The Key to Intelligent Transportation: Identity and Credential Management in Vehicular Communication Systems

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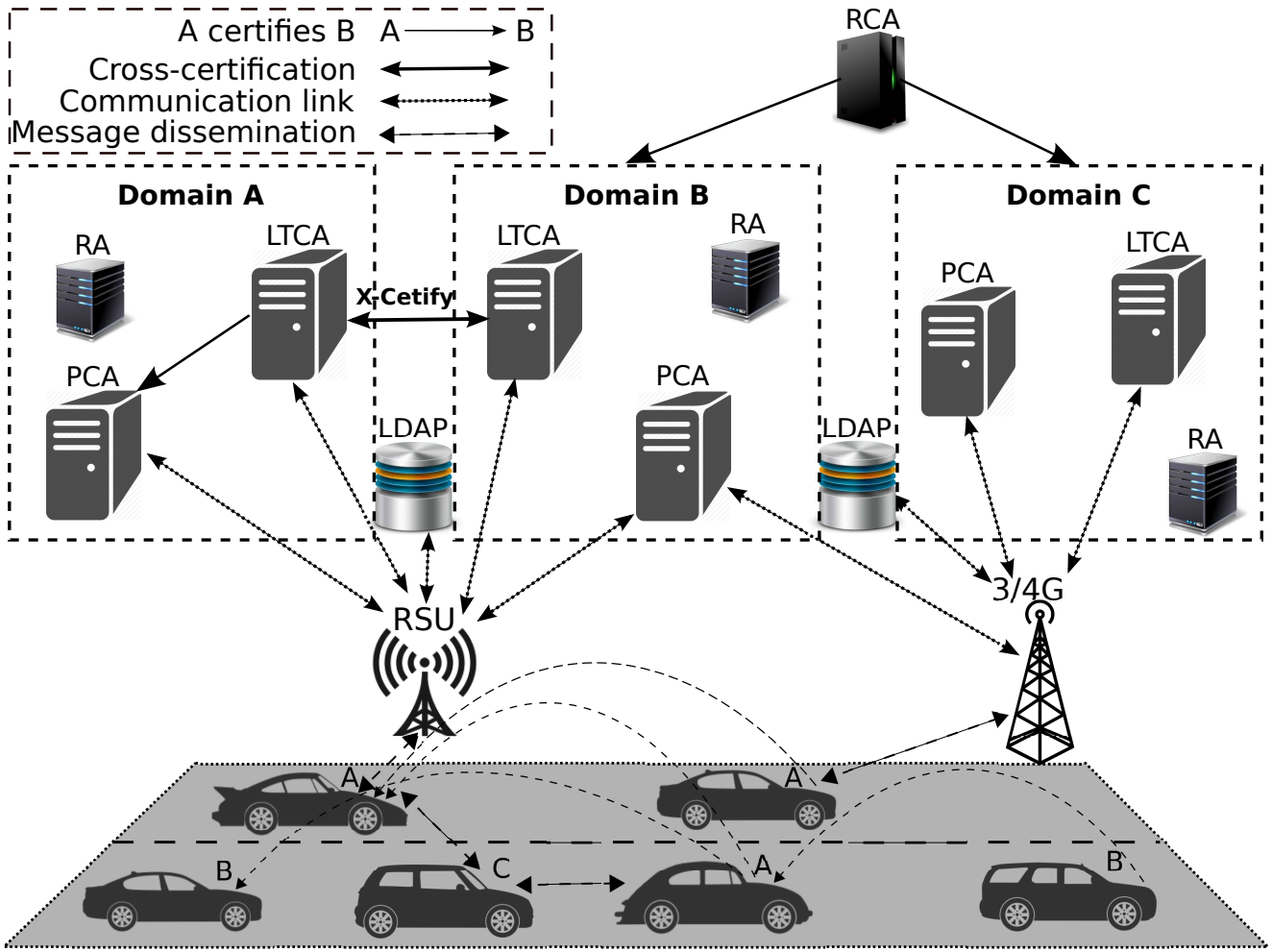
