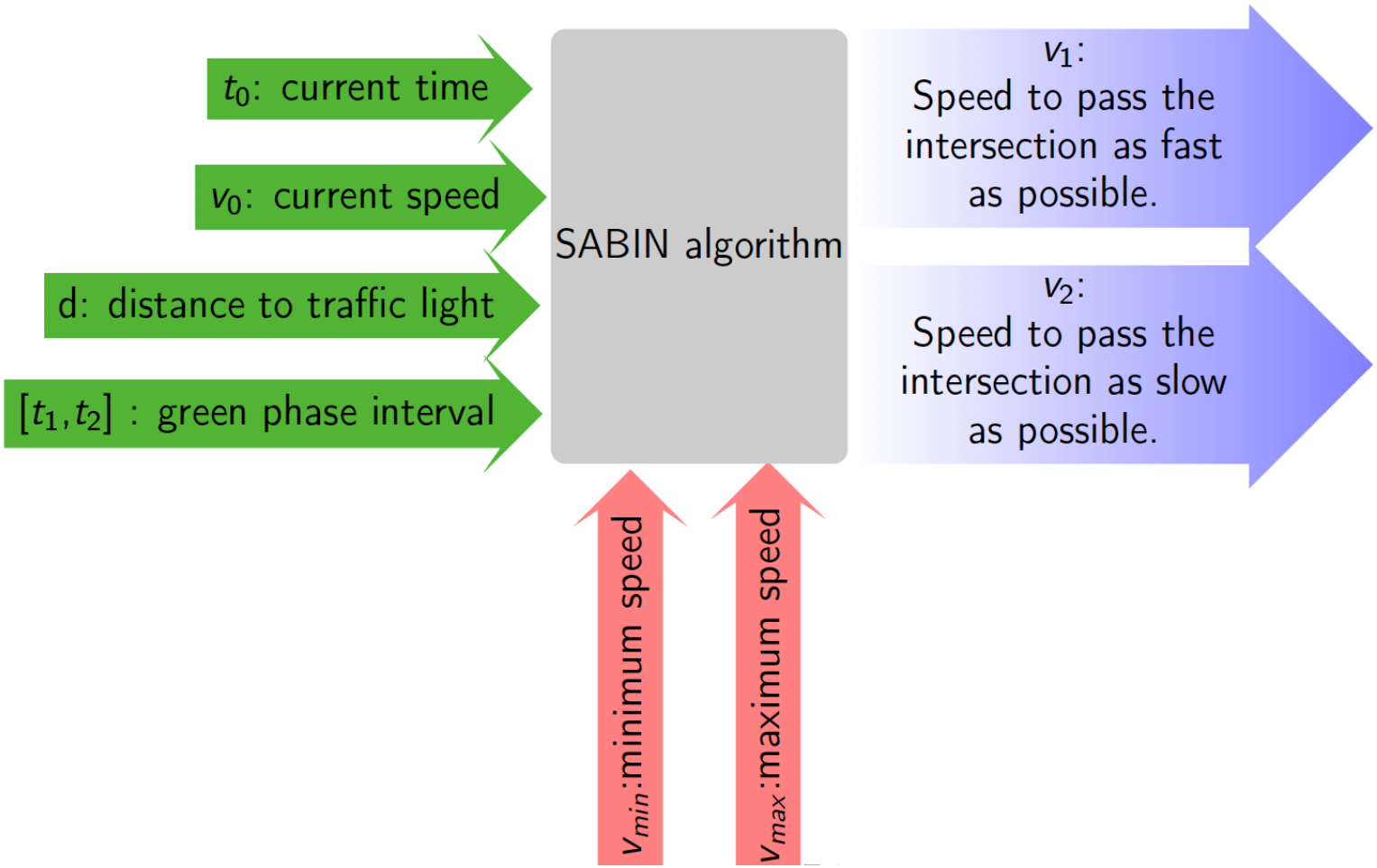


Green Light Optimal Speed Advisory (GLOSA)

A traffic efficiency C-ITS service that uses **Infrastructure-to-vehicle (I2V)** communication mode.



Speed Advisory Boundary fINder (SABIN)



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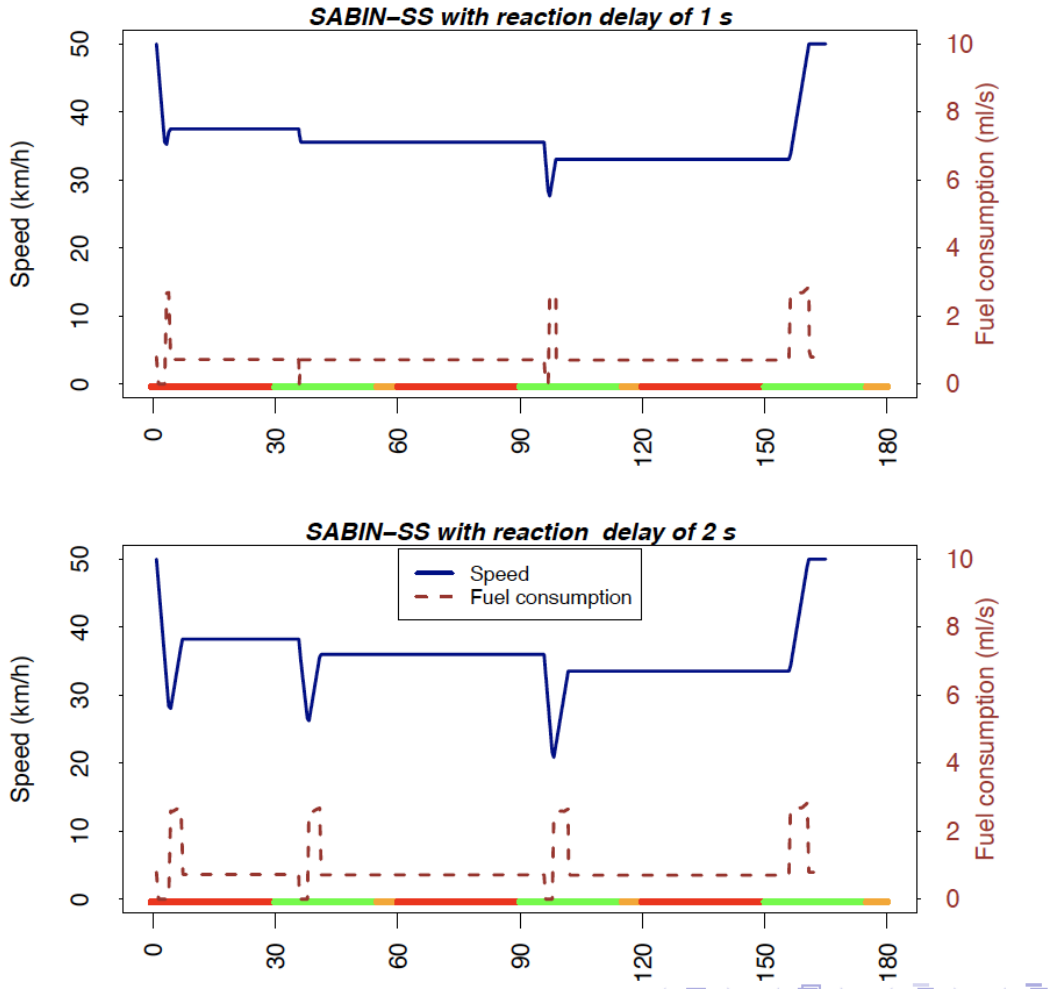
Evaluation of SABIN



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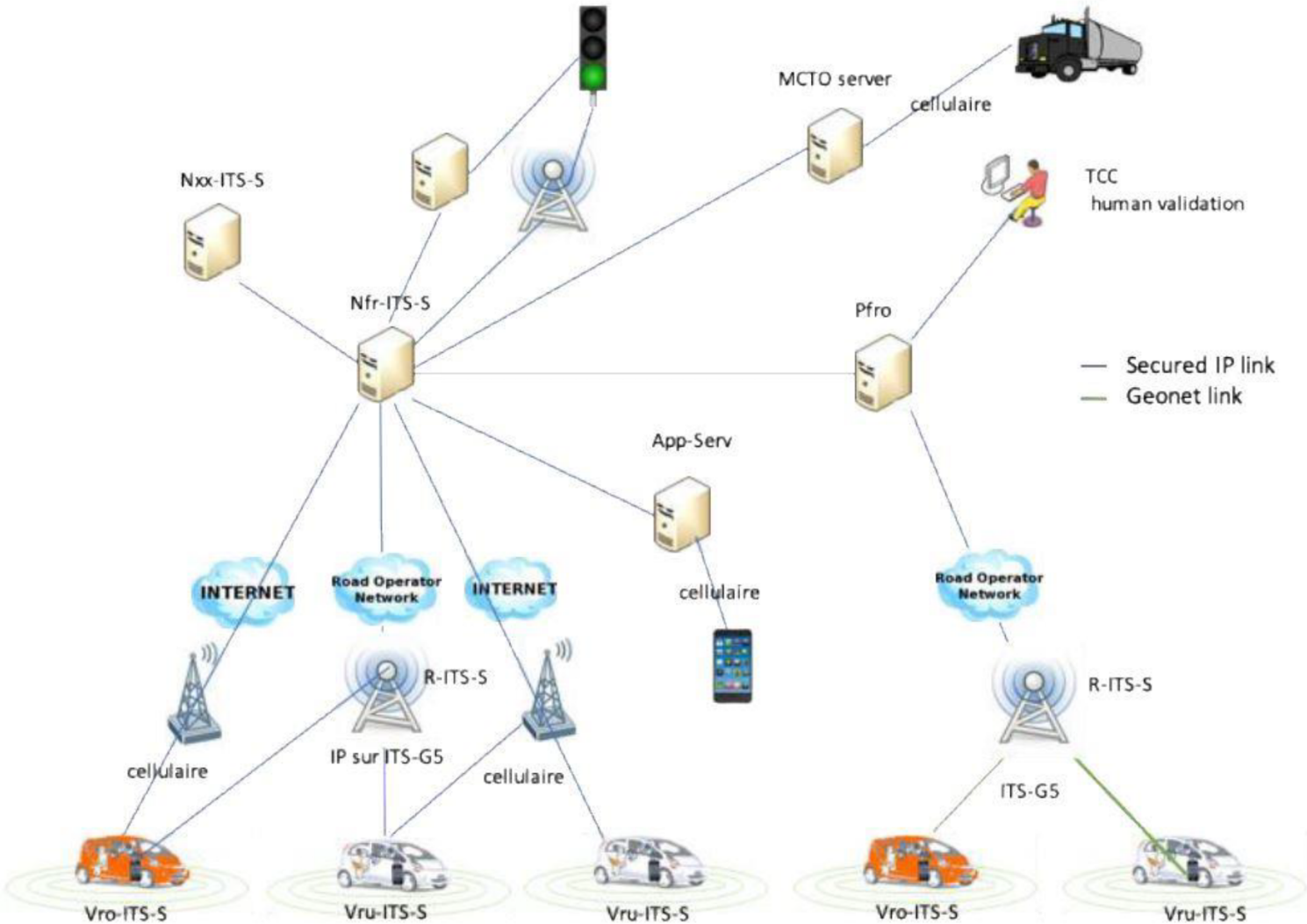
Infrastructure



InDid (2019-2024)

Outline

Clef symétrique

Exemples

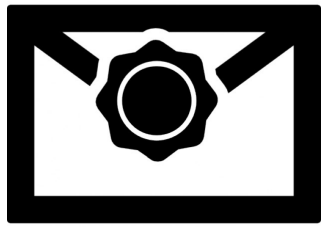
- DES
- AES

Chiffrement à clef publique

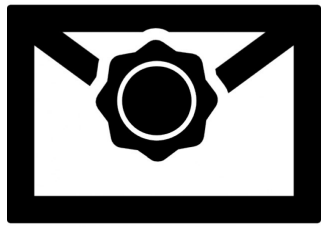
Exemples

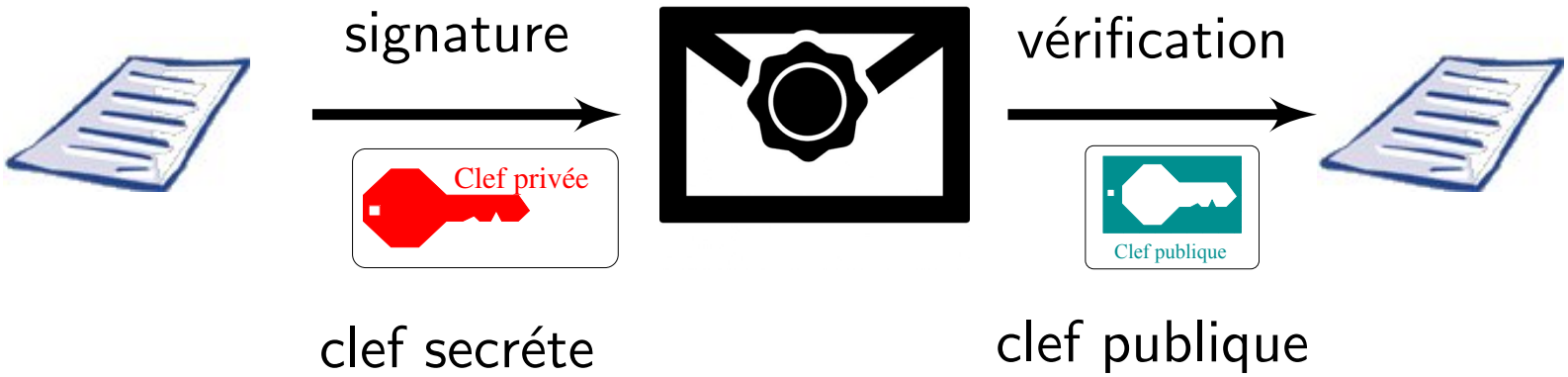
- RSA : $c = m^e \mod n$
- ElGamal : $c \equiv (g^r, h^r \cdot m)$

Signature



Signature





RSA: $m^d \mod n$

PKI : Public Key Infrastructure

- Utiliser des clefs publiques
- Établir une clef symétrique de session
- Confiance
- Certificats
- Authorité de certifications
- Chaîne de confiance

Public Key Infrastructure (PKI)

