教育部「5G行動寬頻人才培育跨校教學聯盟計畫」

5G行動網路協定與核網技術聯盟中心

課程:5G垂直應用網路

單元5
mMTC垂直應用網路技術

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Outline

- 3GPP MTC Architectural Models
  - TS 23.682 - Architecture enhancements to facilitate communications with packet data networks and applications (16.7.0)
- 3GPP E-UTRAN Access for MTC
  - TS 23.401 Clause 4.3.17 Support for Machine Type Communication (MTC) (16.7.0)
- 3GPP 5GS for MTC
  - TS 23.501 Clause 5.31 Support for Cellular IoT (16.5.0)

TS 23.682 Scope

TS 23.682 - Architecture enhancements to facilitate communications with packet data networks and applications (16.7.0)

- The present document specifies architecture enhancements to facilitate communications with packet data networks and applications
  - e.g. Machine Type Communication (MTC) applications on the (external) network/MTC servers
- The present document also specifies transmission of non-IP data via SCEF for the CIoT EPS Optimization
  - The present document also specifies the interface between the SCEF and the SCS/AS
  - The present document also specifies provisioning of UCMF with RACS information

General Concept with End-to-End Communication

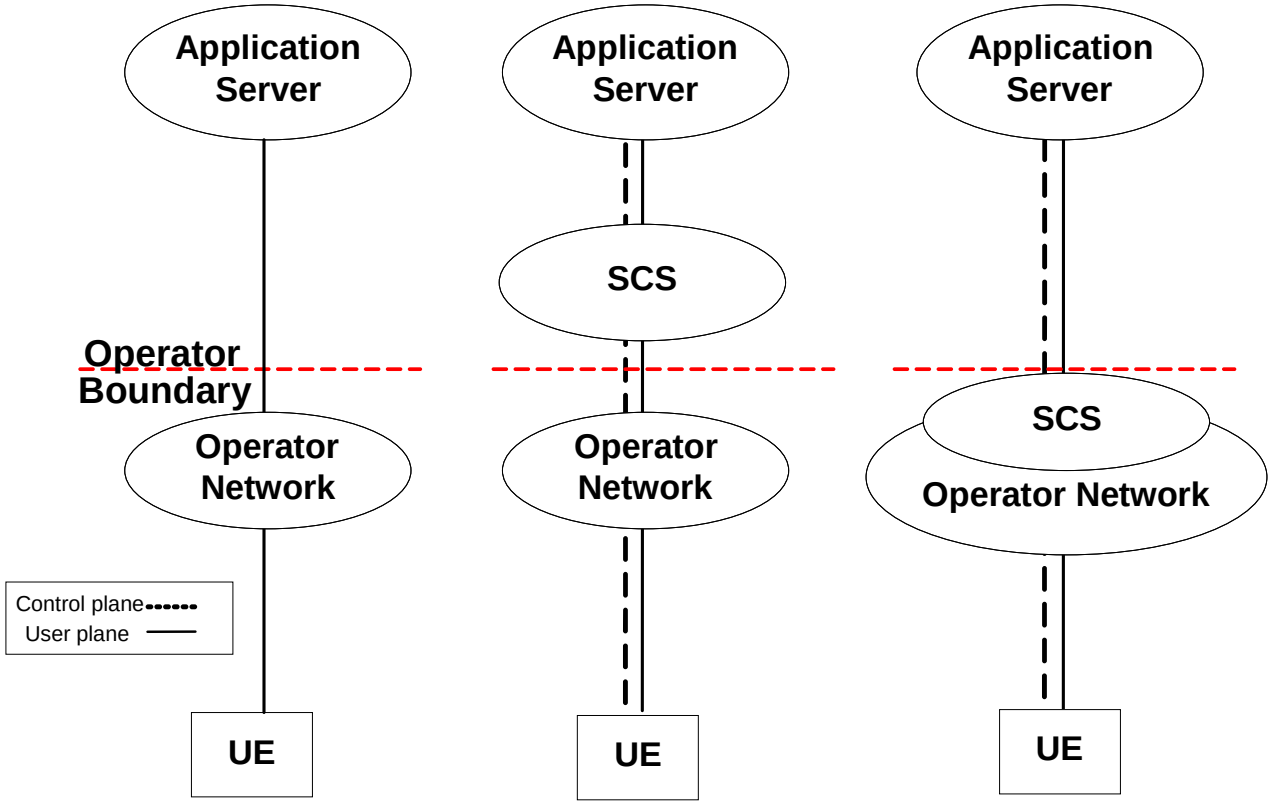
- The end-to-end communications, between the MTC Application in the UE and the MTC Application in the external network, uses services provided by the 3GPP system, and optionally services provided by a Services Capability Server (SCS)