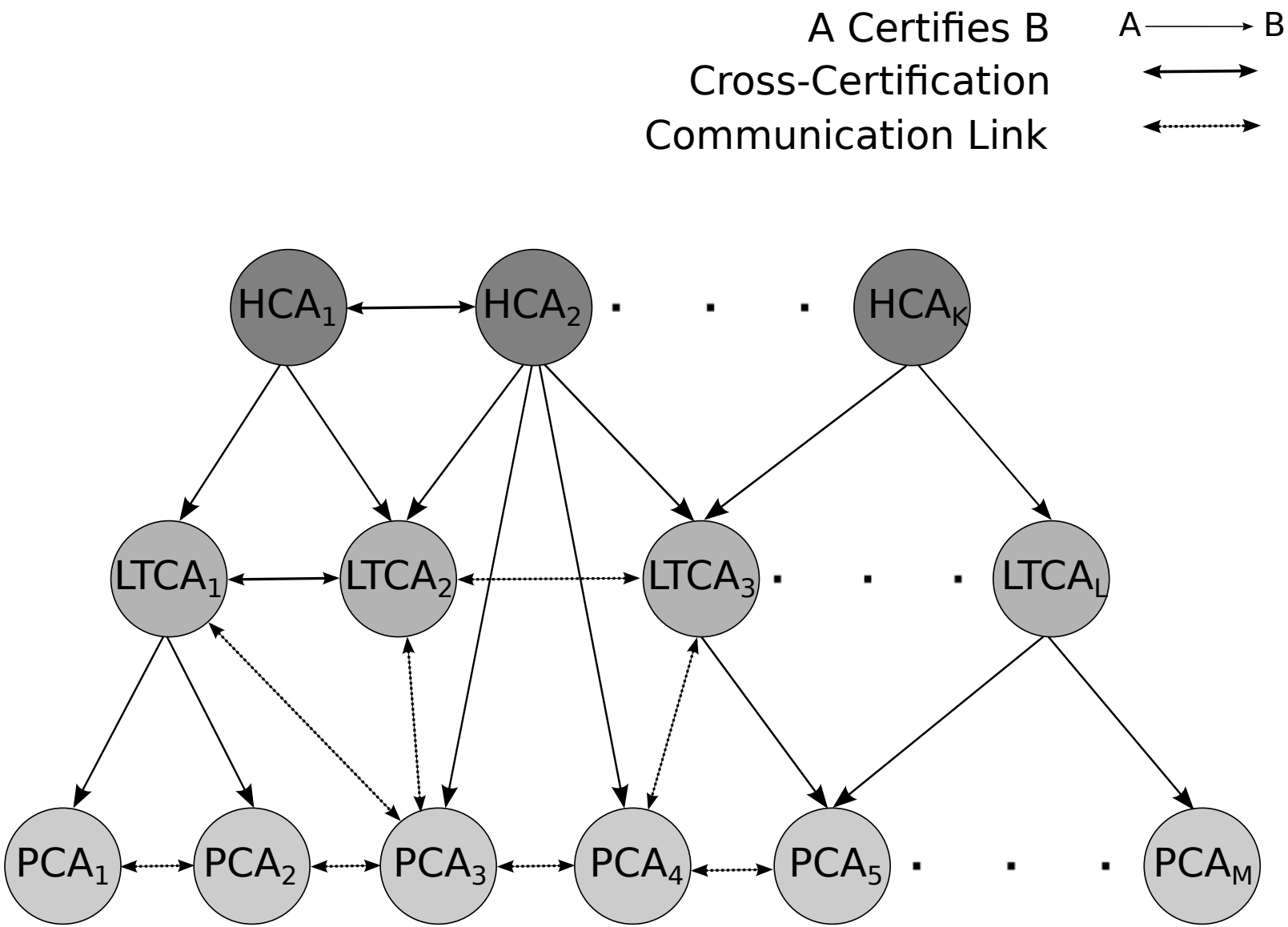
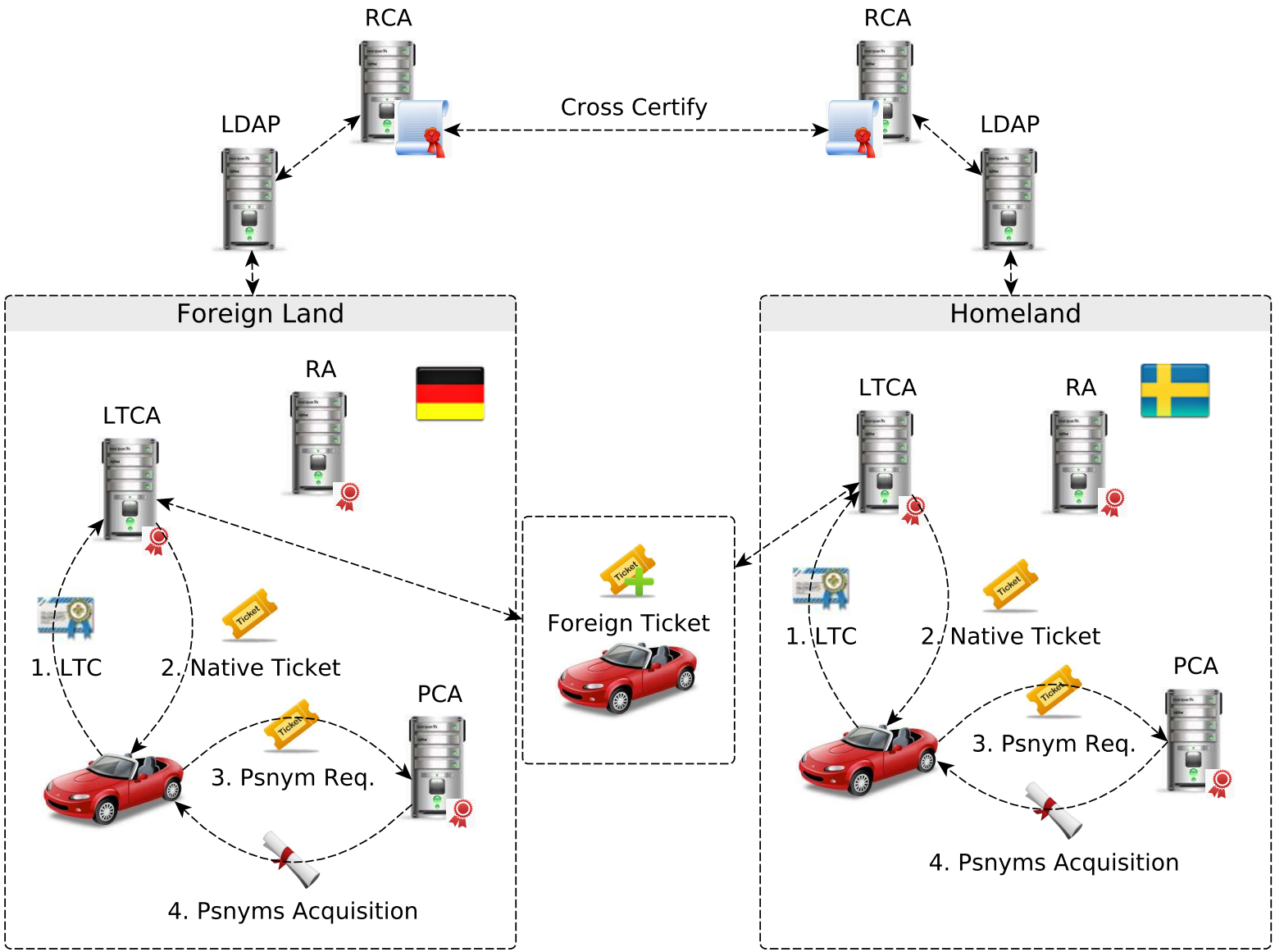
Secure Vehicular Communication (VC) System