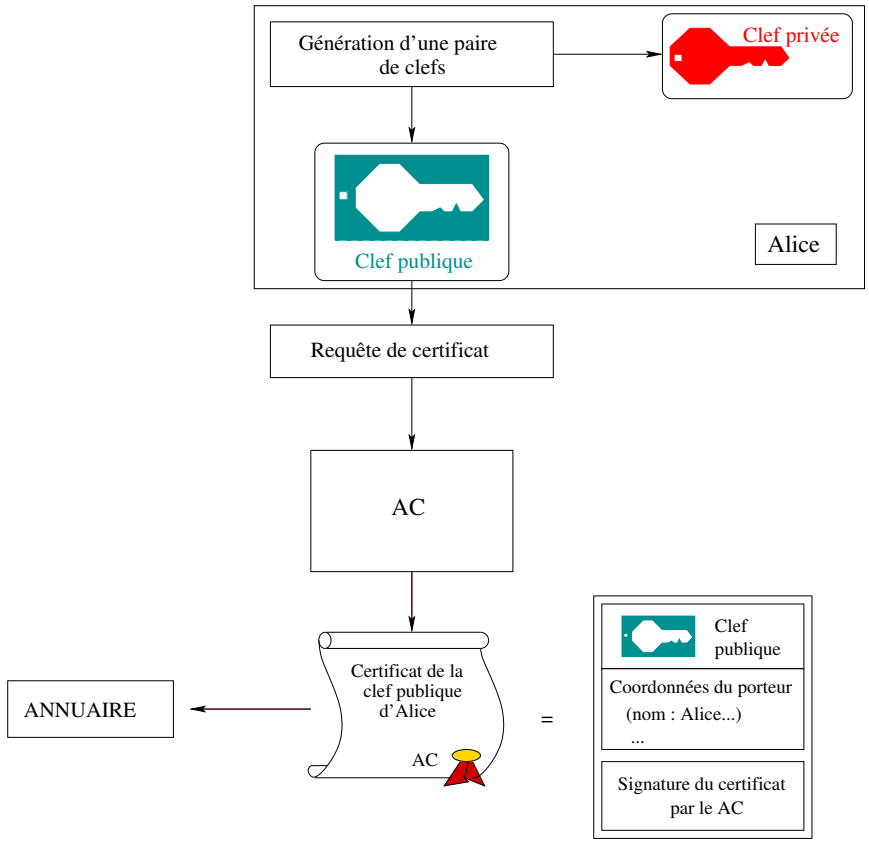
Principales fonctionalités d'une PKI

- Création d'une paire de clef
- Génération d'un certificat
- Remise du certificat au porteur
- Publication des certificats
- Vérification des certificats
- Révocation des certificats (CRL)

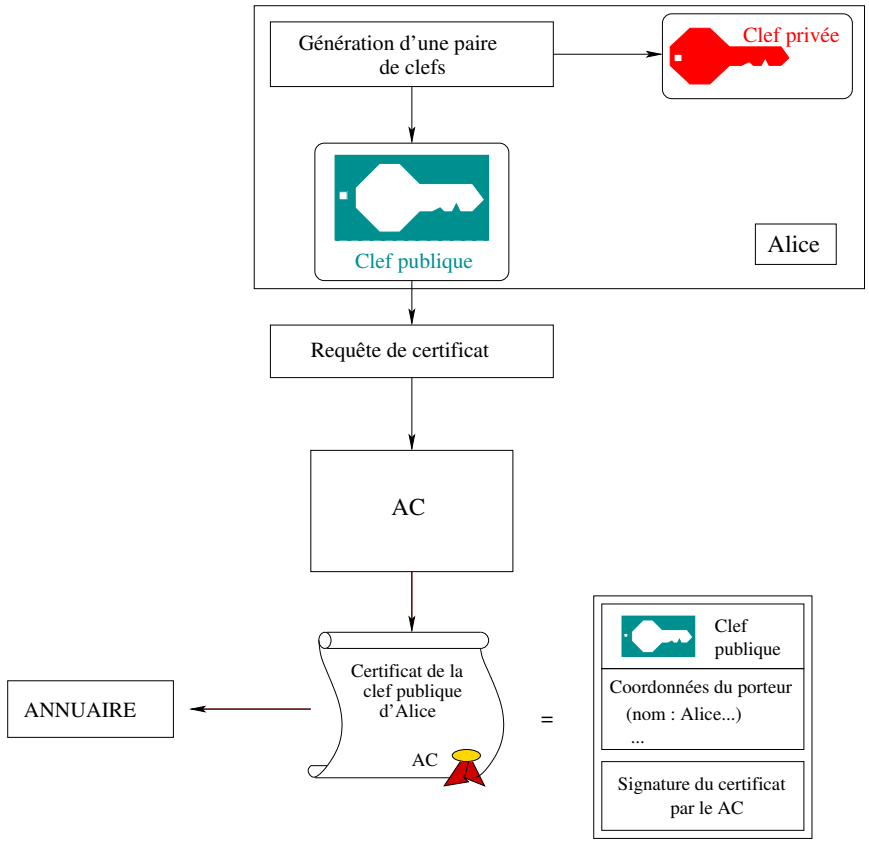
AC : Authorité de Certification

AE : Authorité d'Enregistrement

Public Key Infrastructure (PKI)



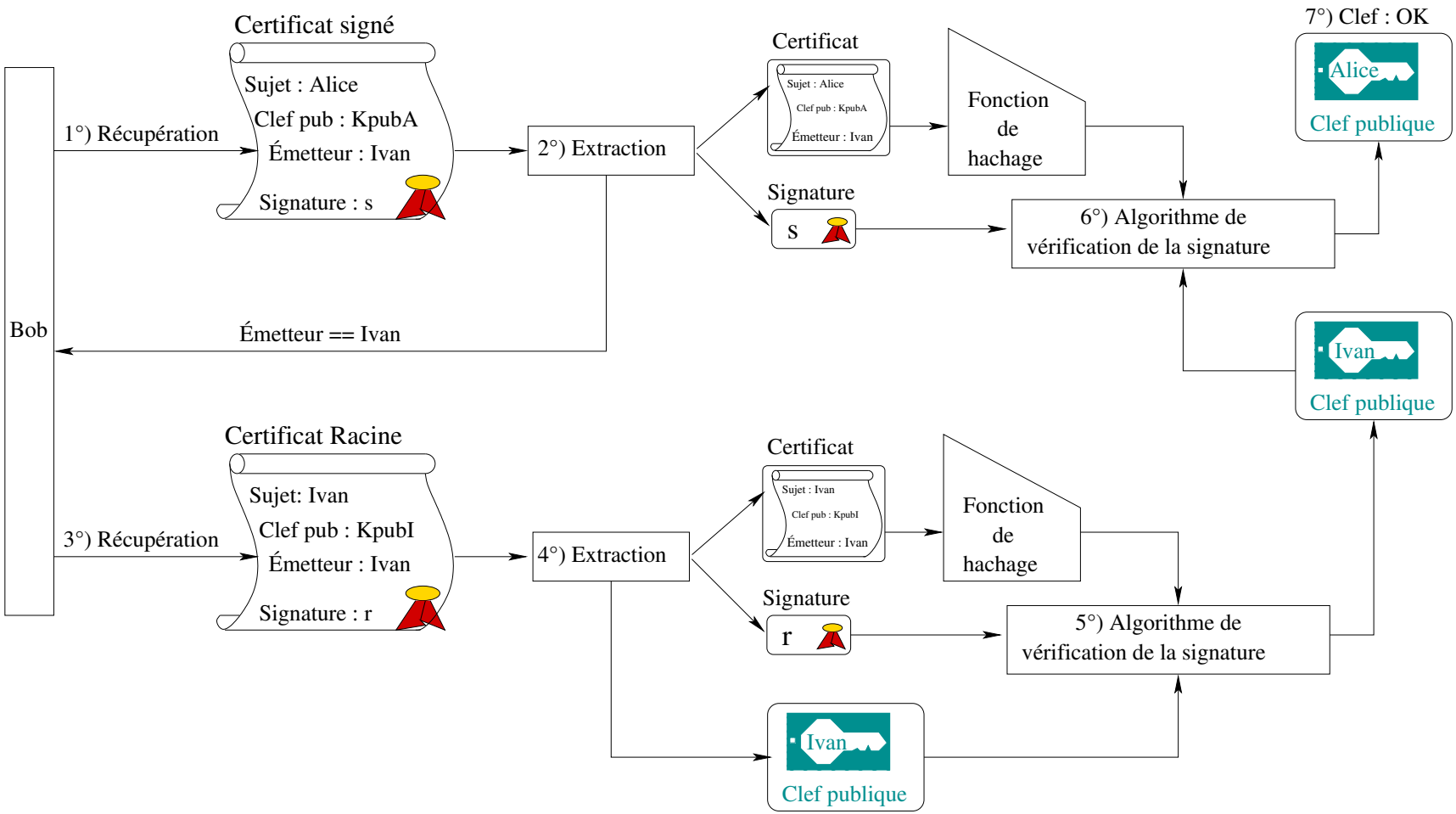
Public Key Infrastructure (PKI)



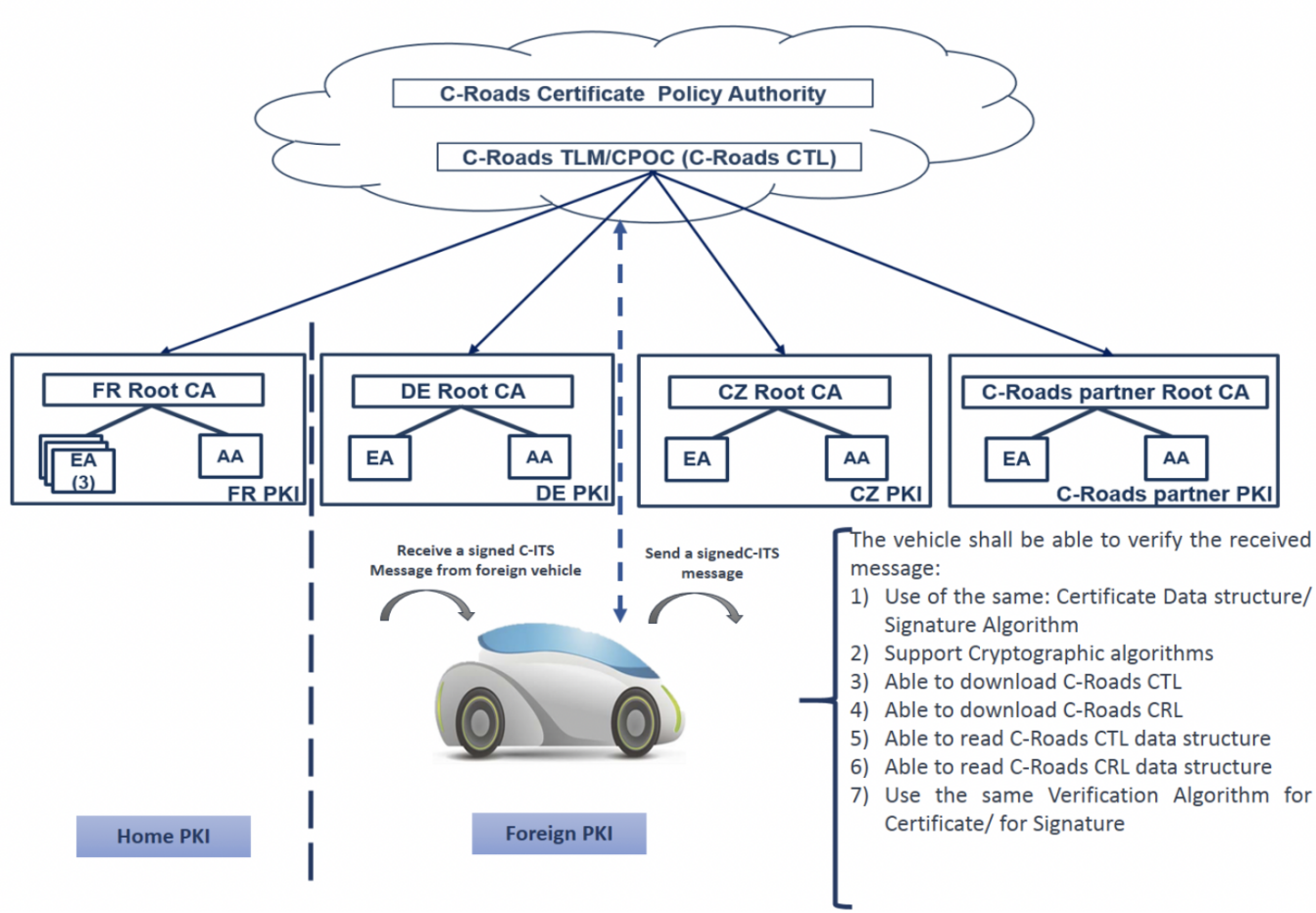
Authentification de l'AC confiance assurée par

