



E2 INTERFACE – THE E2 APPLICATION PROTOCOL (E2AP)

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What is the E2 Interface?



An open interface designed for communication between the near-RT RIC and the E2 Nodes (CU/CU-CP/CU-UP/DU).



E2 Application Protocol (E2AP) is the basic procedural protocol that co-ordinates communication between near-RT RIC and E2 nodes.



Every RIC and CU/DU should follow E2AP (same message structure and procedures).



RAN Function Specific messages are conveyed through E2 Service Models (E2SM)

E2AP/E2SM
Messages

E2AP

SCTP

IP

E2 Interface Protocol Stack

E2AP Terminology

- RAN Function: A specific Function in an E2 Node (Ex: UE context handling, paging, Handover, Cell (re)configuration etc.)
 - RAN Function ID: Identifier of a specific RAN function.
- RIC Service: A service provided on an E2 Node.
 - E2 Node provides access to messages, measurements, and/or enables control from the near-RT RIC.
 - RIC Action ID: Identifier of the specific RIC service action.
- Information Elements (IE): A data item containing a label field, a length indicator and a value.
- Message: Group of Information Elements organized in a specific manner (often nested several levels deep). (Ex: E2 Setup Request, Setup Response, Subscription Request).
- Procedure: Sequential exchange of a set of messages (Ex: Setup Procedure, Subscription Procedure, Removal, Handover procedure etc.).