- The MTC Application in the external network is typically hosted by an Application Server (AS) and may make use of an SCS for additional value added services
  - The 3GPP system provides transport, subscriber management and other communication services including various architectural enhancements motivated by, but not restricted to, MTC (e.g. control plane device triggering)

MTC Architectural Models

- Direct Model
  - The AS connects directly to the operator network in order to perform direct user plane communications with the UE without the use of any external SCS
  - The Application in the external network may make use of services offered by the 3GPP system
- Indirect Model
  - The AS connects indirectly to the operator network through the services of a SCS in order to utilize additional value added services for MTC (e.g. control plane device triggering)
- Hybrid Model
  - The AS uses the direct model and indirect models simultaneously in order to connect directly to the operator's network to perform direct user plane communications with the UE while also using a SCS

Deployment Scenarios for Direct and Indirect Models

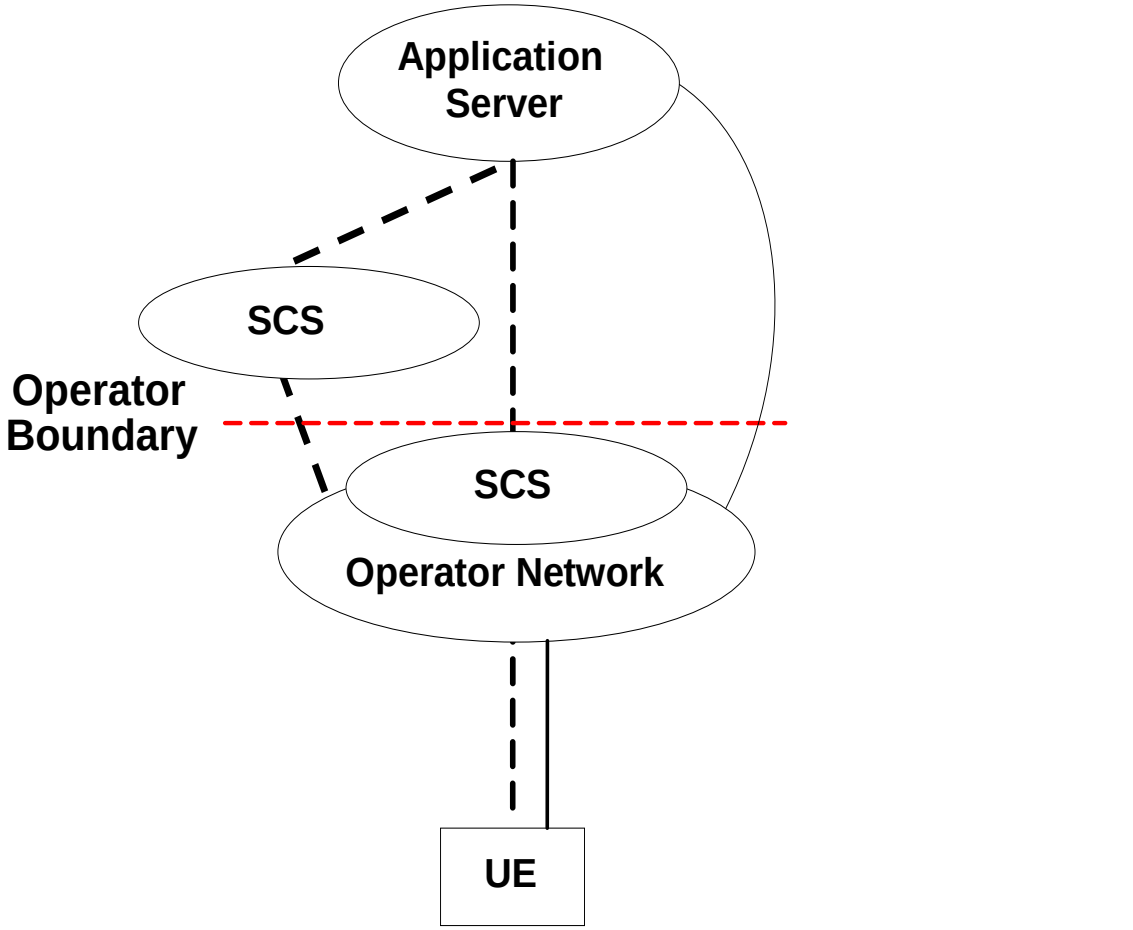


A. Direct Model

B. Indirect Model (MTC Service Provider Controlled)

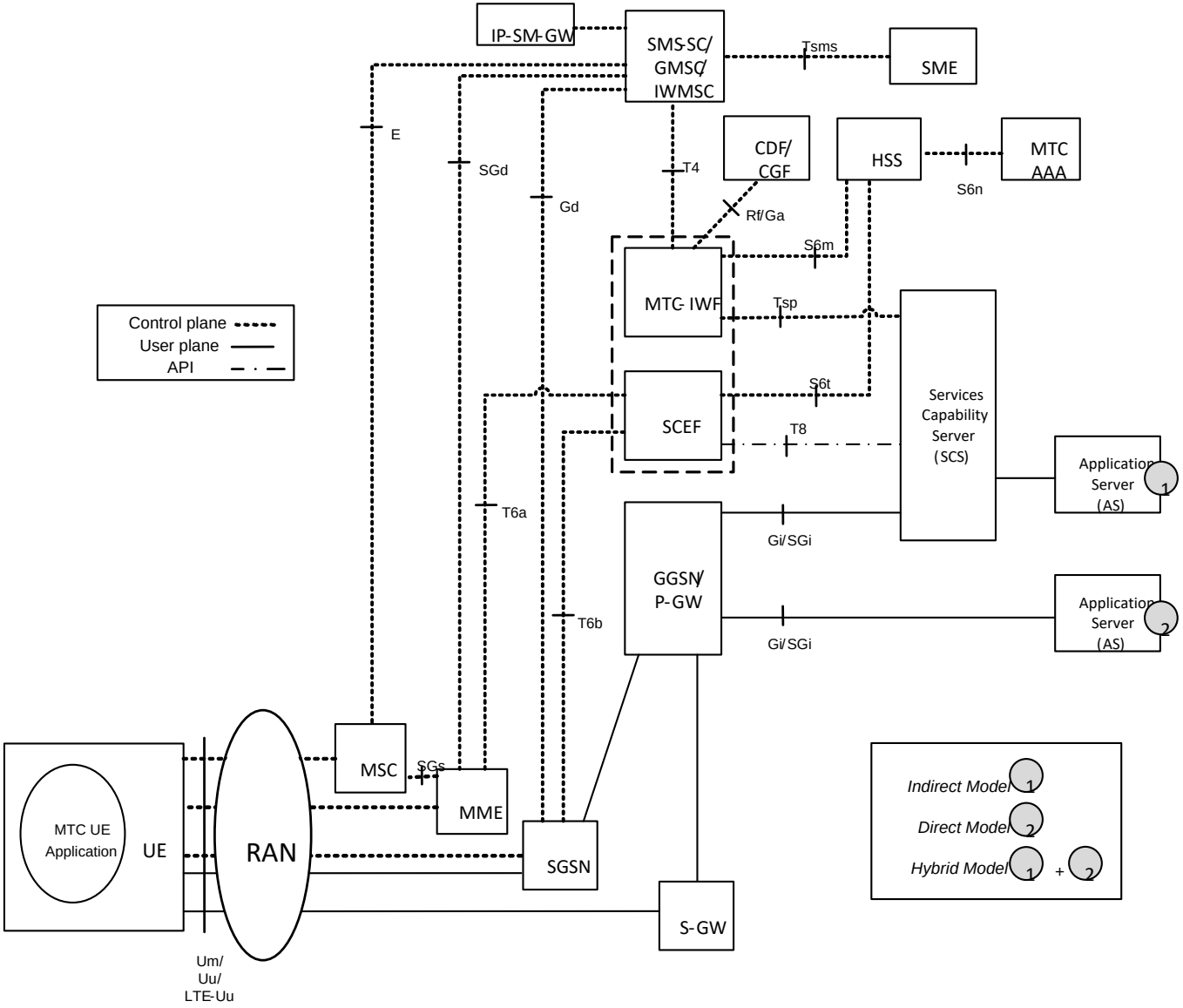
C. Indirect Model (Mobile Network Operator Controlled)