- Chaîne de certificats
- Certificat racine ou certificat auto-signé

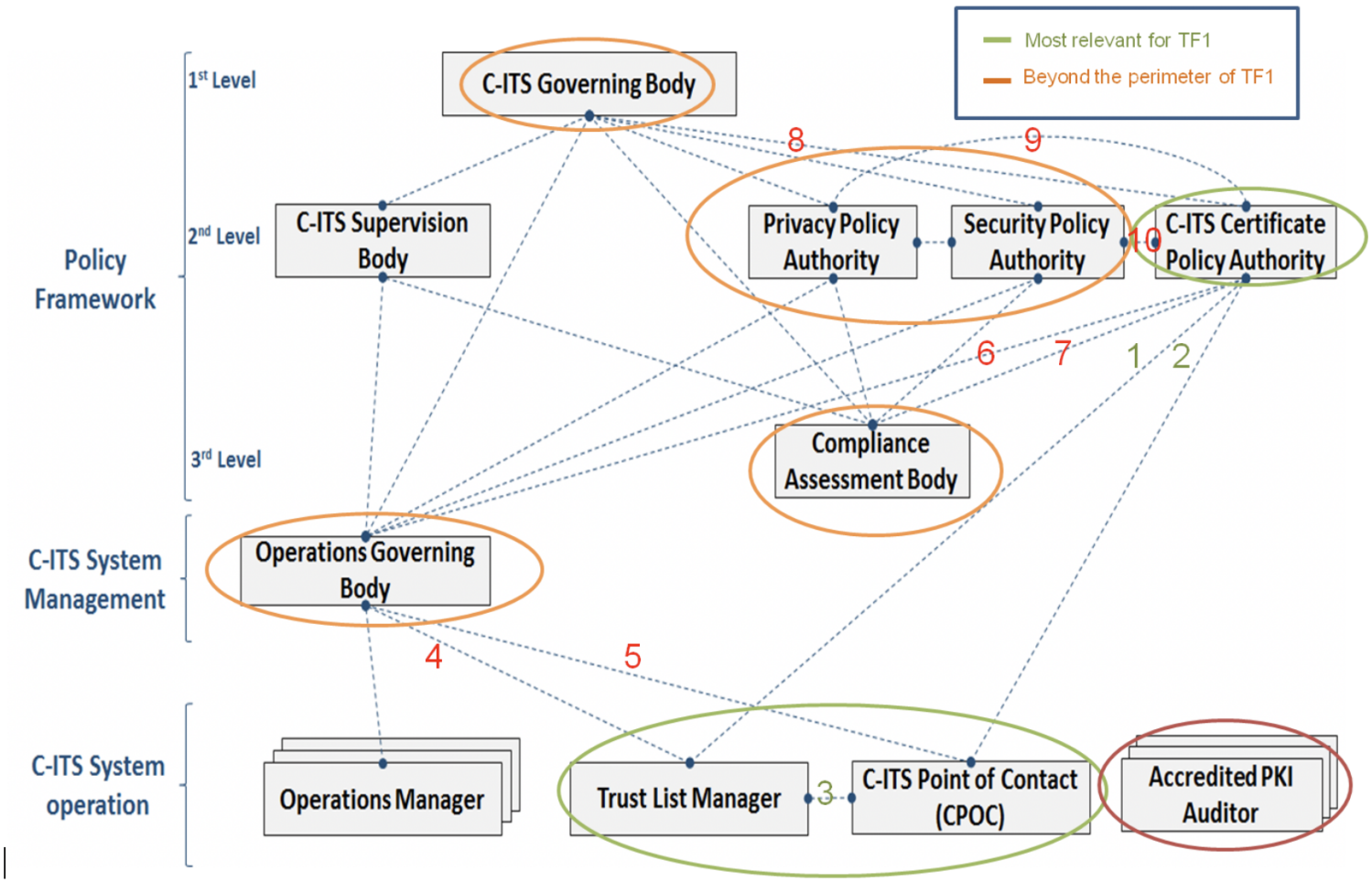
Vérification



Interoperability



PKI Management

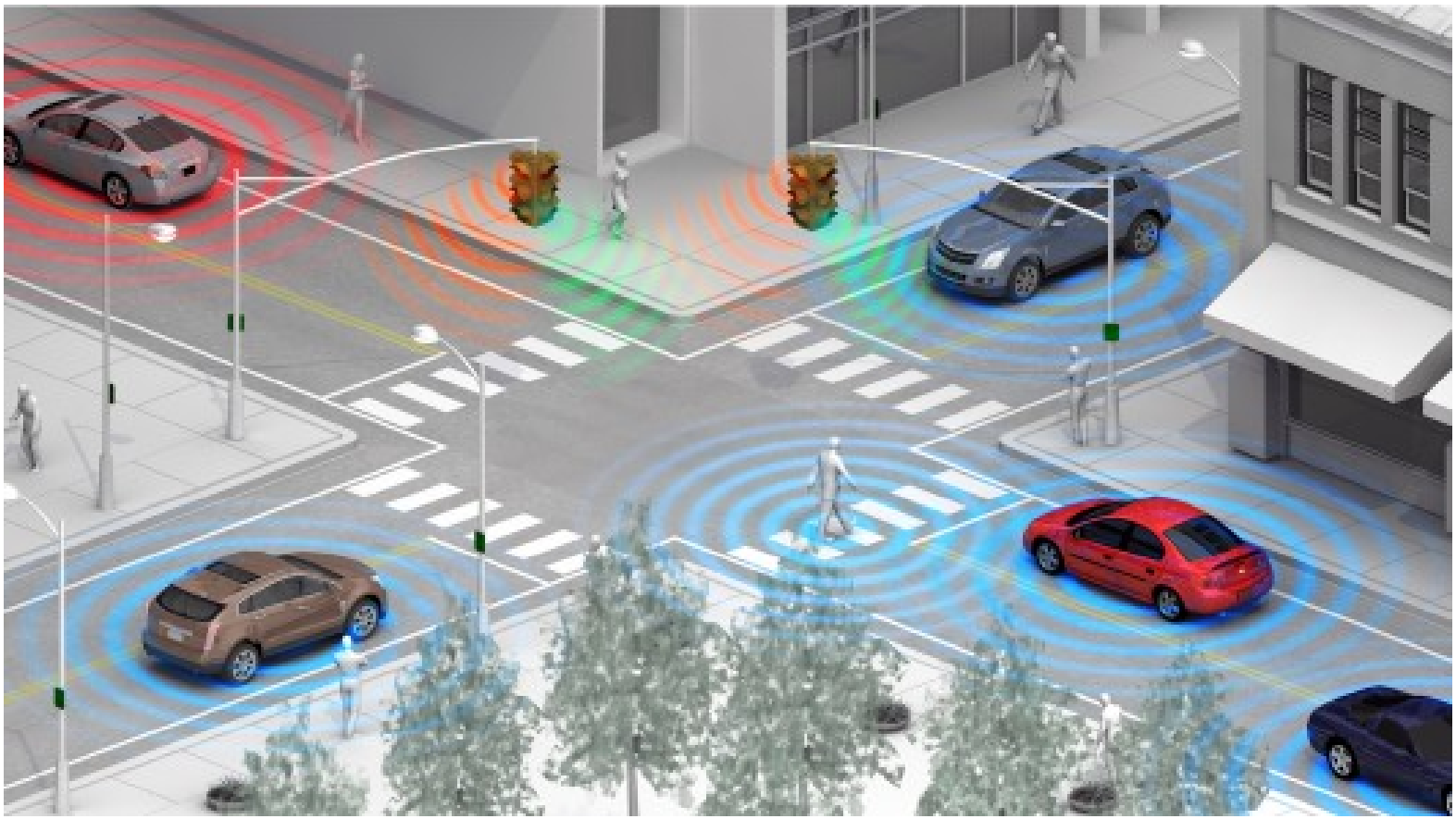


PKI Security Challenges

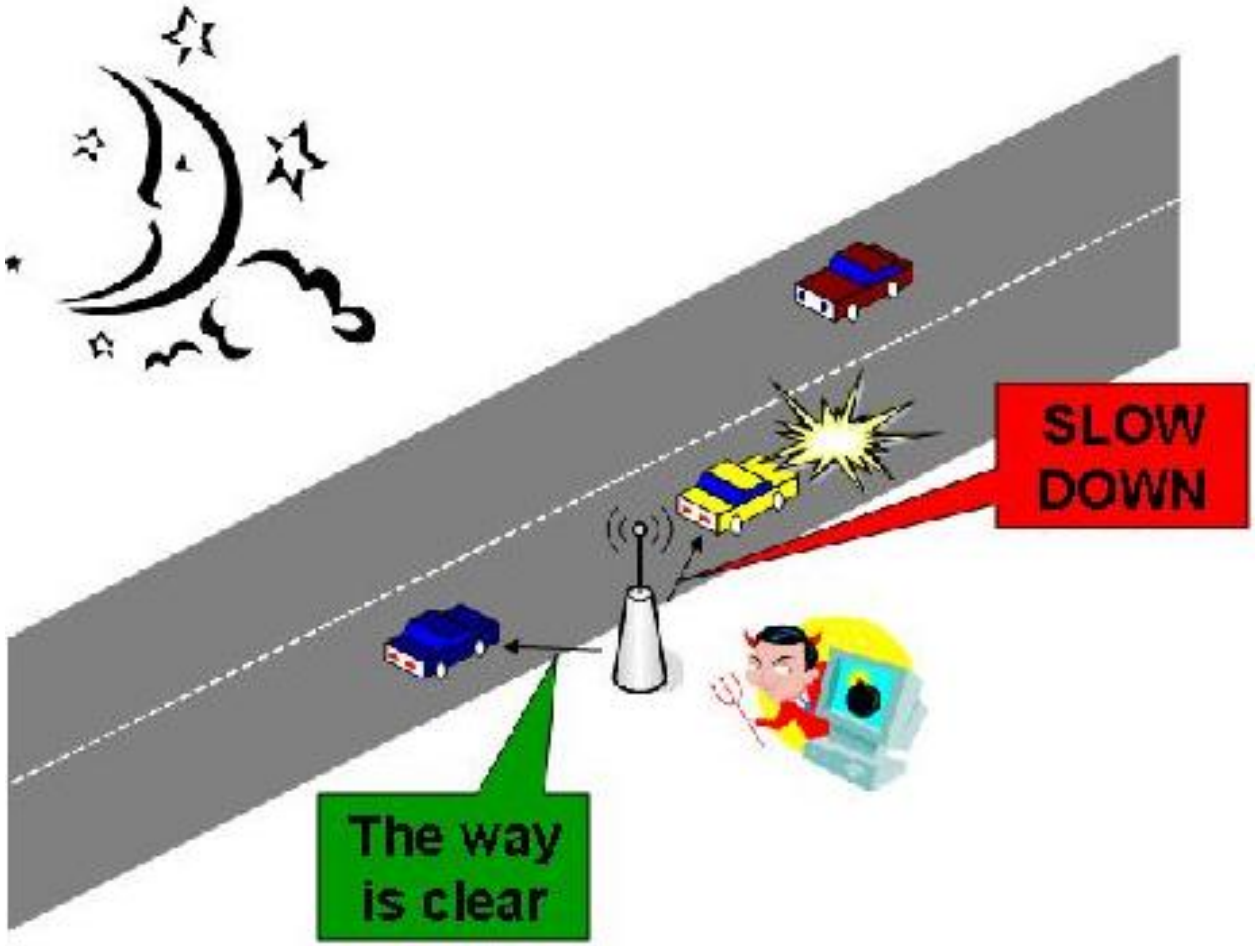
- Key management
- Privacy
- Interoperability
- Different countries

Outline

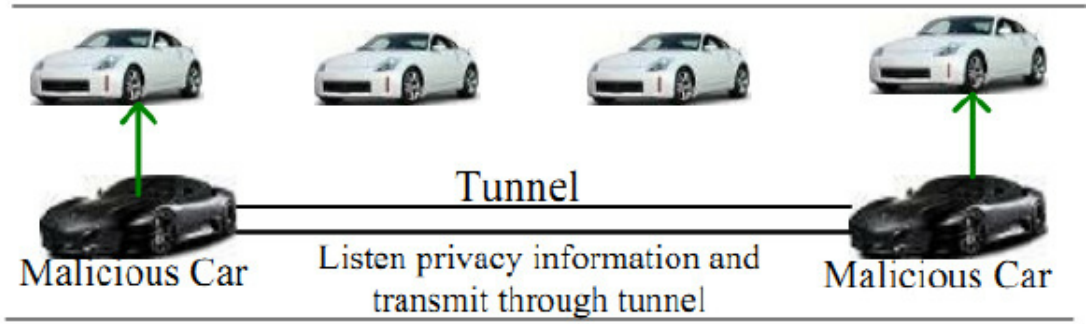
V2V and V2I



Attack on Infrastructure



Wormhole Attack



Proximity Devices Everywhere

What features do we want?

- Security
- Privacy

Examples of Attacks

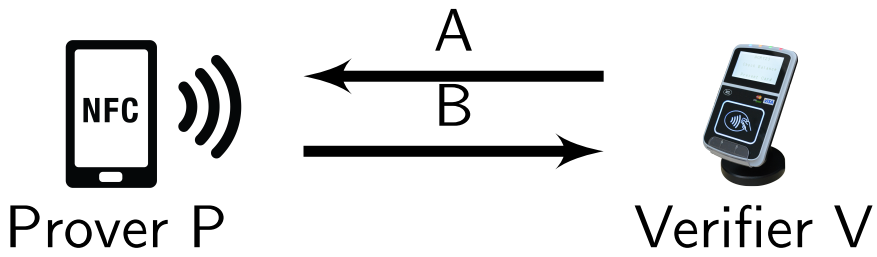
2 VIDEOS

- Achats de tickets de transport
- Ouverture de voiture

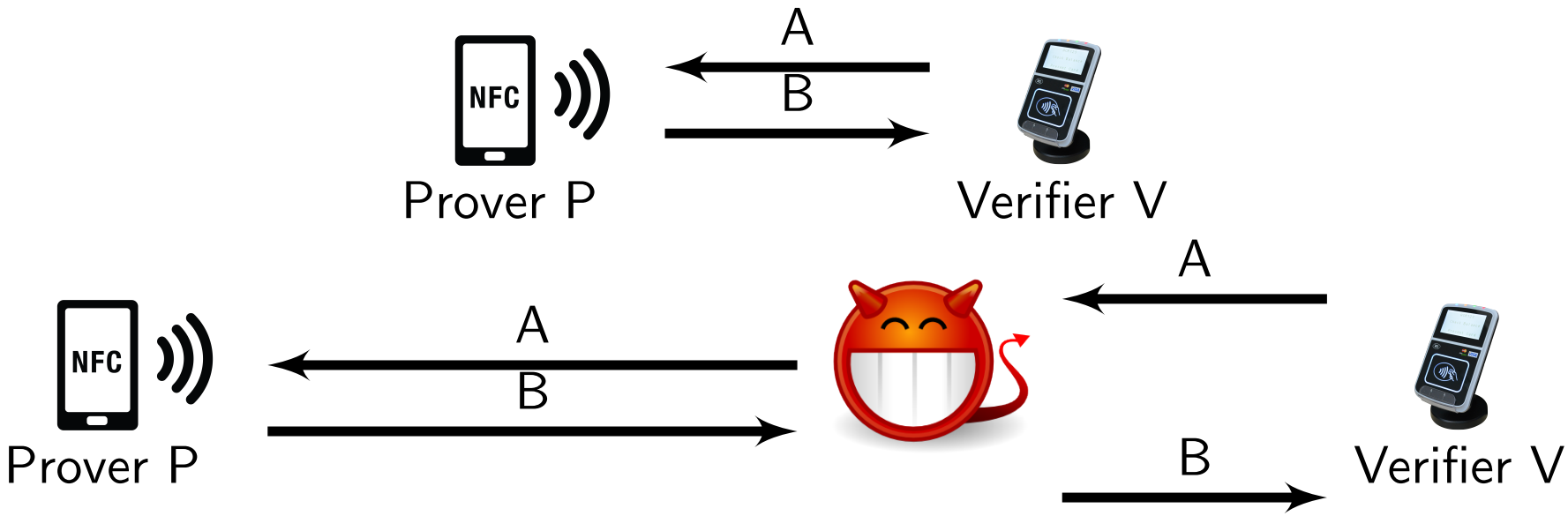
Relay Attacks on Passive Keyless Entry and Start Systems in Modern Cars, by Aurélien Francillon, Boris Danev, Srdjan Capkun, NDSS 2011

`https://www.youtube.com/watch?v=bfjMj8fgsBo`

Security: Relay Attacks (Mafia Fraud)



Security: Relay Attacks (Mafia Fraud)