Hierarchical Organization of the VC Security Infrastructure



VPKI Architecture



State-of-the-art

Projects

SEVECOM, EVITA, PRECIOSA, OVERSEE, DRIVE-C2X, PRESERVE, CAMP-VSC3

Standarization and Harmonization

IEEE 1609.2, ETSI and C2C-CC: VC related specifications for privacy-preserving architectures

Vehicular Public Key Infrastructure (VPKI)

- *Do we indeed have a corner-stone to build upon secure and privacy-protecting VC systems?*
- More precisely, *do we have all answers needed to deploy an identity and credential management infrastructure for VC?*

Privacy Challenges

Stronger adversarial model[1]

- User privacy protection against *honest-but-curious* entities
- Inference of service provider or time

LTCA infers relevant information from the requests[2]

- Direct (C2C-CC design) or indirect (ticket-based designs) approaches
- Actual pseudonym acquisition period
- Targeted PCA that the vehicle seeks to obtain credentials from

Trivially linking pseudonyms issued by the PCA

- Fully-trusted proxy-based scheme (CAMP)[3] that shuffles the requests
- Honest-but-curious proxy?

[1] Gisdakis et al., 2013 and Khodaei et al., 2014.
[2] Khodaei et al., 2014.
[3] Whyte et al. 2013

Resilience Considerations

Sybil-based misbehavior

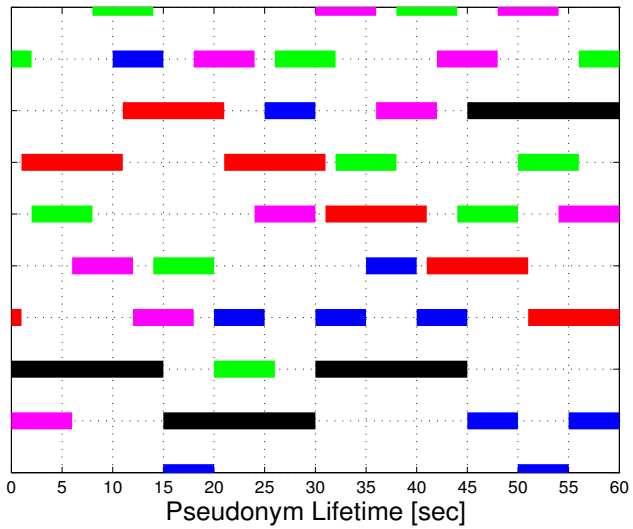
- Acquisition of multiple simultaneously valid credentials
- Allow several pseudonymous valid simultaneously for a specific period of time (C2C-CC or CAMP project)
  - Changing the certificate in a critical traffic situation (e.g., intersection, accident)
  - Safety applications necessitate partial linkability
  - But what if a vehicle gets compromised?
  - Injecting multiple erroneous hazard notification
- VPKI should ensure a compromised vehicle cannot obtain multiple pseudonyms valid simultaneously[4]
  - along with enforcing a policy on the vehicle side
- Standardization bodies and harmonization efforts do not preclude such misbehavior

[4] Khodaei et al., 2014.

Pseudonym Lifetime Policy

- Ideally one pseudonym for a single message authentication
  - But costly, e.g. 10 beacons per sec.
- Safety applications necessitate partial linkability
  - E.g. collision avoidance: inferring a collision hazard based on unlinkable CAMs is hard; requires precise location information
- No conclusive view or guideline for pseudonym lifetime policy

- Sybil-based misbehavior → Non-overlapping lifetime
- Flexible access to PCA → undermine unlinkability
- Timing information makes sets of pseudonyms linkable



Revocation

- Eviction of the wrong doers in case of misbehavior
- Not straightforward in the VC systems
  - Multiplicity of pseudonyms
  - Very large number of pseudonyms, thus huge revocation list
  - Efficient distribution of the revocation list among mobile entities
  - Limited memory and bandwidth consumption for OBU through usage of CRL

Diminish such vulnerability

- Requiring the vehicles to interact with the VPKI regularly
- or at least as frequently as dissemination of information by PCA

The remaining challenge:

- No consensus on the need and the method
  - C2C-CC recommendation to preload with 1500 pseudonyms for a year and let them expire (no revocation)
- Timely dissemination of credential validity information
  - Time, cost, bandwidth, network accessibility, etc.

