ecma INTERNATIONAL

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NFC-SEC:
NFCIP-1 Security Services and Protocol

Standard

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Introduction

This Standard specifies common NFC Security services and a protocol. This Standard is a part of the NFC Security series of standards. The NFC-SEC cryptography standards of the series complement and use the services and protocol specified in this Standard. The third edition has removed annex B because it has been included in ISO/IEC 18092:2013 and it allows implementation on generic NFC connections. This fourth edition is fully aligned with ISO/IEC 13157-1:2014.

This Ecma Standard has been adopted by the General Assembly of June 2015.

NFC-SEC: NFCIP-1 Security Services and Protocol

1 Scope

This Standard specifies the NFC-SEC secure channel and shared secret services for NFCIP-1 and the PDUs and protocol for those services.

NOTE This Standard does not address application specific security mechanisms (as typically needed for smart card related use cases and standardized in the ISO/IEC 7816 series). NFC-SEC may complement application specific security mechanisms of ISO/IEC 7816.

2 Conformance

Conformant implementations implement one or more of the services specified in this Standard, using the security mechanisms from the NFC-SEC cryptography part identified by the selected Protocol Identifier.

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ECMA-340, *Near Field Communication Interface and Protocol (NFCIP-1)*

ECMA-386, *NFC-SEC-01: NFC-SEC Cryptography Standard using ECDH and AES*

ISO/IEC 7498-1:1994, *Information technology -- Open Systems Interconnection -- Basic Reference Model: The Basic Model*

ISO 7498-2:1989, *Information processing systems -- Open Systems Interconnection -- Basic Reference Model -- Part 2: Security Architecture*

ISO/IEC 10731:1994, *Information technology -- Open Systems Interconnection -- Basic Reference Model -- Conventions for the definition of OSI services*

ISO/IEC 11770-1:1996, *Information technology -- Security techniques -- Key management -- Part 1: Framework*

4 Terms and definitions

For the purpose of this Standard, the terms and definitions specified in ECMA-340, ISO/IEC 7498-1, ISO 7498-2, ISO/IEC 10731 and ISO/IEC 11770-1 apply. In addition, the following terms and definitions apply.

4.1
connection
(N)-connection as specified in ISO/IEC 7498-1

4.2
entity
(N)-entity as specified in ISO/IEC 7498-1

4.3
link key
secret key securing communications across a secure channel

4.4
NFC-SEC User
entity using the NFC-SEC service

4.5
protocol
(N)-protocol as specified in ISO/IEC 7498-1

4.6
recipient
NFC-SEC entity that receives ACT_REQ

4.7
secure channel
secure NFC-SEC connection

4.8
sender
NFC-SEC entity that sends ACT_REQ

4.9
service
(N)-service as specified in ISO/IEC 7498-1

4.10
shared secret
secret shared by two peer NFC-SEC Users

5 Conventions and notations

The following conventions and notations apply in this document unless otherwise stated.

5.1 Representation of numbers

The following conventions and notations apply in this document unless otherwise stated.

- Letters and digits in parentheses represent numbers in hexadecimal notation.
- The setting of bits is denoted by ZERO or ONE.
- Numbers in binary notation and bit patterns are represented by sequences of 0 and 1 bits shown with the most significant bit to the left. Within such strings, X may be used to indicate that the setting of a bit is not specified within the string.
- In octets the lsb is bit number 1, the msb bit number 8; in n-length bit strings the lsb is bit number 1 and the msb is bit number n.

5.2 Names

The names of basic elements, e.g. specific fields, are written with a capital initial letter.

6 Acronyms

For the purposes of this Standard, the acronyms specified in ECMA-340 apply. Additionally, the following acronyms apply.