E2AP MESSAGE

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> Frame 295: 326 bytes on wire (2608 bits), 326 bytes captured (2608 bits) on interface lo, id 0
> Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00 (00:00:00:00:00:00)
> Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
> Stream Control Transmission Protocol, Src Port: 48923 (48923), Dst Port: 36421 (36421)
< E2 Application Protocol
  < E2AP-PDU: initiatingMessage (0)
    < initiatingMessage
      procedureCode: id-E2setup (1)
      criticality: reject (0)
    < value
      < E2setupRequest
        < protocolIEs: 4 items
          < Item 0: id-TransactionID
            < ProtocolIE-Field
              id: id-TransactionID (49)
              criticality: reject (0)
            < value
              TransactionID: 0
          < Item 1: id-GlobalE2node-ID
            < ProtocolIE-Field
              id: id-GlobalE2node-ID (3)
              criticality: reject (0)
            < value
              < GlobalE2node-ID: gNB (0)
          < Item 2: id-RANfunctionsAdded
            < ProtocolIE-Field
              id: id-RANfunctionsAdded (10)
              criticality: reject (0)
            < value
              < RANfunctions-List: 1 item
                < Item 0: id-RANfunction-Item
                  < ProtocolIE-SingleContainer
                    id: id-RANfunction-Item (8)
                    criticality: ignore (1)
                  < value
                    < RANfunction-Item
                      ranFunctionID: 147
                      ranFunctionDefinition: 60304f52414e2d4532534d2d4b504d000018312e332e362e312e342e312e35333134382e...
                      < E2SM-KPM-RANfunction-Description
                        < ranFunction-Name
                          < ric-EventTriggerStyle-List: 1 item
                            < Item 0
                              < RIC-EventTriggerStyle-Item
                                ric-EventTriggerStyle-Type: 1
                                ric-EventTriggerStyle-Name: Periodic Report
                                ric-EventTriggerFormat-Type: 1
                              < ric-ReportStyle-List: 1 item
                                ranFunctionRevision: 0
                                ranFunctionOID: 1.3.6.1.4.1.53148.1.2.2.2
                      < Item 3: id-E2nodeComponentConfigAddition
                        < ProtocolIE-Field
                          id: id-E2nodeComponentConfigAddition (50)
                          criticality: reject (0)

```

E2 SETUP PROCEDURE



O-RAN.WG3.E2GAP-R003-v03.01

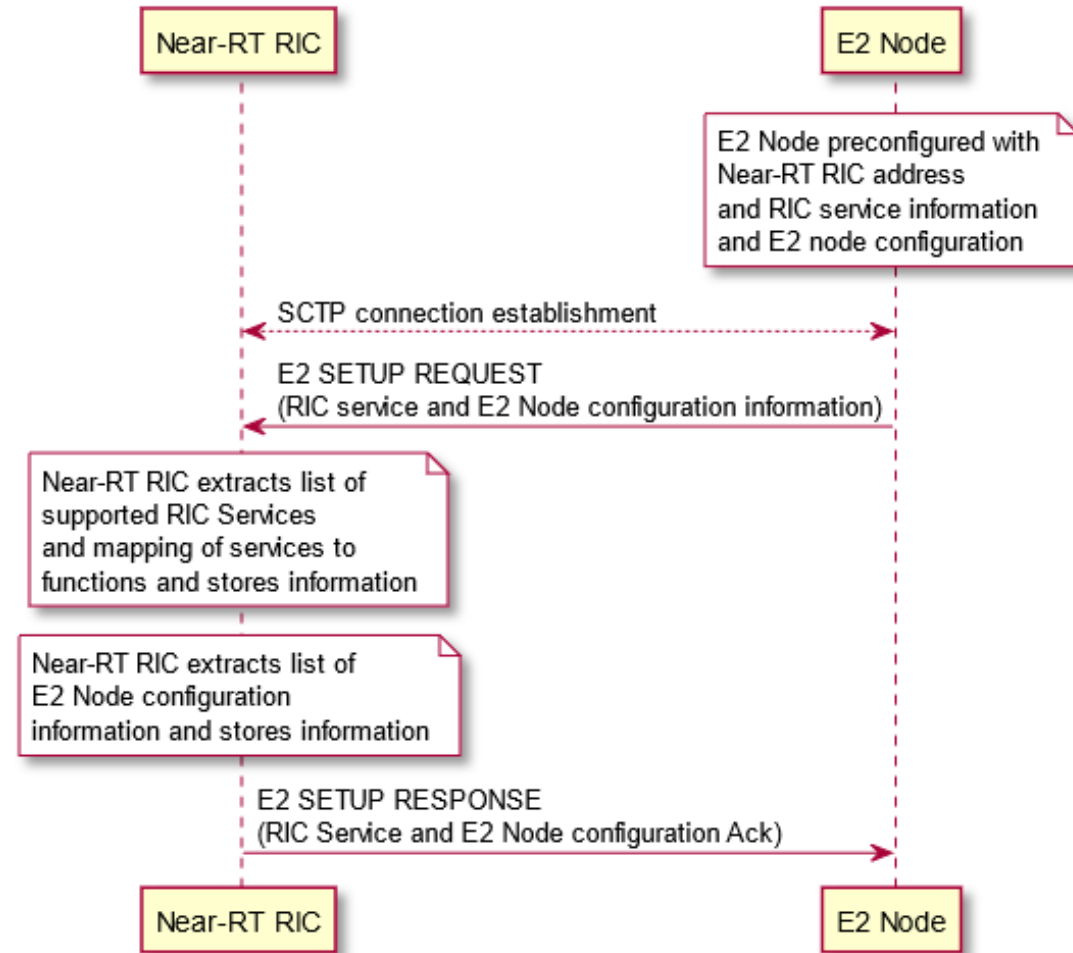


Figure 5.5.2-1: E2 Setup procedure

Types of E2AP Procedures

RIC Functional Procedures:

Procedures used to pass application specific messages between near-RT RIC applications and a target RAN function.

- Support RIC Services – Help in getting information and events from E2 node to provide policy/control information back to E2 node

Global Procedures:

Procedures not directly related to a specific application (Ex: E2 Setup, Reset, Removal, RIC service update, RIC Query etc.)

- Support Interface Management – Setup and maintenance of the E2 link between the E2 node and near-RT RIC.

RIC Services - Types

- **Report Service**: The Report Service is triggered to send RIC Indication messages (of type **report**) that can contain data and telemetry from an E2 Node, upon subscription from an xApp.
 - The report messages can be configured to be sent periodically during subscription.
- **Insert Service**: Through the Insert service an xApp can suspend a specific procedure upon event trigger (through subscription) and get details about suspended procedures through RIC Indication messages (of type **insert**).
 - The procedure can be halted till a timer expires/till a RIC control message is received.
- **Control Service**: The E2 node can receive RIC Control messages triggered autonomously by the RIC (xApp) or due to the consequence of reception of an Insert message.
- **Policy Service**: The policy service allows an xApp to request the E2 node to execute a specific policy (through a Subscription Message) after the occurrence of a specific event.
 - No halting of any procedure. The E2 node adopts the policy specified.
- **Query Service**: The E2 Node allows the RIC (xApp) to query RAN/UE-specific information.

RIC services can be combined within a common subscription with each RIC service implemented as a part of a sequence of actions.



Q: Difference between
Insert and Policy
services?

E2 Service Models (E2SM)



Each RAN Function is associated with one or more E2 Service Models.



The RIC services provided by the RAN function, the message types used, and their styles are specified in the E2 Service Model.



The Service Model also contains description of RAN function dependent Information Elements used in the E2 messages.



xApps need to have the same service Model definitions to effectively communicate with the RAN functions.

O-RAN Standardized Service Models



O-RAN.WG3.E2SM-R003-v03.01

Table 5-2: O-RAN specified E2 Service Models and related OIDs

E2SM short name	OID	Syntax language	Scope
E2SM-NI	iso (1) identified-organization(3) dod(6) internet(1) private(4) enterprise(1) 53148 e2(1) version1 (1) e2sm(2) e2sm-NI-IEs (1)	ASN.1	RAN Function NI "Network Interface" performs the following functionalities: <ul style="list-style-type: none"> - Exposure of Network Interfaces - Modification of both incoming and outgoing network interface message contents - Execution of policies that may result in change of network behavior
E2SM-KPM version1	iso (1) identified-organization(3) dod(6) internet(1) private(4) enterprise(1) 53148 e2(1) version1 (1) e2sm(2) e2sm-KPM-IEs (2)	ASN.1	RAN function KPM "KPM Monitor" performs the following functionalities: <ul style="list-style-type: none"> - Exposure of O-DU's cell related performance IEs through periodic KPM Report. - Exposure of O-CU-CP's cell/UE related performance IEs through periodic KPM Report. - Exposure of O-CU-UP's bearer related performance IEs through periodic KPM Report
