Integration of Generic Data Security Features in the CCSDS Packet TM/TC Standards

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Presentation Structure

- Introduction & Motivation
- Authentication Localization
- Confidentiality Localization
- Impact & Options
- Conclusions

Motivation

- Information security is an issue of growing importance in civilian space missions
  - More intensive use of open techniques and protocols
  - Reuse of mission infrastructures
- Most operational civilian space missions do not have any security implemented
  - An easy approach to introduce end-to-end security is required
  - High level of transparency desired
    - Only a small set of modifications to the existing infrastructure should be necessary
  - Short Term solution required
- Packet TM/TC protocol family as the most popular space link protocol suite should be the basis

Introduction of security features

- Two possible approaches to introduce security
- Option 1: Switch to alternative, security supporting protocols e.g. SCPS
  - Security being an integral part of the design procedure
  - Migration process requires a huge effort
  - Migration means moving away from long-time proven legacy systems
  - Maybe a long term solution
- Option 2: Modify protocol standards that are currently in use
  - For ESA this is mainly CCSDS Packet TM/TC protocol family
  - Many modifications can be kept transparent to the infrastructure
  - Short term solution and focus of this presentation

Kick-off

- CCSDS has published a green book on security (CCSDS 350.0-G-2)
  - Several options for security localization in Packet TM/TC are proposed and investigated in this presentation
- Physical Layer Security not an option for civilian missions
  - Completely prohibits the usage of supporting services
- Generic security standard for civilian space missions shall be developed
- Some guidelines:
  - Minimization of security related overhead
  - Complexity is the arch enemy of security

Security Requirements

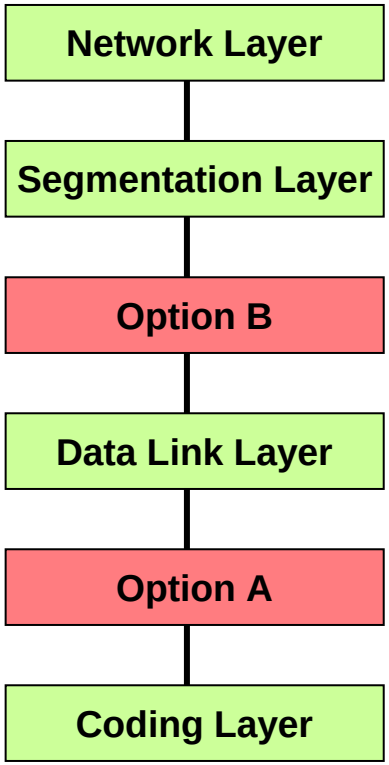
- Telecommand Authentication
  - Authenticates telecommands to prevent malicious commands sent to the spacecraft by an attacker
  - Ensures integrity of telecommands
- Confidentiality
  - Confidentiality of payload telemetry
    - Ensure commercial exploitability of data
    - Ensure exclusive rights to recorded science data
  - Confidentiality of selected telecommands
    - Protect sensitive commands e.g. for key upload
- Other requirements such as non-repudiation possible

TC Authentication

- Provides both Telecommand authentication and integrity
- Requires additional authentication layer in TC stack
  - Introduction of an authentication field
    - Signature, Anti-Replay Counter and other fields
- Overhead Calculation Example
  - Modern secure hashing algorithms provide hashes with at least 160 bit
  - Freshness information must not recycle during a keys lifetime → at least 30-32 bit
  - Together with some arbitrary fields we get an overhead of at least 200 bit (= 25 octets)

Authentication Localization

- Possibilities (according to CCSDS green book):
  - Data Link Layer (Option A - complete frame)
    - Protection of FARM-1 control commands (BC frames)
  - Segmentation Layer (Option B)
    - Current ESA approach
    - MAP Ids provide a selective tool for segments
- Authentication on packet level not applicable as it leaves too many vital data fields unprotected at lower layers



Signature Overhead Reduction

- Signature overhead is quite big especially for short telecommands
- Overhead reduction is desirable
- Various Techniques
  - Signature Truncation (e.g. from 160 to 96 bit)
    - Loss of security (Signature function gets more non-injective)
  - Direct TC encryption (if TC data structure is smaller than the signature)
    - Hashing function would increase length rather than reducing it
  - Usage of compression techniques may reduce length of TC data structure

Confidentiality

- Assuming usage of symmetric block ciphers
- Requires additional confidentiality layer in TM/TC stack
  - Introduction of a Security Header data field
  - Initialization Vector (IV) and other fields (e.g. key identifier) possible
- Overhead Calculation Examples
  - Block ciphers in CBC mode need an IV and padding (worst case: 2x block length)
  - Other header information may additionally increase overhead
  - If counter mode is used, the overhead is the length of the counter
    - Counter may be combined with a layer specific counter