ACT_REQ	Activation Request PDU
ACT_RES	Activation Response PDU
ENC	Encrypted Packet PDU
ERROR	Error PDU
lsb	least significant bit
LSB	Least Significant Byte
msb	most significant bit
MSB	Most Significant Byte
MSG	MesSaGe code
PCI	Protocol Control Information (see ISO/IEC 7498-1)
PDU	Protocol Data Unit (see ISO/IEC 7498-1)
PID	Protocol Identifier
RFU	Reserved for Future Use
SAP	Service Access Point
SCH	Secure Channel service
SDL	Specification and Description Language (as specified in ITU-T Z.100)
SDU	Service Data Unit (see ISO/IEC 7498-1)
SEP	Security Exchange protocol Parameter
SN	Sequence Number
SNV	SN variable
SSE	Shared Secret Service
SVC	SerVicE code
TMN	Terminate PDU
VFY_REQ	Verification Request PDU

VFY_RES Verification Response PDU

7 General

NFC-SEC as illustrated in Figure 1 uses the OSI reference model specified in ISO/IEC 7498-1.

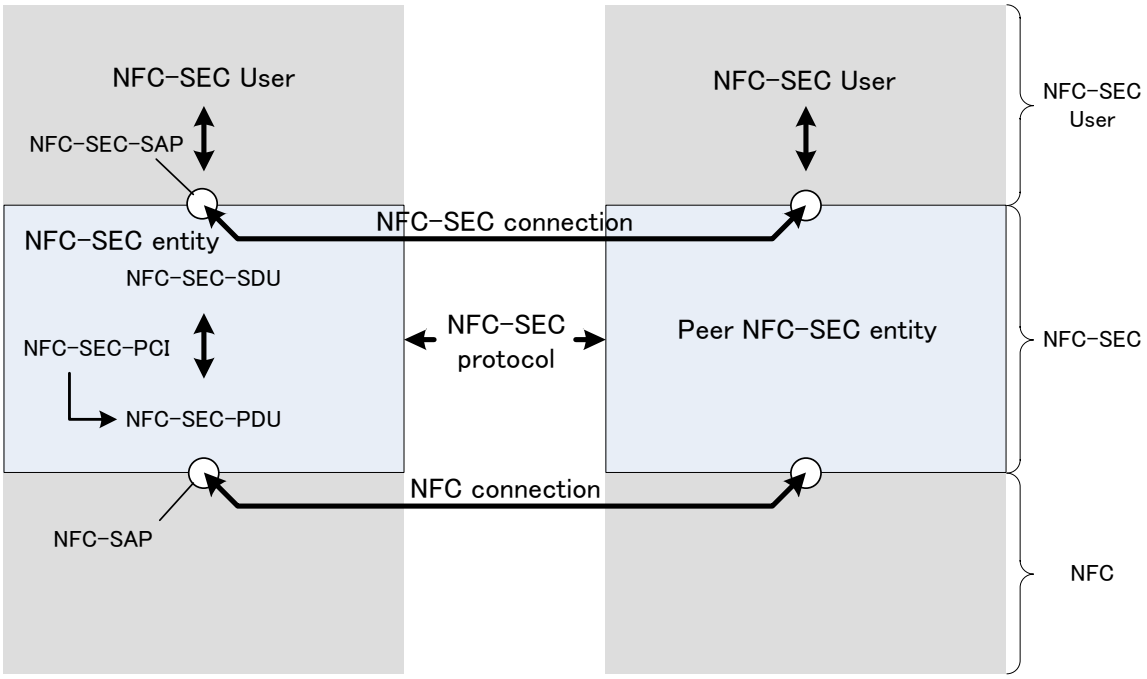


Figure 1 — NFC-SEC architecture

NFC-SEC Users invoke and access the NFC-SEC services through NFC-SEC Service Access Points (NFC-SEC-SAP). NFC-SEC entities obtain NFC-SEC-SDUs (requests) from NFC-SEC Users and return NFC-SEC-SDUs (confirmations) to them.

This Standard specifies the Secure Channel Service (SCH) and the Shared Secret Service (SSE).