Other Challenges

- Extending to anonymous authentication primitives
  - Group signature schemes[5]
  - Zero-knowledge proof[6]
- Extensive experimental validation
  - SEROSA[7]
  - SR-VPKI[8]
- Operational challenges:
  - Who is in charge of the identity and credential management
  - How to establish the trust:
    - [Saab, Scania, Volvo] and [Volkswagen, BMW]
    - [EU] and [US]

[5] Papadimitratos et al., 2007 & Perrig et al., 2009
[6] Förster et al., 2014
[7] Gisdakis et al., 2013
[8] Khodaei et al., 2014

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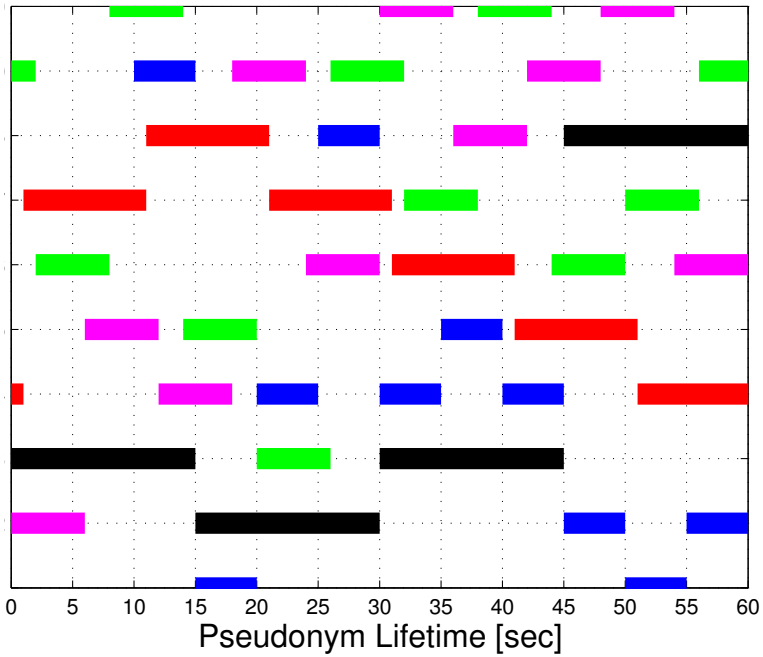
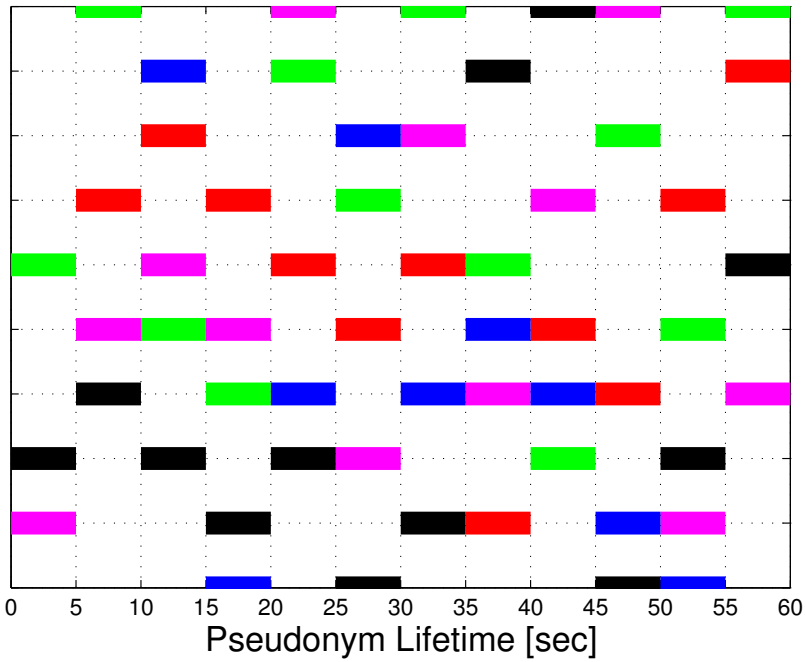
Questions and Discussion

Pseudonym Lifetime Policy



Flexible lifetimes



Fixed lifetimes

- Non-overlapping pseudonym lifetimes from eavesdroppers' perspective
- Distinct lifetimes per vehicle make linkability easier
- Uniform pseudonym lifetime in a domain
- No distinction among obtained pseudonyms set, thus less probable to link pseudonyms