E2SM-KPM version2	iso (1) identified-organization(3) dod(6) internet(1) private(4) enterprise(1) 53148 e2(1) version2 (2) e2sm(2) e2sm-KPM-IEs (2)	ASN.1	RAN function KPM "KPM Monitor" performs the following functionalities: <ul style="list-style-type: none"> - Exposure of available measurements from O-DU, O-CU-CP, and/or O-CU-UP via the RAN Function Definition IE. - Periodic reporting of measurements subscribed from Near-RT RIC.
E2SM-RC	iso (1) identified-organization(3) dod(6) internet(1) private(4) enterprise(1) 53148 e2(1) version1 (1) e2sm(2) e2sm-RC-IEs (3)	ASN.1	RAN function RC "RAN Control" performs the following functionalities: <ul style="list-style-type: none"> - Exposure of RAN control and UE context related information. - Modification and initiation of RAN control related call processes and messages - Execution of policies that may result in change of RAN control behavior
E2SM-CCC	iso (1) identified-organization(3) dod(6) internet(1) private(4) enterprise(1) 53148 e2(1) version1 (1) e2sm(2) e2sm-CCC-IEs (4)	JSON	RAN function CCC "Cell Configuration and Control" performs the following functionalities: <ul style="list-style-type: none"> - Exposure of node level and cell level configuration information - Initiate control and/or configuration of node level and cell level parameters

E2SM-KPM

- The Key Performance Metrics (KPM) Monitor RAN function exposes available measurements from O-DU, O-CU-CP, O-CU-UP and periodically reports measurements subscribed from near-RT RIC (xApp).
- The KPM Monitor RAN function provides the **Report** service in the following styles
 - E2 Node Measurement.
 - E2 Node Measurement for a single UE.
 - Condition-based, UE-level E2 Node Measurement.
 - Common Condition-based, UE-level E2 Node Measurement.
 - E2 Node Measurements for multiple UEs.

RIC Style Type	Style Name	Style Type Description
1	E2 Node Measurement	Used to carry measurement report from a target E2 Node
2	E2 Node Measurement for a single UE	Used to carry measurement report for a single UE of interest from a target E2 Node
3	Condition-based, UE-level E2 Node Measurement	Used to carry UE-level measurement report for a group of UEs per measurement type matching subscribed conditions from a target E2 Node
4	Common Condition-based, UE-level Measurement	Used to carry measurement report for a group of UEs across a set of measurement types satisfying common subscribed conditions from a target E2 Node
5	E2 Node Measurement for multiple UEs	Used to carry measurement report for multiple UE of interest from a target E2 Node

Style Type: A specific approach used to expose a given RIC service.

Format Type: A specific approach used to encode one of the E2AP IEs defined in the E2SM.

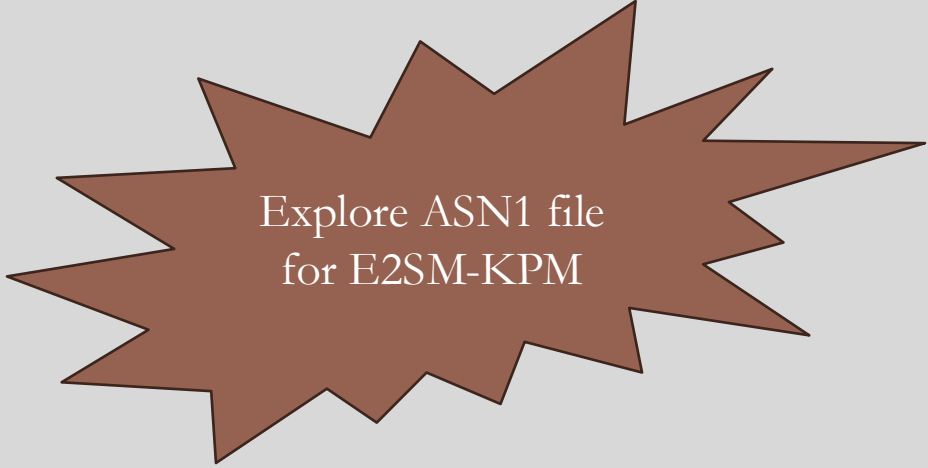
8.2.1.4.1 E2SM-KPM Indication Message Format 1

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Measurements Data		1.. <maxnoofMeas urementRecord >		Contains a set of Measurement Records, each collected at each Granularity Period.
