Functional Specification
of the
OpenPGP application
on
ISO Smart Card Operating Systems

Version 3.3.2

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Many thanks to all people for advice, error correction and hints to this specification.

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History

V1.0 to V1.1:
- Change of access rights for command GENERATE ASYMMETRIC KEY PAIR and P1=81 (reading of public key) to always
- Adjustment of the literature
- New Data Objects for private use, with different access conditions. This optional feature is announced in Extended Capabilities
- New Data Objects for key generation date/time
- Data Object 'PW Status Bytes' (C4) mandatory for GET DATA as single object

V1.1 to V2.0:
- Correction of AID description (RID of FSFE)
- Adjustment of the literature
- Alignment with changes and innovations in ISO 7816 and EN 14890
- Change in VERIFY command and password management
- Enhancement of Extended Capabilities
- Enhancement of Algorithm attributes
- Reset functionality (life cycle management)
- Definition of key import according to ISO 7816-8
- Additional Hash algorithms and different behaviour of PSO:CDS command
- Improvements for cards without MF
- New Data Objects:
    - Cardholder certificate (ISO 7816-6)
    - Extended header list for key import, supporting
        - Cardholder private key template (ISO 7816-6/-8)
        - Cardholder private key (ISO 7816-6/-8)
    - Historical bytes (ISO 7816-4/-6)
    - Algorithm attributes for PUT DATA
    - Resetting Code for PUT DATA
    - SM keys for PUT DATA
- Deletion of DOs 'FF', 'E0'-'E2'
- Support for Secure Messaging
- Support for Command Chaining
- Support for different algorithm and key length (see PUT DATA for Algorithm attributes)
- Introduction of a Resetting Code for RESET RETRY COUNTER
- Simplification in password management
- Several editorial clarifications

V2.01 to 2.1:
- Support for AES algorithm for PSO:DEC.
- New Data Objects:
    - AES-Key for PSO:DEC
- Change access conditions for TERMINATE
- Update list of Status Bytes
- INS for TERMINATE and ACTIVATE corrected

V2.1 to V3.0:

- Adjustment of the literature
- Alignment with changes and innovations from ISO 7816-4, -8 and EN 419212 (former 14890):
    - Introducing Extended length information (DO 7F66)
    - Introducing General feature management (DO 7F74)
    - Add new commands GET NEXT DATA and SELECT DATA from ISO 7816-4
    - Improved description of Secure Messaging
- Extend maximum length of several DOs with variable length and announce max. length in Extended Capabilities
- New Data Objects:
    - Cardholder certificate (ISO 7816-6) for Decipher and Sign
    - Extended length information (DO 7F66)
    - UIF-DOs (D6 - D8)
- Several corrections and editorial improvements
- Obsolet definitions from old versions are deleted
- 3DES is discarded for Secure Messaging
- RSA 1024 is removed
- SHA-1 and RIPEMD-160 are removed
- Modified and additional flow charts
- Enhancement of VERIFY (additional PIN format)
- Support for ECDSA/DH algorithm:
    - Enhancement of GENERATE PUBLIC KEY PAIR
    - Enhancement of key import
    - Enhancement of PSO:CDS, DEC and INT-AUT
    - Enhancement of Algorithm attributes
- Modification of Extended Capabilities
- Introducing User Interaction Flag

V3.0 to V3.0.1:

- Some error corrections
- Enhancement of User Interaction Flag for DOs D6 to D8

V3.0.1 to V3.1:

- Update of the literature
- Enhancement of the VERIFY command (reset and get status)

V3.1 to V3.2:

- Update of the literature
- Update of General feature management (DO 7F74)
- Key import for ECC added (Private Key Template, Algorithm Attributes)

V3.2 to V3.3

- Update of the literature
- Adding Odd Instruction for GET DATA
- Adding PSO:ENCIPHER with AES
- PSO:ENCIPHER and PSO:DECIPHER with AES can handle more than one block
- Adding optional command MANAGE SECURITY ENVIRONMENT (MSE) for commands PSO:DEC (asymmetric) and INTERNAL AUTHENTICATE and introducing key references
- Adding optional KDF-DO (Key Derivation Function) and corresponding flag in Extended Capabilities for calculated passwords
- Indication for other Secure Messaging implementations in Extended Capabilities
- Minor editorial enhancements and corrections

V3.3 to V3.3.1

- Error correction of Algorithm IDs for ECDSA and ECDH
- Minor editorial clearifications

V3.3.1 to V3.3.2

- Editorial clearifications
- Introduction in APDU handling
- Adding examples for command APDUs
- Update of the literature

TABLE OF CONTENTS

1 Introduction

This functional specification describes the OpenPGP application based on the functionality of an ISO smart card operating system. In principle it defines the interface of the application between card and terminal, in this context the OpenPGP software with a standard card reader.

The solution takes care of

- use of international standards,
- avoiding of patents,
- free usage under GNU General Public License,
- independence from specific smart card operating systems (second source),
- easy enhancement for future functionality,
- international use.

Consequently this specification does not deal with the description of the global commands and data fields of the card, the security functions generally provided by the card, any features that apply to more than one application, such as transmission protocols, nor with the description of the general mechanical and electrical characteristics of the card.

In particular, the specification provides a detailed description of the data objects directly related to the applications and their respective content formats. Contents of the application data are only prescribed if they represent a constant factor of the application. In addition all application relevant commands are defined in detail and the specific security functions.

Besides the definitions in this specification a card may support any other protocols, commands, data and variants. However, the OpenPGP application (e. g. GnuPG) should use only the defined features in this specification to be compatible to different implementations.

The encoding values mentioned in the specification are stated in hexadecimal form, unless otherwise indicated.

1.1 Definition of Abbreviations

AC	Access Condition
AES	Advanced Encryption Standard
AID	Application Identifier
APDU	Application Protocol Data Unit
ATR	Answer To Reset
AUT	AUThentication
BCD	Binary Coded Decimal
CLA	CLAss byte
CP	Control Parameter
CRT	Control Reference Template
DEC	DECipher
dec.	Decimal
DF	Dedicated File
DIR	DIRectory
DO	Data Object
DSI	Digital Signature Input
ECDH	Elliptic Curve Diffie Hellman
ECDSA	Elliptic Curve Digital Signature Algorithm
EF	Elementary File
FCI	File Control Information
FCP	File Control Parameter
FID	File IDentifier
INS	INStruction byte
LCS	Life Cycle Status
MF	Master File
OS	Operating System
PK	Public Key
PW	PassWord
RC	Resetting Code
RFU	Reserved for Future Use
RSA	Rivest-Shamir-Adleman
SE	Security Environment
SIG	SIGnature
SK	Secret Key
SM	Secure Messaging
UID	Unique card IDentifier
UIF	User Interaction Flag
URL	Uniform Resource Locator
UTF-8	UCS Transformation Format 8 (compatible with 7-bit US-ASCII for all characters < 80)
VR	Virtual Root data object

2 General Requirements

The OpenPGP application is designed to run under several ISO-compatible card operating systems. The application can be developed on various chips and by different manufacturers. For all implementations, the following requirements should be fulfilled.

Card ->

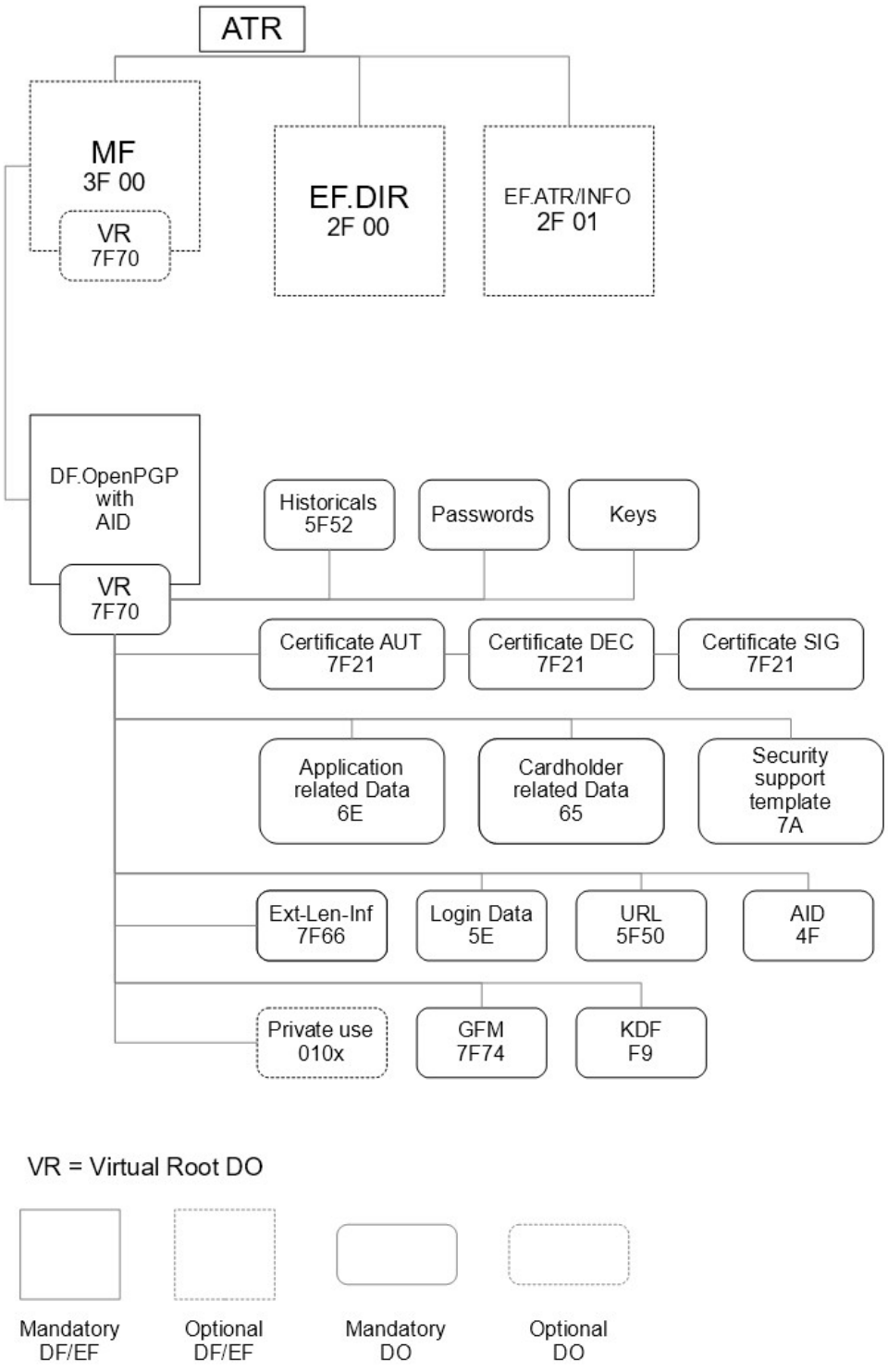
- The OpenPGP application does evaluate Historical bytes for ‘Card capabilities’. For that reason the card shall provide a 'DO Historical bytes' at application level.
- The OpenPGP application may evaluate “Extended length information”. For that reason the card should provide the content as DO at application level.
- As single transmission protocol any ISO protocol is allowed.
  - T=1 is preferred for cards with contacts (extended length, chaining for APDUs > max. command/response length).
- The card may support different transmission protocols.
- High speed modes are requested (maximum as possible for the chip).
- Extended length (Lc and Le) fields are recommended (at least 2048 bytes for a single APDU under T=1)
  - The card shall announce this feature in ‘Card capabilities’.
  - If Extended length is not supported (T=0), the card should support command chaining and/or ENVELOPE/GET RESPONSE for large command/response data.
- Contactless cards should support random UID (Unique card Identifier) to avoid collecting user profiles (Datenschutz).

Reader (informative) ->

- A common driver (CCID, PC/SC or CT-API) shall be supported.
  - The driver should be available for several platforms (e. g. Win32/64, Linux, Macintosh).
- T=1 shall be supported for cards with contacts (T=0 optional).
- High-Speed protocols should be supported.
- Extended length should be supported with a minimum of 2048 bytes for APDUs for in- and ouput.
- Under T=0 ENVELOPE and GET RESPONSE are required to transport long APDUs. Command chaining should be supported.

3 Data Structure

The following diagram gives an overview over files and data objects (DO) relevant for the OpenPGP application. Security related data (e. g. keys, passwords) are stored in accordance with the used OS (files, data objects or other).



4 Directory and Data Objects of the OpenPGP Application

The DF.OpenPGP directory and the data objects contained therein constitute the OpenPGP application. On the card several other applications may exist in specific Dedicated Files (DF).

4.1 Files and Objects under the MF

The OpenPGP application uses its own set of data, including keys and passwords. No files/data of the MF or other DFs are needed for the application. However the operating system may store common data, like passwords, shareable in the card and use them for several applications.

4.1.1 EF.DIR

This optional file under the MF (file identifier: ’2F00’) may contain one or several application templates and/or application identifiers as defined in ISO/IEC 7816-4. The data file is not requested and evaluated by the OpenPGP application, but may be used to declare the application to 3rd parties. The following entries should be added in that case:

- Application Identifier (tag ‘4F’), only the significant values should be used (6 bytes = 'D27600012401')
- Application label (tag ‘50’), the application label should contain the following UTF-8 encoded text: OpenPGP

Example:
An entry in EF.DIR is an application template (Tag 61) in most cases. The template is stored in a record or is appended to a previous template in case of a binary structure of the EF.DIR. An entry has the content:

61 11 4F 06 D27600012401 50 07 'OpenPGP'

If the card indicates DO handling for EF.DIR, then it should support the GET DATA command for reading all DOs in the EF at once ('00CB 2F00 02 5C00 00') directly after a reset.

4.1.2 Historical bytes

In the Answer To Reset (ATR) of a card with contacts Historical bytes may be present. These bytes are available as DO ('5F52') for all types of smart cards on application level also and are relevant only for the selected application in that case. In the OpenPGP card application the DO “Historical bytes” is available directly after SELECT as single DO or in between the “Application Related Data” ('6E').

4.1.3 EF.ATR/INFO

The optional file EF.ATR/INFO under the MF (file identifier: ’2F01’) contains “Extended length information” for APDUs, if extended length is announced in the Historical bytes.

If the card supports additional hardware like buttons or fingerprint sensors for special user interaction EF.ATR/INFO should contain the General feature management DO ('7F74') also. If no additional hardware is present this DO can be omitted.

If the card indicates DO handling for EF.ATR/INFO, then it should support the GET DATA command for reading all DOs in the EF at once ('00CB 2F01 02 5C00 00') directly after a reset.

4.1.3.1 Extended length information

In the OpenPGP card application the DO “Extended length information” ('7F66') shall be available directly after SELECT as single DO and in between the “Application Related Data” ('6E'). The DO contains the following data objects.

7F66	08	*Extended length information*		
		02	02	Maximum number of bytes in a command APDU Unsigned Integer, 2 bytes (Most Significant Bit ... Least Significant Bit)
		02	02	Maximum number of bytes in a response APDU Unsigned Integer, 2 bytes

The maximum length of an APDU field means the total amount of bytes sent to or received from the card (including SM) in any command. If commands exceed the announced maximum length by definition, the card shall support chaining. If a response exceeds the maximum length (e. g. GET DATA), the card answers with status bytes 61xx and the remaining data can be read with GET RESPONSE.

If Extended Length is not supported by a card or if the Extended Length information is not present, then a maximum length of 256 (dec.) bytes is assumed (short length). The card should support chaining for command and response if any defined commands have this requirement.

4.1.3.2 General feature management

In the OpenPGP card application the optional DO “General feature management” ('7F74') may be available directly after SELECT as single DO and in between the “Application Related Data” ('6E'). The DO announced additional hardware for user interaction, if present the User Interaction Flag (UIF) in the related DOs shall be evaluated.

The DO contains a data object with Tag '81' with the following content (only first byte):

b8	b7	b6	b5	b4	b3	b2	b1	Meaning
1	-	-	-	-	-	-	-	Display (defined by ISO/IEC 7816-4)
-	1	-	-	-	-	-	-	Biometric input sensor (defined by ISO/IEC 7816-4)
-	-	1	-	-	-	-	-	Button
-	-	-	1	-	-	-	-	Keypad
-	-	-	-	1	-	-	-	LED
-	-	-	-	-	1	-	-	Loudspeaker
-	-	-	-	-	-	1	-	Microphone
-	-	-	-	-	-	-	1	Touchscreen

Actual only the behaviour for Button is defined, e. g. '7F74 03 81 01 20' announces a button. ISO defines more bytes for additional features, they are not used by the OpenPGP card at the moment.

4.2 DF.OpenPGP

The directory of the OpenPGP application is stored anywhere in the card. It has no fixed File Identifier (FID), so it is easy to integrate the application in any existing context. The FID (if needed) can be chosen by the card manufacturer or any other party. The directory contains all data objects of the application. The OpenPGP application can be selected with a SELECT command directly after a Reset of a card. The SELECT command may return FCPs (File Control Parameter), but the OpenPGP application in the terminal do not need to evaluate them. A valid SELECT of an application directory sets the curConstructedDO

pointer to the Virtual Root DO and adds all data objects in the application to the current template.

4.2.1 Application Identifier (AID)

The OpenPGP application is selectable by a unique application identifier (see SELECT). The AID has a length of 16 bytes (dec.) and is coded in the following way. The AID is unique for each card and it is recommended to integrate this value in certificates, e.g. for client/server authentication. The RID in the AID is registered by FSF Europe e. V./GnuPG e. V.

	RID	PIX				
Coding	D2 76 00 01 24	01	xx xx	xx xx	xx xx xx xx	00 00
Length (dec.)	5	1	2	2	4	2
Name	RID of FSFE	Application	Version	Manufacturer	Serial num-ber	RFU

RID	Registered application provider identifier (unique identification of FSFE), ISO 7816-5
PIX	Proprietary application identifier extension (defined for OpenPGP application)
Application	Indication of the application (OpenPGP)
Version	Version number of the application
Manufacturer	Unique code for the manufacturer of the application (card)
Serial number	Unique serial number
RFU	Reserved for Future Use

Application

This value (1 byte binary) specifies the application. With this definition it is possible to design different applications under control of FSF Europe e. V. in the future. The following values are defined:

00	Reserved
1	OpenPGP application (standard)
2	SmartChess
...	
FF	Reserved

Version

The version number (2 bytes, BCD) gives information about the current status of the application and shall correspond with the related specification. The version number is defined as follows:

Byte 1	Byte 2	
Main version	Secondary version	(values from 00 – 99)

Example: A version

1.0	is coded	01 00
2.1		02 01
11.7		11 07

Manufacturer

To identify a card in open networks (e. g. key servers) and for the purpose of Log-In in local or open networks or to a single computer, it is necessary to have unique application numbers (related to a specific card). For that reason, every card manufacturer or personaliser has a unique address. This manufacturer identification is controlled by FSF Europe e. V. and given to every interested manufacturer for free. Only registered manufactures are allowed to produce applications compatible with an OpenPGP application. The system works similar to MAC addresses on network cards. The 2 bytes are coded binary and the values '0000' and 'FFFF' are reserved for test purposes.

Serial Number

Each OpenPGP application on a card from a manufacturer/personaliser has a unique serial number. The manufacturer/personaliser is responsible that no cards with duplicate numbers will occur in the outside world (like MAC addresses in networks). The number is 4 byte long (binary) and has the format MSB .. .. LSB (Most Significant Bit ... Least Significant Bit). It should start with 00 00 00 01 for the first card with an OpenPGP application of a manufacturer and normally is incremented automatically by him. However gaps in the range of numbers are allowed.

4.3 User Verification in the OpenPGP Application

The OpenPGP application uses two local passwords for user verification, called PW. PW1 is also called user-password and PW3 admin-password. PW1 (user) is the password used for signing and decryption operations, PW3 (admin) is the security officers password. PW1 is needed for everyday use of the card, while PW3 is used to manage the card.

The card checks length and format of the passwords. The storage of the PWs is dependent on the card OS, global PWs (used by other applications as well) may be used but mapped to the application as local. PW1 is used as access condition for the command PSO:CDS, PSO:DEC, INT-AUT, GET DATA and PUT DATA. The OpenPGP application uses PW3 as access condition for the commands RESET RETRY COUNTER, PUT DATA, GENERATE ASYMMETRIC KEY PAIR and TERMINATE DF. All PWs use an error counter with an initial value of 3. This error counter is readable with GET DATA. After correctly verifying the PW, the access status of the corresponding PW remains valid up to a RESET of the card, a SELECT to a different DF or an internal resetting by specific commands.

The command PSO:CDS uses PW1 in a different mode then the other commands, it is valid for one command only and has to be presented again for the next signature calculation, for that reason terminals and software should not cache the passwords of a card! This behaviour is defined in the 1st byte of the 'PW status' DO can be changed by the user by option (announced in Extended Capabilities), so that the password remains valid in the card up to a reset or changing the application. The other passwords are valid for the complete session by default.