To provide the NFC-SEC services, Peer NFC-SEC entities exchange NFC-SEC-PDUs by conforming to the NFC-SEC protocol over NFC-SEC connections.

Peer NFC-SEC entities send and receive NFC-SEC-PDUs through NFC Service Access Points (NFC-SAP). A NFC-SEC-PDU consists of NFC-SEC Protocol Control Information (NFC-SEC-PCI) and a single NFC-SEC-SDU.

8 Services

This Clause specifies two services, SSE and SCH, that NFC-SEC provides to the NFC-SEC User. When invoked, these services enable the cryptographic protected transmission of NFC-SEC User messages between the peer entities by means of a protocol described in Clause 9.

Shared secrets established with the services specified below shall be cryptographically uncorrelated from any shared secrets established beforehand or afterwards.

8.1 Shared Secret Service (SSE)

The SSE establishes a shared secret between two peer NFC-SEC Users, which they can use at their discretion.

Invocation of the SSE shall establish a shared secret by the key agreement and key confirmation mechanisms, according to the NFC-SEC cryptography part that defines the PID.

8.2 Secure Channel Service (SCH)

The SCH provides a secure channel.

Invocation of the SCH shall establish a link key, by derivation from a shared secret established by the key agreement and key confirmation mechanisms, and shall subsequently protect all communications in either direction across the channel, according to the NFC-SEC cryptography part that defines the PID.

9 Protocol Mechanisms

The NFC-SEC protocol comprises the following mechanisms. Figure 2 specifies the sequence of the protocol mechanisms.

9.1 Key agreement

The peer NFC-SEC entities shall establish a shared secret using ACT_REQ and ACT_RES, according to the NFC-SEC cryptography part that defines the PID.

9.2 Key confirmation

The peer NFC-SEC entities shall verify their agreed shared secret using VFY_REQ and VFY_RES, according to the NFC-SEC cryptography part that defines the PID.

9.3 PDU security

PDU security is a mechanism of SCH service only.

The peer NFC-SEC entities shall protect data exchange using ENC, according to the NFC-SEC cryptography part that defines the PID.

This mechanism shall comprise one or more of the following, as specified in the respective NFC-SEC cryptography standard:

- Sequence Integrity, conforming to the requirements of 12.3;
- Confidentiality;
- Data integrity;
- Origin authentication.

9.4 Termination

The peer NFC-SEC entities shall terminate SSE and SCH using TMN.

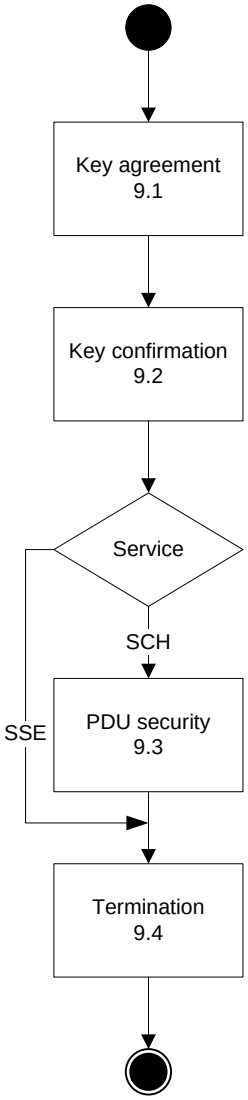


Figure 2 — General flow of the NFC-SEC services

10 States and Sub-states

The NFC-SEC protocol machine in Annex A specifies the state transitions for the states and sub-states in Table 1.

Table 1 — State

State	Description
Idle	NFC-SEC is ready to start a new service upon request from the NFC-SEC User or the peer NFC-SEC Entity.
Select	NFC-SEC is awaiting an ACT_RES.
Established	An NFC-SEC Service is requested. The established state contains two sub-states In the Established_Sender sub-state it is awaiting a VFY_RES. In the Established_Recipient Sub-state it is awaiting a VFY_REQ.
Confirmed	An NFC-SEC service is established. The Confirmed State contains two sub-states, In the Confirmed _SSE sub-state, the shared secret is ready to be retrieved. In the Confirmed _SCH sub-state, secure data exchange is ready.