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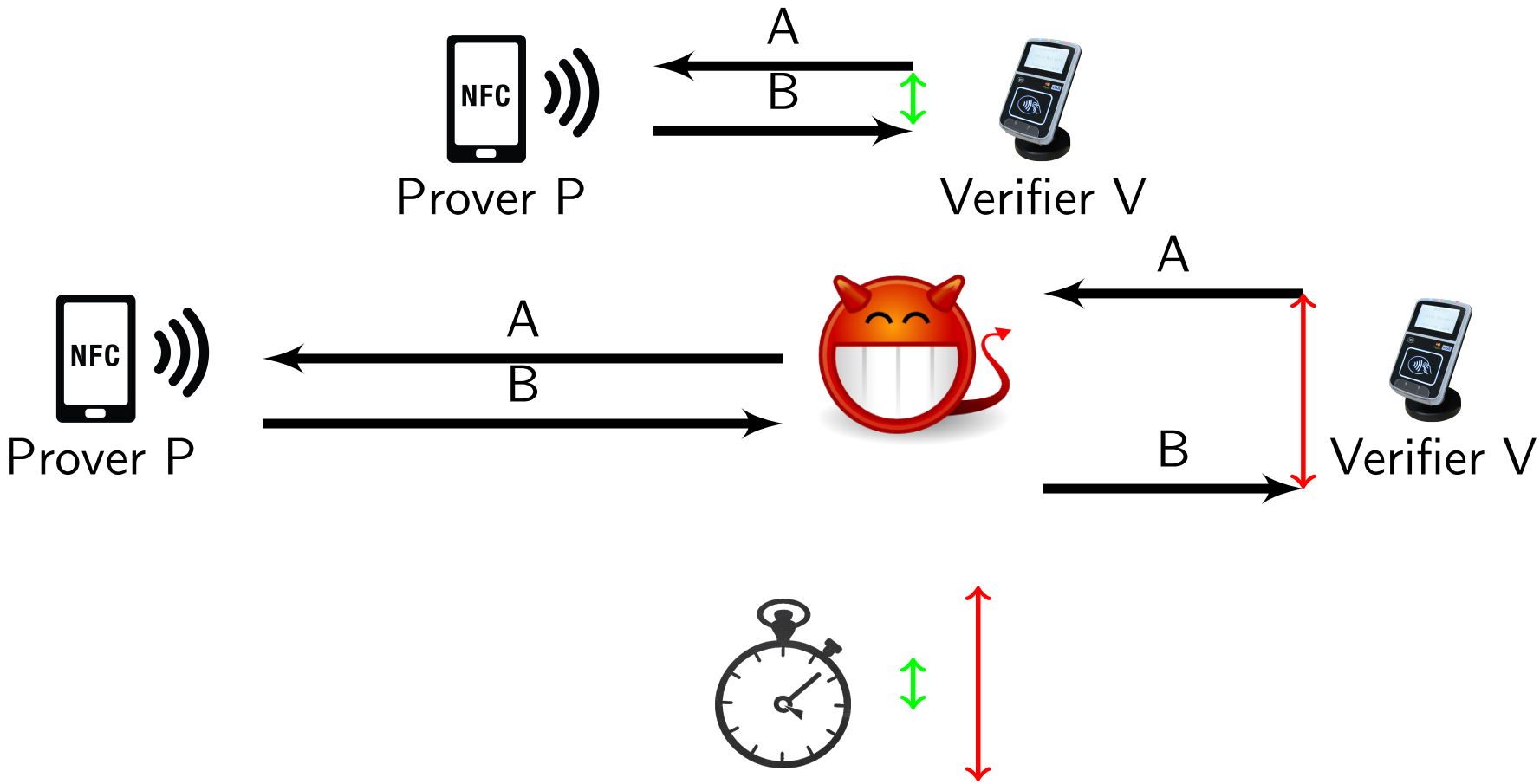
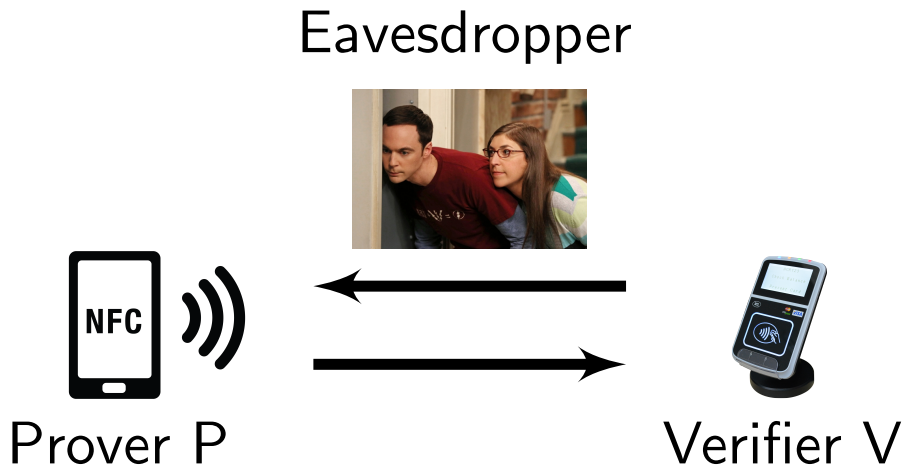
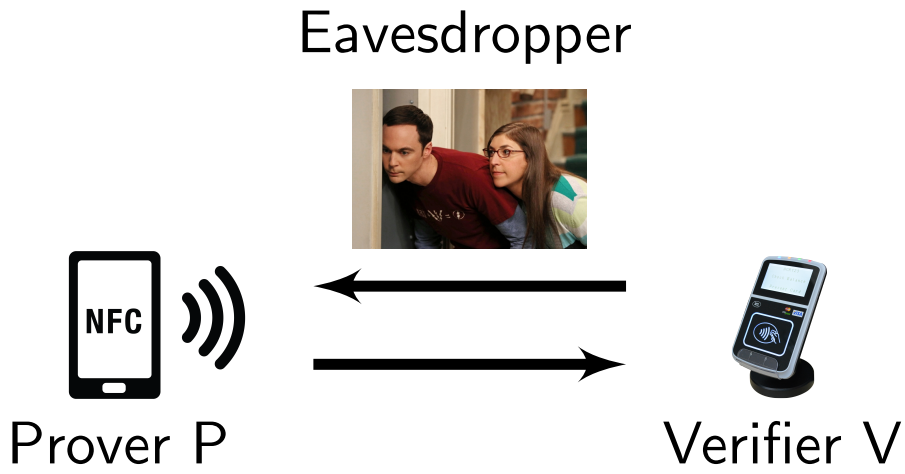


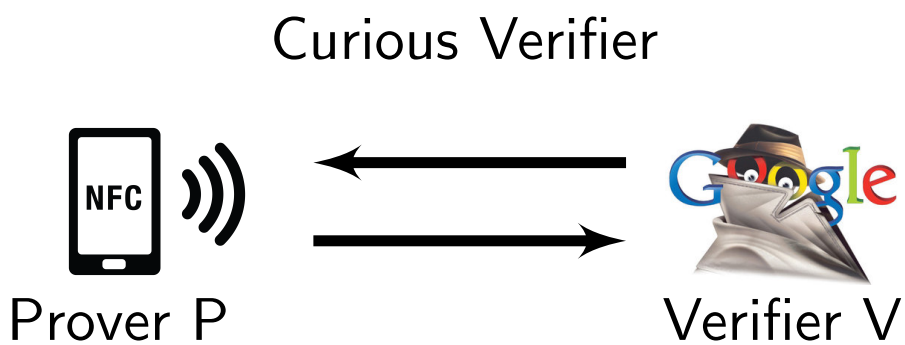
Solution: distance bounding (Brands and Chaum, 1991)

Privacy: Eavesdropper VS Curious Verifier



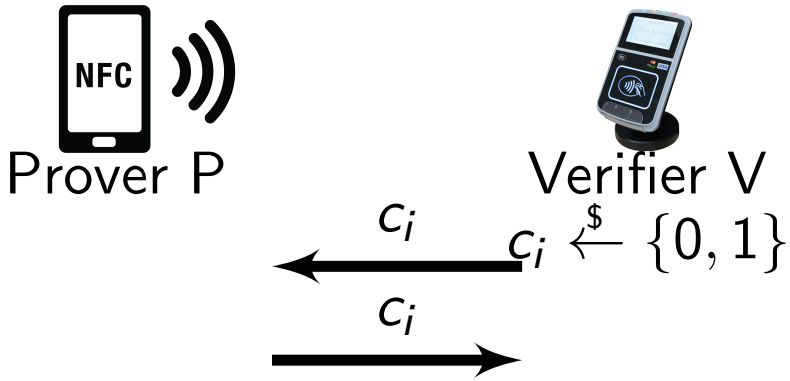
Privacy: Eavesdropper VS Curious Verifier





Some Naive Examples

Echo protocol



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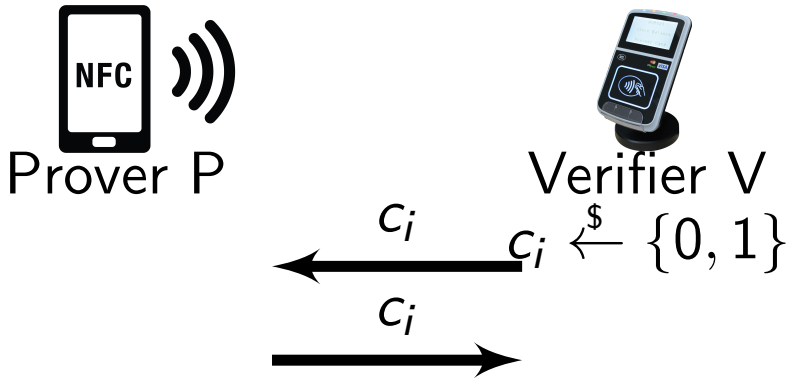
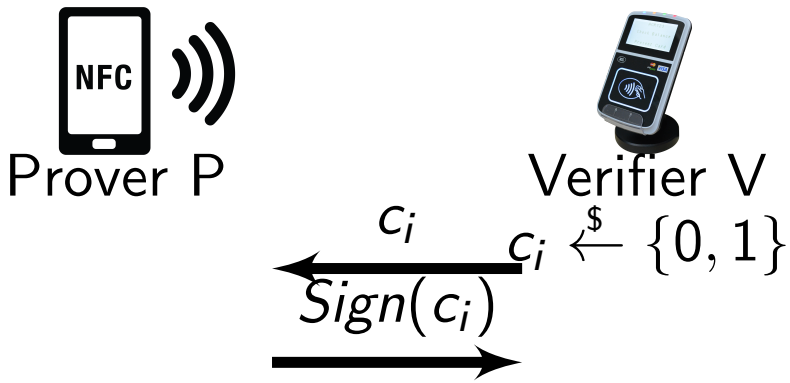
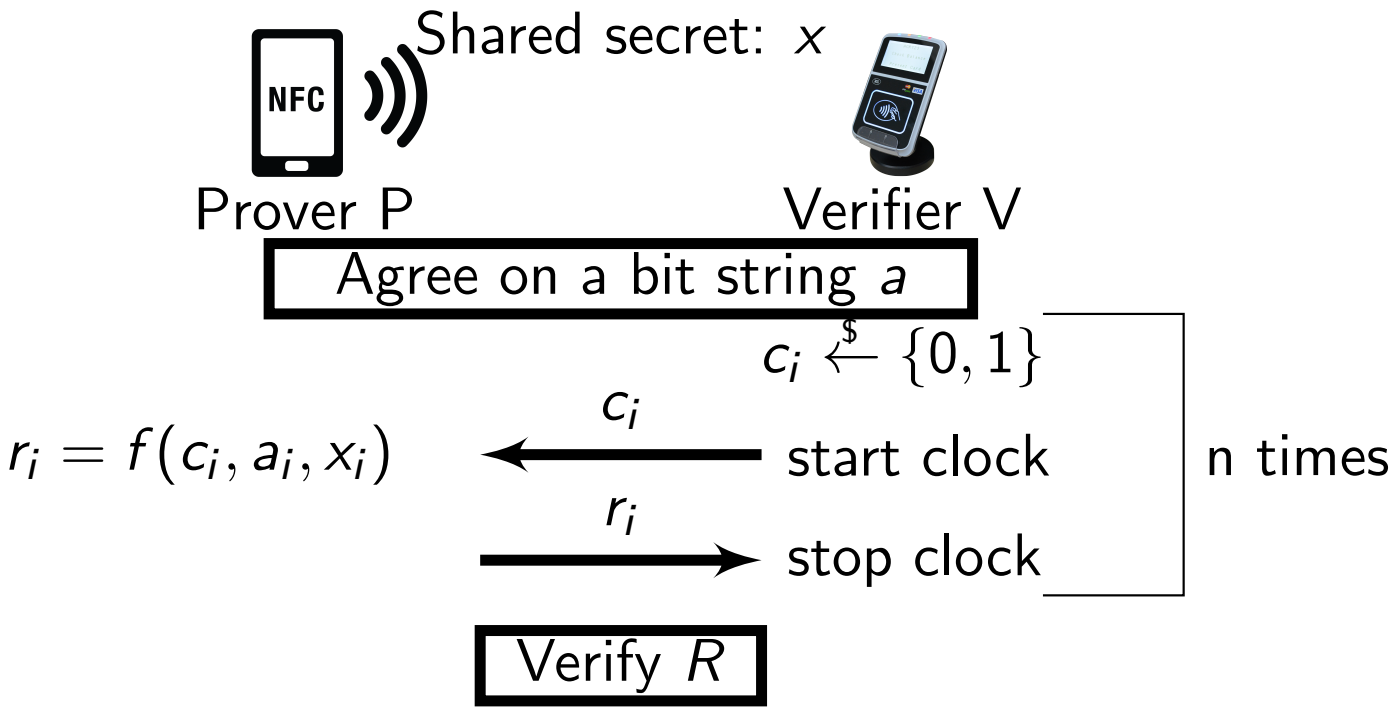