4.3.1 Standard format (UTF-8)

The format of the PWs is UTF-8 (case sensitive) by default. The format and maximum length for each PW (PW1 with 6 characters/digits minimum and PW3 with 8 characters/ digits minimum) is declared in the 'PW status' DO. This format is then valid for all passwords and the resetting code. It is up to the terminal application to align the correct format between all passwords in the card.

If the card is delivered without personalisation and/or PW letter, then a default content is assumed (UTF-8): PW1 = “123456” (6 bytes, 313233343536); PW3 = “12345678” (8 bytes, 3132333435363738). After a card reset, these values are restored also.

It is highly recommended that the card holder changes these default values!

4.3.2 Key derived format

To avoid the transmission and internal storage of passwords in plain format, the card may support the KDF (Key Derived Function) functionality, it is announced in Extended Capabilities. If the corresponding bit signals the KDF format, then a KDF-DO (data object) shall be present in the card. It can be read with GET DATA and Tag F9. The KDF-DO may be empty (set to NONE) or has an invalid value, in that case the standard password format (UTF-8) is valid. If the KDF-DO has a valid content, all passwords and resetting codes in the card shall have a derived content (e. g. hash value calculated by GnuPG with the S2K-function from RFC 4880). It is up to the terminal application to align all PWs and the KDF-DO with correct values, the functionality is transparent to the card. The content of the KDF-DO is not evaluated by any card command, the functionality is handled completely by the terminal application.

If the KDF format is supported, the maximum length for all passwords in the PW status bytes should be at least 64 bytes, to be able to store a SHA512 hash value.

The KDF-DO has the following format and shall be evaluated by the terminal software, if present:

F9	xx	Key Derivation Function for passwords and resetting code		
		81	01	KDF algorithm byte: 00 = NONE (not used) 03 = KDF_ITERSALTED_S2K
		82	01	Hash algorithm byte: 08 = SHA256 0A = SHA512
		83	04	Iteration count (long integer)
		84	xx	Salt bytes for User password (PW1)
		85	xx	Salt bytes for Resetting Code of PW1
		86	xx	Salt bytes for Admin password (PW3)
		87	xx	Initial password hash for User-PW
		88	xx	Initial password hash for Admin-PW

An empty or non-valid KDF-DO should be presented by KDF algorithm byte set to NONE, all other Tags can be omitted, if present they should be evaluated. If KDF algorithm byte is set to NONE all PWs are assumed to have an UTF-8 content. When KDF algorithm byte is set to NONE, the KDF-DO can have the following content:

F9	03	Key Derivation Function for passwords and resetting code		
		81	01	00 (KDF algorithm byte = NONE)

Other Tags (e. g. 87/88 for initial PWs) may be present and should be evaluated.

Here is an example for a valid KDF-DO:

F9	5E	Key Derivation Function for passwords and resetting code		
		81	01	03 = KDF_ITERSALTED_S2K
		82	01	08 = SHA256
		83	04	000186A0
		84	08	30 31 32 33 34 35 36 37
		85	08	10 11 12 13 14 15 16 17
		86	08	41 42 43 44 45 46 47 48
		87	20	773784A602B6C81E3F092F4D7D00E17C- C822D88F7360FCF2D2EF2D9D901F44B6 ("123456" hashed by the KDF with Users salt, SHA256 and 100000 iteration)
		88	20	2675D6164A0D4827D1D00C7EEA620D015C00030A1CAB38B4D0 DD600B27DC9630 ("12345678" hashed by the KDF with Admins salt, SHA256 and 100000 iteration)

4.3.3 PIN block format 2

The card may support the PIN block format 2 (digits only, useful for class 2/3 readers with PIN pad), this is announced in Extended Capabilities. Several cards support this format only and with this enhancement it is possible to add the OpenPGP smart card application to such cards. The format and maximum length for each PW (PW1 with 6 digits minimum and PW3 with 8 digits minimum) is declared in the 'PW status' DO and the format (UTF-8 or PIN block format 2) can be changed by the user by option (announced in Extended Capabilities). If the card supports PIN block format 2 it shall check length and format of the passwords in the relevant commands. If this format is used, then it is valid for all passwords and the resetting code. It is up to the terminal application to align the correct format between all passwords in the card.

4.3.4 Resetting Code

If, for example, the card is issued by an authority or company, the users will get a complete personalised card with keys and password. The user should be able to work with the card, but is not permitted to change card data like keys and DOs under control of the issuer. He shall know his user-password (PW1), but is not aware of the admin-password (PW3). To reset PW1 in the case of a blocked error counter, a special Resetting Code (RC) is introduced. The issuer should give the RC to the user together with his password. The Resetting Code is stored in a DO 'RC'. The maximum length is announced in PW status bytes, the minimum length is 8 characters or digits. The format is the same as for PW1, the admin can change the values (optional). The Resetting Code can be used within the command RESET RETRY COUNTER instead of the admin-password (PW3). It is only valid for resetting PW1. By default DO 'RC' is empty and the related error counter is zero, so it cannot be used. The Resetting Code has an error counter with an initial value of 3. This error counter is readable with GET DATA. The DO 'RC' can be set to any value with a PUT DATA command after correct verification of the admin-password (PW3), the error counter then is set to 3. The format of the resetting code shall be the same than for PW1 and PW3. It is up to the terminal application to align the correct format between all passwords in the card.

4.4 Data Objects (DO)

To keep the interface to terminals simple and for the reason to integrate the OpenPGP application in different card OS, all relevant data elements for the application are stored as data objects. Terminals can run the application only with the SELECT (DATA), GET (NEXT) DATA, PUT DATA and cryptographic commands. Changing of any file identifier, short file identifier, file type or file structure has no influence on the terminal interface. DOs are stored in a TLV (Tag, Length, Value) format, whenever possible definitions of ISO (e. g. 7816-6) are used. This application structure is in compliance with the latest additions of ISO 7816-4, where each DF may have a Virtual Root data object (Tag '7F70') and any DO under this root may have its own access conditions. The OpenPGP card application does not use the DO '7F70' directly.

4.4.1 DOs for GET DATA

The following DOs shall be supported by the GET (NEXT) DATA command. They can be accessed at least in the OpenPGP DF of the card. Simple DOs (S) return only the value with GET DATA. Constructed DOs (C, marked yellow) are returned including their tag and length. In constructed DOs additional DOs may occur (not defined here) but are not evaluated by the OpenPGP application in the terminal. The DOs in cursive letters cannot accessed directly with GET DATA as single DO, the OpenPGP application in the terminal uses the non-cursive DOs (mostly constructed) only. Some of the DOs are optional (marked green), the occurrence is announced in Extended Capabilities. DOs may appear several times in the table, if they are defined as single DO and occur in constructed DOs also. The order of DOs in a constructed DO may vary.

Tag	Format	Length	Description
0101	S	0 – max.	Optional DO for private use (binary, proprietary), can be used to store any information. The maximum length of this DO is announced in Extended Capabilities.
0102	S	0 – max.	Optional DO for private use (binary, proprietary), can be used to store any information. The maximum length of this DO is announced in Extended Capabilities.
0103	S	0 – max.	Optional DO for private use (binary, proprietary), can be used to store any information. The maximum length of this DO is announced in Extended Capabilities.
0104	S	0 – max.	Optional DO for private use (binary, proprietary), can be used to store any information. The maximum length of this DO is announced in Extended Capabilities.
4F	S	5 - 16 (dec.)	Full Application identifier (AID), ISO 7816-4
5E	S	0 – max.	Login data (binary, proprietary) This DO can be used to store any information used for the Log-In process in a client/server authentication (e.g. user name of a network). The maximum length of this DO is announced in Extended Capabilities.
5F50	S	0 – max.	Uniform resource locator (URL, as defined in RFC 1738). The URL should contain a Link to a set of public keys in OpenPGP format, related to the card. The maximum length of this DO is announced in Extended Capabilities.
5F52	S	0 – 15 (dec.)	Historical bytes, Card service data and Card capabilities shall be included, mandatory for the OpenPGP application.
7F66	C	08	Extended length information (ISO 7816-4) with maximum number of bytes for command and response.
7F74	C	03	General feature management (optional)
65	C	var.	Cardholder Related Data
5B	*S*	*0 – 39 (dec.)*	*Name according to ISO/IEC 7501-1)*
5F2D	*S*	*2 - 8*	*Language preferences (according to ISO 639)*

Tag	Format	Length	Description
5F35	*S*	*1*	*Sex (according to ISO 5218)*
6E	C	var.	Application Related Data
4F	S	5 – 16 (dec.)	Application identifier (AID), ISO 7816-4
5F52	S	0 – 15 (dec.)	Historical bytes, Card service data and Card capabilities shall be included, mandatory for the OpenPGP application.
7F66	C	08	Extended length information (ISO 7816-4) with maximum number of bytes for command and response.
7F74	C	03	General feature management (optional)
73	*C*	*var.*	*Discretionary data objects*
C0	*S*	*10 (dec.)*	*Extended Capabilities* *Flag list*
C1	*S*	*var.*	*Algorithm attributes signature* *1 Byte Algorithm ID, according to RFC 4880/6637* *further bytes depending on algorithm (e. g. length modulus and length exponent).*
C2	*S*	*var.*	*Algorithm attributes decryption*
C3	*S*	*var.*	*Algorithm attributes authentication*
C4	S	7	PW status Bytes 1st byte: 00 = PW1 (no. 81) only valid for one PSO:CDS command 01 = PW1 valid for several PSO:CDS commands 2nd byte: max. length and format of PW1 (user) Bit 1-7 = max. length Bit 8 = 0 for UTF-8 or derived password 1 for PIN block format 2 3rd byte: max. length of Resetting Code (RC) for PW1 4th byte: max. length and format of PW3 (admin), see 2nd byte for PW1 Byte 5, 6, 7 (first byte for PW1, second byte for Resetting Code, third byte for PW3): Error counter of PW1, RC and PW3. If 00 then the corresponding PW/RC is blocked. Incorrect usage decrements the counter, correct verification sets to default value = 03.
C5	*S*	*60 (dec.)*	*Fingerprints (binary, 20 bytes (dec.) each for Sig, Dec, Aut in that order), zero bytes indicate a not defined private key.*
C6	*S*	*60 (dec.)*	*List of CA-Fingerprints (binary, 20 bytes (dec.) each) of "Ultimately Trusted Keys". Zero bytes indicate a free entry. May be used to verify Public Keys from servers.*
CD	*S*	*12 (dec.)*	*List of generation dates/times of public key pairs, binary. 4 bytes, Big Endian each for Sig, Dec and Aut. Each value shall be seconds since Jan 1, 1970. Default value is 00000000 (not specified).*

Tag	Format	Length	Description
D6	S	02	User Interaction Flag (UIF) for PSO:CDS (optional): If not supported, DO is not available. First byte = 00: UIF disabled (default) 01: UIF enabled 02: UIF permanently enabled (not changeable with PUT DATA, optional) Second byte = Content from General feature management ('20' for button/keypad)
D7	S	02	UIF for PSO:DEC (optional): See UIF for PSO:CDS
D8	S	02	UIF for PSO:AUT (optional): See UIF for PSO:CDS
7A	C	5	Security support template
93	*S*	*3*	*Digital signature counter (counts usage of Compute Digital Signature command), binary, ISO 7816-4.*
7F 21	C	0 – max.	Cardholder certificate (each for AUT, DEC and SIG) These DOs are designed to store a certificate (e. g. X.509) for the keys in the card. They can be used to identify the card in a client-server authentication, where specific non-OpenPGP-certificates are needed, for S-MIME and other x.509 related functions. The maximum length of the DOs is announced in Extended Capabilities. The content should be TLV-constructed, but is out of scope of this specification. The DOs are stored in the order AUT (1st occurrence), DEC (2nd occurrence) and SIG (3rd occurrence). Storing the AUT certificate at first occurrence is for downward compatibility with older versions of this specification.

Tag	Format	Length	Description
C4	S	7	PW Status Bytes (binary) 1st byte: 00 = PW1 (no. 81) only valid for one PSO:CDS command 01 = PW1 valid for several PSO:CDS commands 2nd byte: max. length and format of PW1 (user) Bit 1-7 = max. length Bit 8 = 0 for UTF-8 or derived password 1 for PIN block format 2 3rd byte: max. length of Resetting Code (RC) for PW1 4th byte: max. length and format of PW3 (admin), see 2nd byte for PW1 Byte 5, 6, 7 (first byte for PW1, second byte for Resetting Code, third byte for PW3): Error counter of PW1, RC and PW3. If 00, then the corresponding PW/RC is blocked. Incorrect usage decrements the counter, correct verification sets to default value = 03.
F9	C	var.	KDF-DO, announced in Extended Capabilities (optional)

4.4.2 DOs for PUT DATA

The following DOs are supported by the PUT DATA command. They can be accessed at least in the OpenPGP DF of the card. The content of possibly empty DOs can be deleted with PUT DATA and empty Lc (no data).

Tag	Format	Length	Description
0101	S	0 – max.	Optional DO for private use (binary)
0102	S	0 – max.	Optional DO for private use (binary)
0103	S	0 – max.	Optional DO for private use (binary)
0104	S	0 – max.	Optional DO for private use (binary)
4D	C	var.	Extended Header list (used for optional key import), uses: 7F48 (Cardholder private key template) 5F48 (Cardholder private key)
5B	S	0 – 39 (dec.)	Name
5E	S	0 – max.	Login data
5F2D	S	2 - 8	Language preferences
5F35	S	1	Sex
5F50	S	0 – max.	Uniform resource locator (URL)
7F 21	C	0 – max.	Cardholder certificate (AUT, DEC, SIG) These DOs are designed to store a certificate (e.g. X.509) for the AUT-, DEC- and SIG-key in the card. The maximum length of the DOs is announced in Extended Capabilities. The content should be TLV-constructed, but is out of scope of this specification. The DOs are stored in the order AUT (1st occurrence), DEC (2nd occurrence) and SIG (3rd occurrence).
C1	S	var.	Optional DO (announced in Extended Capabilities). Algorithm attributes signature
C2	S	var.	Optional DO (announced in Extended Capabilities). Algorithm attributes decryption
C3	S	var.	Optional DO (announced in Extended Capabilities). Algorithm attributes authentication
C4	S	1 or 4	Optional DO (announced in Extended Capabilities). 1st PW Status Byte (1 byte binary): 00 = PW1 (No. 81) only valid for one PSO:CDS command 01 = PW1 valid for several PSO:CDS commands 2nd byte: max. length and format of PW1 (user) Bit 1-7 = max. length Bit 8 = 0 for UTF-8 or derived password 1 for PIN block format 2 3rd byte: max. length of Resetting Code (RC) for PW1 4th byte: max. length and format of PW3 (admin), see PW1 The card should check new values for compatibility with the implementation and should reject wrong definitions. Especially length information (byte 3 and relevant parts of byte 2 and 4) should not be changed.

Tag	Format	Length	Description
C7	S	20 (dec.)	Fingerprint (binary) for signature key, format according to RFC 4880
C8	S	20 (dec.)	Fingerprint (binary) for decryption key
C9	S	20 (dec.)	Fingerprint (binary) for authentication key
CA	S	20 (dec.)	1st CA-Fingerprint in list (binary)
CB	S	20 (dec.)	2nd CA-Fingerprint in list (binary)
CC	S	20 (dec.)	3rd CA-Fingerprint in list (binary)
CE	S	4	Generation date/time of signature key (Big Endian, format according to RFC 4880
CF	S	4	Generation date/time of decryption key (Big Endian)
D0	S	4	Generation date/time of authentication key (Big Endian)
D1	S	16 / 32	Optional DO (announced in Extended Capabilities) for SM. SM-Key-ENC for cryptogram (16 or 32 bytes in case of AES128/256). The stored SM-Key shall match the announced algorithm in Extended Capabilities.
D2	S	16 / 32	Optional DO (announced in Extended Capabilities) for SM. SM-Key-MAC for cryptographic checksum (16 or 32 bytes in case of AES128/256). The stored SM-Key shall match the announced algorithm in Extended Capabilities.
D3	S	0 / 8 - xx	Resetting Code, 0 or 8 to xx bytes (dec.), binary
D5	S	16 / 32	Optional DO (announced in Extended Capabilities) for PSO:ENC/DEC with AES (32 bytes dec. in case of AES256, 16 bytes dec. in case of AES128).
D6	S	02	User Interaction Flag (UIF) for PSO:CDS (optional): If not supported, DO is not available. First byte = 00: UIF disabled (default) 01: UIF enabled 02: UIF permanently enabled (optional, a PUT DATA command shall abort if the old content is 02. Changing of a value 02 may be only possible with a factory reset – Terminate/Activate). Second byte = Content from General feature management ('20' for button/keypad)
D7	S	02	UIF for PSO:DEC (optional): See UIF for PSO:CDS
D8	S	02	UIF for PSO:AUT (optional): See UIF for PSO:CDS
F4	C	var.	Optional DO (announced in Extended Capabilities) for SM. Container for both SM keys (ENC and MAC) with Tags D1 and D2. Useful for updating or deleting both keys simultaneous.
F9	C	var.	KDF-DO, announced in Extended Capabilities (optional)

4.4.3 DOs in Detail

The following chapter describes some DOs in detail, especially the application specific DOs.

4.4.3.1 Private Use

These optional DOs can be used by the card holder, administrator or any application for proprietary data (e. g. password list). The difference between the DOs are the access conditions. The presence and maximum length of the DOs is announced in Extended Capabilities.

4.4.3.2 Name

This interindustry data element consists of 0 to 39 bytes, each byte is a character from ISO 8859-1 (Latin 1) alphabet (identical to 7-bit-US-ASCII for characters < 80). The data element consists of surname (e. g. family name and given name(s)) and forename(s) (including name suffix, e. g., Jr. and number). Each item is separated by a ´<´ filler character (3C), the family- and fore-name(s) are separated by two ´<<´ filler characters.

4.4.3.3 Language Preferences

This data element consists of 1 to 4 pairs of bytes (e. g. 2 bytes or 6 bytes) with coding according to ISO 639-1, ASCII lower case (e. g. de = german; en = english; nl = dutch; fr = french). At least one entry (2 bytes) should be present, the first entry has highest priority. The information can be used by the terminal for the user interface (e. g. language of text).

4.4.3.4 Sex

This data element of 1 byte (binary) represents the ´Sex´ of a person according to ISO 5218. The following values are defined for the OpenPGP application:

Male	31
Female	32
Not announced	39

The terminal can use the information for the user interface.

4.4.3.5 User Interaction Flag

The optional feature User Interaction Flag adds a special behaviour to the related commands. If the flag is enabled (or permanently enabled) and a button or keypad is present, the related function will only run if a special button (on a keypad ENTER button) on the card or device is pressed by the user. This is a security function against viruses/trojans that try to call the functions on the card without knowledge of the user. The flags are evaluated by the card and can be changed by the card holder with the admin password (optional). Cards may support a permanently enabling for a flag, in that case the value cannot be changed any more (except factory reset). If the user did not finish the action (abort, timeout) the card should answer with SW1SW2 = 6600.

4.4.3.6 Extended Capabilities

The Extended Capabilities consists of 10 bytes (dec.) with the following meaning. The first byte is a table that indicates additional features to the terminal. A set bit (1) means that the function is available, a value equalling zero means that the function is not available. Bits can be set simultaneous.

Coding of byte 1 of Extended Capabilities:

b8	b7	b6	b5	b4	b3	b2	b1	Meaning
1	-	-	-	-	-	-	-	Secure Messaging supported
-	1	-	-	-	-	-	-	Support for GET CHALLENGE The maximum supported length of a challenge can be found in Extended Capabilities.
-	-	1	-	-	-	-	-	Support for Key Import
-	-	-	1	-	-	-	-	PW Status changeable (DO C4 available for PUT DATA)
-	-	-	-	1	-	-	-	Support for Private use DOs (0101-0104)
-	-	-	-	-	1	-	-	Algorithm attributes changeable with PUT DATA
-	-	-	-	-	-	1	-	PSO:DEC/ENC with AES
-	-	-	-	-	-	-	1	KDF-DO (F9) and related functionality available

The other bytes are coded as follows:

Byte	Length	Value
02	01	Secure Messaging Algorithm (SM) 00 = no SM or proprietary implementation 01 = AES 128 bit 02 = AES 256 bit 03 = SCP11b If SM is not supported (see 1st byte), the coding is 00
03 - 04	02	Maximum length of a challenge supported by the command GET CHALLENGE (unsigned integer, Most Significant Bit ... Least Significant Bit). If GET CHALLENGE is not supported (see 1st byte), the coding is 0000
05 - 06	02	Maximum length of Cardholder Certificates (DO 7F21, each for AUT, DEC and SIG), coded as unsigned integer (Most Significant Bit ... Least Significant Bit).
07 - 08	02	Maximum length of special DOs with no precise length information given in the definition (Private Use, Login data, URL, Algorithm attributes, KDF etc.), coded as unsigned integer (Most Significant Bit ... Least Significant Bit).
09	01	PIN block 2 format 0 = not supported 1 = supported
0A	01	MSE command for key numbers 2 (DEC) and 3 (AUT) 0 = not supported 1 = supported

4.4.3.7 Algorithm Attributes

This DO announces information related to the supported algorithm of the card. The terminal shall use this information for the key import functionality (if available). The formats are used by the key generation in the card and are also related to the output format of the corresponding command.