Upon transition to the Idle state any shared secret and link key shall be destroyed.

11 NFC-SEC-PDUs

Secure data shall be conveyed in the NFC-SEC Payload field of the NFC-SEC-PDU as specified in Figure 3.

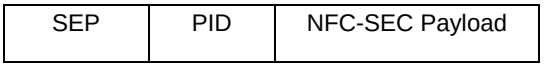


Figure 3 — Structure of NFC-SEC PDU

Table 2 specifies the *NFC-SEC-PDUs* fields for the NFC-SEC commands as mandatory (m), prohibited (p), conditional (c). The conditionality (c) is further specified in 11.3.

Table 2 — NFC-SEC-PDU Fields

NFC-SEC commands	SEP	PID	NFC-SEC Payload
ACT_REQ	m	m	c
ACT_RES	m	p	c
VFY_REQ	m	p	c
VFY_RES	m	p	c
ENC	m	p	c
TMN	m	p	p
ERROR	m	p	c

11.1 Secure Exchange Protocol (SEP)

The 1-byte Secure Exchange Protocol (SEP) field is specified as follows:

- The value of 00b in the SVC indicates that the PDU is part of an SSE exchange. The value of 01b in the SVC indicates that the PDU is part of an SCH exchange.
- The MSG code identifies the PDU type as specified in Table 3. All other codes are RFU.

- The RFU bits shall be set ZERO. Receivers shall reject PDUs with RFU bits set to ONE.

Figure 4 specifies the bit assignment.

msb							**lsb**
Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1
RFU		SVC		MSG			

Figure 4 — Bit assignment of SEP

Table 3 — PDU types and their MSG codes

Code	NFC-SEC command	Description
0000	ACT_REQ	Activation request to request a new service.
0001	ACT_RES	Activation response, to accept a service request.
0010	VFY_REQ	Verification request to submit check values for verification of the Sender's shared secret.
0011	VFY_RES	Verification response to submit check values for verification of the Recipient's shared secret.
0100	ENC	Encrypted packet for secure data exchange.
0110	TMN	Terminate request to terminate a service.
1111	ERROR	Error an Indication of an error.
Other		RFU

11.2 Protocol Identifier (PID)

Each NFC-SEC cryptography part of this Standard defines a distinct 8-bit PID that is only included in ACT_REQ.

11.3 NFC-SEC Payload

The TMN PDU shall contain no NFC-SEC Payload field. The NFC-SEC Payload field shall consist of an integer number of octets. Its use in the ERROR PDU is specified in the Error sub-clause below. Its use, structure and encoding in all other PDUs is specified in NFC-SEC cryptography part that defines the PID.

11.4 Terminate (TMN)

The TMN PDU consists of the SEP field only as specified in Table 2.

11.5 Error (ERROR)

The ERROR PDU starts with the SEP field and, if it contains a payload, this payload shall contain a zero-terminated octet string in the NFC-SEC Payload field.

12 Protocol Rules

This Clause specifies rules for the NFC-SEC protocol.

12.1 Protocol and Service Errors

- When a NFC-SEC entity receives a PDU in a state where it is not allowed, it shall respond with an ERROR PDU.
- When a NFC-SEC entity receives a PDU that it does not support or with invalid contents as specified in NFC-SEC cryptography standard, it shall respond with an ERROR PDU.
- When a NFC-SEC entity receives or sends an ERROR PDU, it shall set the protocol state to Idle.
- When a NFC-SEC entity receives or sends an ERROR PDU, it shall send an ERROR SDU to the NFC-SEC User.
- When a NFC-SEC entity receives a SDU in a state where it is not allowed or with invalid contents, it shall respond with an ERROR SDU and leave the state unchanged.