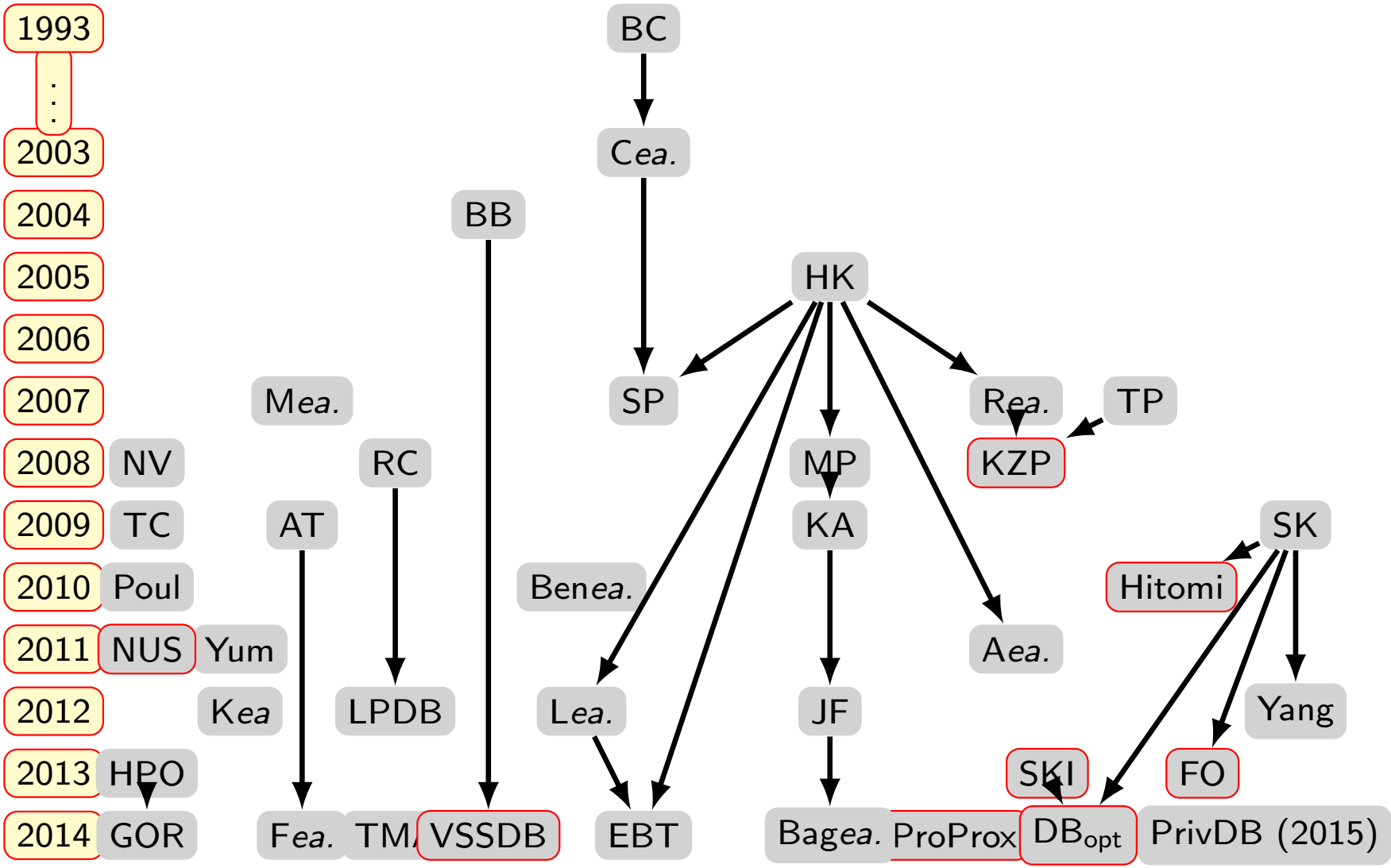
Signature



Typical DB protocol

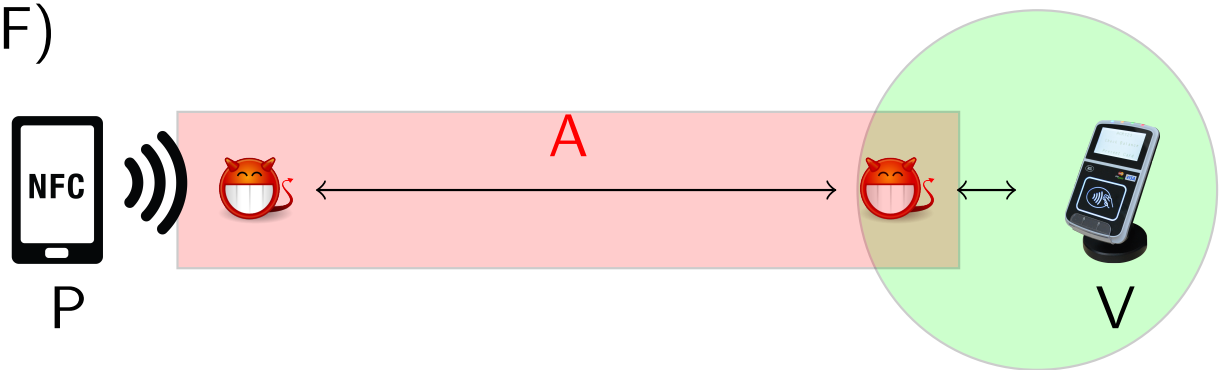


Survey : 42 protocols from 1993 to 2015.



Threats against honest provers

Mafia Fraud (MF)



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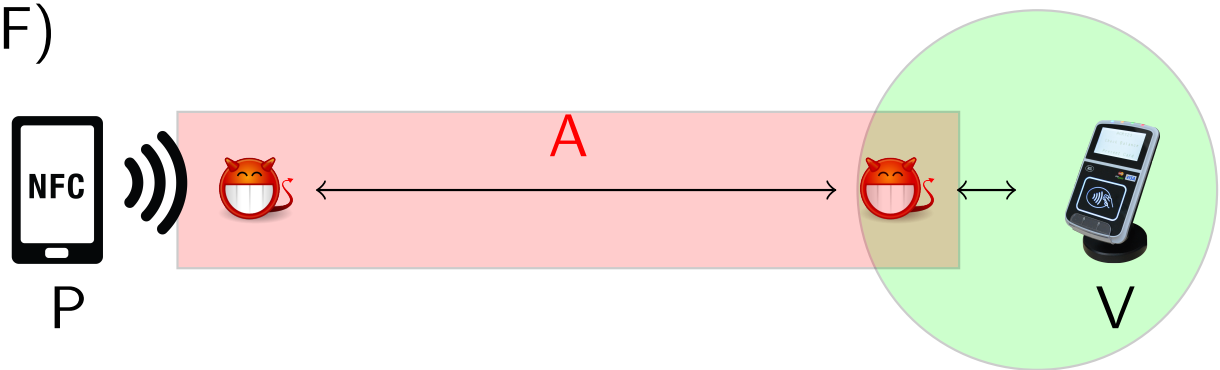
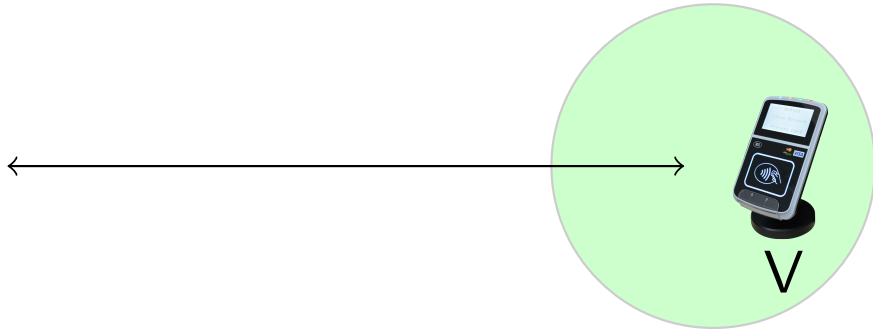


User tracking

Threats: malicious Provers

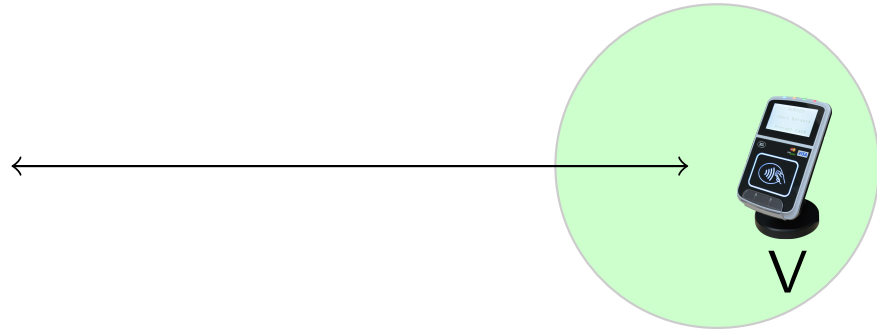
Distance Fraud (DF)

P

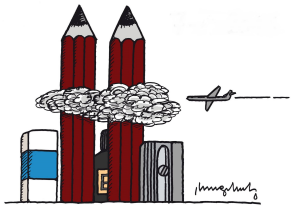


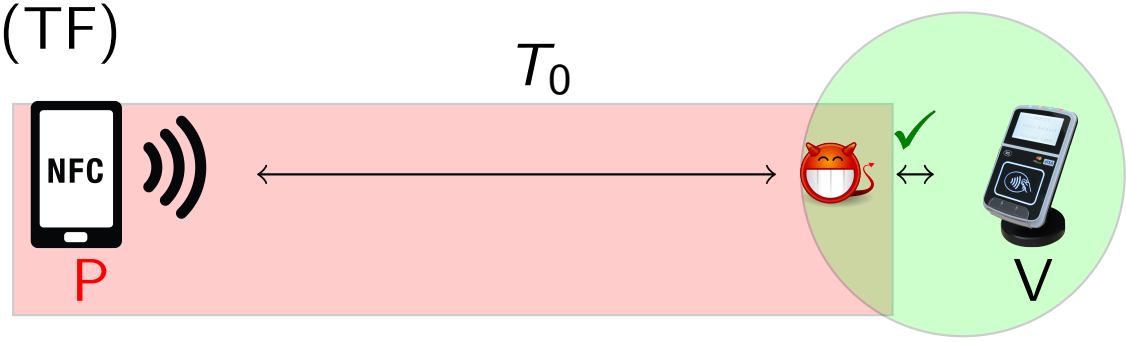
Threats: malicious Provers

Distance Fraud (DF)



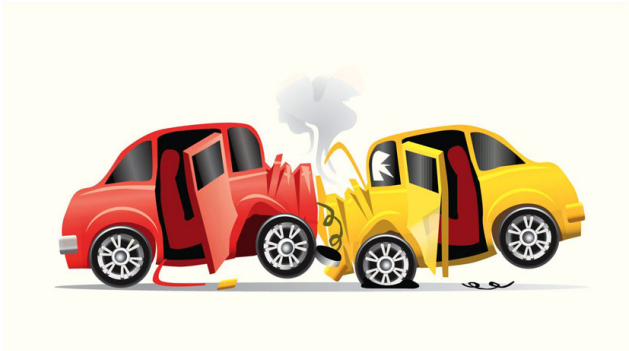
Terrorist Fraud(TF)



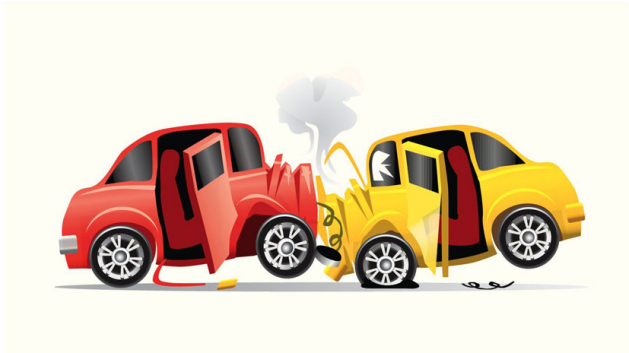


TREAD & SPADE

Outline

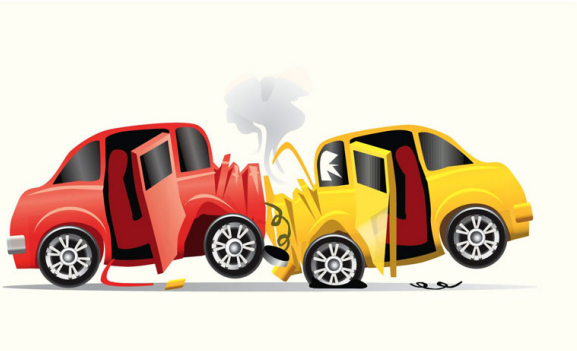



RIP



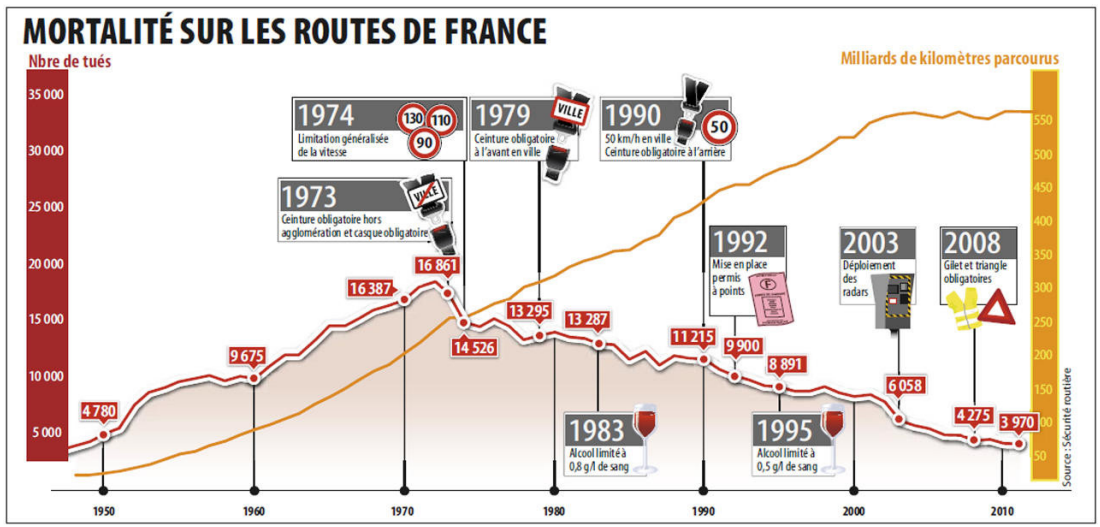

RIP


NON PORT DE LA CEINTURE DE SÉCURITÉ
-4 points
sur le permis de conduire
135 €
Amende forfaitaire
POINTS.12