The content of the DO is optionally changeable (announced in Extended Capabilities) with PUT DATA. This is useful if the card supports several algorithms or different key length. The attributes can be changed independent for each key, so it is possible for example to use different key length for signing and decrypting. A card should reject unsupported values in the DO. The supported values are manufacturer specific, please ask your card vendor for the correct parameters if the card supports changing of the attributes.

If the attributes of an existing key are changed and do no longer match with the stored key, the card should delete this key internally or prevent it from usage.

RSA:

Byte	Length	Value
01	01	Algorithm ID (RFC 4880) 01 = RSA (Encrypt or Sign)
02 - 03	02	Length of modulus n in bit (e. g. 2048 bit decimal = 0800), binary
04 - 05	02	Length of public exponent e in bit (e. g. 32 bit decimal = 0020), binary
06	01	Import-Format of private key 00 = standard (e, p, q) 01 = standard with modulus (n) 02 = crt (Chinese Remainder Theorem) 03 = crt with modulus (n)

ECDSA:

Byte	Length	Value
01	01	Algorithm ID (RFC 4880 and 6637) 13 = ECDSA for PSO:CDS and INT-AUT 12 = ECDH for PSO:DEC
02 - xx	var.	OID of relevant curve, binary (see annex)
last	01	Import-Format of private key, optional standard (private key only) if Format byte is not present FF = standard with public key

4.4.3.8 Supported algorithms

An OpenPGP smart card V3.0 or higher shall support the following algorithms with their specific details.

Mandatory:

RSA 2048 or higher for PSO:CDS, PSO:DEC and INTERNAL AUTHENTICATE

Optional:

ECDSA 256 bit or higher for PSO:COMPUTE DIGITAL SIGNATURE and INTERNAL AUTHENTICATE

ECDH 256 bit or higher for PSO:DECIPHER

AES 128 bit or higher for Secure Messaging and/or PSO:DECIPHER/ENCIPHER

For ECDSA/ECDH the following curves are recommended (EN 419212):

Domain parameters standardized by

- “SEC 2: Recommended Elliptic Curve Domain Parameters", Version 2.0, by Certicom or
- ECC Brainpool working group.

From this recommendation the following curves should be used for an OpenPGP smart card and will be available in common smart card products:

The prime field curves

- ansix9p256r1
- ansix9p384r1
- ansix9p521r1

from [ANSI X9.62], compliant with [FIPS-186-3] and

- brainpoolP256r1
- brainpoolP384r1
- brainpoolP512r1

from [RFC5639].

At least one of this curves shall be supported by an OpenPGP smart card if EC is available. Details of the curve parameters can be found in the annex.

4.4.3.9 Private Key Template

If the card supports key import (see Extended Capabilities), the terms of the corresponding private key are coded in the following way. The function does not matter how the key is stored in the card internally. The function does not set the value of the corresponding fingerprint. The key import uses a PUT DATA command with odd INS (DB) and an Extended header list (DO 4D) as described in ISO 7816-8.

The DOs in the Extended Header list start with a Control Reference Template (CRT) of the referenced key.

Digital signature: B6 00 (Tag, Length)
Confidentiality: B8 00
Authentication: A4 00

The next DO consists of a Cardholder private key template (7F48), that describes the input and the length of the content of the following DO. The last DO (Cardholder private key, 5F48) represents a concatenation of the key data elements according to the definitions in DO '7F48'.

The order of the DOs is mandatory (the card may support any order), xx means a length field (1, 2 or 3 bytes). Unnecessary DOs in between DO 7F48 should be stripped off (see format of private in Algorithm attributes).

4D	xx	*Extended Header list for RSA*					
		B6 or B8 or A4	00	*Control Reference Template to indicate the private key*			
		7F48	xx	*Cardholder private key template*			
				91	xx	*Public exponent: e*	*key format: standard and crt*
				92	xx	*Prime1: p*	*standard and crt*
				93	xx	*Prime2: q*	*standard and crt*
				94	xx	*PQ: 1/q mod p*	*crt*
				95	xx	*DP1: d mod (p - 1)*	*crt*
				96	xx	*DQ1: d mod (q - 1)*	*crt*
				97	xx	*Modulus: n*	*optional for standard and crt*
		5F48	xx	Concatenation of key data as defined in DO 7F48			

Some smart cards with RSA algorithm support only one coding for the Public Exponent (e. g. 65537 dec.). The card may reject an imported key, if e does not match the internal requirements. But the card shall accept 65537 dec. (010001) as value for e.

Smart cards may not be able to calculate a public key. In that case the public key can be integrated in the key import. This feature is announced in 'Algorithm attributes'.

The length of the key data shall match the values given in the DO 'Algorithm attributes' (C1 – C3). E. g., if the Modulus n has a length of 2048 bit (dec.), then p and q have a fixed length of 1024 bits each.

4D	xx	*Extended Header list for ECDSA and ECDH*			
		B6 or B8 or A4	00	*Control Reference Template to indicate the private key*	
		7F48	xx	*Cardholder private key template*	
				92	xx	*Private key*
				99	xx	*Public key (optional)*
		5F48	xx	Concatenation of key data as defined in DO 7F48	

The private key for EC is always stored in big-endian format and zero-padded to the adjusted underlying field size. The adjusted underlying field size is the underlying field size that is rounded up to the nearest 8-bit boundary.

In case of a signature key (CRT B6), the card internally resets the signature counter to zero.

4.4.4 Length Field of DOs

According to ISO 7816-4 the length field in TLV-structures has the following format:

Number of bytes	First byte	Second byte	Third byte	Value (dec.)
1	00 – 7F	-	-	0 – 127
2	81	00 - FF	-	0 – 255
3	82	0000 - FFFF		0 - 65535

5 Security Architecture

All commands and data of a smart card are under control of the security of the card operating system. ISO defines mechanisms, attributes (e. g. in FCP) and environments for security purposes. Because this features are quite complex and may differ from card to card (depending on mask developer), the OpenPGP application does not evaluate security related items of a card.

This chapter is informative for the card developer and defines the access conditions for all commands and data objects of the application in a common way. The described security features are mandatory for the card, but the coding or the way of implementation is up to the card developer, manufacturer or personaliser. Private keys and passwords shall not be readable from the card with any command or function. Commands and data have access conditions to be fulfilled.

The following tables show all access conditions for the OpenPGP application. READ is a synonym for all functions and commands of the operations system that present data to the external world, WRITE is a synonym for all functions and commands that change data in the eeprom/flash of the chip. If constructed DOs are processed, the access conditions of each single DO shall be fulfilled.

Access conditions for relevant commands:

Command	Access condition	Description
SELECT (DATA)	Always	
GET (NEXT) DATA	Various	Depending on Data Objects
VERIFY	Always	
CHANGE REFERENCE DATA	Always	
RESET RETRY COUNTER	VERIFY of PW3 or Resetting Code	
PUT DATA	Various	Depending on Data Objects
GENERATE ASYMMETRIC KEY PAIR	Always (read pub-key) VERIFY of PW3 (generate key-pair)	
PSO: COMPUTE DIGITAL SIGNATURE	VERIFY of PW1	With PW no. 81
PSO: ENCIPHER/DECIPHER	VERIFY of PW1	With PW no. 82
INTERNAL AUTHENTICATE	VERIFY of PW1	With PW no. 82
GET CHALLENGE	Always	

Command	Access condition	Description
MANAGE SECURITY ENVIRON-MENT	Always	
TERMINATE DF	VERIFY of PW3 or Always if PW3 is blocked	If PW3 is blocked or not usable (e. g. eeprom error), the access condition is always.
ACTIVATE FILE	Always	Has only affect if the application is in termination state.
Other commands	Various	e. g. commands for person-alisation

Access conditions for Data Objects:

Data Object	READ	WRITE	Description
Private use (0101)	Always	Verify PW1	With PW no. 82
Private use (0102)	Always	Verify PW3	
Private use (0103)	Verify PW1	Verify PW1	With PW no. 82
Private use (0104)	Verify PW3	Verify PW3	
AID (4F)	Always	Never	Writing possible only dur-ing personalisation (manu-facturer)
Login data (5E)	Always	Verify PW3	
Name (5B)	Always	Verify PW3	
Language preference (5F2D)	Always	Verify PW3	
Sex (5F35)	Always	Verify PW3	
URL (5F50)	Always	Verify PW3	
Card holder private key (5F48)	Never	Verify PW3	Relevant for all private keys in the application (sig-nature, decryption, authen-tication)
Cardholder certificates (7F21)	Always	Verify PW3	
DS-Counter (93)	Always	Never	Internal Reset during key generation
Extended Capabilities (C0)	Always	Never	Writing possible only dur-ing personalisation
Algorithm attributes (C1 – C3)	Always	Verify PW3	
PW1 Status bytes (C4)	Always	Verify PW3	Only 1st byte can be changed, other bytes only during personalisation
Fingerprints (C5, C7 – C9)	Always	Verify PW3	
CA-Fingerprints (C6, CA – CC)	Always	Verify PW3	
Generation date/time of key pairs (CD – D0)	Always	Verify PW3	
SM-Key-ENC (D1)	Never	Verify PW3	
SM-Key-MAC (D2)	Never	Verify PW3	
Resetting Code (D3)	Never	Verify PW3	

Data Object	READ	WRITE	Description
AES-Key for PSO:ENC/DEC (D5)	Never	Verify PW3	
SM-Key-Container (F4)	Never	Verify PW3	
General feature management (7F74)	Always	Never	
Extended length information (7F66)	Always	Never	
User Interaction Flag PSO:CDS (D6)	Always	Verify PW3	
User Interaction Flag PSO:DEC (D7)	Always	Verify PW3	
User Interaction Flag PSO:AUT (D8)	Always	Verify PW3	
KDF-DO (F9)	Always	Verify PW3	

In case that the card supports Secure Messaging, a correct command in SM mode is equivalent with reaching the access condition for PW3 (Verify PW3).

The application supports 3 private keys for the PSO commands COMPUTE DIGITAL SIGNATURE (CDS), ENCIPHER/DECIPHER (ENC/DEC) and INTERNAL AUTHENTICATE (IA). These keys have a unique reference number (Key-Ref):

- Signatur key (SIG-key) has Key-Ref = 1
- Decryption key (DEC-key) has Key-Ref = 2
- Authentication key (AUT-key) has Key-Ref = 3

After selecting the application the keys are aligned with a special command as default. For some keys it is possible to be used with other commands as well by assigning them to this command with the MANAGE SECURITY ENVIRONMENT (MSE) command. This command and the functionality is optional and announced in Extended Capabilities. The possible combinations are explained in the following table.

Command	Default Key-Ref	Optional Key-Ref
PSO: COMPUTE DIGITAL SIGNATURE	1	-
PSO: ENCIPHER/DECIPHER	2	3
INTERNAL AUTHENTICATE	3	2

After switching a key to another command the application should set it back to the default value if the usage is done. This is because the standard OpenPGP application (e. g. GnuPG) always assumes the default bindings of the keys to defined commands.

6 Historical Bytes

Historical bytes are part of the ATR (Answer To Reset) from a card with contacts, the ´format byte (T0)´ indicates the presence of Historical bytes in bits 1- 4, according to ISO 7816-3. An alternative way of reading Historical bytes is a special DO with the Tag '5F52'. Because not all cards provide Historical bytes with an appropriate content, the OpenPGP application uses this DO. In the Historical bytes the presence of the DOs 'Card service data byte' and 'Card capabilities' are relevant. The DO is coded according to ISO 7816-4.

The DO 'Historical bytes' ('5F52') is part of the “Application related data” and can be read with the GET DATA command from within the OpenPGP card application. It is relevant for the application and may differ from Historical bytes in the ATR.

The first Historical byte is the "category indicator byte". If the category indicator byte is set to '00', '10' or '80', then the format is in accordance with ISO. Any other value indicates a proprietary format. The OpenPGP application assumes a category indicator byte set to '00'. The remaining Historical bytes consist of optional consecutive COMPACT-TLV data objects followed. The last 3 bytes of the Historical bytes are a status indicator byte and two processing status bytes SW1/SW2 (normally '9000').

The status indicator byte is evaluated by the OpenPGP application as follows:

00 = No information given
Card does not offer life cycle management, commands TERMINATE DF and ACTIVATE FILE are not supported

03 = Initialisation state
OpenPGP application can be reset to default values with an ACTIVATE FILE command

05 = Operational state (activated)
Card supports life cycle management, commands TERMINATE DF and ACTIVATE FILE are available

The COMPACT-TLV format has a Tag in the first nibble of a byte (bit 5-8) and a length in the second nibble (bit 1-4). For the OpenPGP application a TL with '73' is relevant, it announces a DO 'Card capabilities' with 3 bytes. In addition a TL with '31' announces a DO 'Card service data' with 1 byte, that is interpreted by the OpenPGP application also. Other DOs may appear.

6.1 Card Capabilities (73)

This interindustry data element consists of three software function tables (1 byte each) according to ISO 7816-4. The first software function table indicates selection methods supported by the card. The second software function table is the "data coding byte". The third software function table indicates the ability to chain commands, the support for Extended Lc and Le fields and to handle logical channels. A set Bit (1) means that the function is available (unless otherwise specified), a value equal zero means that the function is not available. Bits can be set simultaneous. For the OpenPGP application only the third table (byte 3) is relevant (yellow marked functions should be evaluated in this version).

Command chaining, length fields and logical channels (third byte):

b8	b7	b6	b5	b4	b3	b2	b1	Meaning
x	-	-	-	-	-	-	-	Command chaining
-	x	-	-	-	-	-	-	Extended Lc and Le fields
-	-	x	-	-	-	-	-	Extended Length Information in EF.ATR/ INFO
-	-	-	x	x	-	-	-	Logical channel number assignment
-	-	-	-	-	y	z	t	Maximum number of logical channels

If Extended Length is announced in bit 7, then the DO “Extended length information” shall be present in the OpenPGP card application.

6.2 Card service data (31)

This interindustry data element consists of 1 byte according to ISO 7816-4. A set Bit (1) means that the function is available (unless otherwise specified), a value equal zero means that the function is not available. Bits can be set simultaneous. For the OpenPGP application yellow marked functions should be evaluated in this version.

Command chaining, length fields and logical channels (third byte):

b8	b7	b6	b5	b4	b3	b2	b1	Meaning
x	-	-	-	-	-	-	-	Application Selection by full DF name (AID)
-	x	-	-	-	-	-	-	Application Selection by partial DF name
-	-	x	-	-	-	-	-	DOs available in EF.DIR
-	-	-	x	-	-	-	-	DOs available in EF.ATR/INFO Should be set to 1, if Extended Length is supported
-	-	-	-	x	x	x	-	EF.DIR and EF.ATR/INFO access services by the GET DATA command (BER-TLV) Should be set to 010, if Extended Length is supported
-	-	-	-	-	-	-	x	Card with MF (0) Card without MF (1)

7 Commands

The OpenPGP application is based on the functionality of ISO 7816-4, -8 and -9. Thus the standard OS commands are available to the 'external environment'. The communication with a card is in an APDU format (Application Protocol Data Unit) and called “Command-Response pair”. The following table shows the construction in general (taken from ISO 7816-4).

Field	Description	No. of bytes
Command header	Class byte (CLA)	1
	Instruction byte (INS)	1
	Parameter bytes (P1/P2)	2
Lc field	Absent for encoding Nc = 0, present for encoding Nc > 0	0, 1 or 3
Command data field	Absent if Nc = 0, present as a string of Nc bytes if Nc > 0	Nc
Le field	Absent for encoding Ne = 0, present for encoding Ne > 0	0, 1, 2 or 3
Response data field	Absent if Nr = 0, present as a string of Nr bytes if Nr > 0	Nr
Response trailer	Status bytes denoted SW1-SW2	2

Note: No. of bytes = 0 means that the field is not present.

The following rules apply for APDUs:

- In any command APDU with Lc and Le fields, short and extended length fields shall not be combined.
- In a command APDU longer than 5 bytes, the use of extended length fields is indicated by the first byte after P2 equal to '00'.
- Nc denotes the number of bytes in the command data field.
  - If the Lc field is absent, then Nc is zero.
  - A short Lc field consists of one byte not set to '00' (1 to 255 dec.).
  - An extended Lc field consists of three bytes: one byte set to '00' followed by two bytes not set to '0000' (1 to 65535 dec.).
- Ne denotes the maximum number of bytes expected in the response data field.
  - If the Le field is absent, then Ne is zero.
  - A short Le field consists of one byte with any value.
  - If the byte is set to '00', then Ne is 256 dec.
  - An extended Le field consists of either three bytes (one byte set to '00' followed by two bytes with any value) if the Lc field is absent, or two bytes (with any value) if an extended Lc field is present.
  - If the two bytes are set to '0000', then Ne is 65536 dec.
- Nr denotes the number of bytes in the response data field. Nr shall be less than or equal to Ne.

7.1 Usage of ISO Standard Commands

The following table shows all standard commands of an ISO operating system, which are used by the OpenPGP application. Only the given subsets (P1/P2) of a command shall be implemented, however the card may provide other functions.

Command		INS	P1	P2	Comment
SELECT		A4	04	00	AID = 1-16 Byte (partial AID is recommended) P2 = 00 for first or only occurrence
SELECT DATA		A5	01/02/03	04	P1 = Occurrence number of DOs with same tag (DO 7F21) P2 = First or only occurrence of a DO after skipping P1 occurrences and Return the data control Information (DO 62)
GET DATA		CA	xx	xx	Supported as defined for specified DOs
GET NEXT DATA		CC	xx	xx	Supported as defined for specified DOs
VERIFY		20	00/FF	81/82/83	Local PW1 or PW3
CHANGE REFERENCE DATA		24	00	81/83	Change of PW1 or PW3
RESET RETRY COUNTER		2C	00/02	81	Resets the retry counter of PW1 and sets a new value for PW1. In the command data the new PW1 is present.
PUT DATA		DA or DB	xx	xx	Supported as defined for specified DOs
GENERATE ASYMMETRIC KEY PAIR		47	80/81	00	P1 = 80: Generation of internal private key, public key in response (DO 7F49) P1 = 81: Reading of actual public key Relevant key is addressed by a CRT in the command data
PERFORM SECURITY OPERATION (PSO)		2A	xx	xx	As defined in the next lines
	COMPUTE DIGITAL SIGNATURE	2A	9E	9A	Input are plain data (e. g. hash code), length shall match the algorithm and key length of the card, digital signature in response for RSA
	DECIPHER	2A	80	86	Input: Padding indicator byte (00 or 02) and encrypted data for RSA/AES; DO for ECDH Response: Plain data / Shared

Command		INS	P1	P2	Comment
					secret
	ENCIPHER	2A	86	80	Input: Plain data (multiple of 16 bytes) Response: Padding indicator byte (02) and plain data for AES
INTERNAL AUTHENTICATE		88	00	00	Authentication input related to algorithm
GET RESPONSE		C0	00	00	Used under T=0 and for retrieving long DOs with GET DATA under any protocol
GET CHALLENGE		84	00	00	Fully supported (Le defines length of random number), optional command. If supported the card shall provide any length according to simple Le. If extended Le is supported the maximum length is announced in Extended Capabilities
TERMINATE DF		E6	00	00	The command puts the application into the termination state. After termination only SELECT and ACTIVATE FILE are available
ACTIVATE FILE		44	00	00	In the OpenPGP application the termination state is equivalent to the initialisation state. An ACTIVATE FILE command in this stage resets all DOs to default values and sets the application into the operational state. The usage of this command in operational state (not terminated) has no effect to any data
MANAGE SECURITY ENVIRONMENT		22	41	A4/B8	Set (41) private key for INT-AUT (A4) or PSO:DEC (B8) Optional and announced in Extended Capabilities

Additional commands for production, personalisation and other applications are out of scope of this specification.

7.2 Commands in Detail

The following section describes some of the commands in more detail. In all examples short Lc/Le is used. If the card provides extended Lc/Le than the terminal should extend the fields to a length of 2 or 3 bytes for data length >255 (dec.). Commands that should support Secure Messaging, if available (option), are marked with a Class byte of 0C. Other codings of the Class byte are possible.