12.2 Interworking Rules

- A NFC-SEC implementation may set an upper bound on the NFC-SEC-SDU length. Send Data requests specified in A.2 with longer SDUs shall be rejected.
- One NFC-SEC-PDU shall contain exactly one NFC-SEC-SDU.
- NFC-SEC Entities shall discard any duplicate NFC-SEC–PDUs, as specified in the Sequence Integrity clause.

12.3 Sequence Integrity

NFC-SEC cryptography standards providing sequence integrity shall specify the sequence integrity mechanism in conformance to the following:

- Each NFC-SEC Entity shall maintain its SNV.
- Upon SCH establishment, the Recipient shall initialise its SNV with the same initial value as the Sender's SNV as specified in the NFC-SEC cryptography part that defines the PID.
- The NFC-SEC cryptography part that defines the PID specifies a range on the SNV values.
- Upon sending of ENC, the NFC-SEC Entity shall increase their SNV by 1, and then place it into the SN field.
- The SN field shall be protected by the PDU security mechanism to make any change detectable.
- Upon receipt of an ENC, the NFC-SEC Entity shall extract the SN field and compare it with its SNV. If SN == SNV, then the PDU shall not be submitted to the NFC-SEC User but discarded, and the state and SNV shall remain unchanged as specified in A.4.4.
- The NFC-SEC entity shall increase its SNV by 1.
- The 'PDU content valid?' condition in A.4.4 shall be true if SN equals SNV and false otherwise.

NOTE In case of sequence integrity errors, NFC-SEC aborts the SCH and notifies both peer-NFC-SEC-USERs of the incident. It is up to the NFC-SEC-USERs to re-establish a SCH with new keys or to abort the transaction.

12.4 Cryptographic Processing

Before sending and after receipt of PDUs other than TMN and ERROR, cryptographic processing occurs as specified by the cryptography part that defines the PID. If the outcome of the cryptographic processing of incoming PDUs is negative, then the ‘PDU content valid’ decision in Annex A is false.

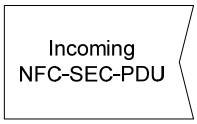
Annex A
(normative)

Protocol Machine Specification

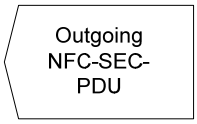
The NFC-SEC protocol machine in this Annex specifies the sequence of PDUs to establish and terminate the SSE, and to establish, use and terminate the SCH.

In addition the Protocol machine specifies which PDUs may be sent or received in which state.

A.1 SDL Symbols

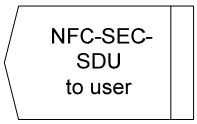


NFC-SEC-PDU received from the peer NFC-SEC entity, delivered by the local NFC entity.



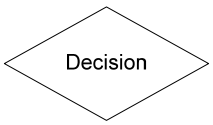
NFC-SEC-PDU sent to the peer NFC-SEC entity, submitted to the local NFC entity.

NFC-SEC-SDU obtained from the NFC-SEC User, requesting the NFC-SEC entity to perform an action.



NFC-SEC-SDU submitted to the NFC-SEC User, either in response to a previous request or to indicate an event.

State. In a state the protocol machine awaits an event. Events not foreseen in the diagrams constitute protocol errors.



A branching condition in the processing of events.

A.2 Request SDUs

Request SDUs are submitted by NFC-SEC Users to request the NFC-SEC service. Parameters are given in brackets. Requirements on the parameter values are specified in NFC-SEC cryptography standards.

NOTE The actual implementation method of the request primitives (e.g. method calls, inter-process PDUs), is outside the scope of this Standard.

Service Invocation	Request the invocation of a new service (type of service, PID).

Send Data	Request the sending of data. Admitted only to SCH (data).
Retrieve Data	Request the retrieval of data received. Admitted only to SCH.
Retrieve Secret	Request the retrieval of a shared secret established. Admitted only to SSE.
Terminate	Request termination of service (type of service).

