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Security in V2X Communications for UAS Networks

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About Me (Highlights)[1]

Current position: Senior Lecturer @ ZHAW, member of InIT ISE Group

Education:

Bogazici University, Istanbul, TURKEY. Ph.D. in Computer Eng., 2013

- In addition to academia, more than 10 years of experience in technology companies ("on-off" mode)
- Involved in various Horizon 2020, Horizon Europe, ITEA, CELTIC, Innosuisse, and TÜBiTAK (TR) research projects as senior researcher, project coordinator and academic consultant
- >100 scholarly papers, two patents (1 US, 1TR), IEEE senior member, ACM member
- Currently, a member of the IEEE 1920.2 Vehicle to Vehicle Communications for Unmanned Aircraft Systems and the IEEE 3349 Space System Cybersecurity Work Groups

Current key research interests: Information security, Future Internet, Critical Infrastructure Protection (space cybersecurity)

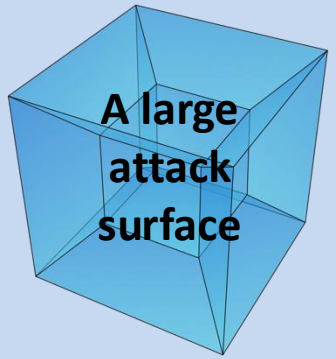
[1] More information: www.zhaw.ch/en/about-us/person/gueu/

Outline

Key message:

UAS networking security

$$\frac{\text{Vulnerabilities} \times (\{\text{Cyber} + \text{Physical}\}\ \text{sec\_issues})}{\text{Resource constraints} + \text{Heterogeneity}} =$$



- Outline:
  - Security in V2V UAS Networks
  - Challenges
  - What to consider for security solutions
  - IEEE 1920.1/2 WG outcomes

Security aspects in UAS networks

Physical security

As CPS, open to physical manipulations (compare that to a data center)

Use-case driven, close interaction with the physical world

Cybersecurity

Connected systems

Ad hoc mode («pure» U2U)

Infrastructure-based mode (tethering to 5G, 6G, NextG ...)

Hybrid mode

May become a security threat on its own.

Mission critical services emerging ...

Challenges against UAS network security

Some old ...

- Cyber threats on CIA
- Access control
- Software security
- IoT security
- Mobile ad hoc network security
- ...

Some new ...

- DoSt attacks
- Quantum computing
- AI security
- Scale
- Omnipresence
- Democratization

Some magnified ...

- Physical security
- Resource constraints
- Supply chain security
- Security management in a fragmented world
- **Standardization** ☺ (A tale of two cities: security vs aviation people)

Core elements of security solutions for UAS networks

Key guidelines

- Use existing knowledgebase as much as possible (e.g., Tactics, Techniques, and Procedures (TTPs))
- Keep CPS perspective
- Do not let things to be excuses:

  «Sorry, no resources ☹»

  «First, we need it running!»

  «Security is frankly not the top priority in this phase of our project ☹»

  …

Core elements of security solutions for UAS networks (cont.)

Solutions

- **Security by design**
- Additional security controls (layers)
- Deeper monitoring and threat awareness: *A Good Decision Relies on Good Data. $(GD)^2$*
- Dedicated security functions, e.g., SIEMs
- Resource-aware security controls
- More open systems based on standards

  → **CHECK OUT our work on IEEE P1920.2 standard ;-)**
- Security testing of UAS (e.g., vulnerabilities or baseline security testing)

  Can AI be used for large-scale testing of numerous network nodes autonomously?
- Pursue smarter systems regarding security -> «I see LLMs everywhere … » -> what about their security?