7.2.1 SELECT

With this command the OpenPGP application in the terminal selects the corresponding application on the card. Only the significant bytes of the AID are presented in the command data. Possible response data (FCI) don't need to be evaluated by the application. A valid SELECT of the OpenPGP application sets the curConstructedDO pointer to the Virtual Root DO and adds all data objects in the application to the current template. The curDO pointer is undefined, so a following GET/PUT DATA command will always reference the first occurrence of a DO. The command sets all private keys (Key-Ref) to their default bindings.

Command:

CLA	00
INS	A4
P1	04
P2	00
Lc	06
Data field	D2 76 00 01 24 01
Le	00

Response:

Data field	FCI or empty
SW1-SW2	9000 or specific status bytes

Example:

```
CLA INS P1 P2 Lc              Le
00  A4  04 00 06 D27600012401 00

FCI   FCP                                                 FMD            SW1SW2
6F 1D 62 15 8410D27600012401030300000000F500008A0105 64 04 5302BEDD 9000

Note: In my implementations >= 3.3 the FMD contains a DO '53' with the remaining
free bytes of the application.
```

7.2.2 VERIFY

The VERIFY command is used to check the correct password given in the command data and set an appropriate access status for the relevant password. If the command is called without data, the actual access status of the addressed password is returned or the access status is set to 'not verified'.

With P1 = 00 and password data in the command one of the passwords of the application is verified. PW1 has two modes and can be used with 2 different numbers (in P2). PW 1 with P2 = 81 sets the access conditions for a PSO:CDS command only. Depending on the PW1 status byte (see Extended Capabilities) this access condition is only valid for one PSO:CDS command or remains valid for several attempts. PW1 with P2 = 82 sets the access condition for several other functions and remains valid up to a reset or SELECT of a different application.

If the command is called with P1 = 00 and no data (Lc empty), then the actual access status of the addressed password in P2 is returned. If the password is still verified the cards answers with normal status bytes (SW1-SW2 = 9000). If the password is not checked and the verification is required, then the card answers with the status bytes 63CX, where 'X' encodes the number of further allowed retries.

If the command is called with P1 = FF, then Lc shall be empty (no data in the command data field). The addressed password in P2 is resetted to the status 'not verified'. To use commands that are protected by this password, VERIFY with correct password data has to be called again.

Command:

CLA	00 / 0C
INS	20
P1	00 / FF
P2	81 (PW1) or 82 (PW1) or 83 (PW3)
Lc	xx (min. 06 for PW1, min. 08 for PW3, max. see DO ´C4´) in case of UTF-8 or derived format 08 in case of PIN block format 2 Absent for status check or Reset
Data field	Corresponding PW in correct format or absent
Le	Empty (means not present in command)

Response:

Data field	None
SW1-SW2	9000 or specific status bytes

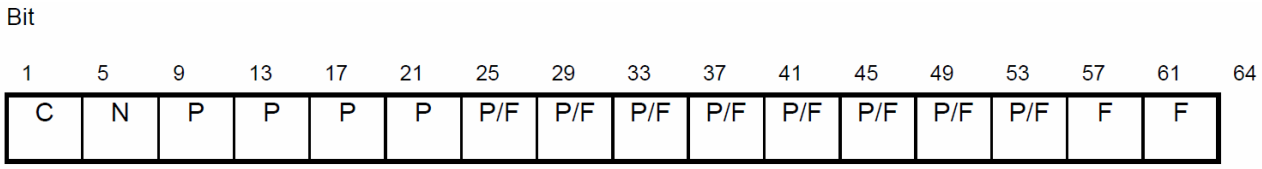
Example:

```
CLA INS P1 P2 Lc
00  20  00 82 06 313233343536

SW1SW2
9000
```

PIN block format 2

This format can be set in the PW status bytes (optional, announced in Extended Capabilities) and has the following structure (taken from ISO 9564-3):



where

C is the control field, 4-bit field value 0010 (2);

N is the PIN length, 4-bit binary number with permissible values 0100 (4) to 1100 (12);

P is the PIN digit, 4-bit field with permissible values 0000 (zero) to 1001 (9);

P/F is the PIN/Fill digit, with P or F determined by PIN length;

F is the fill digit, 4-bit field value 1111 (15).

The card shall evaluate the PIN block format 2 if used, e. g. check format and the internal PIN length for correct minimum length.

7.2.3 CHANGE REFERENCE DATA

With this command the passwords of the application can be changed. In compliance with EN 419212 only one P1 variation from ISO 7816-4 is defined for signature cards. The command can be accessed without restrictions, the actual PW is part of the command data and will be verified first by the card. The length of the existing password is known in the card, so that neither a delimiter nor padding for filling up fixed formats is necessary for UTF-8 or derived passwords. The length of the new UTF-8/derived password therefore computes $L_{new} = Lc - L_{old}$. PIN block format 2 passwords have a fixed length of 8 bytes.

Command:

CLA	00 / 0C
INS	24
P1	00
P2	81 (PW1) or 83 (PW3)
Lc	xx
Data Field	Actual PW + New PW Length of new UTF-8 or derived PW: min. 06 for PW1, min. 08 for PW3 For max. length see DO ´C4´ For PIN block format 2 two blocks (8 bytes each) for old and new PIN are concatenated
Le	Empty (means not present in command)

Response:

Data field	None
SW1-SW2	9000 or specific status bytes

The card shall evaluate the PIN block format 2 if used, e. g. check format and the internal PIN length for correct minimum length.

Example:

```
CLA INS P1 P2 Lc
00  24  00 81 0C 313233343536 363534333231

SW1SW2
9000
```

7.2.4 RESET RETRY COUNTER

With this command the error counter and the value of PW1 can be resetted, that means the new value is stored and the error counter is set to the default value (3). RESET RETRY COUNTER can be used after correct verification of PW3 (P1 = 02) or by presenting the Resetting Code (DO D3) in the command data (P1 = 00). Usage of secure messaging is equivalent to PW3. The length of the Resetting Code is known by the card, so that neither a delimiter nor padding for filling up fixed formats is necessary for UTF-8 and derived passwords. The length of the new UTF-8/derived password therefore computes $L_{new} = Lc - L_{RC}$.

Command:

CLA	00 / 0C
INS	2C
P1	00 / 02
P2	81 (PW1)
Lc	xx (min. 06 for PW1, max. see DO ´C4´)
Data field	New PW (P1 = 02) or Resetting Code + New PW (P1 = 00)
Le	Empty (means not present in command)

Response:

Data field	None
SW1-SW2	9000 or specific status bytes

PIN block format 2 passwords have a fixed length of 8 bytes. The card shall evaluate the PIN block format 2 if used, e. g. check format and the internal PIN length for correct minimum length.

Example:

```
CLA INS P1 P2 Lc
00  2C  00 81 0E 3132333435363738 313233343536

SW1SW2
9000
```

7.2.5 SELECT DATA

With this command a DO in the current template can be selected. The command is needed to address DOs with several instances with the same Tag (e. g. 7F21, Card holder certificate). A successful command sets the curDO pointer to the addressed DO and makes it the current DO, a following GET DATA or PUT DATA will access this current DO. Setting the first instance (P1 = 00) will work with every accessible DO, higher values will only work for DOs with several instances.

Possible response data (Control Parameter = CP) don't need to be evaluated by the application.

Command:

CLA	00
INS	A5
P1	xx = Occurrence number of an instance to skip 00 – 02 is defined for the OpenPGP application
P2	04 = First occurrence after skipping P1 occurrences with CP in response
Lc	xx
Data Field	60 xx (General reference DO) 5C xx (Tag list) Tag of the DO to be selected
Le	00

Response:

Data field	Control Parameters (CP) or empty
SW1-SW2	9000 or specific status bytes

Examples:

```
' Selects the 1st occurrence of the Card holder certificate (AUT)
CLA INS P1 P2 Lc                  Le
00  A5  00 04 06 60 04 5C 02 7F21 00

SW1SW2
9000

' Selects the 2nd occurrence of the Card holder certificate (DEC)
00 A5 01 04 06 60 04 5C 02 7F21 00

' Selects the 3rd occurrence of the Card holder certificate (SIG)
00 A5 02 04 06 60 04 5C 02 7F21 00
```

7.2.6 GET DATA

With this command DOs can be read from the card. The Tag (simple or constructed) is given in P1/P2 (e. g. 5F50 for URL or 006E for Application Related Data). For simple DOs only the value is in the response field (e. g. 5F50 = URL returns a byte string representing the URL without leading Tag/Length). For constructed DOs all values (child DOs) returned are encapsulated with their Tag/Length (e. g. 0065 = Cardholder Related Data returns the concatenation of the following DOs (L = Length): 5B L Name 5F2D L Language Preferences 5F35 L Sex).

If the DO is longer than the maximum supported length for a response of a card, then the card may answer with status bytes 61xx and return only the first part of the data, xx indicate the remaining data in the card. The data may be truncated at any position and shall be concatenated later in the terminal. The terminal can read the missing data with a following GET RESPONSE command and Le = 00 (or 0000 for extended Le). This can be repeated several times (another status byte 61xx). The reading of data is complete if any command (GET DATA or GET RESPONSE) answers with status bytes 9000.

A valid GET DATA makes the first occurrence of the addressed DO to the current DO, if the curDO pointer was undefined. Otherwise (e. g. previous SELECT DATA) the current DO with the addressed Tag is returned.

GET DATA with odd INS (CB) is used for reading data from EF.DIR and/or EF.ATR/INFO.

Command:

CLA	00 / 0C
INS	CA / CB
P1	xx (00 if Tag has a length of only one byte)
P2	xx
Lc	Empty or 02 (odd INS)
Data Field	None or General Reference DO (odd INS)
Le	00

Response:

Data field	Addressed data or DOs (maybe partially)
SW1-SW2	9000 or 61xx or specific status bytes

Examples:

```
CLA INS P1 P2 Le
00  CA  00 65 00

                                                        SW1SW2
5B 0B 546573743C3C5465737469 5F2D 02 6465 5F35 01 31 9000


CLA INS P1 P2 Le
00  CA  7F 21 000000

3082033C30820224A003020102020207D7300D06092A864886F70D01010505003081A6310B300906
0355040613024348311330110603550408130A4B616E746F6E205A7567310C300A06035504071303
5A756731143012060355040A130B476C6F62657461632041473 11E301C060355040B131543657274
6966696361746520417574686F726974793119301706035504031310476C6F626574616320434120
5465737431233021060 92A864886F70D010901161463615F7465737440676C6F62657461632E636F
6D301E170D3039303432333037353234325A170D303931313039303037353234325A307B310B300906
0355040613024453111300F060355040A13085754432054657374310E300C060355040B13054475
6261693118301606035504031 30F3030303130303030313136303A504E312F302D06092A864886F7
0D010901162064756261693030303130303030313136304077746 32D6D656D6265722E6F72673081
9F300D06092A864886F70D010101050003818D0030818902818100CE6084DA65B511551703E682D7
EF7222FA6777662181487DFB9CA381EB971F102190C6324D9DC022E8F99D7A25D5B427E6D12B71F3
E5B03AD136CE66BF6E15966B41016E4B2D391F757DF5F273B52B27294135608A7BFA9D675AA4D34A
9023E11B9BAC6D33C21F3B34BE051AFA563DC710605EF914C65C53169F8FBF268772650203010001
A3223020301106096086480186F84201010404030204B0300B0603551D0F0404030204F0300D0609
2A864886F70D01010505000382010100 40BF3EC7C76DF7CB7A4C9FDC7A12B168B9718B01344EDD87
812EAE9D5825E60BC3929F6EB8D2F808071256010D3899FB1194754403DDE536476122FD71345D28
CDAE9584D6EAD8EB80B393A526B47665F04487FD01886BB2899C55EA34446E928AF84842E5FF5B22
339675605F72C947158760694E80A74A43ADC020DA2C4CFFCF535ACE774D5CE38459E1FEF10C28FC
5C2C607805C62CCBE40292CE41AE17FE47FD988ADA6C400E9C4078F8FD7BFDA47F7C9AFD126F6D26
454B7159E6FCC4B43C0B37A2B61A98D540F10BA022E3602970373AA82B6A7FCDC66384BDBD9DC67A
D153D81E0B562155E30CAB3CC696E025E0A1006AC9E5E920D6A015E69043C224 9000 (SW1SW2)
```

7.2.7 GET NEXT DATA

With this command other instances of DOs with the same Tag can be read from the card. The command is only valid for the user certificate (7F21) that has 3 occurrences. The command can be used only of the curDO pointer is still set to a valid occurrence of DO '7F21'. It selects the next occurrence automatically (internal SELECT DATA) and returns the data field of the DO.

With the following commands in a sequence all certificates can be read from the card:
GET DATA with P1P2= 7F21 returns the 1st occurrence (AUT certificate)
GET NEXT DATA with P1P2= 7F21 returns the 2nd occurrence (DEC certificate)
GET NEXT DATA with P1P2= 7F21 returns the 3rd occurrence (SIG certificate)

This way is quicker than reading all certificates with SELECT DATA and following GET DATA, but it is still possible to do it in that way. If you only want to read the 3rd occurrence (SIG certificate), for e. g., then a SELECT DATA with following GET DATA is more useful.

Command:

CLA	00 / 0C
INS	CC
P1	7F
P2	21
Lc	Empty
Data Field	None
Le	00

Response:

Data field	Addressed DO
SW1-SW2	9000 or 61xx or specific status bytes

Example:

```
CLA INS P1 P2 Le
00  CC  7F 21 000000

SW1SW2
9000 (empty DO)
```

7.2.8 PUT DATA

With this command DOs can be written to the card. The Tag is given in P1/P2 (e. g. 5F50 for URL or 005B for Name). For simple DOs only the value is in the data field (without leading Tag/Length). The command can only be used after correct presentation of PW3 (except DO 0101 and DO 0103 after correct verification of PW1 with No. 82).

For key import in compliance with ISO 7816-8 an Extended header list is supported with an odd INS of the command. In that case P1/P2 has the value 3FFF (references the current DF for the DOs in the Extended header list).

An empty data field (Lc absent) deletes the content of a DO with variable length (e. g. URL), but not the DO itself.

A valid PUT DATA makes the first occurrence of the addressed DO to the current DO, if the curDO pointer was undefined. Otherwise (e. g. previous SELECT DATA) the content of the current DO with the addressed Tag is replaced.

Command:

CLA	00 / 0C
INS	DA / DB
P1	xx = 00 if Tag has a length of one byte only = 3F in case of odd INS
P2	xx (FF in case of odd INS)
Lc	xx or empty
Data Field	Addressed data or Extended header list or empty
Le	Empty

Response:

Data field	None
SW1-SW2	9000 or specific status bytes

Example:

```
CLA INS P1 P2 Lc
00  DA  00 5B 0B 546573743C3C5465737469

SW1SW2
9000
```

7.2.9 GET RESPONSE

This command is needed under T=0 for some command cases according to ISO 7816-3 and under any protocol (e.g. T=1) for receiving long data that cannot be transmitted in one response.

After receiving status bytes with 61 xx, the terminal should send a GET RESPONSE command with xx or 00 in the Le field.

Command:

CLA	00 / 0C
INS	C0
P1	00
P2	00
Lc	Empty
Data field	Empty
Le	00 (xx given in previous SW2)

Response:

Data field	Data
SW1-SW2	9000 or 61xx or specific status bytes

7.2.10 PSO: COMPUTE DIGITAL SIGNATURE

The command for digital signature computation is shown in the table below. The hash value (ECDSA) or the DigestInfo is delivered in the data field of the command. Signature key as well as signature algorithm and the related Digital-Signature-Input formats are implicitly selected. The command always use the SIG-key (Key-Ref 1).

The command is only possible after correct presentation of PW1 with No. 81. The command internally checks the PW1 Status byte DO (first byte), if the value is 00, then the access condition (No. 81 of PW1) is reset and the PW has to be verified again for the following command.

It is possible to use the command outside of the OpenPGP environment (e. g. S-MIME), for that reason it is possible to store a related certificate (Tag 7F21) as 3rd occurrence into the card.

Command:

CLA	00
INS	2A
P1	9E
P2	9A
Lc	Length of subsequent data field
Data field	Data to be integrated in the DSI: hash value (ELC) or DigestInfo (RSA)
Le	00

Response:

Data field	Digital signature
SW1-SW2	9000 or specific status bytes

The DSI format for RSA:

According to PKCS #1 the DSI is generated internally by the card and has the following structure:

Description	Length	Value
Start byte	1	00
Block type	1	01
Padding string (PS)	N-3-L	FF ... FF
Separator	1	00
Data field	L	DigestInfo

In compliance with PKCS #1, the card checks that the DigestInfo in the command data (only the data field of the DSI) field is not longer than 40% of the length of the modulus of the signature key, otherwise the command is rejected.

DSI for ECDSA:
The DSI consists of the hash value which was calculated (28, 32, 48 or 64 bytes, dec.). If the required DSI for the computation is longer than the hash value, then the DSI is filled with leading zero bits by the card.

Example:

```
CLA INS P1 P2 Lc
00  2A  9E 9A 53
3051300D060960864801650304020305000440BEE92930604C4533052389A321F206C5B11EF8D7CB
2381F2B83BECFC40BA2570240D4FA11D2DD406AEF8E74AE60F586C9046A2797195861BE6F1E03FDA
F5C28D 00 (Le)

7D4D27FA989530EFA4C1B9C912322CA6F9A218D248D2BE2E11D943AF6403ABE3CF401C461F7531F9
0B76707FAD29BF25D5FEBC7D97B208E68A9EFB9F57AA785C9A7CA836D92CA06F3164525CC73A17AC
FFF6A046C8831352EFA99801E9C01BC34646EF0A23F24FC0D51CE0E6B5B6DF141702F914163B772E
2467E513C7AA6D1504BB2D104D2B5B10866B13C378DDB587016FEF5F6A99A575A6E743D5B83113C4
E996192D1034A326BCFFA1BE8397C694CD644D89D053398DFDA1AA2EAE2FCD0AE121554CE513D017
76D8F8BC2DC0BF64A2B1DE6BA92FC2207980F581B72969B19B7929B00623F839116ED4F0B8456FB7
7F154AA1BC62178991E20DF75FF2D766 9000 (SW1SW2)
```

7.2.10.1 Hash Algorithms

The following hash algorithms are supported by RFC 4880 and can be used as input in the DSI. Older SHA-1 and RIPEMD-160 are not allowed for DSI in actual standards and should be avoided for the OpenPGP smart card also. However the card may not check the integrity of a DSI.

Hash algorithm	*Length of hash-code (dec.)*
SHA-224	28
SHA-256	32
SHA-384	48
SHA-512	64

7.2.10.2 DigestInfo for RSA

The following tables show the contents of defined DigestInfos for RSA. The card may not check the correctness of the DigestInfo.

SHA-224:

Tag	*Length*	*Value*	*Description*
30	2D		Tag/Length of Sequence
30	0D		Tag/Length of Sequence
06	09	608648016503040204	OID of the SHA-224 {2 16 840 1 101 3 4 2 4}
05	00	-	TLV coding of ZERO
04	1C	xx...xx	hash-code

SHA-256:

Tag	*Length*	*Value*	*Description*
30	31		Tag/Length of Sequence
30	0D		Tag/Length of Sequence
06	09	608648016503040201	OID of the SHA-256 {2 16 840 1 101 3 4 2 1}
05	00	-	TLV coding of ZERO
04	20	xx...xx	hash-code

SHA-384:

Tag	*Length*	*Value*	*Description*
30	41		Tag/Length of Sequence
30	0D		Tag/Length of Sequence
06	09	608648016503040202	OID of the SHA-384 {2 16 840 1 101 3 4 2 2}
05	00	-	TLV coding of ZERO
04	30	xx...xx	hash-code

SHA-512:

Tag	*Length*	*Value*	*Description*
30	51		Tag/Length of Sequence
30	0D		Tag/Length of Sequence
06	09	608648016503040203	OID of the SHA-512 {2 16 840 1 101 3 4 2 3}
05	00	-	TLV coding of ZERO
04	40	xx...xx	hash-code

7.2.11 PSO: DECIPHER

The command is used by the application as key decipherment service. The command can be used after correct presentation of PW1 (with No. 82) only. For confidential document exchange, the following scheme is applied:

- The key transport is organised by enciphering the content encryption key with the receivers public key.
- The document enciphering is done with a symmetrical algorithm (e. g. AES).

The card is not involved in the enciphering of the document. The software computes the content encryption key, enciphers the document and finally enciphers the content encryption key by using the receivers public key. The card performs a key decryption applying the private key for decryption in a DECIPHER command to the cryptogram contained in the data field of the command.