A.3 Confirm SDUs

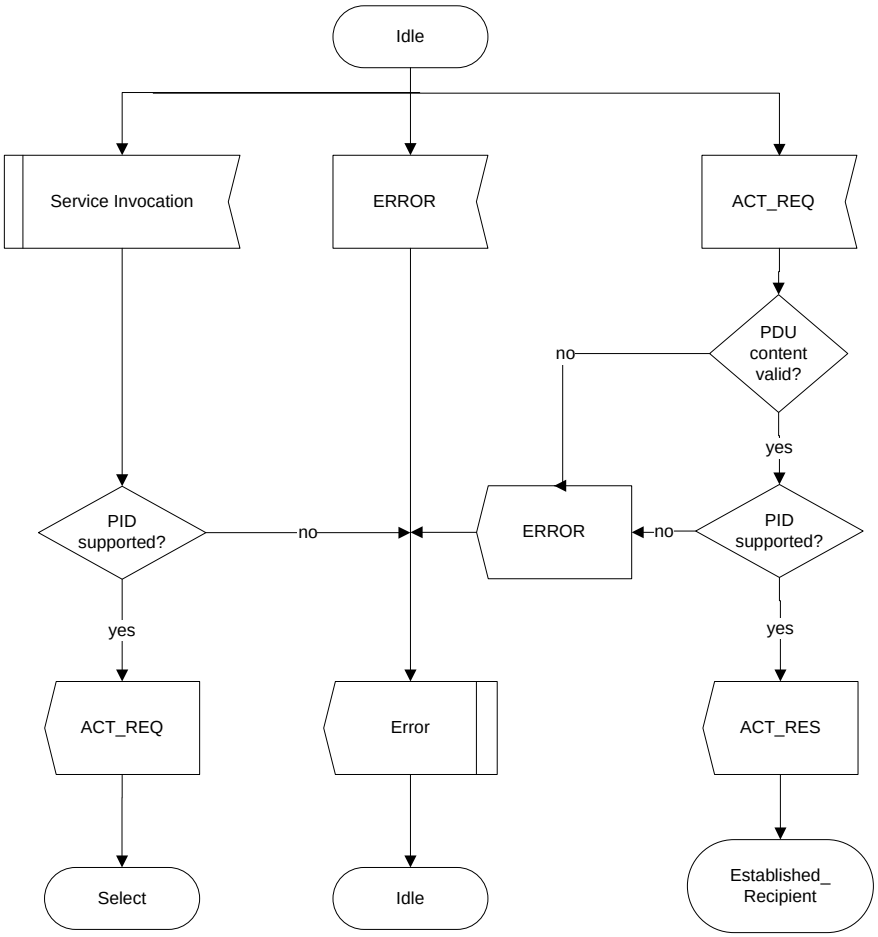
Confirm SDUs are submitted by NFC-SEC entities to NFC-SEC Users. Parameters are given in brackets. Requirements on the parameter values are specified in NFC-SEC cryptography standards.

NOTE The actual implementation method of the confirm primitives (e.g. method calls, inter-process PDUs), is outside the scope of this Standard.