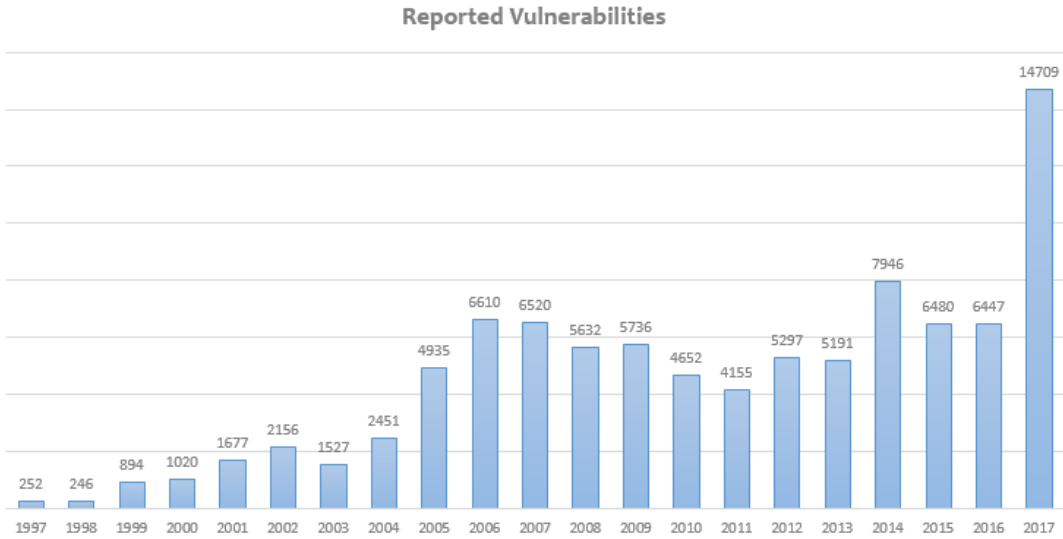



RIP


NON PORT DE LA CEINTURE DE SÉCURITÉ
-4 points
sur le permis de conduire
135 €
Amende forfaitaire
POINTS 12


MORTALITÉ SUR LES ROUTES DE FRANCE
Nbre de tués
Milliards de kilomètres parcourus
35 000
30 000
25 000
20 000
15 000
10 000
5 000
550
500
450
400
350
300
250
200
150
100
50
1974
Limitation généralisée de la vitesse
130
110
90
1979
Ceinture obligatoire à l'avant en ville
VILLE
1990
50 km/h en ville
Ceinture obligatoire à l'arrière
50
1973
Ceinture obligatoire hors agglomération et casque obligatoire
VILLE
1992
Mise en place permis à points
2003
Déploiement des radars
2008
Gilet et triangle obligatoires
4 780
9 675
16 387
16 861
14 526
13 295
13 287
11 215
9 900
8 891
6 058
4 275
3 970
1983
Alcool limité à 0,8 g/l de sang
1995
Alcool limité à 0,5 g/l de sang
1950
1960
1970
1980
1990
2000
2010
Source : Sécurité routière

L'argus


Reported Vulnerabilities
252
246
894
1020
1677
2156
1527
2451
4935
6610
6520
5632
5736
4652
4155
5297
5191
7946
6480
6447
14709
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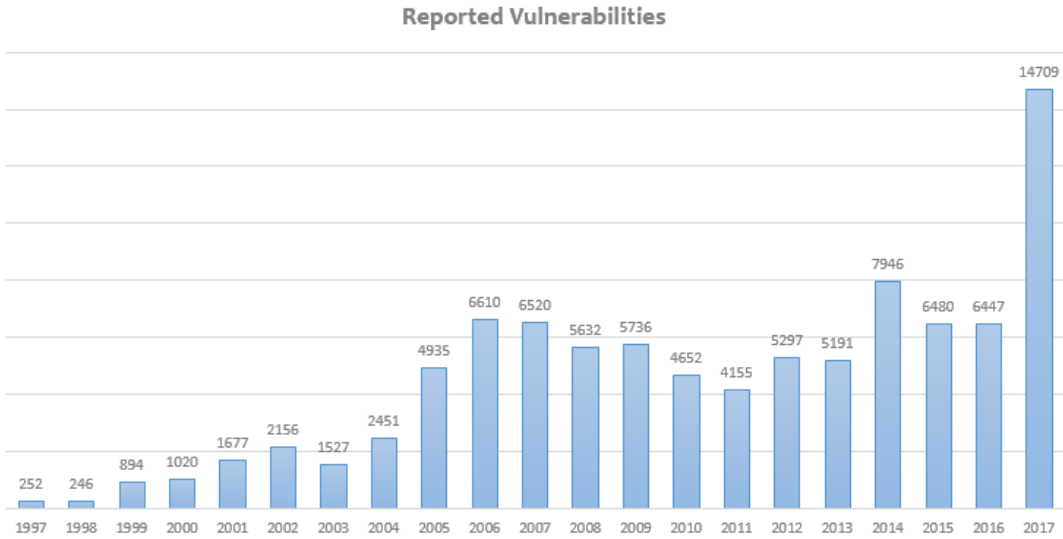
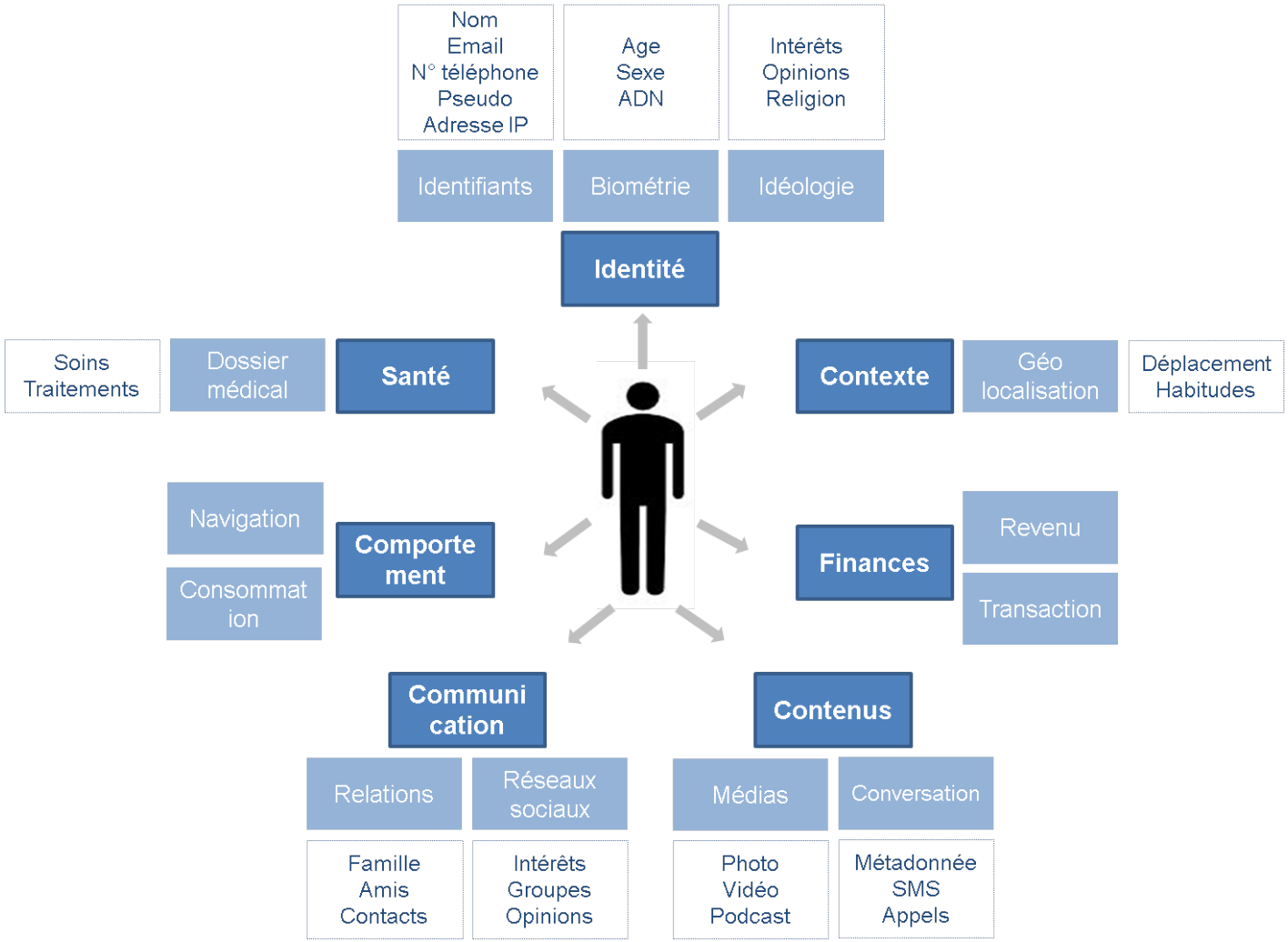


Règlement Général sur la Protection des Données
GDPR : General Data Protection Regulation

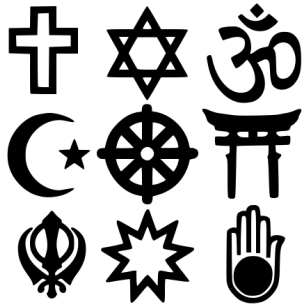
Qui est touché ?

TOUT LE MONDE !

Qu'est-ce qu'une donnée personnelle ?



Qu'est-ce qu'une donnée personnelle **sensible**?



Collecte sans consentement préalable écrit, clair et explicite

Plus de droits pour vos données !

Sanction

Plus de transparence

Droit à l'oubli

Guichet unique

Protection des mineurs

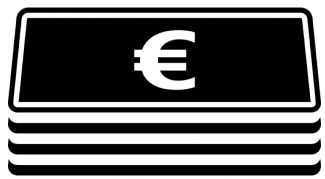
Portabilité

RPGD : en 6 étapes @CNIL

1. Désigner un pilote
2. Cartographier
3. Prioriser
4. Gérer les risques
5. Organiser
6. Documenter

Sanctions

20 millions



ou 4 %

Outline

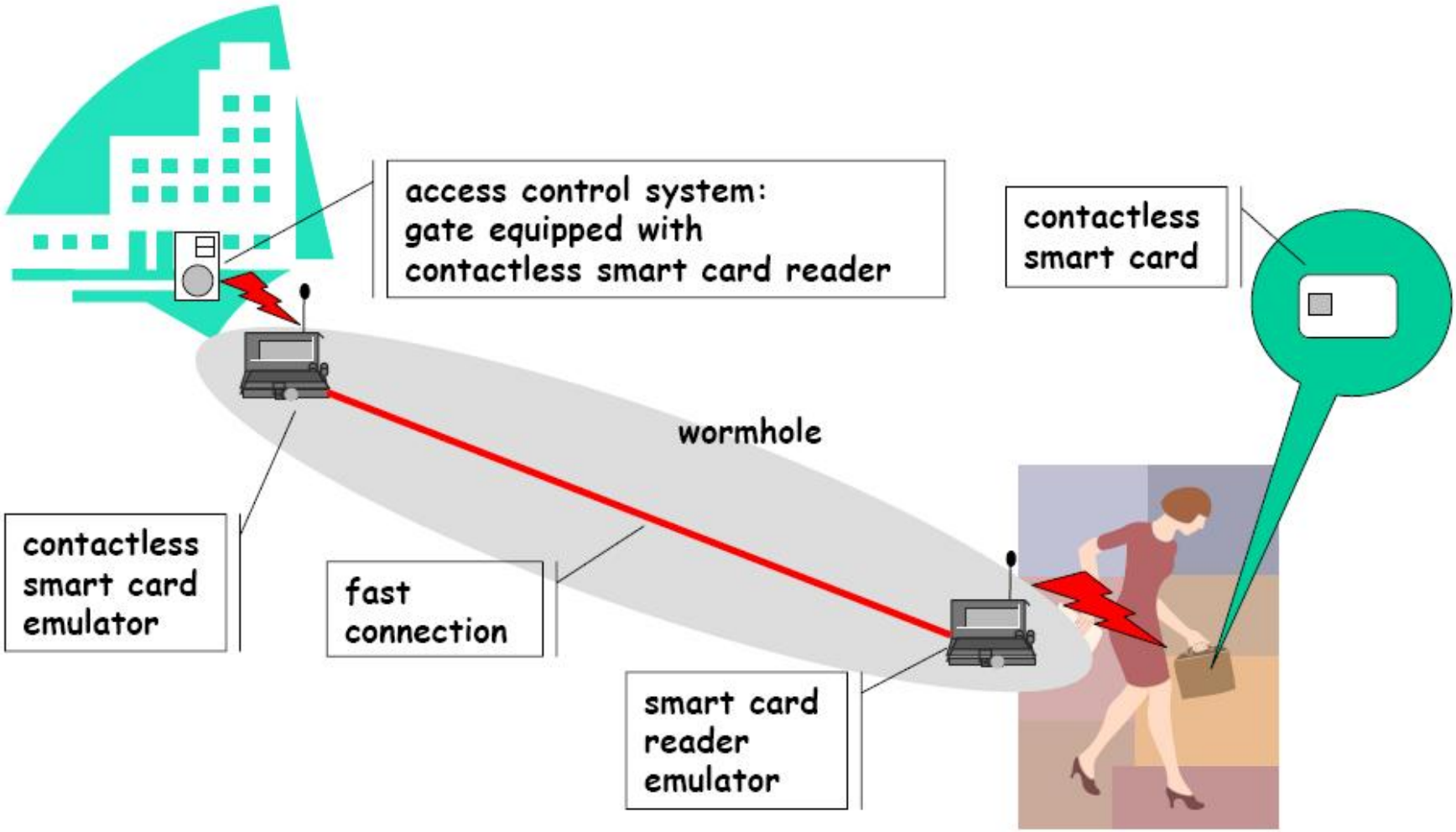
Several Possible Attackers

- Insider vs Outsider
- Active vs Passive
- Local vs Extended
- Single vs Multiple
- Laptop vs Server



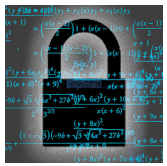



Wormhole Attack



What is cryptography based security?

Cryptography:



- Primitives: RSA, Elgamal, AES, DES, SHA-3 ...
- Protocols: Distributed Algorithms

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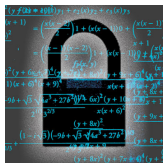

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- Non Repudiation ...

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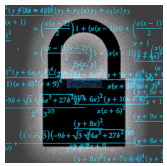

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- CPA, CCA ...

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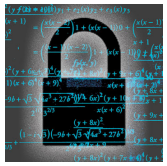

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Designing **secure** cryptographic protocols is **difficult**

Is it preserving your privacy?