>Measurements Record		1.. <maxnoofMeas urementValue>		Contains measured values in same order as in the <i>Measurements Information List</i> IE if present, otherwise in the order defined in the subscription.
>>CHOICE <i>Measured Value</i>				
>>>Integer Value	M		INTEGER (0..4294967295)	
>>>Real Value	M		REAL	
>>>No Value	M		NULL	
>Incomplete Flag	O		ENUMERATED (true, ...)	Indicates that the measurements record is not reliable.
Measurement Information List		0.. <maxnoofMeas urementInfo>		
>CHOICE <i>Measurement Type</i>				
>>Measurement Name	M		8.3.9 Measurement Type Name	
>>Measurement ID	M		8.3.10 Measurement Type ID	
>List of Labels		1.. <maxnoofLabel info>		
>>Label Information	M		8.3.11 Measurement Label	
Granularity Period	O		8.3.8 Granularity Period	Collection interval of measurements

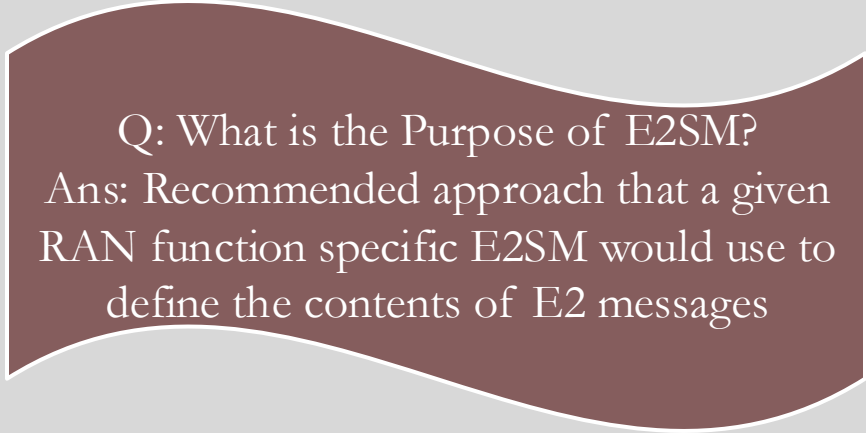
8.2.1.4.3 E2SM-KPM Indication Message Format 3

IE/Group Name	Presence	Range	IE type and reference	Semantics description
List of UE Measurement Reports		1.. <maxnoofUEMe asReport>		
>UE ID	M		8.3.24	
>Measurements Report	M		8.2.1.4.1 E2SM-KPM Indication Message Format 1	Contains Measurement Data for a UE for a Reporting Period.

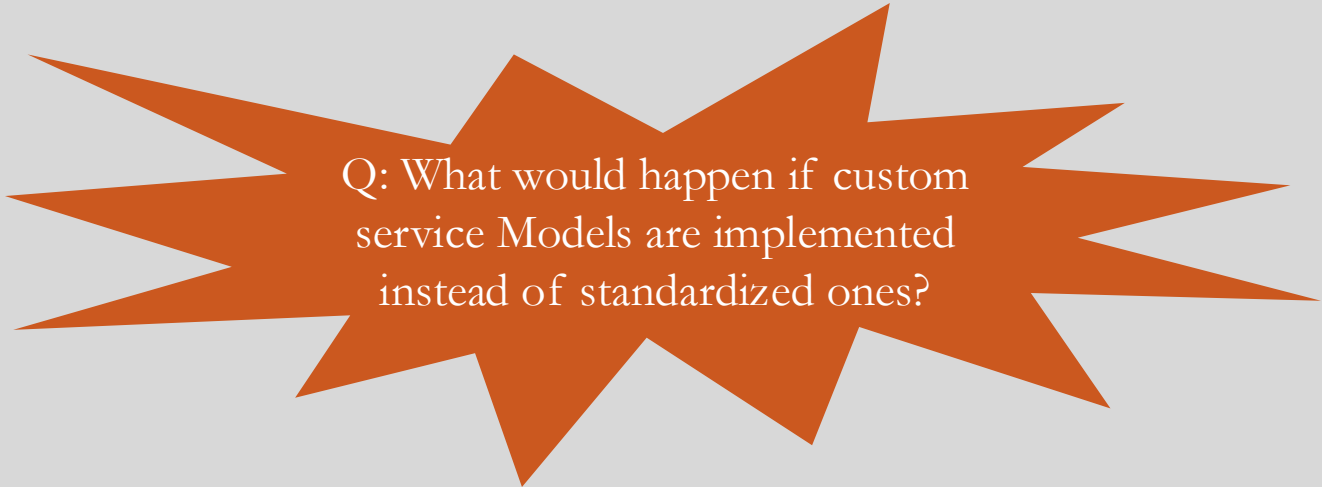
E2-SM Message formats



Explore ASN1 file
for E2SM-KPM



Q: What is the Purpose of E2SM?
Ans: Recommended approach that a given
RAN function specific E2SM would use to
define the contents of E2 messages



Q: What would happen if custom
service Models are implemented
instead of standardized ones?

Apply a display filter ... <Ctrl-/>						
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000			E2AP	953	E2setupRequest
2	0.000620			E2AP	60	E2setupResponse

Frame 1: 953 bytes on wire (7624 bits), 953 bytes captured (7624 bits)		0000	00 01 00 83 b4 00 00 04 00 31
DLT: 155, Payload: e2ap (E2 Application Protocol)		0010	00 09 00 00 f1 10 30 00 00 19
E2 Application Protocol		0020	00 00 08 40 83 6d 00 00 93 83
E2AP-PDU: initiatingMessage (0)		0030	4e 2d 45 32 53 4d 2d 4b 50 4d
initiatingMessage		0040	2e 36 2e 31 2e 34 2e 31 2e 35
procedureCode: id-E2setup (1)		0050	2e 32 2e 32 2e 32 05 00 4b 50
criticality: reject (0)		0060	74 6f 72 00 01 01 07 00 50 65
value		0070	20 52 65 70 6f 72 74 01 01 10
E2setupRequest		0080	20 4e 6f 64 65 20 4d 65 61 73
protocolIEs: 4 items		0090	74 01 01 00 05 00 40 43 51 49
Item 0: unknown (49)		00a0	00 60 52 53 52 51 02 c0 44 52
ProtocolIE-Field		00b0	61 63 6b 65 74 44 72 6f 70 52
id: Unknown (49)		00c0	80 44 52 42 2e 52 6c 63 53 64
criticality: reject (0)		00d0	6d 69 74 74 65 64 56 6f 6c 75
value		00e0	44 52 42 2e 52 6c 63 53 64 75
Item 1: id-GlobalE2node-ID		00f0	69 74 74 65 64 56 6f 6c 75 6d
ProtocolIE-Field		0100	01 00 01 02 11 00 45 32 20 4e
id: id-GlobalE2node-ID (3)		0110	61 73 75 72 65 6d 65 6e 74 20
criticality: reject (0)		0120	73 69 6e 67 6c 65 20 55 45 01
value		0130	51 49 00 60 52 53 52 50 00 60
GlobalE2node-ID: gNB (0)		0140	44 52 42 2e 52 6c 63 50 61 63