Deployment Scenarios for Hybrid Models

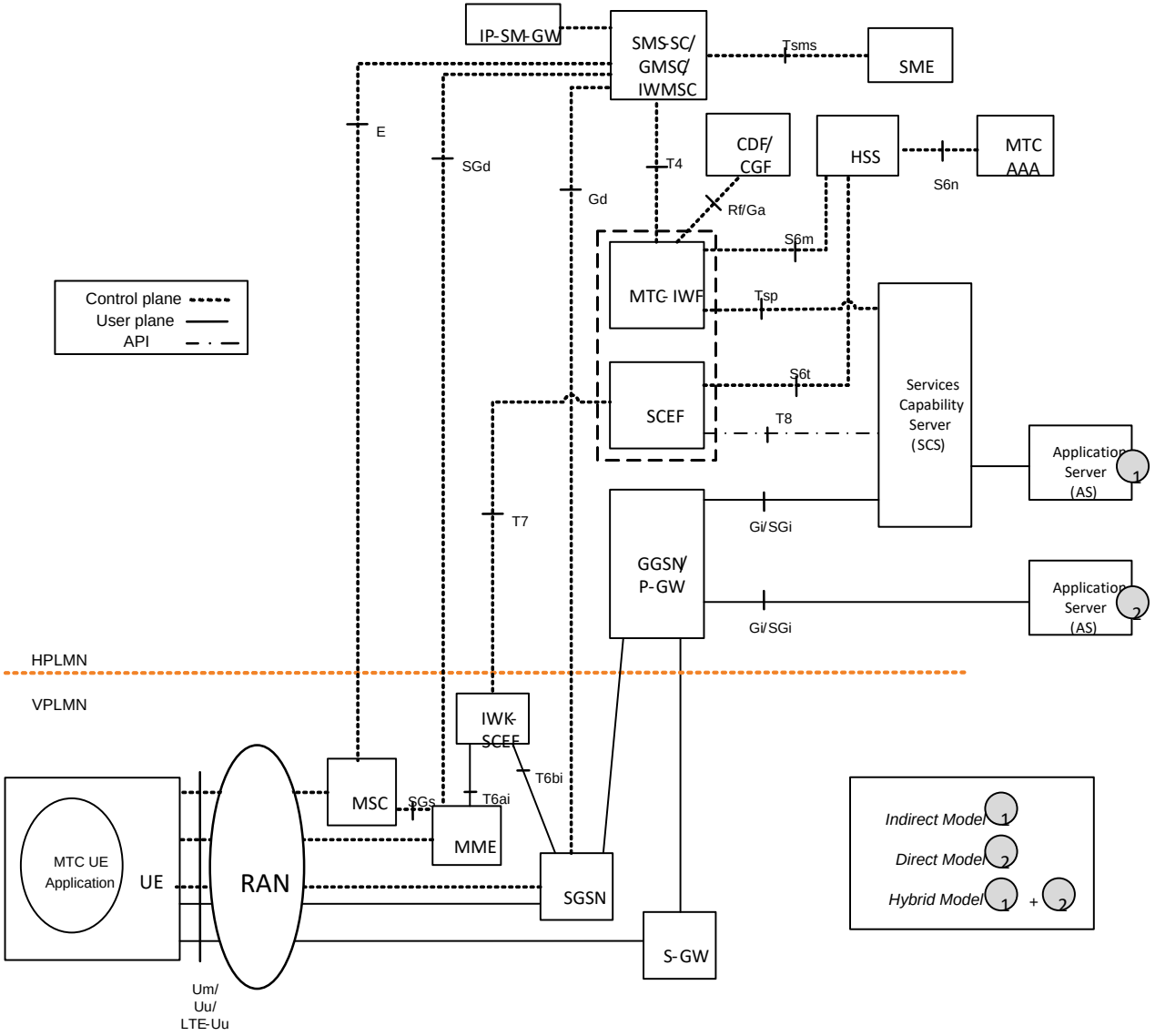


Hybrid Model