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4096 RSA encryption

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Environs 60 températures possibles: 35 ... 41

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$$\{35\}_{pk}, \{35, 1\}_{pk}, ..., \{41\}_{pk}$$

3-pass Shamir

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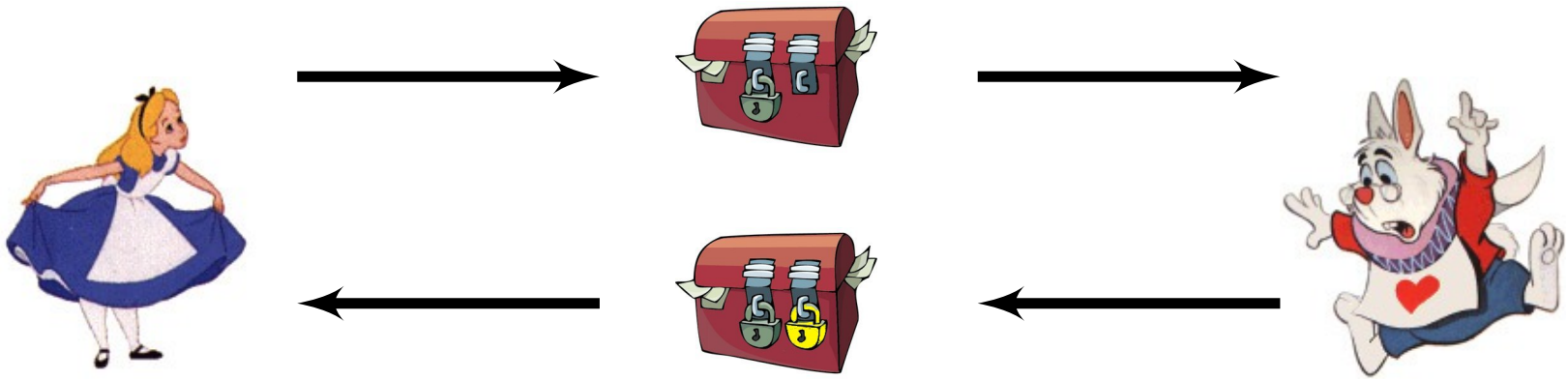
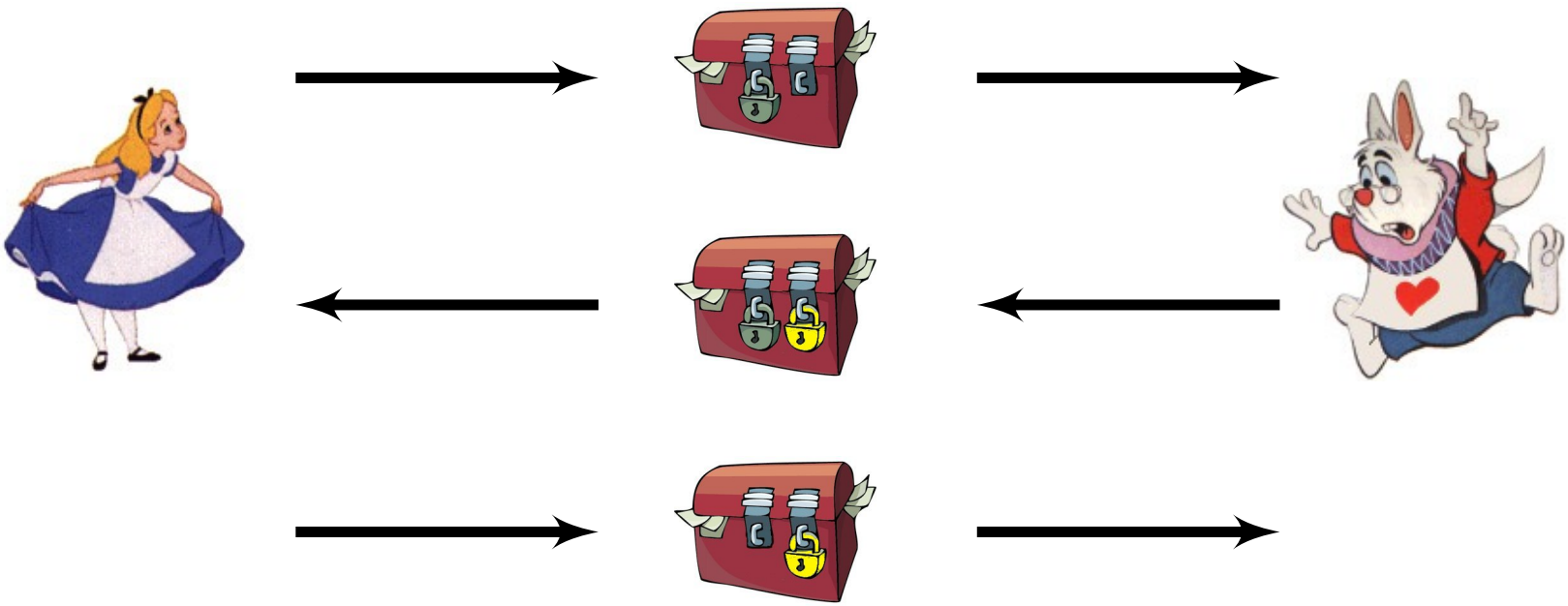


3-pass Shamir



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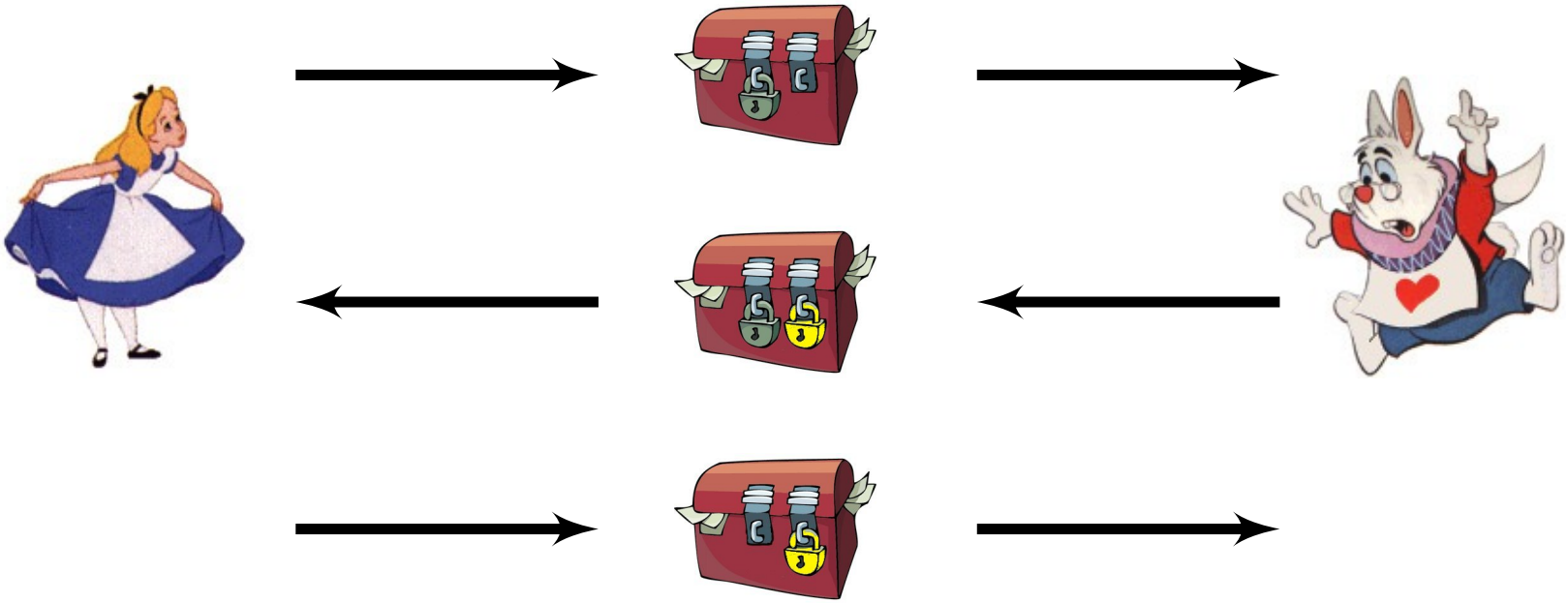
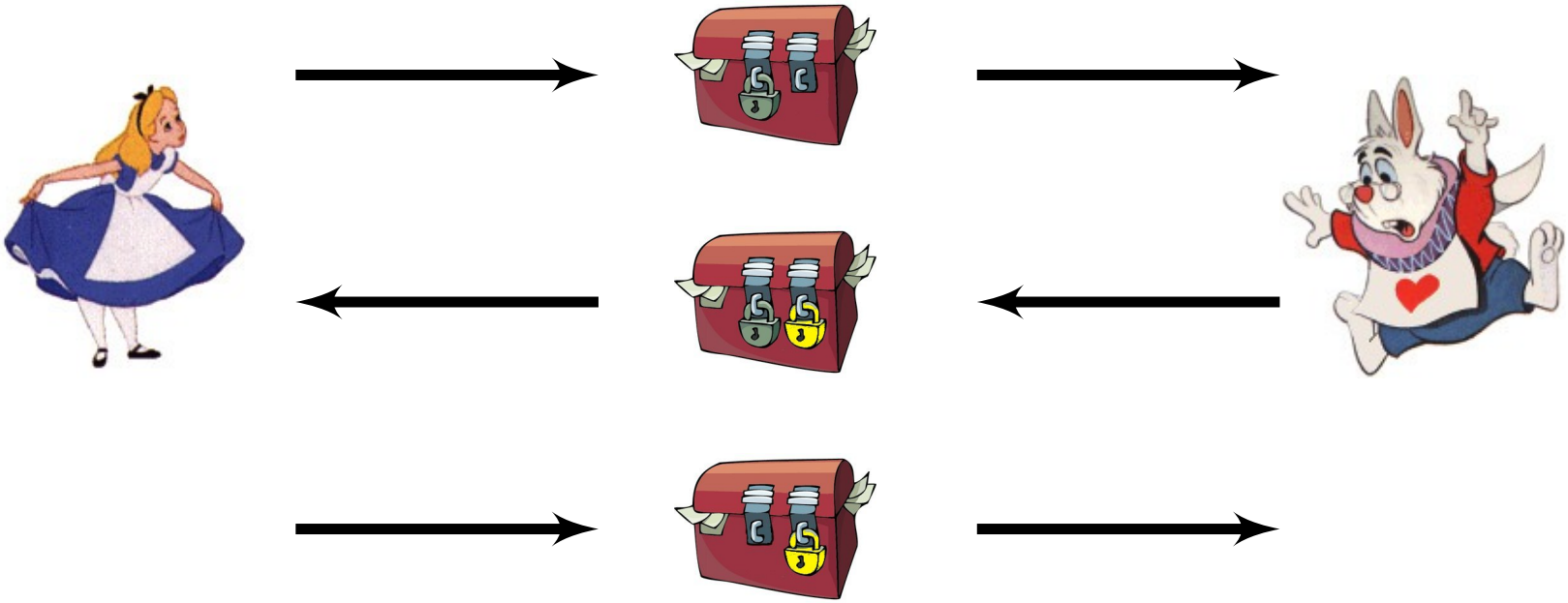


Abstract Representation

$$1 \quad A \quad \rightarrow \quad B \quad : \quad \{m\}_{K_A}$$

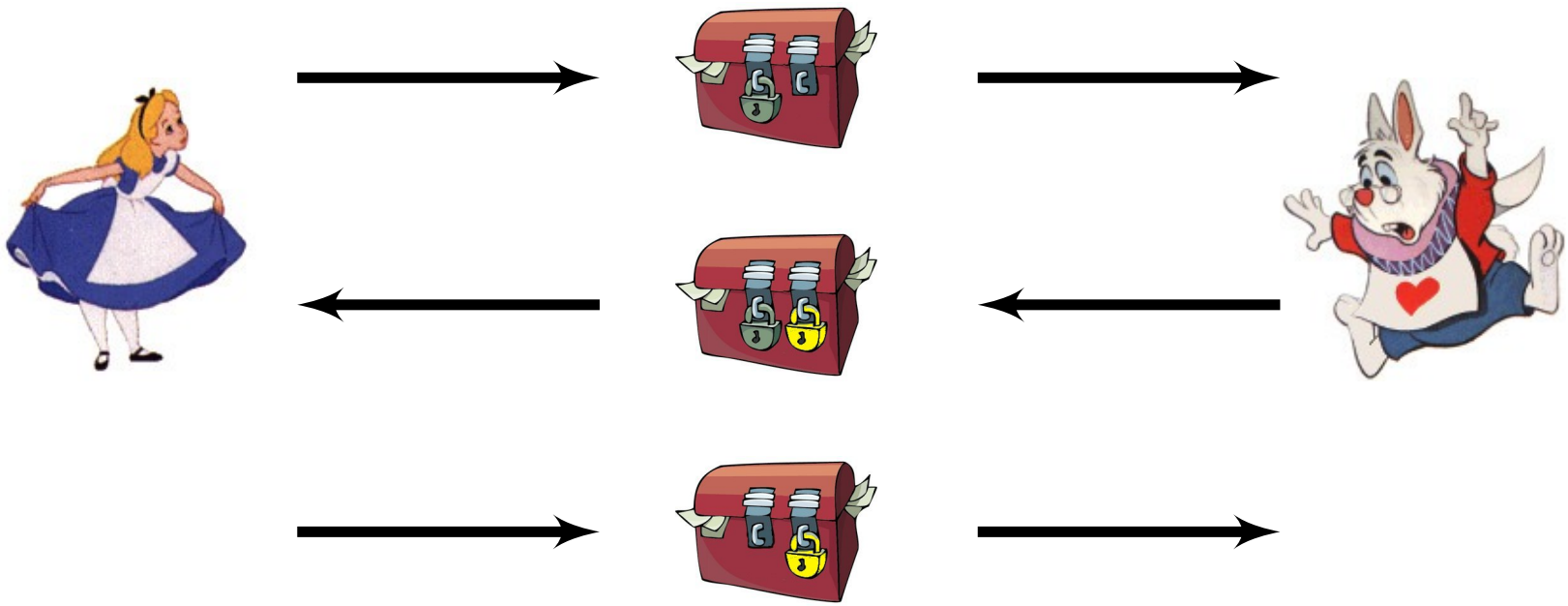
3-pass Shamir



Abstract Representation

$$
\begin{array}{llcll}
1 & A & \rightarrow & B & : \{m\}_{K_A} \\
2 & B & \rightarrow & A & : \{\{m\}_{K_A}\}_{K_B}
\end{array}
$$