In case of the RSA algorithm the command input (except padding indicator byte) shall be formatted according to PKCS#1 before encryption:

Description	Length	Value
Start byte	1	00
Block type	1	02
Padding string (PS)	N-3-L	Non-zero-random-bytes
Separator	1	00
Data field	L	Message

PS is a byte string consisting of randomly generated non-zero bytes. The length of PS shall be at least 8 bytes. The formatted string shall consist of N bytes where N is the length of the modulus of the private key for decryption. The Padding indicator byte and the encrypted message is given to the command in the command data. The card decrypts all bytes after the padding indicator byte, checks the conformance of correct PKCS#1 padding and returns the plain text (length = message) in the response.

In case of ECDH the card supports a partial decrypt only. The input is a cipher DO with the following data:

A6	xx	*Cipher DO*			
		7F49	xx	Public Key DO	
				86	xx	*External Public Key*

The external public key for ECDH consists of of two raw big-endian integers with the same length as a field element each. In compliance with EN 419212 the format is

04 || x || y

where the first byte (04) indicates an uncompressed raw format.

The card shall abort the command if the given OID does not match the defined curve for the command (see Algorithm attributes).

With its own private key and the given public key the card calculates a shared secret in compliance with the Elliptic Curve Key Agreement Scheme from Diffie-Hellman. The shared secret is returned in the response, all other calculation for deciphering are done outside of the card.

The command can be used with the DEC-Key (Key-Ref 2) or the AUT-key (Key-Ref 3) if the MANAGE SECURITY ENVIRONMENT (MSE) command is available, the DEC-Key is the default after selecting the OpenPGP application. The keys can be switched with the optional MSE command.

By option (announced in Extended Capabilities) the card supports the decryption of a plain text with an AES-key stored in a special DO (D5). In this case the command input (except padding indicator byte) shall be a multiple of 16 bytes. A key shall be present in DO (D5), the Padding indicator byte (02) and the encrypted message is given to the command in the command data. The card decrypts all bytes after the padding indicator byte and returns the plain text in the response. For decryption with AES an Initial Chaining Value (ICV) of zero bytes is assumed, for more than one block (16 bytes) the Cipher Block Chaining mode (CBC) is used.

Command:

CLA	00
INS	2A
P1	80 = Return plain value
P2	86 = Enciphered data present in the data field
Lc	xx = Length of subsequent data field
Data field	Padding indicator byte (00) for RSA or (02) for AES followed by cryptogram Cipher DO 'A6' for ECDH
Le	00

Response:

Data field	Plain data (RSA or AES) / Shared secret (ECDH)
SW1-SW2	9000 or specific status bytes

It is possible to use the command outside of the OpenPGP environment, for that reason it is possible to store a related certificate (Tag 7F21) as 2nd occurrence into the card.

Example:

```
CLA INS P1 P2 Lc
00  2A  80 86 000101
007A5001264619DEF4625F993B4DA0ED6C09253BA66BC28077BCEC790CCCA95C860D24FB87EDB35E
FA85F2E1A04E6AD9355DF0DDE2832B964A57DBF7386C1C10FF6C5590E2410F753FDC19F04DE13CFD
E45B466D57D6583B64165D1BBF34EFB3D0B689BB1EA2C22FCB1303F8762395704BD9B9286B112C43
F53928B3C166CB176756C7E18961031F8648246D5DCB30E8394E6A1EDBFD52B4927F04A3542E4B4A
F67E787E4B97D1BFE161EA69CCA46AE8848771EF07736176F9AABEE1B58F36DBD91ECDFA26643C48
957775144BA05DCAC938F20EC0E96491E4F2F90DB4666C7169CBC27106A3AD6821E8B3C002C81823
5C8D8A21563DCA81D5C31657E4E5752A7C01 00 (Le)

                                                                    SW1SW2
090A59DBA229F98187FAB3694FDF35FF0B6FFD52F2BCF5E1A811CEA4B330D0D1871305 9000
```

7.2.12 PSO: ENCIPHER

The optional command (announced in Extended Capabilities) can be used by applications as encipherment service. The command can be used after correct presentation of PW1 (with No. 82) only.

The command supports the encryption of a plain text with an AES-key stored in a special DO (D5).

In case of the AES algorithm the command input shall be a multiple of 16 bytes. A key shall be present in DO (D5), the Padding indicator byte (02) and the encrypted message are returned in the response data field.

For encryption with AES an Initial Chaining Value (ICV) of zero bytes is assumed, for more than one block (16 bytes) the Cipher Block Chaining mode (CBC) is used.

Command:

CLA	00
INS	2A
P1	86 = Return enciphered data with Padding indicator byte
P2	80 = Plain data present in the data field
Lc	16 or multiple of 16
Data field	Plain data
Le	00

Response:

Data field	Padding indicator byte (02) for AES followed by cryptogram
SW1-SW2	9000 or specific status bytes

Example:

```
CLA INS P1 P2 Lc                                    Le
00  2A  86 80 10 00112233445566778899AABBCCDDEEFF 00

                                    SW1SW2
0262F679BE2BF0D931641E039CA3401BB2 9000
```

7.2.13 INTERNAL AUTHENTICATE

The INTERNAL AUTHENTICATE command can be used for Client/Server authentication. The usage is up to the terminal, the card only provides this command for asymmetric algorithms. The input data shall be an Authentication Input (AI) compliant with PKCS#1 for RSA, the card does an internal PKCS#1-padding and calculates a signature with the corresponding secret key for authentication. For ECDSA the input is a hash value only. The command can be used after correct presentation of PW1 (with No. 82) only.

In compliance with PKCS #1, the card checks in case of RSA that the AI in the command data field is not longer than 40% of the length of the modulus of the signature key, otherwise the command is rejected.

PKCS#1-Padding for Authentication Input used with RSA:

Description	Length	Value
Start byte	1	00
Block type	1	01
Padding string (PS)	N-3-L	FF...FF
Separator	1	00
Data field	L	Authentication Input (AI)

The resulting input for the signature in case of RSA has the length N. The card calculates the signature with the private key for authentication: sign(SK_{Aut})[00 | 01 | PS | 00 | AI] and returns the result as authentication data in the response.

For ECDSA the AI consists of the hash value which was calculated (28, 32, 48 or 64 bytes, dec.). If the required AI for the computation is longer than the hash value, then the AI is filled with leading zero bits by the card.

The command is used outside of the OpenPGP environment, for that reason it is possible to store a related certificate (Tag 7F21) as 1st occurrence into the card.

The command can be used with the AUT-key (Key-Ref 3) or the DEC-Key (Key-Ref 2) if the MANAGE SECURITY ENVIRONMENT (MSE) command is available, the AUT-Key is the default after selecting the OpenPGP application. The keys can be switched with the optional command.

Command:

CLA	00
INS	88 = INTERNAL AUTHENTICATE
P1	00
P2	00
Lc	xx = Length of subsequent data field
Data Field	Authentication Input (AI) for RSA: Lc <= 0,4 * N, e. g.: Lc <= 102 for 2048 bit modulus for ECDSA: Hash value (values are decimal)
Le	00

Response:

Data field	Signature
SW1-SW2	9000 or specific status bytes

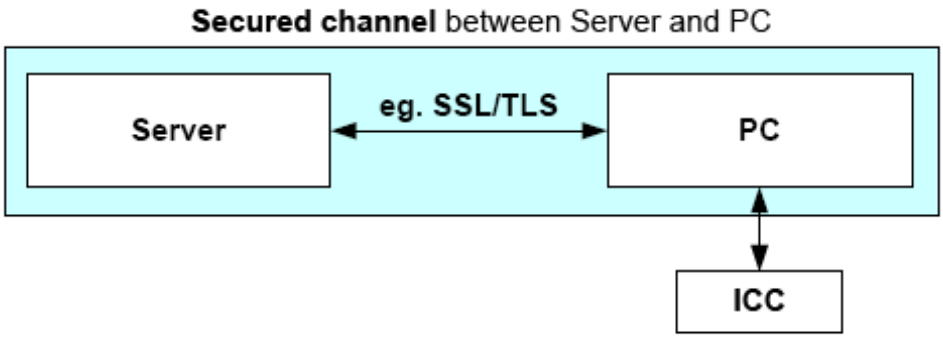
Example:

```
CLA INS P1 P2 Lc                      Le
00  88  00 00 0A 546573742D446174656E 00

1FB3B9004417ABE5B47581619033CF67135420FEC834E77494A4E7618B5A5DBFEA2AC8D228D838A5
AFDFE7A3CE2DE596E147BC0035A2E8204AAFC79375A1EAA8F6E324FD98091D28E7B16D732FE1FDC5
78CCEE20659C83F7B0032F89A4EC1916D9E73BF2DEBAF911E1559B54A2F11687C4A8ED5071CD662F
7EFB9A38CABAFD2B80DF81574A70F5DB40C6ED67D5B89F8F42D6CBF4AA016C47D39DD2E6FB1E5335
9D91597B8E3A044C1DF2357F9E0FB06B940AFF1F6BEF486305F88984B0672DCE0344A6D5280E47E1
5E9F5E5EF288DE2830FC4F23339E11B5FCBCE3B8C0AE1706848EA7AA0B155EE3C6AAA39EB8D927BB
5B3A558B31343C07356DD6DBAE5FB489 9000 (SW1SW2)
```

7.2.13.1 Client/Server Authentication

This specification covers only the case where the card performs a digital signature computation applying the private key for authentication in an INTERNAL AUTHENTICATE command to the authentication input contained in the data field of the command after formatting the input. The mechanism can be used, for example, with Secure Shell (SSH), PK Kerberos, SSL/TLS or WTLS. All these protocols base on the same cryptographic algorithms. In particular they are all using PKCS #1 padding format in the case of RSA.



In the above example (taken from EN 419212-5), client/server authentication establishes a secured channel between a remote server and a PC. The ICC will be used as a cryptographic toolbox in order to provide the cryptographic functionality to the PC. If a process needs a certificate from the card that is not provided by OpenPGP (e. g. x.509), then it can be stored in the DO 'Cardholder certificate' (7F21 AUT) as 1st occurrence.

7.2.14 GENERATE ASYMMETRIC KEY PAIR

This command either initiates the generation and storing of an asymmetric key pair, i. e., a public key and a private key in the card, or returns the public key of an asymmetric key pair previously generated in the card or imported. The card should use 65537 dec. (10001 bin.) as default value for e, but other values are accepted by the outside world. In case of key pair generation the command does not set the values of the corresponding fingerprint. After receiving the public key the terminal has to calculate the fingerprint and store it in the relevant DO. The generation of a key pair for digital signature resets the digital signature counter to zero (000000), other related DO (e. g. certificates) may be resetted also. The command can only be used after correct presentation of PW3 for the generation of a key pair. Reading of a public key is always possible.

Command:

CLA	00 / 0C
INS	47
P1	80 = Generation of key pair 81 = Reading of actual public key template
P2	00
Lc	02
Data field	CRT for relevant function
Le	00

Response:

Data field	Public key as a set of data objects
SW1-SW2	9000 or specific status bytes

Defined CRTs (Control Reference Template) for the command (generation of key pair or reading of public key).

Digital signature: B6 00 (Tag, Length)
Confidentiality: B8 00
Authentication: A4 00

Defined DOs for response (xx = Length):

7F49 xx

Set of public key data objects for RSA
81 xx Modulus (a number denoted as n coded on x bytes)
82 xx Public exponent (a number denoted as v, e.g. 65537 dec.)

Set of public key data objects for ECDSA/ECDH
86 xx Public key (a point denoted as PP on the curve, equal to x times PB where x is the private key, coded on 2z or z+1 bytes)

The public key for ECDSA/DH consists of of two raw big-endian integers with the same length as a field element each. In compliance with EN 419212 the format is

04 || x || y

where the first byte (04) indicates an uncompressed raw format.

A card may send other DOs in compliance with ISO 7816-8, but only the mandatory DOs defined above need to be evaluated.

Example:

```
CLA INS P1 P2 Lc          Le
00  47  80 00 000002 B600 0000

7F49 82010A 81 820100
869CEF69AF38A066E399F2CE85538A4D05FD9B33E4422DD1652F1643B786EA080D5EF265B6343776
0F390C6724D04216B2F5BC504DF4F33D60911D7E5281C0C97CFC23CCBC175F6C96E01CEEEAA408B2
60E8BCB3299ADE4937D0A805181892942368C8E7377660AF43CB565F14EDC77FE3CF8706115D390E
1ED2D1B9A4FF3465602E9F6083C451879D8B26B04E784A4B3E728A7E501553DA12AA67EB103BEC8E
DD04989A9FDB8DB712539EEB41A04C73CAC40777B3C1E133AA26918D2241ACAB20F245A950F69BE6
48F74BFFB5F254CAC76F003924053E02D62DBB6501325EA999FC58311000E9761DF35696072E2917
E96A75C1CAA7CEABAC8DBC1049A15BC1 82 04 00010001 9000 (SW1SW2)
```

7.2.15 GET CHALLENGE

This optional command (announced in Extended Capabilities) generates a random number of the length given in Le. It is a service to the terminal application because smart cards often generate high sophisticated random numbers by certified hardware. Several smart card implementations have limitations for the length of the random number, so the maximum length is announced in Extended Capabilities.

The command is mandatory if the cards supports Secure Messaging.

Command:

CLA	00
INS	84
P1	00
P2	00
Lc	Empty
Data field	Empty
Le	xx (01-FF for Short Le, 0001-maximum for Extended Le)

Response:

Data field	Challenge with length xx
SW1-SW2	9000 or specific status bytes

Example:

```
CLA INS P1 P2 Le
00  84  00 00 0A

                     SW1SW2
FBEA790A2107506F9430 9000
```

7.2.16 TERMINATE DF

This optional command (announced in Life Cycle Status indicator in Historical bytes) sets the Life Cycle Status indicator to 03 and puts the card into initialisation state. The behaviour of the application is similar to the termination state, no commands can be used except SELECT, which return specific status bytes (6285). After a Reset of the card and a new selection an ACTICATE FILE command is possible. That command is designed to renew a card in case of blocked passwords or other problems. The command is allowed after correct verification of PW3 (Admin-PW) or secure messaging (SM) if PW3 is available.

If PW3 is blocked or not accessible (e. g. memory failure) and SM is disabled, then TERMINATE can be used without access conditions. This prevents the card from any status that makes it unusable.

Command:

CLA	00 / 0C
INS	E6
P1	00
P2	00
Lc	Empty
Data field	Empty
Le	Empty

Response:

Data field	Empty
SW1-SW2	9000 or specific status bytes

Example:

```
CLA INS P1 P2
00  E6  00 00

SW1SW2
9000
```

7.2.17 ACTIVATE FILE

This optional command (announced in Life Cycle Status indicator in Historical bytes) can be used to reset all values (DOs, Keys, PWs etc.) to their default values (after production/ initialisation). The command has effect only, if the life cycle status is in initialisation state (indicator byte set to 03). If the command is used in operational state, it will end with status bytes 9000, but nothing in the application will be changed (dummy command). The command can be used directly after TERMINATE DF without resetting the card.

Command:

CLA	00 / 0C
INS	44
P1	00
P2	00
Lc	Empty
Data field	Empty
Le	Empty

Response:

Data field	Empty
SW1-SW2	9000 or specific status bytes

Example:

```
CLA INS P1 P2
00  44  00 00

SW1SW2
9000
```

7.2.18 MANAGE SECURITY ENVIRONMENT

This optional command (announced in Extended Capabilities) assigns a specific key to a command. After selecting the OpenPGP application the private keys are linked to a default command:

- Signature key (Key-Ref 1) binded to PSO:COMPUTE DIGITAL SIGNATURE
- Decryption key (Key.Ref 2) binded to PSO:DECIPHER
- Authentication key (Key-Ref 3) binded to INTERNAL AUTHENTICATE

The DEC-key (Key-Ref 2) can be assigned to the command INTERNAL AUTHENTICATE and the AUT-Key (Key.Ref 3) can be linked to the command PSO:DECIPHER also. Before running these commands the assignments can be SET with the MSE command by referencing the functionality in P2 (A4 for INT-AUT and B8 for PSO:DEC) and addressing the new key in a Control Reference Template (CRT) with his reference number (Key-Ref) in the command data. The new assignment is valid until a new SET with MSE is done, the card is resetted or the application is selected. The assignment is useful for applications (e. g. Microsoft CSP) that use one key and certificate for several purposes (e. g. signing and decrypting with the same key).

Command:

CLA	00
INS	22
P1	41 (SET for computation, decipherment, internal authentication and key agreement)
P2	A4 (Authentication) / B8 (Confidentiality)
Lc	03
Data field	83 01 xx (Reference for a secret key for direct use) xx (Key-Ref) = 02 for the DEC-Key = 03 for the AUT-Key
Le	Empty (means not present in command)

Response:

Data field	None
SW1-SW2	9000 or specific status bytes

Example:

```
CLA INS P1 P2 Lc
00  22  41 A4 03 830102

SW1SW2
9000
```

7.3 Command Usage under Different I/O Protocols

For the OpenPGP application the T=1 protocol (ISO 7816-3) is recommended for cards with contacts. However other protocols (one or more) in a card are possible too. The OpenPGP application is designed to run under every protocol (e. g. T=0, contactless) that is provided by the card reader. If contactless protocols (e. g. ISO 14443) are implemented, card and reader should support Secure Messaging (e. g. VERIFY) to avoid data tracking 'over the air'.

7.4 Class Byte Definitions

For the OpenPGP application all standard commands are used with a class byte (CLA) coding according to ISO. The following values are defined (CLA 10 and 1C are only relevant if the card supports command chaining). Other codings of the Class byte may appear for proprietary functions and/or SM.

CLA	Description
00	CLA without SM (last or only command of a chain)
0C	CLA with SM and header authentication (last or only command of a chain)
10	CLA without SM (command is not the last command of a chain)
1C	CLA with SM and header authentication (command is not the last command of a chain)

7.5 Secure Messaging (SM)

The OpenPGP application defines secure messaging with static keys in this version and uses a variant of SM from EN 419212 with AES without Send Sequence Counter (CBC mode). Command data are encrypted first and then protected by a cryptogram. SM is optional and announced in Extended Capabilities. Only a sub-set of the commands may support SM (see CLA-Definition in the command section). SM is designed as a replacement of the Admin-PW (PW3) and can be used to change data objects online (helpful for company cards, admin = company; user = employee). It is highly recommended to use SM for security related commands (e. g. VERIFY) if the OpenPGP application runs in contactless mode, because all data on the interface can be traced easily within a range of several meters.

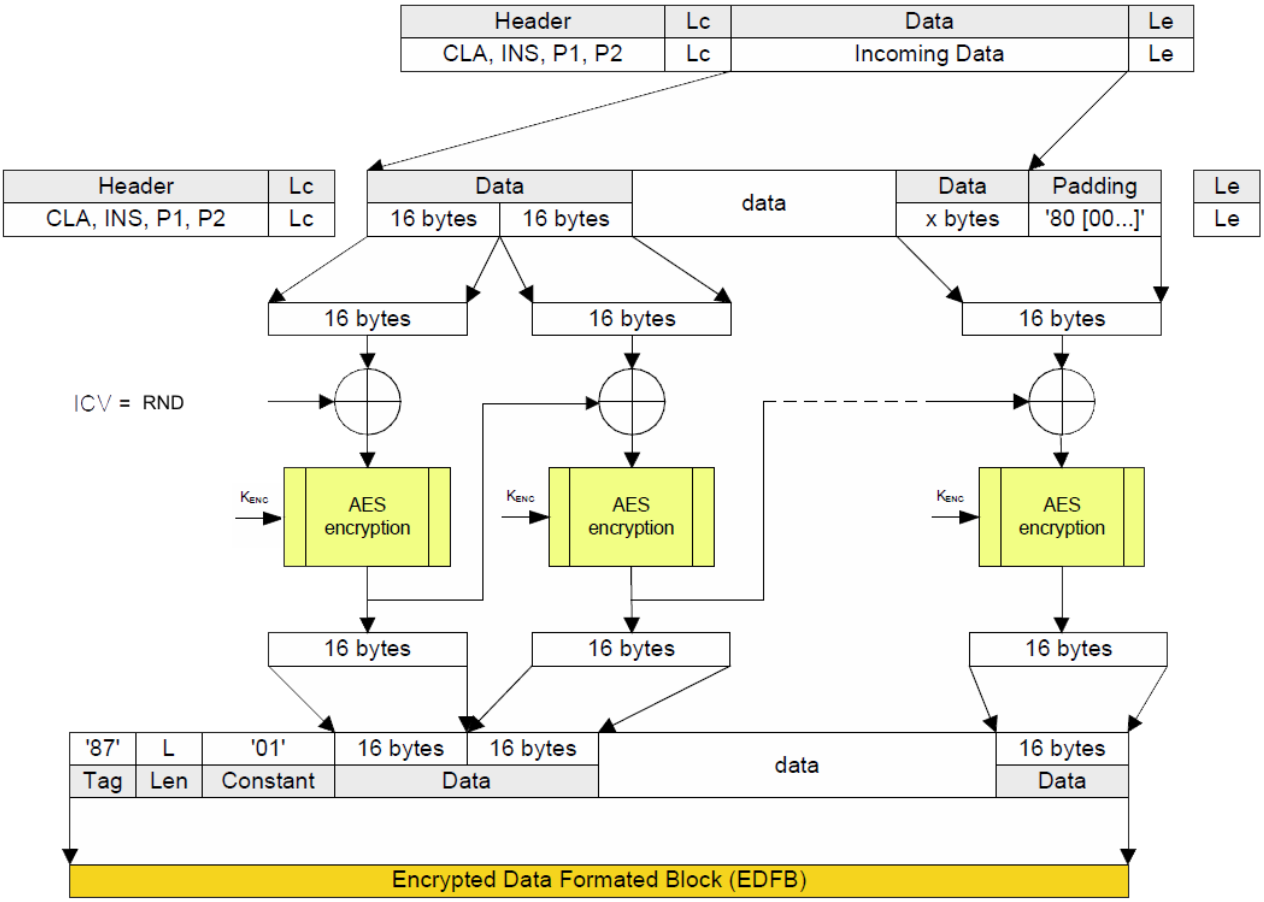
SM is defined for the algorithm AES with 128 or 256 bit. The supported algorithm is announced in Extended Capabilities, the related keys are stored in the application DOs

'SM Key-ENC' and 'SM Key-MAC'. By default the content of the DOs is empty and SM will not work. The keys can be set with a PUT DATA command after correct presentation of the Admin-PW (PW3). Form that point on all related commands can be used with SM. A command with correct SM has the same access condition to data in the application than a VERIFY with PW3.