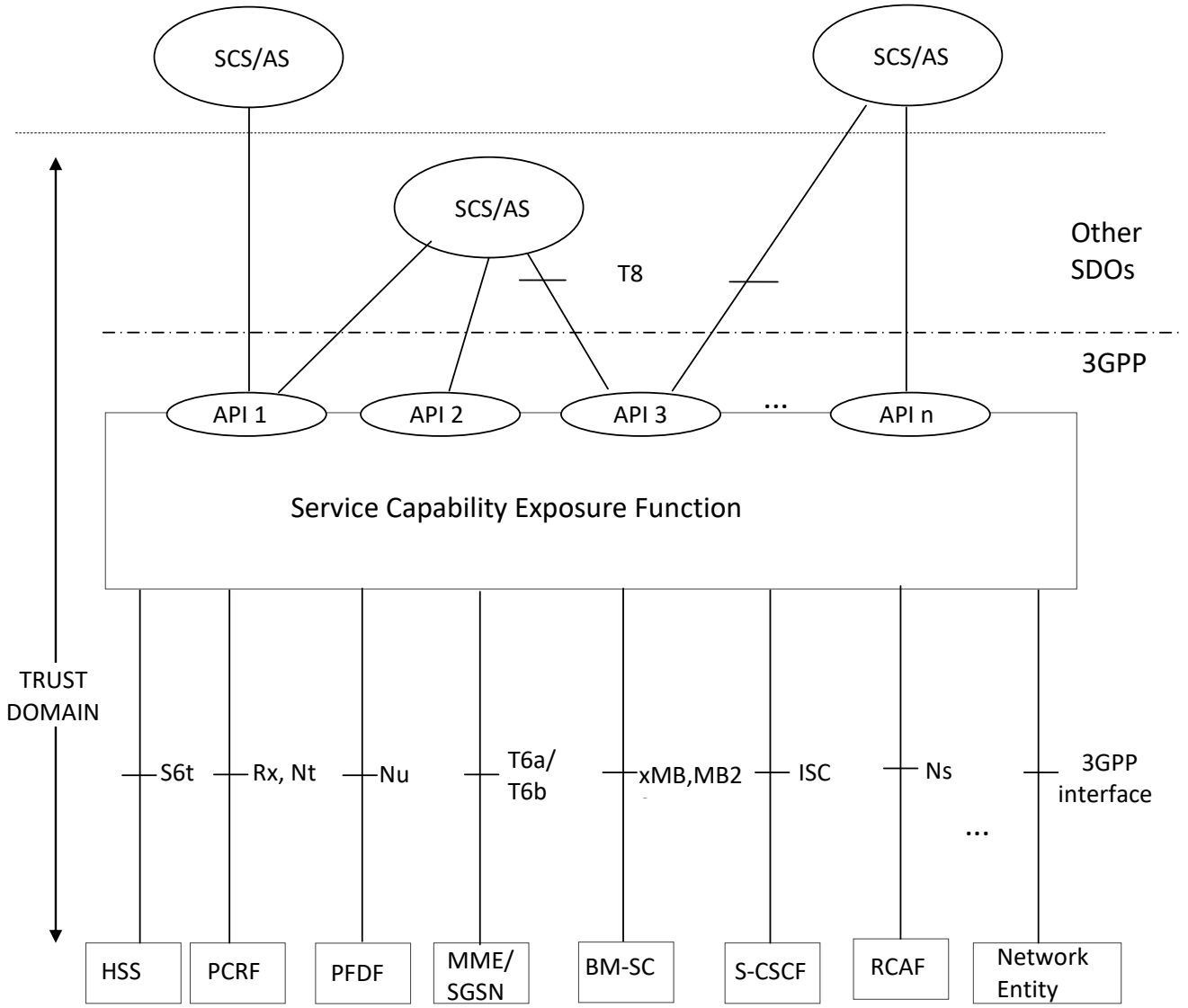
3GPP Architecture for Machine-Type Communication (Non-roaming)