3-pass Shamir



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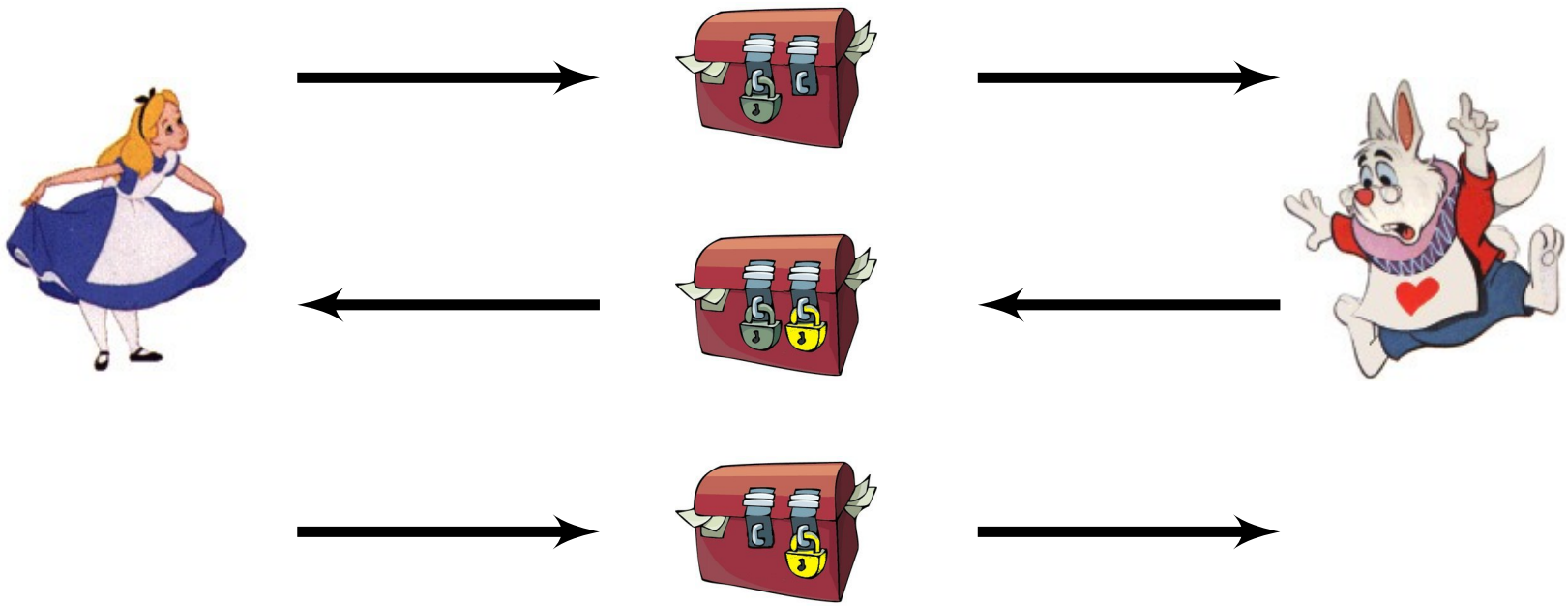
Commutative Encryption

3-pass Shamir



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$$

Commutative Encryption

Logical Attack on Shamir 3-Pass Protocol (I)

Perfect encryption one-time pad (Vernam Encryption)

$\{m\}_k = m \oplus k$

XOR Properties (ACUN)

- $(x \oplus y) \oplus z = x \oplus (y \oplus z)$ **A**ssociativity
- $x \oplus y = y \oplus x$ **C**ommutativity
- $x \oplus 0 = x$ **U**nity
- $x \oplus x = 0$ **N**ilpotency

Logical Attack on Shamir 3-Pass Protocol (I)

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Vernam encryption is a commutative encryption :

$$\{\{m\}_{K_A}\}_{K_I} = (m \oplus K_A) \oplus K_I = (m \oplus K_I) \oplus K_A = \{\{m\}_{K_I}\}_{K_A}$$

Logical Attack on Shamir 3-Pass Protocol (II)

Perfect encryption one-time pad (Vernam Encryption)

$$\{m\}_k = m \oplus k$$

Shamir 3-Pass Protocol

$$\begin{array}{llll} 1 & A & \rightarrow & B : \quad m \oplus K_A \\ 2 & B & \rightarrow & A : \quad (m \oplus K_A) \oplus K_B \\ 3 & A & \rightarrow & B : \quad m \oplus K_B \end{array}$$

Passive attacker :

$$m \oplus K_A \qquad m \oplus K_B \oplus K_A \qquad m \oplus K_B$$

Logical Attack on Shamir 3-Pass Protocol (II)

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Shamir 3-Pass Protocol

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Passive attacker :

$$m \oplus K_A \oplus m \oplus K_B \oplus K_A \oplus m \oplus K_B = m$$

Necessity of Tools to Analyze Cryptographic Protocols

- Protocols are small recipes.
- Non trivial to design and understand.
- The number and size of new protocols.
- Out-pacing human ability to rigourously analyze them.

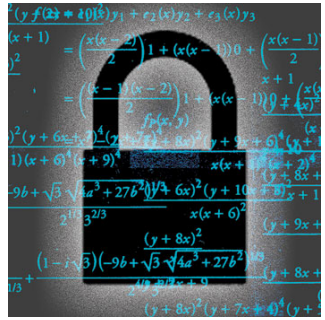
GOAL : A tool is finding flaws or establishing their correctness.

- completely automated,
- robust,
- expressive,
- and easily usable.

Existing Tools: AVISPA, Scyther, Proverif, Tamarin ..

Formal Verification Approaches

Designer



Attacker

Formal Verification Approaches

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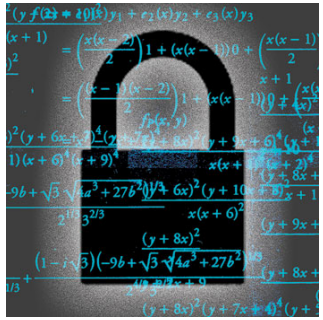

Attacker

Security Team

Formal Verification Approaches

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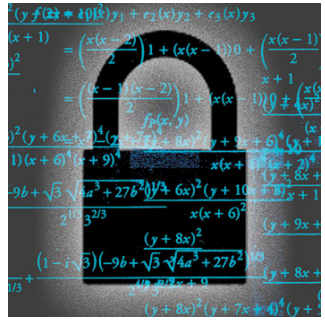

Attacker

Give a proof

Security Team

LIMOS
LABORATOIRE D'INFORMATIQUE,
DE MODÉLISATION ET D'OPTIMISATION DES SYSTÈMES

Formal Verification Approaches

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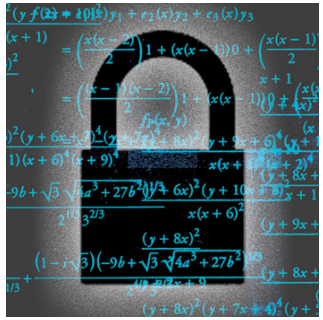

Attacker

Give a proof

Find a flaw

Security Team

Applications

Outline

Things to bring home

Several **challenges** in VANETs, specially in **security**:

- Connected Vehicule will be subject to more and more attacks
- Security should be taken into account
- Distance Bounding can help also in Vehicule context
- Designing secure protocols is difficult
- Formal methods are useful for designing secure protocols




Protocol + Properties + Intruder $\Rightarrow$ Security

Thanks for your attention

Questions ?

Second Example

Needham Schroeder Key Echange 1976

$$A \rightarrow B : \{A, N_A\}_{Pub(B)}$$

$$B \rightarrow A : \{N_A, N_B\}_{Pub(A)}$$

$$A \rightarrow B : \{N_B\}_{Pub(B)}$$

- Use cryptography
- Small programs
- Distributed

Cryptography is not sufficient !

Example : Needham Schroeder Key Echange

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Broken 17 years after, by G. Lowe

$$A \to I : \{A, N_A\}_{Pub(I)} \qquad I \to B : \{A, N_A\}_{Pub(B)}$$

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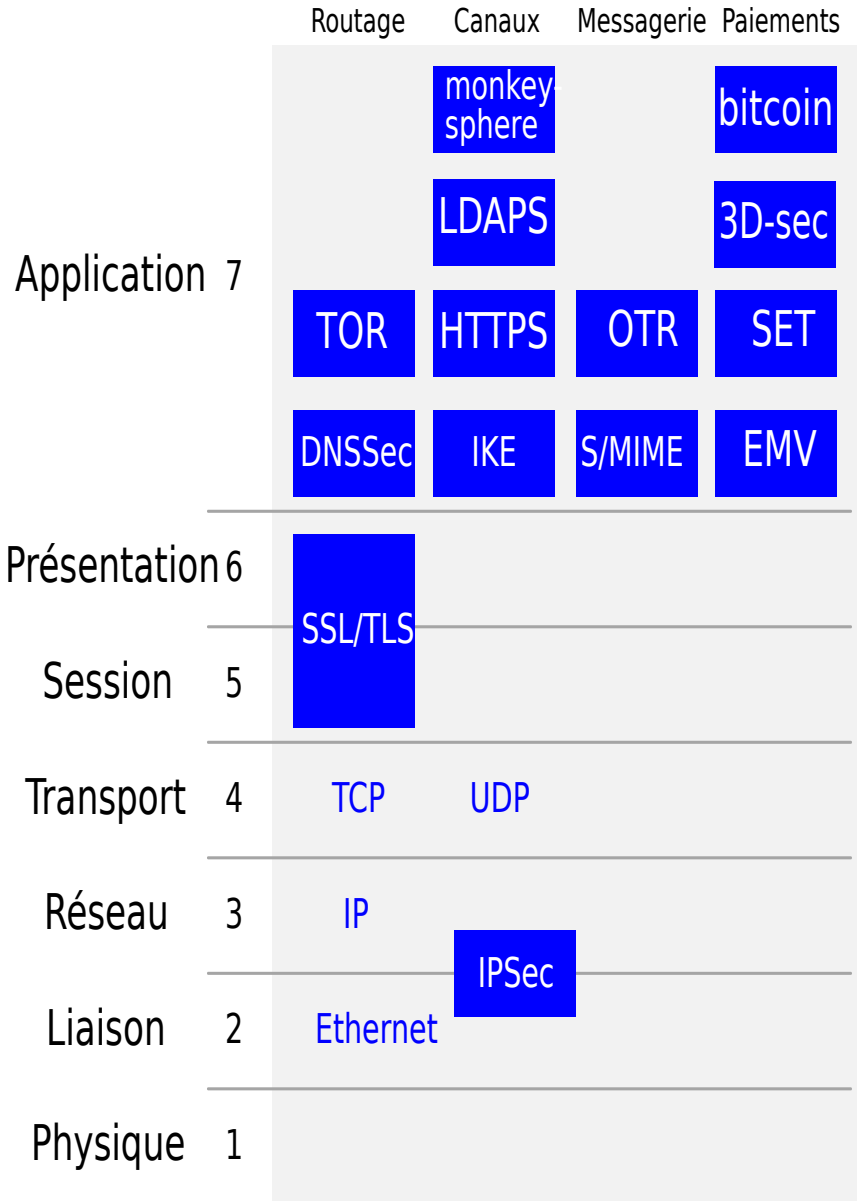
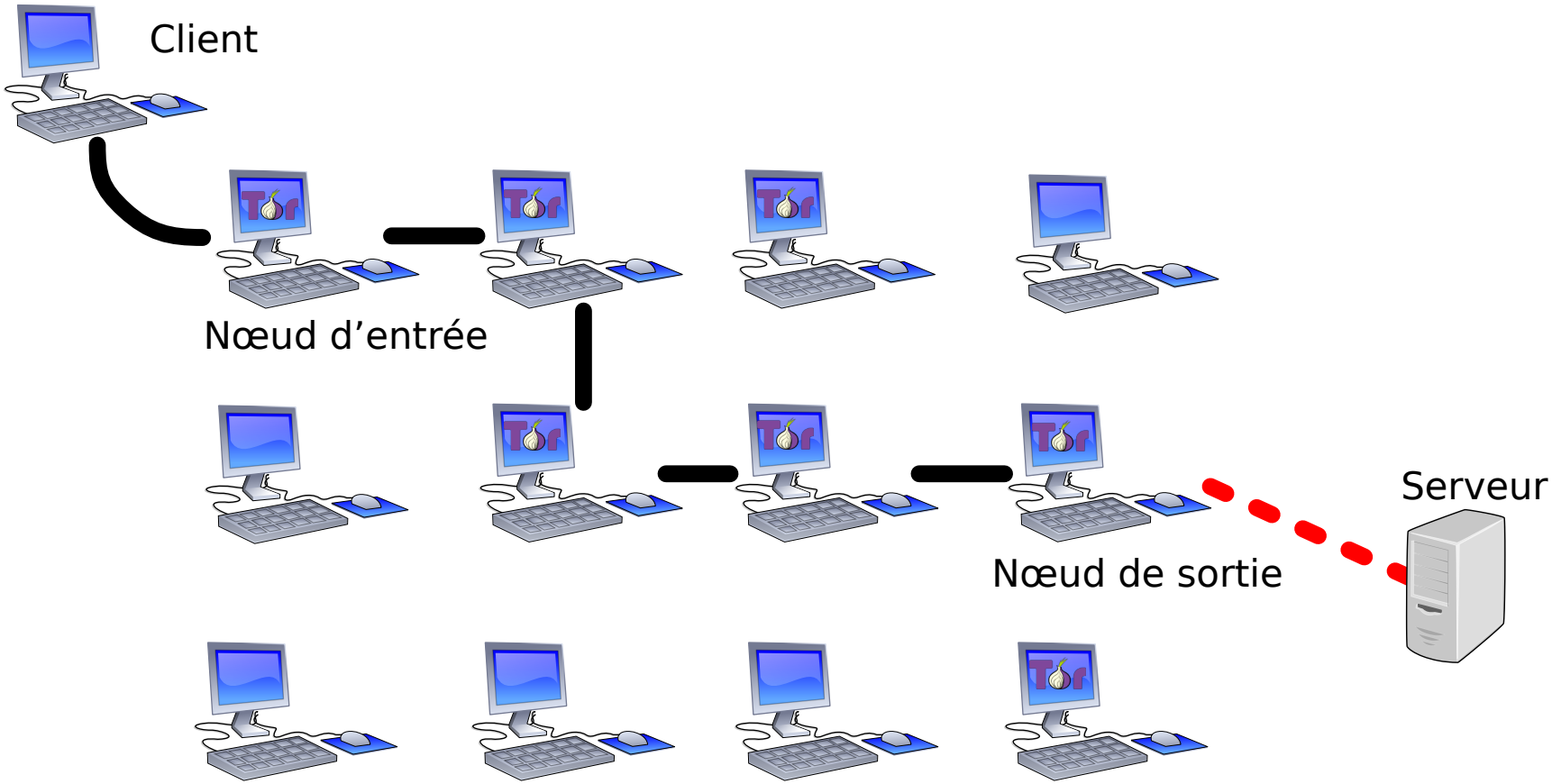
Computer-Aided Security

Applications



Application : The Onion Router



https://www.torproject.org

Application : Tor