gNB		0150	70 52 61 74 65 44 6c 03 80 44
global-gNB-ID		0160	53 64 75 54 72 61 6e 73 6d 69
plmn-id: 00f110		0170	6c 75 6d 65 44 4c 03 80 44 52
gNB-ID: gNB-ID (0)		0180	64 75 54 72 61 6e 73 6d 69 74
gNB-ID: 000019b0 [bit length 28, 4 LSB pad bits, 0000 0...		0190	75 6d 65 55 4c 01 01 01 01 00
Item 2: id-RANfunctionsAdded		01a0	6e 64 69 74 69 6f 6e 2d 62 61
ProtocolIE-Field		01b0	45 2d 6c 65 76 65 6c 20 45 32
id: id-RANfunctionsAdded (10)		01c0	4d 65 61 73 75 72 65 6d 65 6e
criticality: reject (0)		01d0	40 43 51 49 00 60 52 53 52 50
value		01e0	02 c0 44 52 42 2e 52 6c 63 50
RANfunctions-List: 0 items		01f0	72 6f 70 52 61 74 65 44 6c 03
Item 3: unknown (50)		0200	6c 63 53 64 75 54 72 61 6e 73
ProtocolIE-Field		0210	56 6f 6c 75 6d 65 44 4c 03 80
id: Unknown (50)		0220	63 53 64 75 54 72 61 6e 73 6d
criticality: reject (0)		0230	6f 6c 75 6d 65 55 4c 01 01 01
value		0240	43 6f 6d 6d 6f 6e 20 43 6f 6e
		0250	2d 62 61 73 65 64 2c 20 55 45
		0260	20 4d 65 61 73 75 72 65 6d 65

E2 Packet Captures (E2 Setup Request)

Apply a display filter ... <Ctrl-/>						
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000			E2AP	953	E2setupRequest
2	0.000620			E2AP	60	E2setupResponse
▶ Frame 2: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) DLT: 155, Payload: e2ap (E2 Application Protocol)						
▼ E2 Application Protocol <ul style="list-style-type: none"> ▼ E2AP-PDU: successfulOutcome (1) <ul style="list-style-type: none"> successfulOutcome <ul style="list-style-type: none"> procedureCode: id-E2setup (1) criticality: reject (0) value <ul style="list-style-type: none"> ▼ E2setupResponse <ul style="list-style-type: none"> ▼ protocolIEs: 4 items <ul style="list-style-type: none"> ▼ Item 0: unknown (49) <ul style="list-style-type: none"> ProtocolIE-Field <ul style="list-style-type: none"> id: Unknown (49) criticality: reject (0) value ▼ Item 1: id-GlobalRIC-ID <ul style="list-style-type: none"> ProtocolIE-Field <ul style="list-style-type: none"> id: id-GlobalRIC-ID (4) criticality: reject (0) value <ul style="list-style-type: none"> GlobalRIC-ID <ul style="list-style-type: none"> pLMN-Identity: 00f110 ric-ID: 000190 [bit length 20, 4 LSB pad bits, 0000 0000 0000... ▼ Item 2: id-RANfunctionsAccepted <ul style="list-style-type: none"> ProtocolIE-Field <ul style="list-style-type: none"> id: id-RANfunctionsAccepted (9) criticality: reject (0) value <ul style="list-style-type: none"> RANfunctionsID-List: 0 items ▼ Item 3: unknown (52) <ul style="list-style-type: none"> ProtocolIE-Field <ul style="list-style-type: none"> id: Unknown (52) criticality: reject (0) value 						
0000	20	01	00	38	00	00 04 00 31 00 00
0010	07	00	00	f1	10	00 01 90 00 09 00
0020	05	00	00	93	00	00 00 34 00 12 00
0030	00	00	e0	6e	67	69 6e 74 65 72 60

E2 Packet Captures (E2 Setup Response)

No.	Time	Source	Destination	Protocol	Length	Info
9	21.049634674	127.0.0.1	127.0.0.1	E2AP	122	RICsubscriptionRequest
10	21.049929854	127.0.0.1	127.0.0.1	E2AP	114	SACK (Ack=1, Arwnd=106496) , RICsubscriptionResponse