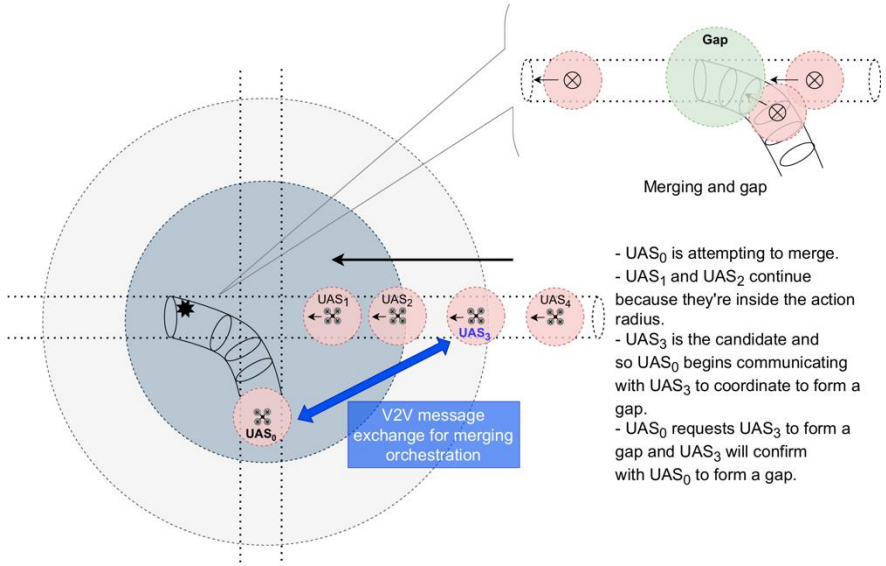
  Cognitive systems

  …

V2V missions/use cases lead to sec. requirements - (IEEE 1920.2 case)

Let’s switch to more specific uses:

- Collision Avoidance
- Merging and Spacing/Sequencing of Traffic
- Airborne Separation
- Airborne Rerouting
- Collaborative Sensing of Weather Conditions
- …



Security landscape and vulnerabilities in V2V UAS networks (@IEEE 1920.1/2)

- Data: C2, telemetry, navigation safety messages such as Detect-And-Avoid (DAA), and application-specific data information for applications in Visual Line of Sight (VLoS) and Beyond Visual Line of Sight (BVLoS), …
- No Endpoint Protection Platforms (EPP) and Endpoint Detection and Response (EDR) system
- May be high risk
- Profile:
    - Small UAVs have limited resources in terms of energy consumption and computational processing
    - Conventional cyber-security solutions? Not always.
    - Patching and fixes? («IoT's world»)
    - UAVs have many types of hardware and software components

UAS vulnerabilities

Hence, UAS vulnerabilities stem from various factors:

- Inadequate policies and procedures to develop and maintain hardware and software UAS platforms.
- Insufficient defense and security protections and the curse of closed systems
- Remote access without appropriate access control policies and authentication
- Inadequate secured wireless communication protections
- Lack of tools to detect anomalous activity

Threat model

Passive and active attacks are possible. Adversaries come with different capabilities.