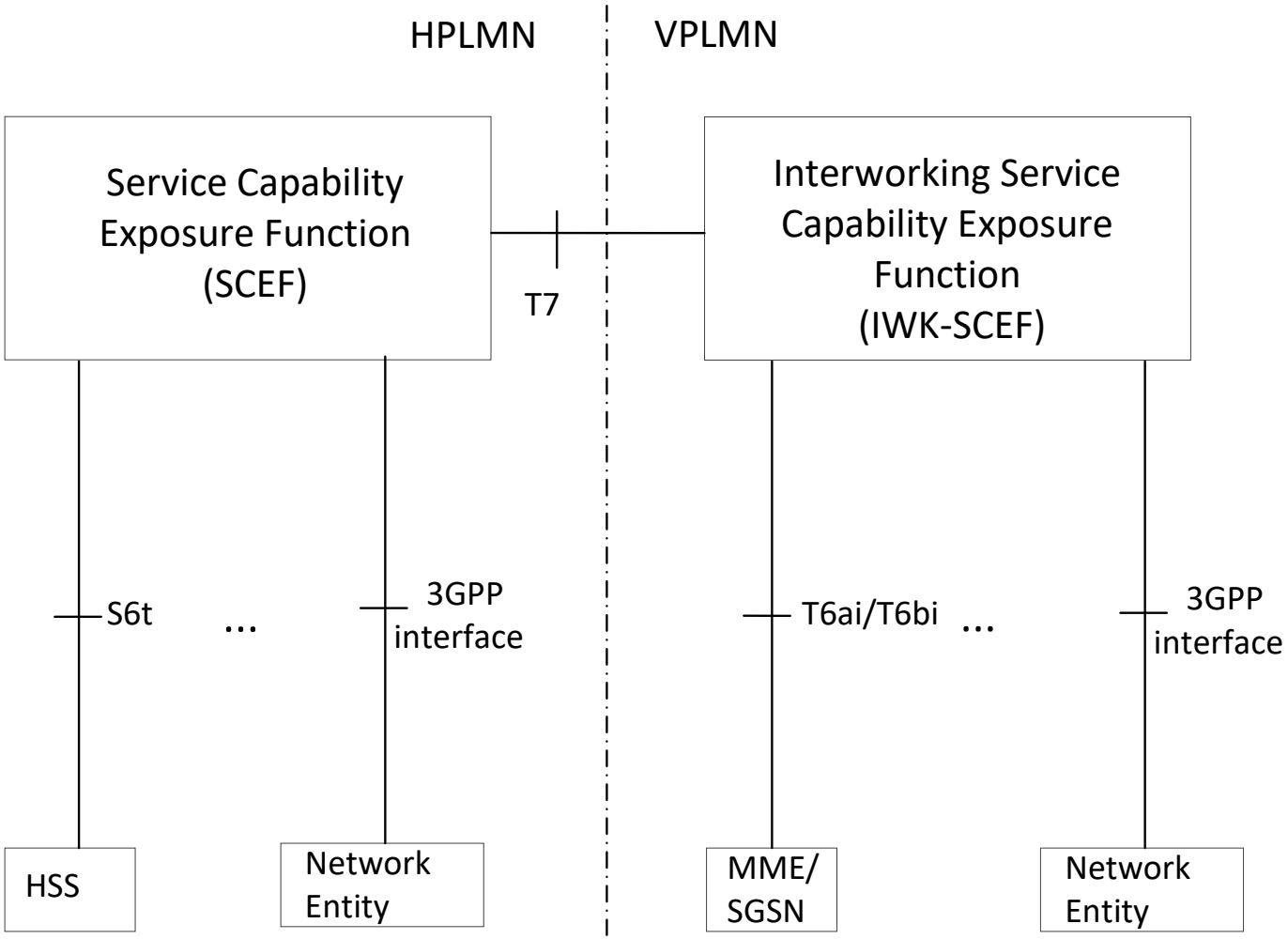
3GPP Architecture for Machine-Type Communication (Roaming)