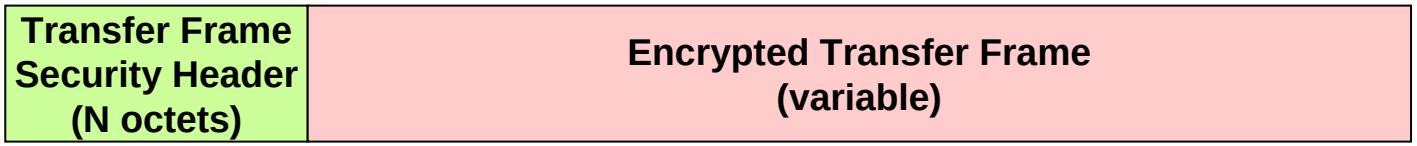
Confidentiality Localization

- Situation more complex than with authentication
  - Application dependent
  - Impact on availability of services (e.g. SLE)
- Network Layer
  - Application driven (APID) encryption possible
  - Encryption of packet data field
  - Use Packet secondary header to make security transparent
  - Alternative: Use CCSDS encapsulation packet standard

Encrypted Packet

Confidentiality Localization

- Data Link Layer Option A
  - High level of Security
  - No Transparency



Option A encrypted Transfer Frame

- Data Link Layer Option B
  - TM: Full transparency through usage of secondary header
  - TC: Limited transparency but more availability then in Option A

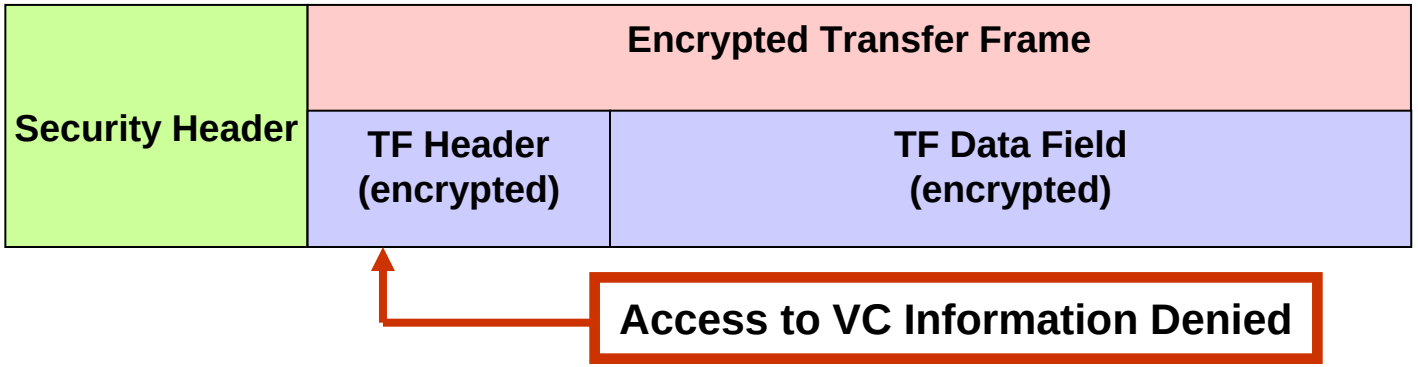
Option B encrypted Transfer Frame

Further Options

- Combined Authentication and Encryption
  - Merging Confidentiality and Authentication Layers
  - Special focus must lie on the cipher mode (Counter, CBC and other modes have weaknesses when used for providing integrity)
  - Reduction of overhead and complexity is achieved with this technique
- Payload Data Masses
  - Some science spacecrafts payload telemetry downlink may occupy huge bandwidths
  - Encryption must be parallelizable to be fast enough → Counter or other parallelizable modes required
- Combining space link security with ground data dissemination systems
  - End-to-End protection from spacecraft to customers

Cross Support Services

- Data link layer encryption (both options) can have impact on the availability of SLE services
- Cross Support Services must access relevant data fields to provide functionality
- Traditional conflict between security and availability
- Example situation: R-CF trying to access virtual channel information



Conclusion & Future Work

- Introduction of security to CCSDS TM/TC standards possible with justifiable effort
- A good trade-off between security and overhead can be found for both authentication and confidentiality
- Proper set of security standards eliminate the need for proprietary security solutions
  - Security Level classification required
- Future Work will focus on
  - Definition of a complete set of security protocol standards for ESA
  - Confidentiality and authentication overhead reduction
  - Emergency Commanding Solutions

Any Questions ?

Thank You!