If existing keys are replaced with PUT DATA, the card shall use the new values for the calculation of the response. The deletion of SM-keys should be done simultaneous with the DO 'F4', otherwise the functionality of SM is undefined. A key is deleted by writing an empty data string with PUT DATA.

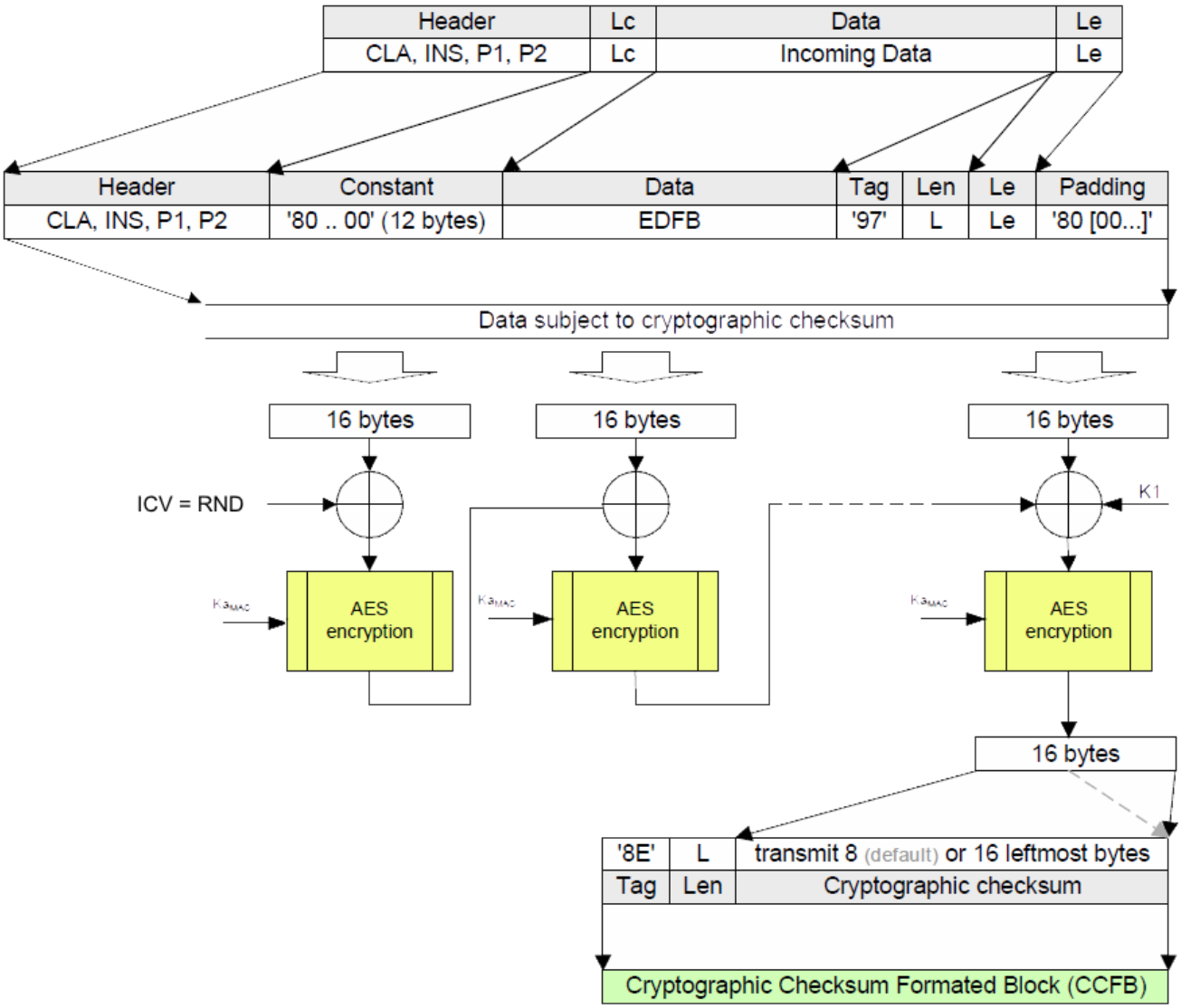
Rules for SM usage:

- For a command with even INS, any command/response data is encrypted and capsulated in a Tag 87 with padding indicator (01).
- For a command with odd INS, any command/response data is encrypted and capsulated in a Tag 85 without padding indicator.
- Commands with response (Le field not empty) have a protected Le-field (Tag 97) in the command data.
- Commands with response have a protected processing status (Tag 99) in the response.
- Commands without response (e. g. Case 3) have no processing status and/or MAC in the response field (SW1SW2 only).
- All SM-commands have at least an unencrypted MAC (Tag 8E) in the command data field.
- To protect the SM commands against replay attacks, a random number (RND) of 16 bytes is used as Initial Chaining Value (ICV). Before each command with SM the external world shall read a RND with 16 bytes from the card (Get Challenge). The last challenge from the card is internally used as ICV and is valid for one command and the response only.
- Encryption is done first in CBC-Mode with ICV = RND.
- MACing is done on the encrypted data with ICV = RND in CMAC-Mode.

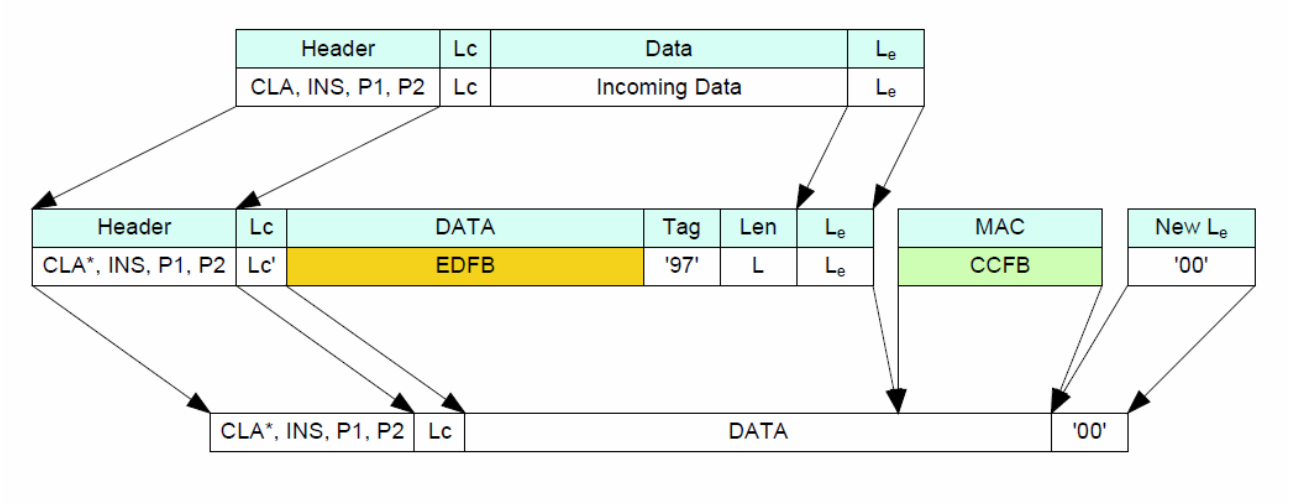


APDU command data encryption (even INS) with AES in CBC mode

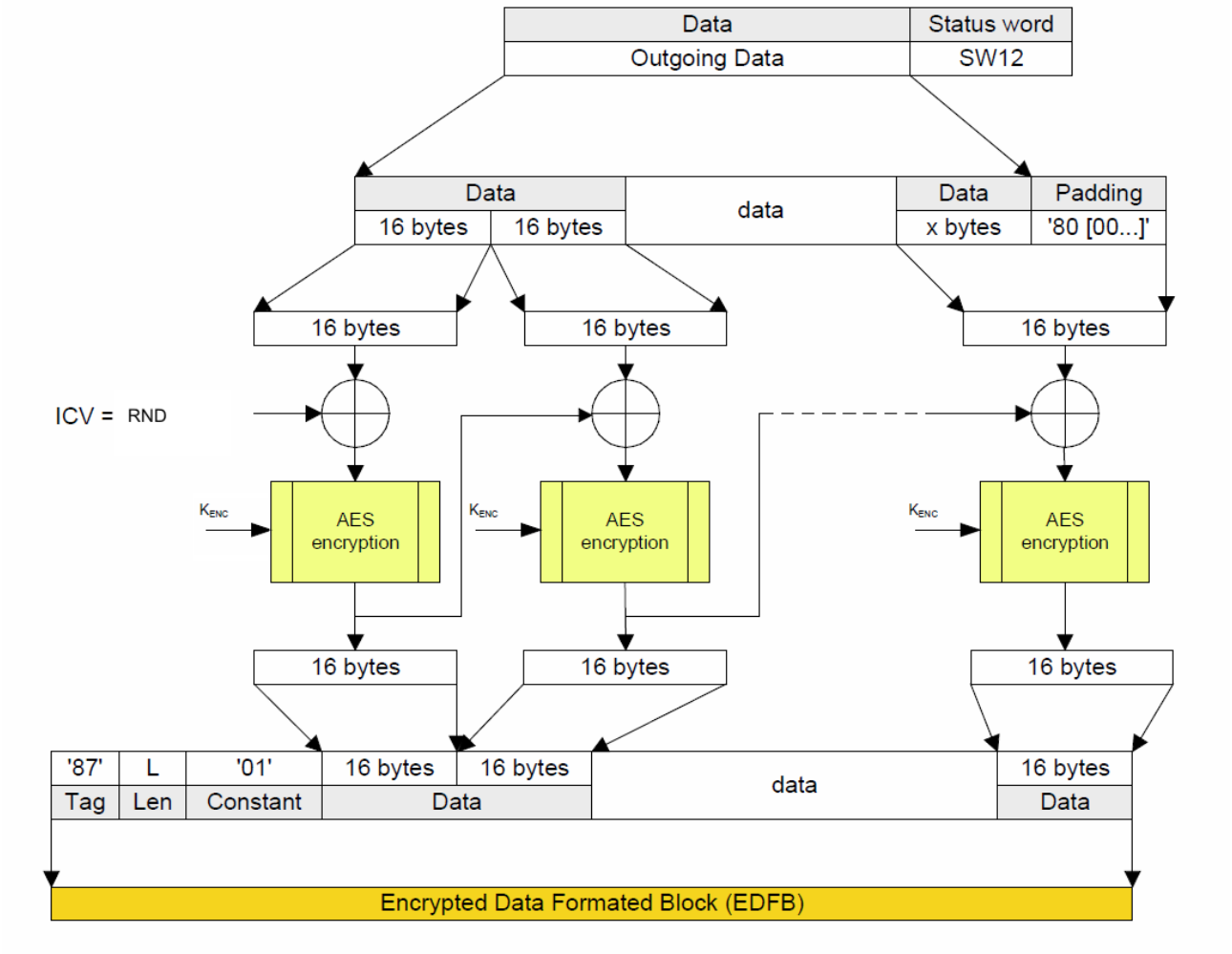
For odd INS the Tag for EDFB is '85' and the padding indication (constant '01') is omitted.



APDU computation of AES cryptographic checksum in CMAC mode

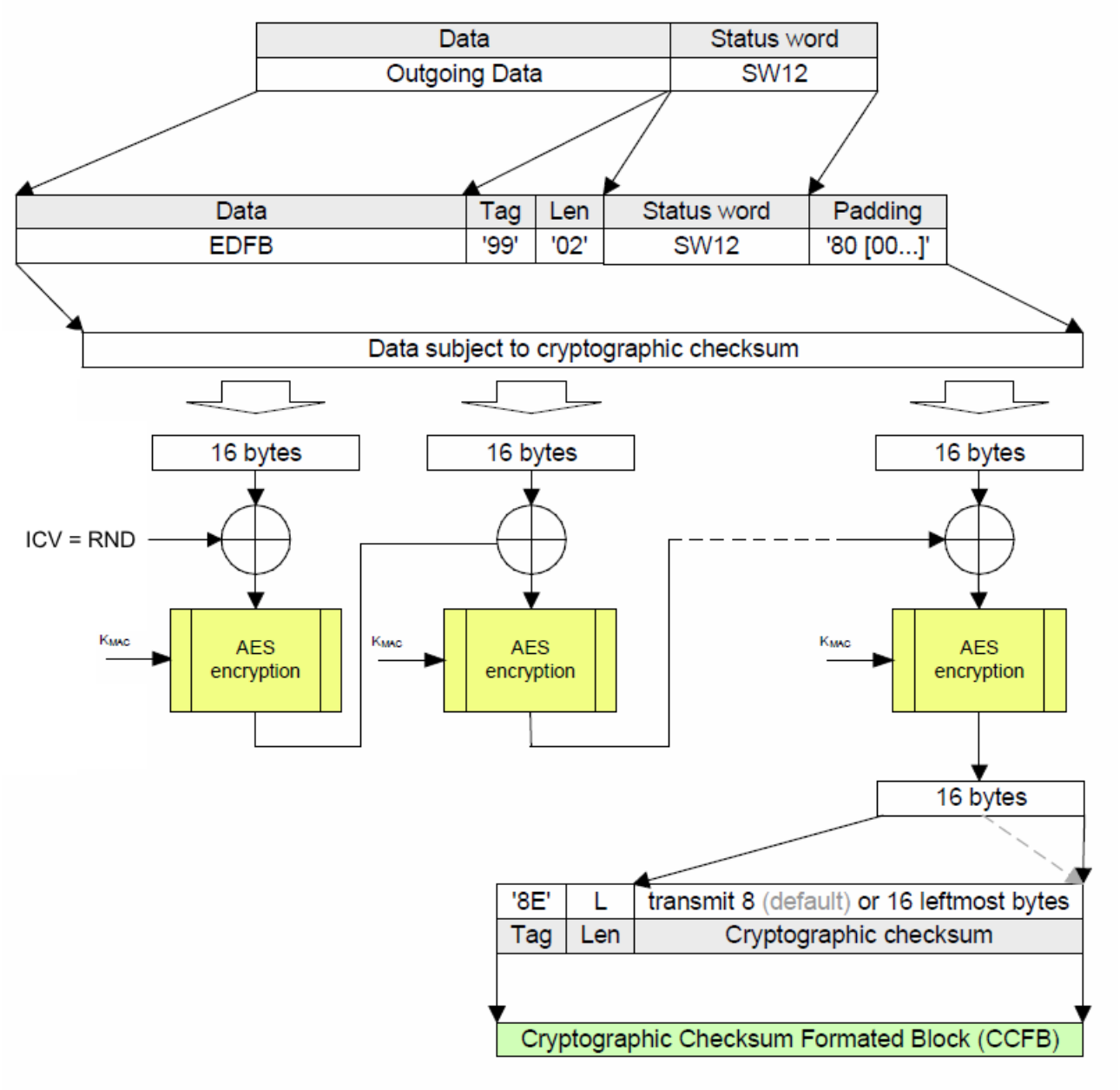


Final APDU command construction

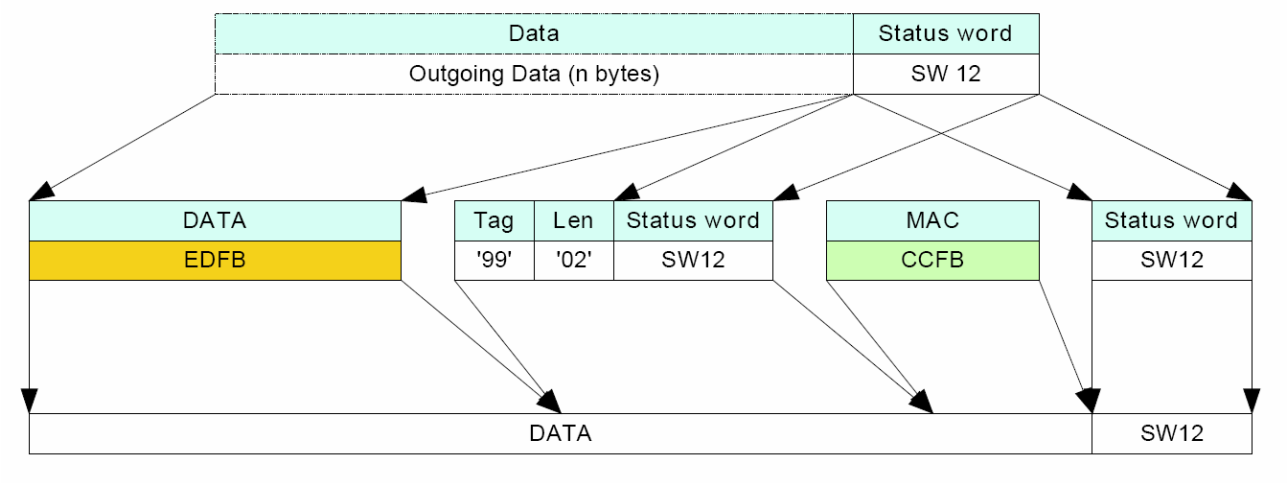


Response APDU data encryption using AES in CBC-mode

For odd INS the Tag for EDFB is '85' and the padding indication (constant '01') is omitted.



Response APDU computation of cryptographic checksum with AES in CMAC-Mode



Final response APDU contruction

7.5.1 Proprietary SM

The card or application may support other variants of Secure Messaging. They can be indicated in Extended Capabilities and may have a specific coding in the Class byte. The coding, the usage in commands and additional data objects, keys and certificates etc. are not part of this specification.

7.6 Logical Channels

The OpenPGP application does not use logical channels in this version. Channel number zero is assumed for all commands.

7.7 Command Chaining

If command data are too long for a single command (e. g. PSO:DEC with RSA 2048 and support of Short length only) a card may provide command chaining. The feature is announced in card capabilities in the Historical bytes.

If chaining is used, the CLA of a command shall be set to the appropriate value and the command data consist of the first block of the complete command data. The card stores the data block internally and wait for a follow-up command with the same INS/P1/P2. If sufficient the next data block is concatenated by the card, up to an equal command with no chaining bit in the CLA. Then the command is executed with the whole data from all previous commands in this chain.

The length of a data field in a command with chaining bit in CLA should be equal to the maximum input buffer of the card announced in ATR/INFO.

Chaining can be combined with Secure Messaging, the complete length of a single command shall not exceed the maximum input buffer of the card announced in ATR/INFO.