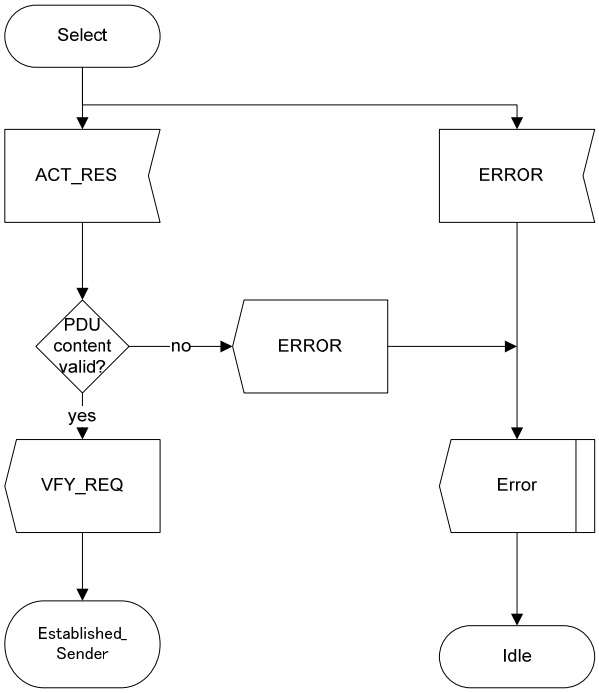
Established	Indicates the successful establishment of a service (type of service).
Data Sent	Indicates the result of a Send Data request (status). This result may be positive or negative, the latter due to a send error, or because the NFC-SEC entity was not ready for sending.
Data Available	Indicates the receipt of data.
Return Data	Response to a Retrieve Data request (data).
Return Secret	Response to a Retrieve Secret request (shared secret).
Terminated	Indicates to a user the termination of a service (type of service).
Error	Indicates an error during processing of a request or a PDU, or any other error. The parameters may reflect the error reason and details (details).

A.4 SDL Diagrams

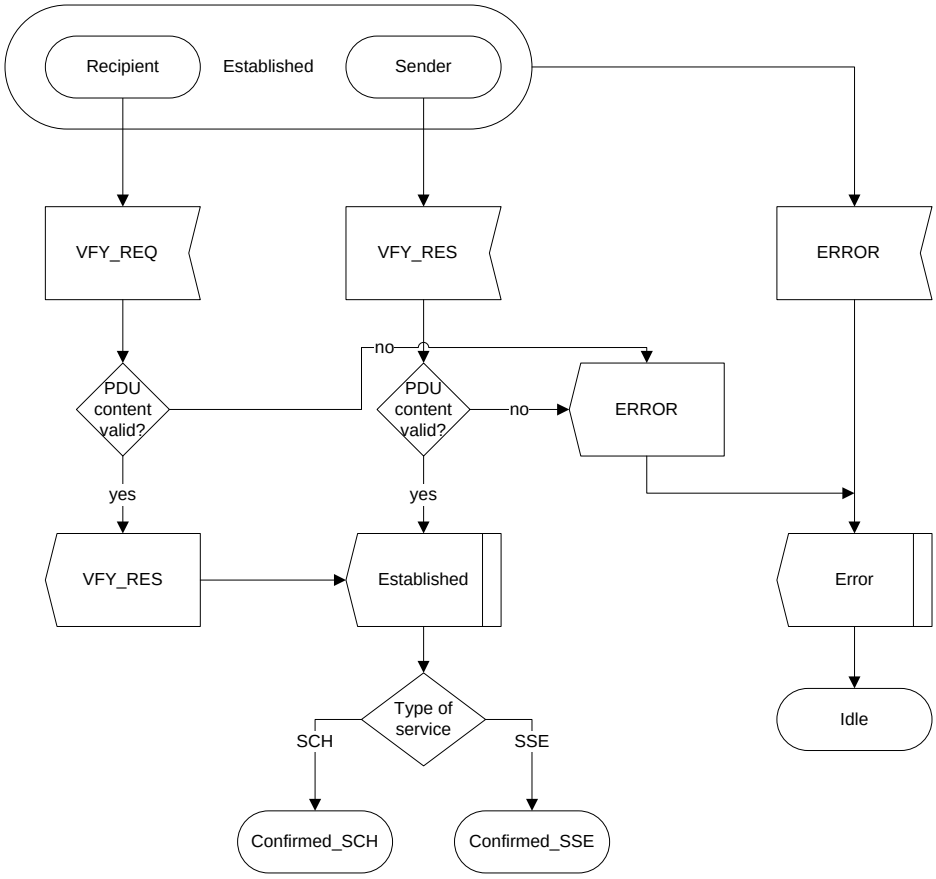
A.4.1 Idle State



A.4.2 Select State



A.4.3 Established State



A.4.4 Confirmed State