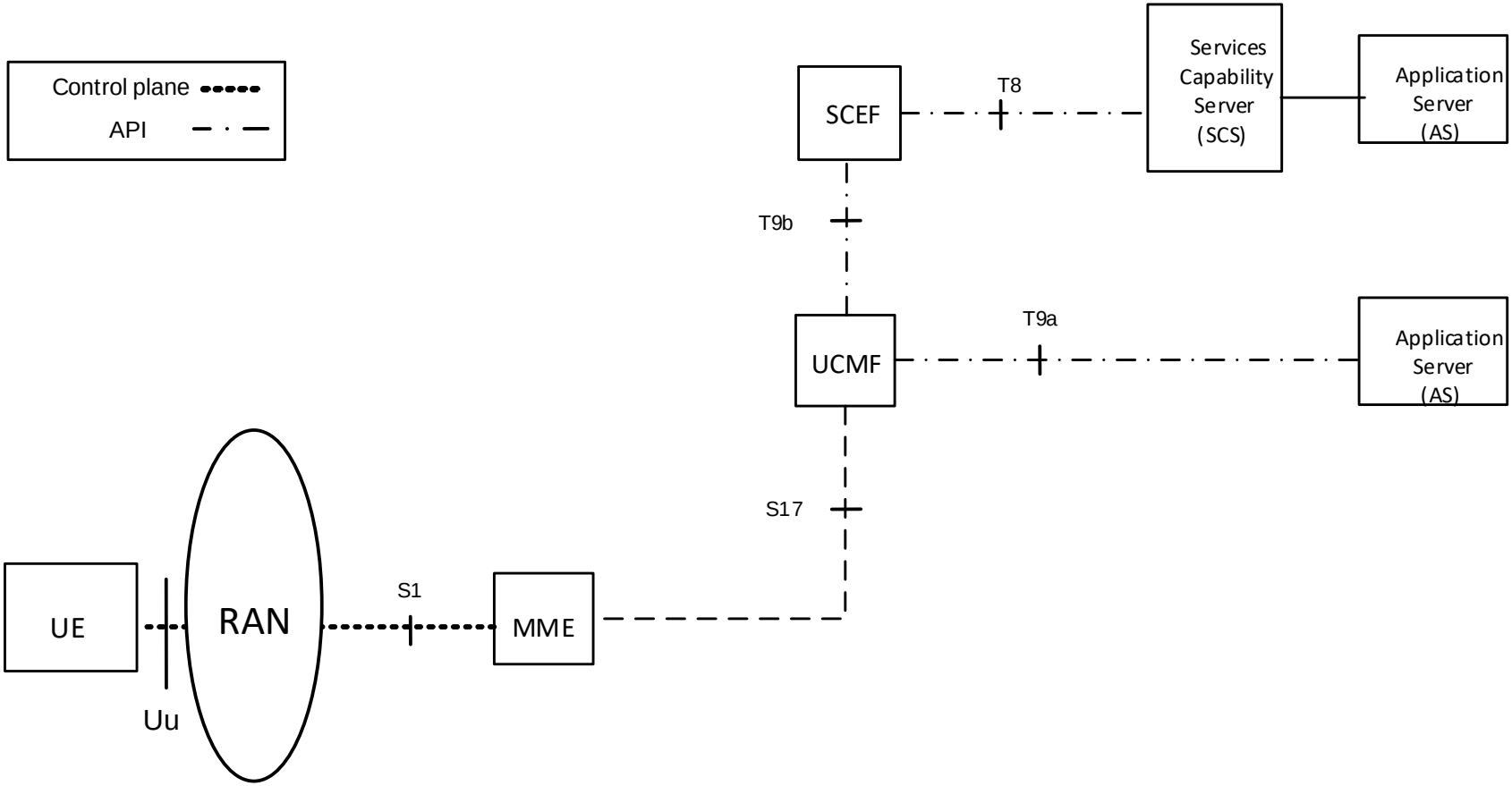
3GPP Non-roaming Architecture for Service Capability Exposure