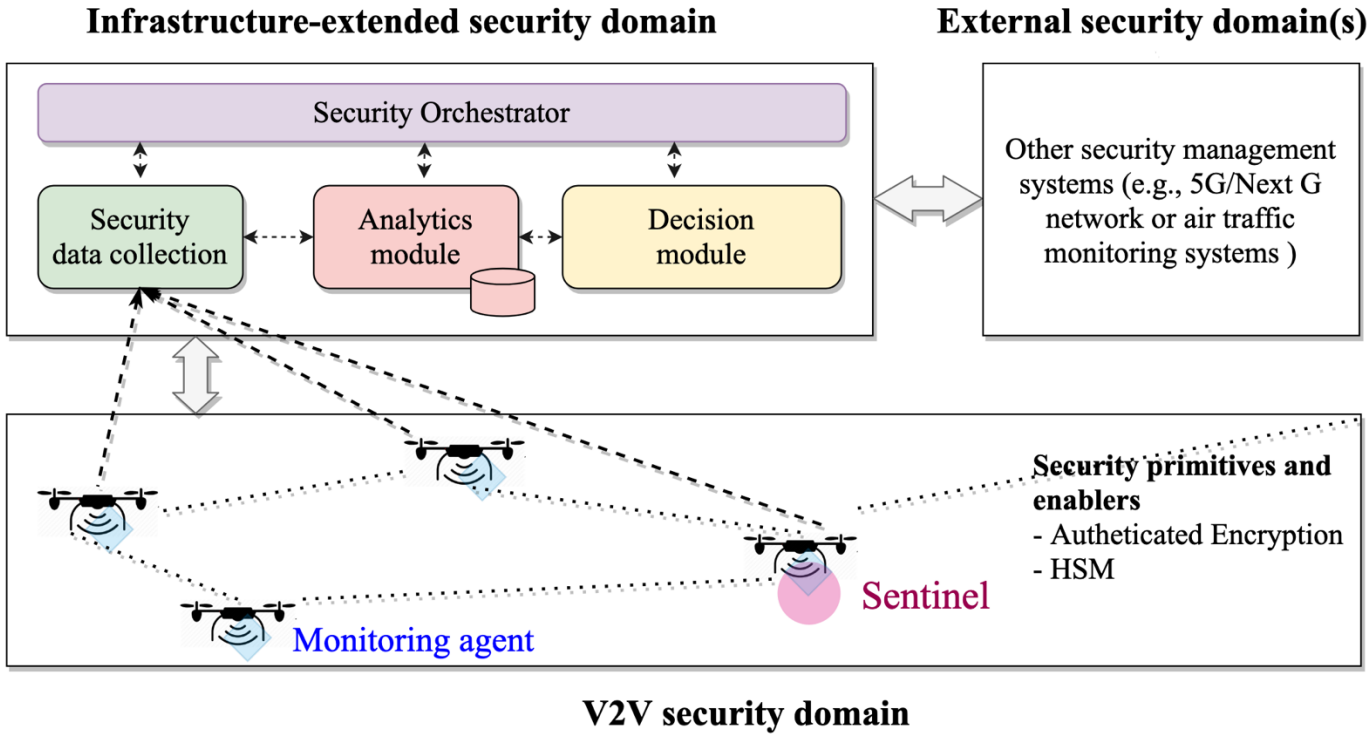
- Spoofing of (civil) GPS and Remote ID signals
- Jamming communication links (GPS, Remote ID, C2, DAA, data communications).
- DoS and DoSt attack
- Eavesdropping on command & control, data communications, or telemetry signals.
- Interception and altering command & control, data communications, GPS, or Remote ID signals.
- GPS denial
- Attacks on components and supply chain compromises (Remember the «Crypto AG»?)
- Lateral movements
- …

Security and trust model for UAS networks

How to prevent these threats -> Via a security protocol with the following capabilities?

- **Mutual entity authentication:** Data origin authentication for sender and receiver.
- **Mutual explicit key agreement authentication:** Mutual explicit key authentication is the property obtained when the sender and receiver have the assurance that only the other party knows the negotiated shared key.
- **Confidentiality:** Data information is protected with encryption.
- **Verification of data integrity:** The legitimacy of messages and protection against data tampering is implemented with authenticated encryption and Message Integrity Code (MIC).
- **Authorization policies are based on the ZTA:** Access to resources (control station, UAV interfaces, sensors, and actuators) is never granted until a subject, asset, or workload is verified by reliable authentication and authorization (access rules) while minimizing end-to-end latency.
- **Trusted computing techniques:** Use HW support such as TEEs

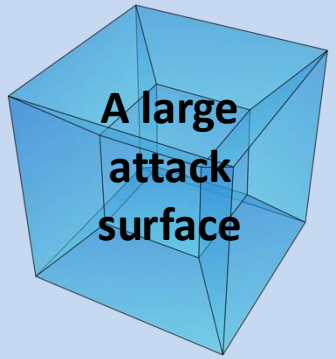
V2V UAS security management framework



Finally, so what could we have for security management in this scope?

Conclusion

$$\frac{\text{Vulnerabilities} \times (\{\text{Cyber} + \text{Physical}\}\ \text{sec\_issues})}{\text{Resource constraints} + \text{Heterogenity}} =$$



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