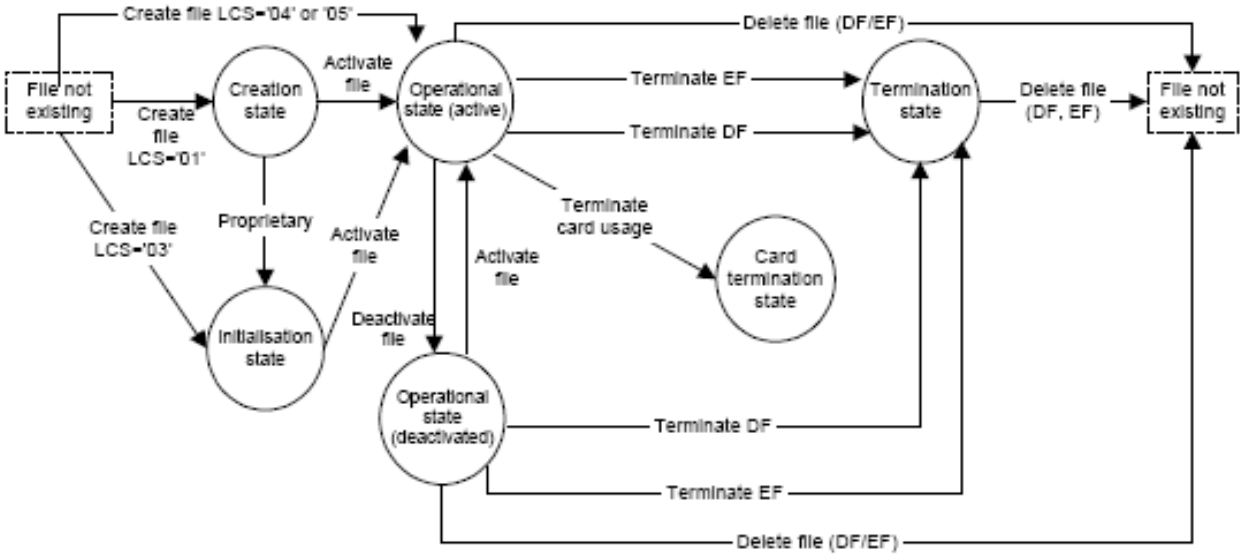
Commands that may support chaining have an appropriate coding in their CLA definition.

For performance reasons chaining should be avoided, all modern card readers support APDUs with 2 KB and more.

7.8 Life Cycle Management

Many users of an OpenPGP card asked me if it would be possible to RESET a card to the origin state at delivery time (all DOs empty or with default values). ISO 7816 offers no command directly for that purpose, but it can be done with a behaviour of the card called Life Cycle Status (LCS). A card can have a life cycle from 'creation state' to 'initialisation state' to 'operational state' (that can be activated or deactivated) up to 'termination state'. ISO defines two types of LCS: primary state, that allows only transitions in one direction and is irreversible and secondary state, that is application specific and reversible.

The following figure from ISO 7816-9 demonstrates it:



The solution for the OpenPGP application uses an application specific secondary state, that has some additions to the defined behaviour in ISO. In the phase from initialisation to operational state a card normally gets its data. The ISO command ACTIVATE FILE (related to a DF) can set this state. So the solution for the OpenPGP application is to use the ACTIVATE FILE command to reset all values in the card to their default values (user DOs empty, PWs to default values, keys/fingerprints empty etc.).

ISO defines no direct way from operational to initialisation state. The solution for the secondary state in the OpenPGP application is a transition of the termination state. After termination, the OpenPGP application falls back to initialisation state. Then the card can be resetted (re-newed) by an ACTIVATE FILE command.

Because this behaviour is proprietary and cannot be implemented on all existing platforms, it is optional and announced in the Life Cycle Status indicator in the Historical bytes.

7.9 Status Bytes

After a command the chip returns a pair of status bytes (return code). All codings of ISO 7816-4 are valid for the card and may occur in a specific context.

The following table shows possible coding for status bytes:

61	xx	Command correct, xx bytes available in response (normally used under T=0 or for commands under any protocol with long response data that cannot be transmitted in one response)
62	85	Selected file in termination state
63	CX	Password not checked, 'X' encodes the number of further allowed retries
64	02-80	Triggering by the card 0E = Out of Memory (BasicCard specific)
65	81	Memory failure
66	00	Security-related issues (reserved for UIF in this application)
67	00	Wrong length (Lc and/or Le)
68	81	Logical channel not supported
68	82	Secure messaging not supported
68	83	Last command of the chain expected
68	84	Command chaining not supported
69	82	Security status not satisfied PW wrong PW not checked (command not allowed) Secure messaging incorrect (checksum and/or cryptogram)
69	83	Authentication method blocked PW blocked (error counter zero)
69	85	Condition of use not satisfied
69	87	Expected SM data objects missing (e. g. SM-key)
69	88	SM data objects incorrect (e. g. wrong TLV-structure in command data)
6A	80	Incorrect parameters in the data field
6A	82	File or application not found
6A	88	Referenced data not found
6B	00	Wrong parameters P1-P2
6D	00	Instruction (INS) not supported
6E	00	Class (CLA) not supported
90	00	Command correct

8 Literature

European Standard (2017):
EN 419212-1, Application Interface for Secure Elements for Electronic Identification, Authentication and Trusted Services, Part 1: Introduction and common definitions

European Standard (2017):
EN 419212-2, Application Interface for Secure Elements for Electronic Identification, Authentication and Trusted Services, Part 2: Signature and Seal Services

European Standard (2017):
EN 419212-3, Application Interface for Secure Elements for Electronic Identification, Authentication and Trusted Services, Part 3: Device Authentication Protocols

European Standard (2017):
EN 419212-4, Application Interface for Secure Elements for Electronic Identification, Authentication and Trusted Services, Part 4: Privacy specific Protocols

European Standard (2017):
EN 419212-5, Application Interface for Secure Elements for Electronic Identification, Authentication and Trusted Services, Part 5: Trusted eServices

Fontaine, Arnaud (2016):
Secure Messaging for OpenPGP card version 3.x

gematik (2017):
Einführung der Gesundheitskarte – Spezifikation des Card Operating System (COS), Version 3.10.0

ISO/IEC (2003):
ISO 9564-3, Personal Identification Number management and security, Part 3: Requirements for offline PIN handling in ATM and POS systems

ISO/IEC (2006):
ISO/IEC 7816-3, Identification cards - Integrated circuit cards - Part 3: Cards with contacts: Electrical interface and transmission protocols

ISO/IEC (2013):
ISO/IEC 7816-4, Identification cards - Integrated circuit cards - Part 4: Organization, security and commands for interchange

ISO/IEC (2014):
ISO/IEC 7816-4, Identification cards - Integrated circuit cards - Part 4: Organization, security and commands for interchange; Technical Corrigendum 1

ISO/IEC (2016):
ISO/IEC 18328-3, Identification cards – ICC managed devices, Part 3: Organization, security and commands for interchange

ISO/IEC (2016):
ISO/IEC FDIS 7816-6.2, Identification cards - Integrated circuit cards - Part 6: Interindustry data elements for interchange

ISO/IEC (2016):
ISO/IEC FDIS 7816-8, Identification cards - Integrated circuit cards, Part 8: Commands for security operations

ISO/IEC (2017):
ISO/IEC 7816-9, Identification cards - Integrated circuit cards, Part 9: Commands for card management

RSA Laboratories (2002):
PKCS #1 v2.1: RSA Encryption Standard

The Internet Society (2007):
RFC 4880: OpenPGP Message Format

The Internet Society (2012):
RFC 6637: Elliptic Curve Cryptography (ECC) in OpenPGP

ANNEX

9 Flow Charts

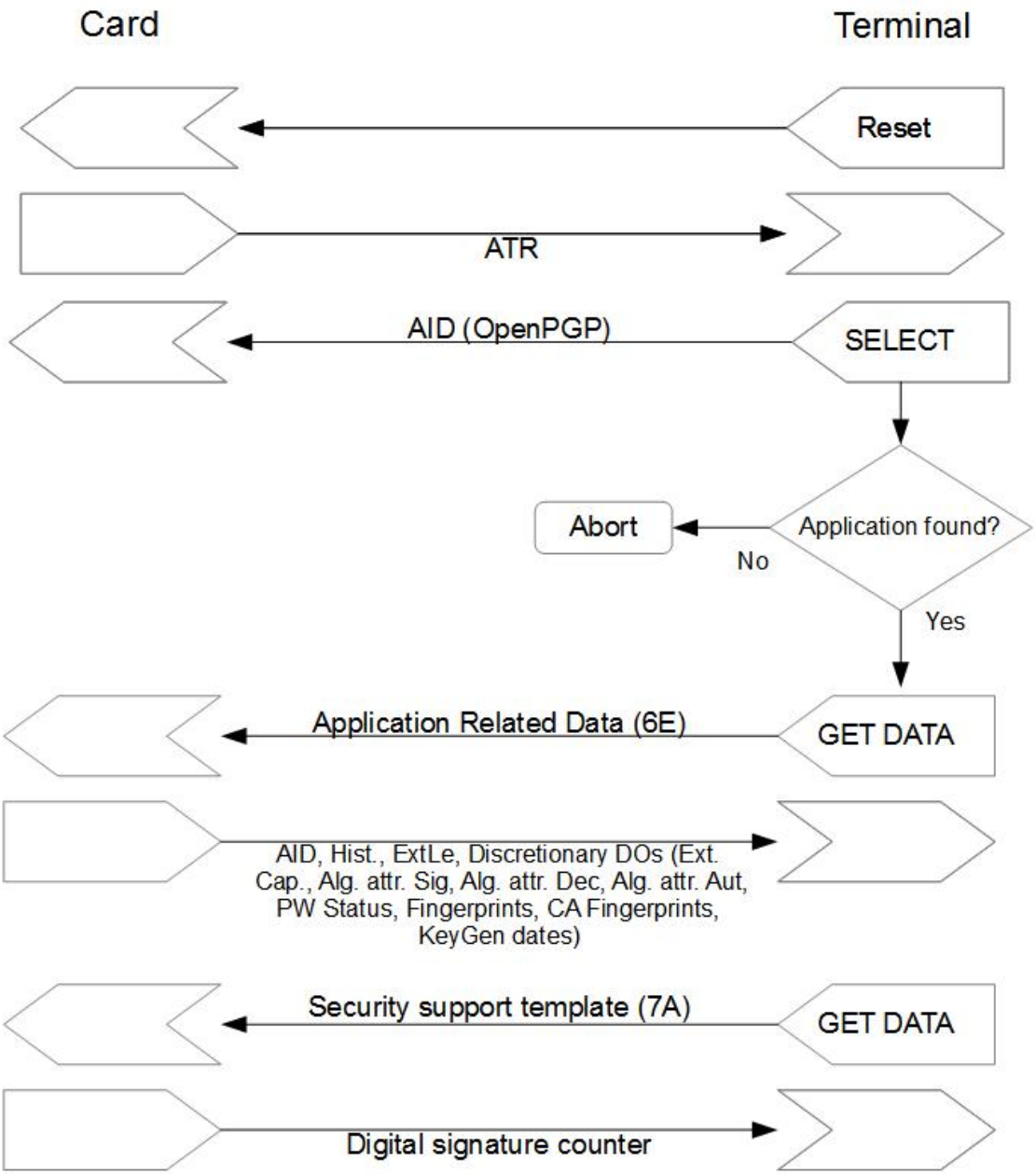
The communication scenarios illustrate some possibilities for the use of the OpenPGP application. Only a few functions are described, there are several additional functions available. The data in the commands may not be complete and are informative only.

In principle, the application sequences to be realised apply to the application structure described in the specification. The realisation of the application sequences is generally made possible by the global commands provided to the card by the operating system, taking account of the security structure.

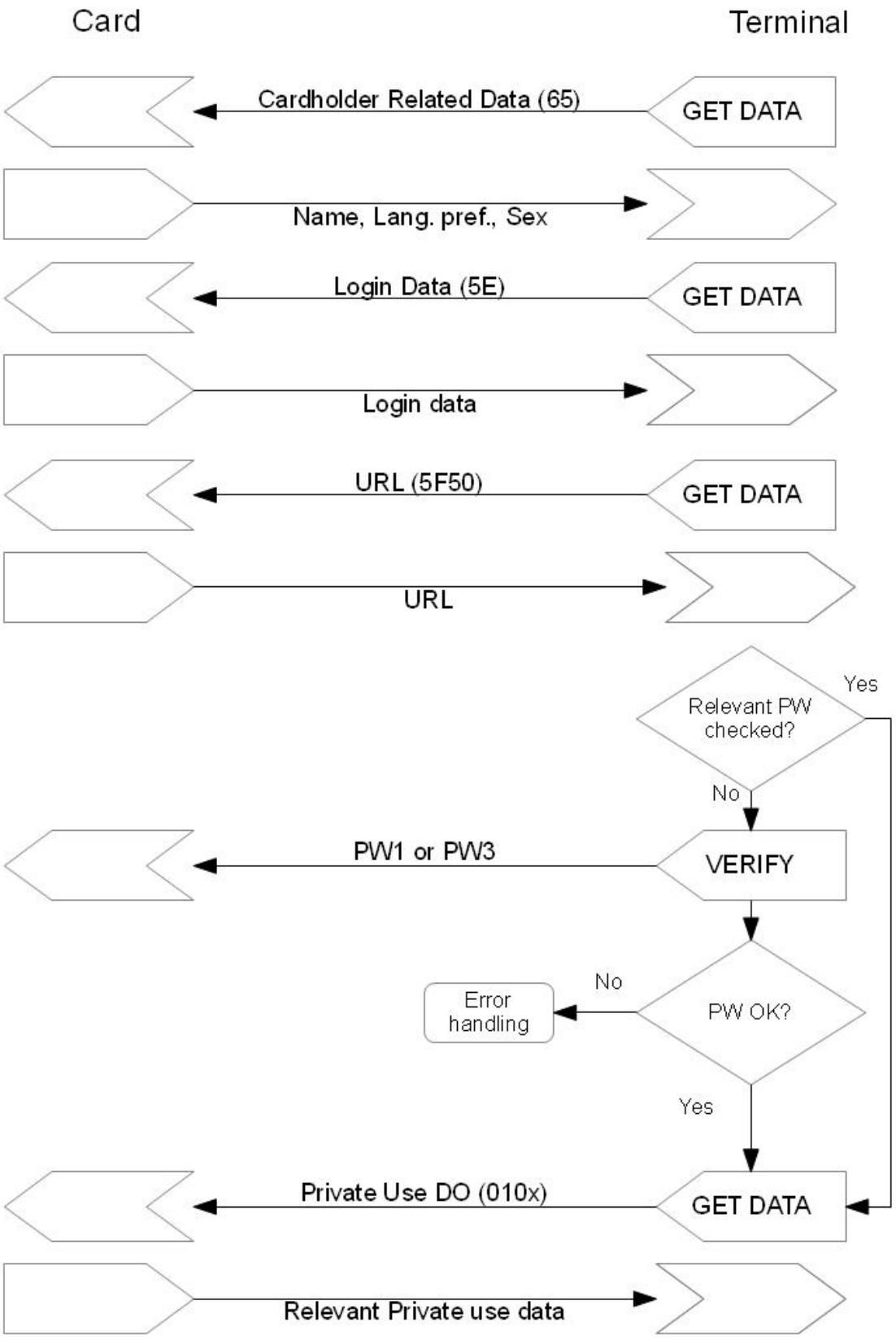
With respect to the sequences, only those application data are considered that are relevant at the interface between card and terminal. Standard return codes, header information and error events are not included for reasons of clarity. The scenarios are intended to clarify the essential mechanisms of the application and are used to facilitate a better understanding of the entire specification. They are not intended to serve as the only basis for the realisation of terminal programs.

As long as the security guidelines required by the applications are observed, the modification of the following scenarios is possible.

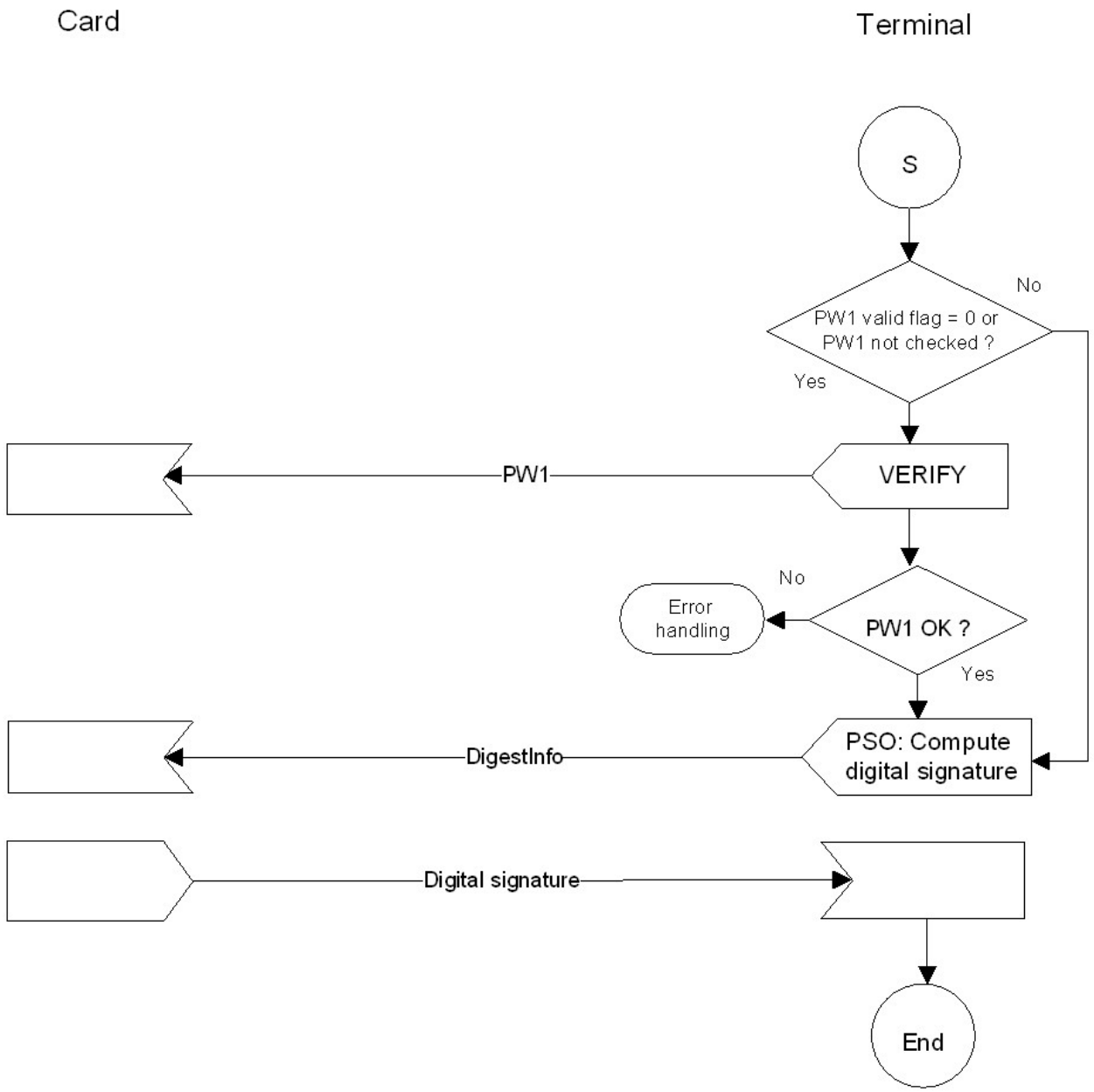
9.1 Application Selection reading main DOs