```

▶ Frame 9: 122 bytes on wire (976 bits), 122 bytes captured (976 bits) on interface lo, id 0
▶ Ethernet II, Src: 00:00:00:00:00:00 (00:00:00:00:00:00), Dst: 00:00:00:00:00:00 (00:00:00:00:00:00)
▶ Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
▶ Stream Control Transmission Protocol, Src Port: 36421 (36421), Dst Port: 48784 (48784)
▼ E2 Application Protocol
  ▼ E2AP-PDU: initiatingMessage (0)
    ▼ initiatingMessage
      procedureCode: id-RICsubscription (8)
      criticality: reject (0)
      ▼ value
        ▼ RICsubscriptionRequest
          ▼ protocolIEs: 3 items
            ▼ Item 0: id-RICrequestID
              ▼ ProtocolIE-Field
                id: id-RICrequestID (29)
                criticality: reject (0)
                ▼ value
                  ▼ RICrequestID
                    ricRequestorID: 1021
                    ricInstanceID: 0
            ▼ Item 1: id-RANfunctionID
              ▼ ProtocolIE-Field
                id: id-RANfunctionID (5)
                criticality: reject (0)
                ▼ value
                  RANfunctionID: 147
            ▼ Item 2: id-RICsubscriptionDetails
              ▼ ProtocolIE-Field
                id: id-RICsubscriptionDetails (30)
                criticality: reject (0)
                ▼ value
                  ▼ RICsubscriptionDetails
                    ricEventTriggerDefinition: 0004
                    ▼ E2SM-KPM-EventTriggerDefinition: eventDefinition-Format1 (0)
                      eventDefinition-Format1
                    ▼ ricAction-ToBeSetup-List: 1 item
                      ▼ Item 0: id-RIcAction-ToBeSetup-Item
                        ▼ ProtocolIE-SingleContainer
                          id: id-RIcAction-ToBeSetup-Item (19)
                          criticality: reject (0)
                          ▼ value
                            ▼ RIcAction-ToBeSetup-Item
                              ricActionID: 0
                              ricActionType: report (0)
                              ricActionDefinition: 000101000000003052535250012000000000
                              ▼ E2SM-KPM-ActionDefinition
                                ric-Style-Type: 1

```

No.	Time	Source	Destination	Protocol	Length	Info
17	24.371765301	127.0.0.1	127.0.0.1	E2AP	130	RICIndication
19	25.471309833	127.0.0.1	127.0.0.1	E2AP	130	RICIndication
E2 Application Protocol						
E2AP-PDU: initiatingMessage (0)						
initiatingMessage						
procedureCode: id-RIcIndication (5)						
criticality: reject (0)						
value						
RICindication						
protocolIEs: 6 items						
Item 0: id-RICrequestID						
ProtocolIE-Field						
id: id-RICrequestID (29)						
criticality: reject (0)						
value						
RICrequestID						
ricRequestorID: 1021						
ricInstanceID: 0						
Item 1: id-RANfunctionID						
ProtocolIE-Field						
id: id-RANfunctionID (5)						
criticality: reject (0)						
value						
RANfunctionID: 147						
Item 2: id-RIcActionID						
ProtocolIE-Field						
id: id-RIcActionID (15)						
criticality: reject (0)						
value						
RIcActionID: 0						
Item 3: id-RIcIndicationType						
ProtocolIE-Field						
id: id-RIcIndicationType (28)						
criticality: reject (0)						
value						
RIcIndicationType: report (0)						
Item 4: id-RIcIndicationHeader						
ProtocolIE-Field						
id: id-RIcIndicationHeader (25)						
criticality: reject (0)						
value						
RIcIndicationHeader: 006515c903						
E2SM-KPM-IndicationHeader: indicationHeader-Format1 (0)						
indicationHeader-Format1						
Item 5: id-RIcIndicationMessage						
ProtocolIE-Field						
id: id-RIcIndicationMessage (26)						
criticality: reject (0)						
value						
RICindicationMessage: 08000000010041000000305253525001200000						
E2SM-KPM-IndicationMessage-Format1						
pm-Containers: 1 item						
Item 0						
PM-Containers-List						