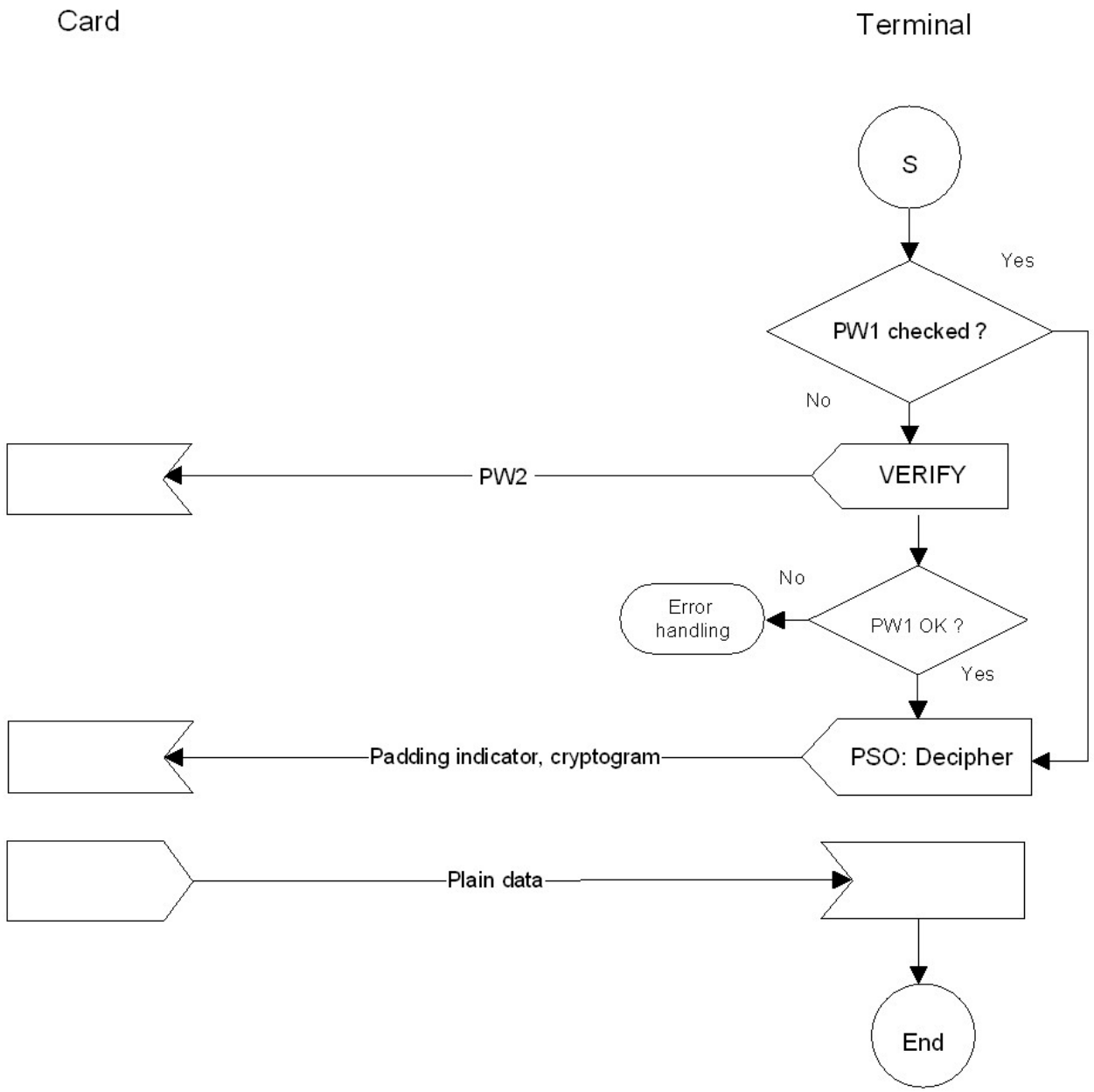
9.2 Reading optional Data objects



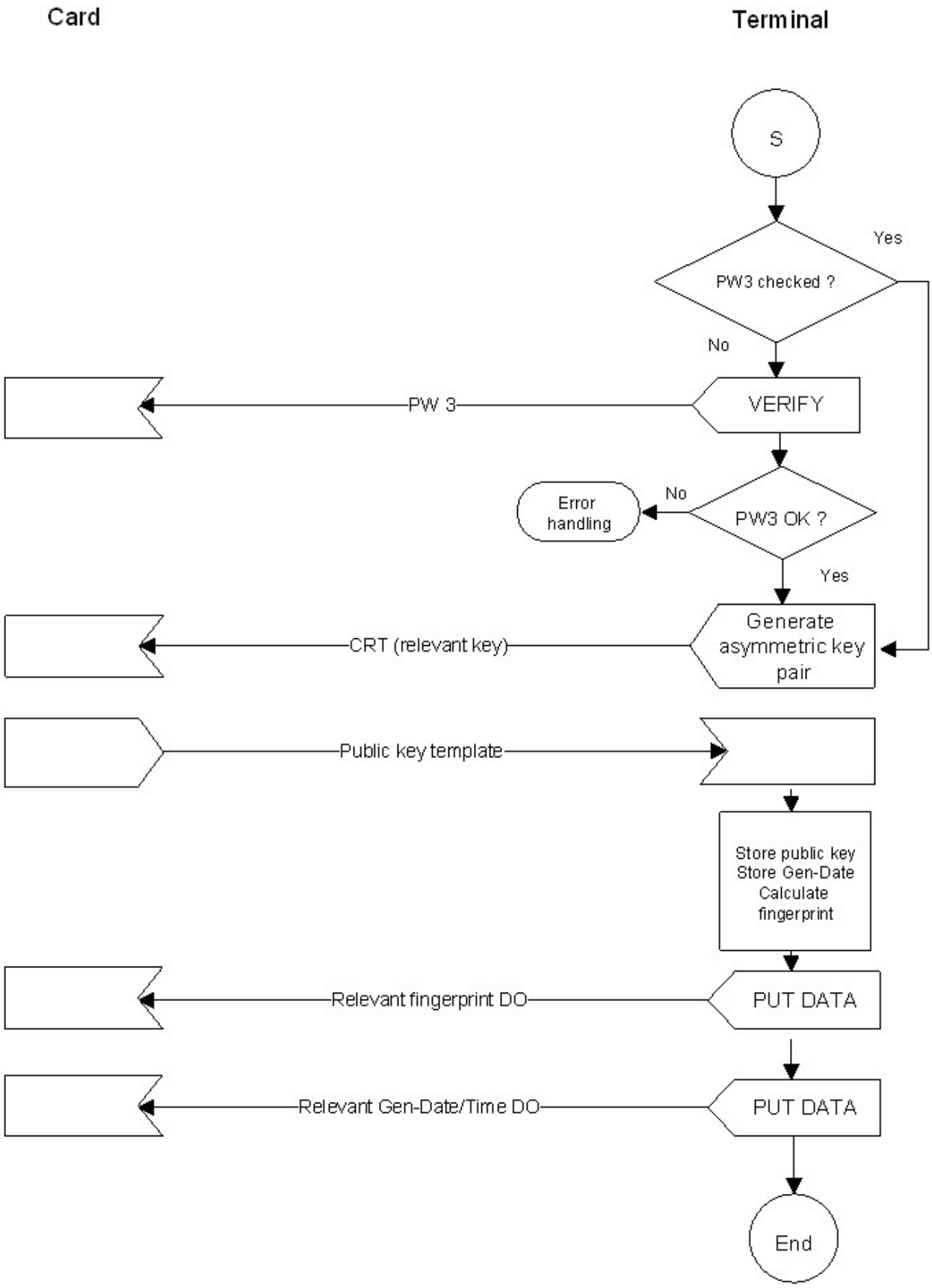
9.3 Compute Digital Signature



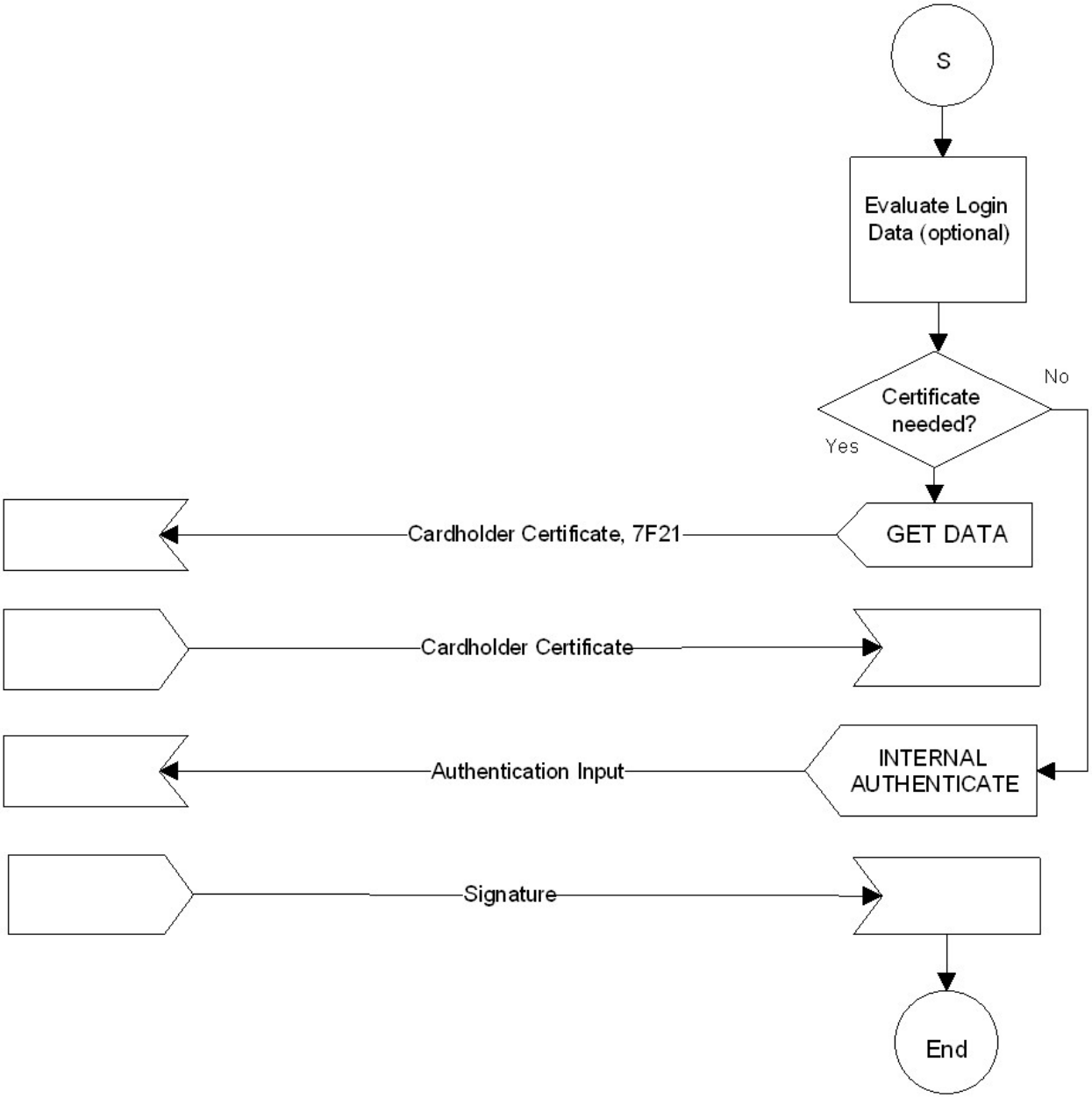
9.4 Decrypt Message



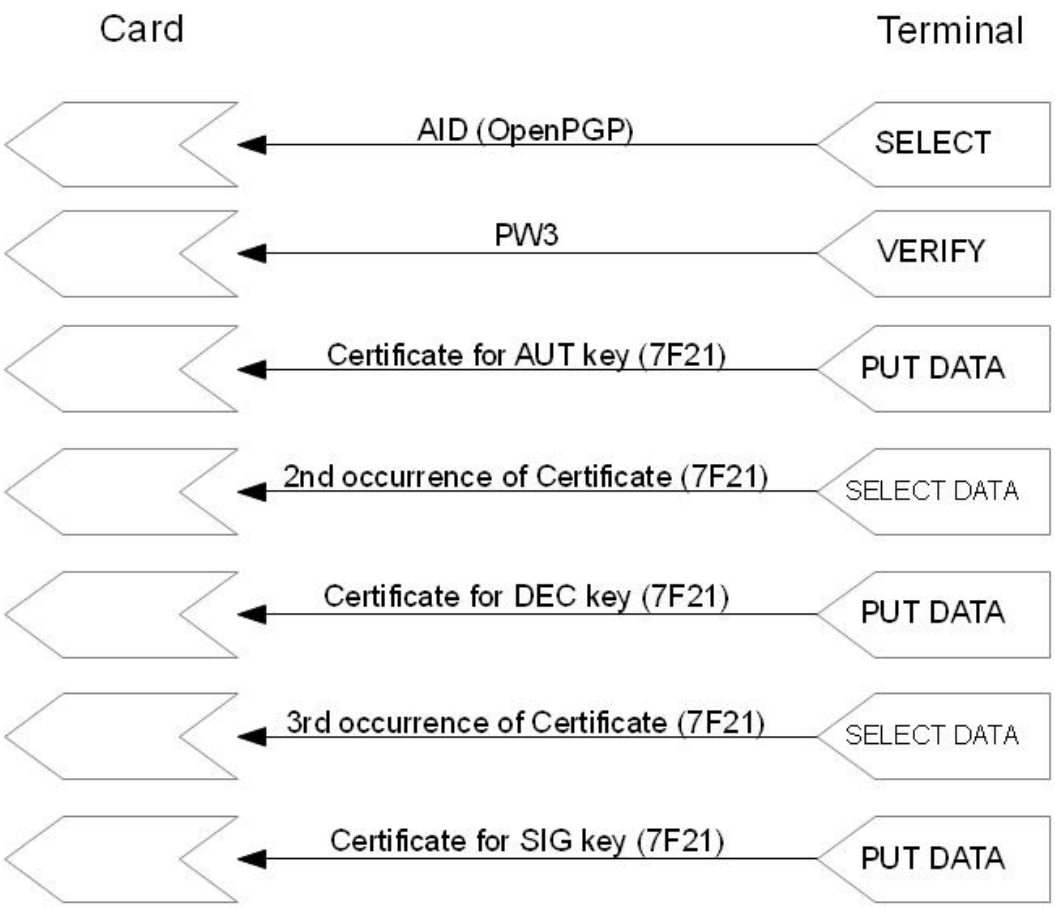
9.5 Generate Private Key



9.6 Client/Server Authentication



9.7 Storage of Card Holder Certificates



10 Domain parameter of supported elliptic curves

Most tables and values are taken from gematik specification “Spezifikation des Card Operation System (COS), Version 3.7.0”.

ansix9p256r1, OID = {1.2.840.10045.3.1.7} = ´2A8648CE3D030107´

The used domain parameters are from [ANSI X9.62] and are identical with [FIPS 186–4].

p	´FFFFFFFF 00000001 00000000 00000000 00000000 FFFFFFFF FFFFFFFF FFFFFFFF´
a	´FFFFFFFF 00000001 00000000 00000000 00000000 FFFFFFFF FFFFFFFF FFFFFFFC´
b	´5AC635D8 AA3A93E7 B3EBBD55 769886BC 651D06B0 CC53B0F6 3BCE3C3E 27D2604B´
G	compressed: ´03 6B17D1F2 E12C4247 F8BCE6E5 63A440F2 77037D81 2DEB33A0 F4A13945 D898C296´ as coordinates: xg = ´6B17D1F2 E12C4247 F8BCE6E5 63A440F2 77037D81 2DEB33A0 F4A13945 D898C296´ yg = ´4FE342E2 FE1A7F9B 8EE7EB4A 7C0F9E16 2BCE3357 6B315ECE CBB64068 37BF51F5´
n	´FFFFFFFF 00000000 FFFFFFFF FFFFFFFF BCE6FAAD A7179E84 F3B9CAC2 FC632551´
h	1

ansix9p384r1, OID = {1.3.132.0.34} = '2B81040022'

p	´FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFE FFFFFFFF 00000000 00000000 FFFFFFFF´
a	´FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFE FFFFFFFF 00000000 00000000 FFFFFFFC´
b	£0.00
G	compressed: ´03 AA87CA22 BE8B0537 8EB1C71E F320AD74 6E1D3B62 8BA79B98 59F741E0 82542A38 5502F25D BF55296C 3A545E38 72760AB7´ as coordinates: xg = ´AA87CA22 BE8B0537 8EB1C71E F320AD74 6E1D3B62 8BA79B98 59F741E0 82542A38 5502F25D BF55296C 3A545E38 72760AB7´ yg = ´3617DE4A 96262C6F 5D9E98BF 9292DC29 F8F41DBD 289A147C E9DA3113 B5F0B8C0 0A60B1CE 1D7E819D 7A431D7C 90EA0E5F´
n	´FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF C7634D81 F4372DDF 581A0DB2 48B0A77A ECEC196A CCC52973´
h	1

ansix9p521r1, OID = {1.3.132.0.35} = '2B81040023'

p	´01FF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF´
a	´01FF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFC´
b	´0051 953EB961 8E1C9A1F 929A21A0 B68540EE A2DA725B 99B315F3 B8B48991 8EF109E1 56193951 EC7E937B 1652C0BD 3BB1BF07 3573DF88 3D2C34F1 EF451FD4 6B503F00´
G	compressed: ´0200C6 858E06B7 0404E9CD 9E3ECB66 2395B442 9C648139 053FB521 F828AF60 6B4D3DBA A14B5E77 EFE75928 FE1DC127 A2FFA8DE 3348B3C1 856A429B F97E7E31 C2E5BD66´ as coordinates: xg = ´000000C6 858E06B7 0404E9CD 9E3ECB66 2395B442 9C648139 053FB521 F828AF60 6B4D3DBA A14B5E77 EFE75928 FE1DC127 A2FFA8DE 3348B3C1 856A429B F97E7E31 C2E5BD66´ yg = ´00000118 39296A78 9A3BC004 5C8A5FB4 2C7D1BD9 98F54449 579B4468 17AFBD17 273E662C 97EE7299 5EF42640 C550B901 3FAD0761 353C7086 A272C240 88BE9476 9FD16650´
n	´01FF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFA 51868783 BF2F966B 7FCC0148 F709A5D0 3BB5C9B8 899C47AE BB6FB71E 91386409´
h	1

brainpoolP256r1, OID={1.3.36.3.3.2.8.1.1.7} = ´2B2403030208010107´

The used domain parameters are from [RFC5639].

p	´A9FB57DB A1EEA9BC 3E660A90 9D838D72 6E3BF623 D5262028 2013481D 1F6E5377´
a	´7D5A0975 FC2C3057 EEF67530 417AFFE7 FB8055C1 26DC5C6C E94A4B44 F330B5D9´
b	´26DC5C6C E94A4B44 F330B5D9 BBD77CBF 95841629 5CF7E1CE 6BCCDC18 FF8C07B6´
G	as coordinates: xg = ´8BD2AEB9 CB7E57CB 2C4B482F FC81B7AF B9DE27E1 E3BD23C2 3A4453BD 9ACE3262´ yg = ´547EF835 C3DAC4FD 97F8461A 14611DC9 C2774513 2DED8E54 5C1D54C7 2F046997´
n	´A9FB57DB A1EEA9BC 3E660A90 9D838D71 8C397AA3 B561A6F7 901E0E82 974856A7´
h	1

brainpoolP384r1, OID={1.3.36.3.3.2.8.1.1.11} = ´2B240303020801010B´

p	´8CB91E82 A3386D28 0F5D6F7E 50E641DF 152F7109 ED5456B4 12B1DA19 7FB71123 ACD3A729 901D1A71 87470013 3107EC53´
a	´7BC382C6 3D8C150C 3C72080A CE05AFA0 C2BEA28E 4FB22787 139165EF BA91F90F 8AA5814A 503AD4EB 04A8C7DD 22CE2826´
b	´04A8C7DD 22CE2826 8B39B554 16F0447C 2FB77DE1 07DCD2A6 2E880EA5 3EEB62D5 7CB43902 95DBC994 3AB78696 FA504C11´
G	as coordinates: xg = ´1D1C64F0 68CF45FF A2A63A81 B7C13F6B 8847A3E7 7EF14FE3 DB7FCAFE 0CBD10E8 E826E034 36D646AA EF87B2E2 47D4AF1E´ yg = ´8ABE1D75 20F9C2A4 5CB1EB8E 95CFD552 62B70B29 FEEC5864 E19C054F F9912928 0E464621 77918111 42820341 263C5315´
n	´8CB91E82 A3386D28 0F5D6F7E 50E641DF 152F7109 ED5456B3 1F166E6C AC0425A7 CF3AB6AF 6B7FC310 3B883202 E9046565´
h	1

brainpoolP512r1, OID={1.3.36.3.3.2.8.1.1.13} = ´2B240303020801010D´

p	´AADD9DB8 DBE9C48B 3FD4E6AE 33C9FC07 CB308DB3 B3C9D20E D6639CCA 70330871 7D4D9B00 9BC66842 AECDA12A E6A380E6 2881FF2F 2D82C685 28AA6056 583A48F3´
a	´7830A331 8B603B89 E2327145 AC234CC5 94CBDD8D 3DF91610 A83441CA EA9863BC 2DED5D5A A8253AA1 0A2EF1C9 8B9AC8B5 7F1117A7 2BF2C7B9 E7C1AC4D 77FC94CA´
b	´3DF91610 A83441CA EA9863BC 2DED5D5A A8253AA1 0A2EF1C9 8B9AC8B5 7F1117A7 2BF2C7B9 E7C1AC4D 77FC94CA DC083E67 984050B7 5EBAE5DD 2809BD63 8016F723´
G	as coordinates: xg = ´81AEE4BD D82ED964 5A21322E 9C4C6A93 85ED9F70 B5D916C1 B43B62EE F4D0098E FF3B1F7 8E2D0D48 D50D1687 B93B97D5F 7C6D5047 406A5E68 8B352209 BCB9F822´ yg = ´7DDE385D 566332EC C0EABFA9 CF7822FD F209F700 24A57B1A A000C55B 881F8111 B2DCDE49 4A5F485E 5BCA4BD8 8A2763AE D1CA2B2F A8F05406 78CD1E0F 3AD80892´
n	´AADD9DB8 DBE9C48B 3FD4E6AE 33C9FC07 CB308DB3 B3C9D20E D6639CCA 70330870 553E5C41 4CA92619 41866119 7FAC1047 1DB1D381 085DDADD B5879682 9CA90069´
h	1