3GPP Roaming Architecture for Service Capability Exposure



3GPP Architecture for RACS



Reference Points

The description of the MTC and Service Capability Exposure related reference points

- Tsms: Reference point used by an entity outside the 3GPP network to communicate with UEs used for MTC via SMS
- Tsp: Reference point used by a SCS to communicate with the MTC-IWF related control plane signalling
- T4: Reference point used between MTC-IWF and the SMS-SC in the HPLMN
- T6a: Reference point used between SCEF and serving MME
- T6b: Reference point used between SCEF and serving SGSN
- T6ai: Reference point used between IWK-SCEF and serving MME
- T6bi: Reference point used between IWK-SCEF and serving SGSN
- T7: Reference point used between IWK-SCEF and SCEF
- T8: Reference point used between the SCEF and the SCS/AS
- T9a: Reference point used between UCMF and AS
- T9b: Reference point used between UCMF and SCEF
- S6m: Reference point used by MTC-IWF to interrogate HSS/HLR
- S6n: Reference point used by MTC-AAA to interrogate HSS/HLR
- S6t: Reference point used between SCEF and HSS
- Rx: Reference point used by SCEF and PCRF
- Ns: Reference point used between SCEF and RCAF
- Nt: Reference point used by SCEF and PCRF
- Nu: Reference point used by SCEF to interact with the PFDF

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TS 23.401 Clause 4.3.17 Support for MTC

- This clause provides an overview about functionality for Machine Type Communications according to service requirements described in TS 22.368
- MTC functionality is provided by the visited and home networks when the networks are configured to support machine type communication
  - It applies to both the non-roaming case and the roaming case and some functionality may be dependent upon the existence of appropriate roaming agreements between the operators
- MTC functionality is performed by UEs that are configured to support different options
  - Some of the MTC functions are controlled by subscriber data
  - Other MTC functions are based on indicators sent by the UE to the network

Protection from Potential MTC Related Overload

- As normal signalling from large numbers of UEs may cause overload independently whether the UE is used for MTC or not, generic functionality for overload and congestion control is required
- The total signalling from large numbers of UEs is a concern in at least two situations
  - When an application (running in many UEs) requests many UEs to do "something" at the same time; and/or
  - When many UEs are roamers and their serving network fails, then they can all move onto the local competing networks, and potentially overload the not (yet) failed network(s)

Standardised Indications and Mechanisms

a) Where applicable, UEs can be configured for enhancements as described in subsequent bullets Post-manufacturing configuration can be performed remotely
b) For mobile originated services, UEs configured for low access priority provide the E-UTRAN with information indicating that the RRC connection establishment request has low access priority
c) RRC signalling has the capability of providing 'extended wait timers' when rejecting messages from UEs
   – These 'extended wait timers' are only used by UEs that access the network with low access priority
d) The MME can initiate rejection of RRC connection establishments in the E-UTRAN for UEs that access the network with low access priority
   – In addition, MME signalling or O&M can trigger E-UTRAN to initiate Extended Access Barring
e) Overload messages from the MME to E-UTRAN are extended to aid the RAN in performing the functionality in bullets b, c and d above
f) UEs configured with a long minimum periodic PLMN search time limit have an increased minimum time in between searches for more preferred PLMNs

Standardised Indications and Mechanisms (Cont.)

g) At PLMN change, UEs configured to perform Attach with IMSI at PLMN change do this rather than a TA update with GUTI
   – Thus avoiding the need to reject the TA update, and to request the IMSI following the subsequent Attach with GUTI

h) For mobile originated services, UEs configured for low access priority provide a low access priority indication to the MME in NAS signalling that permit the MME to undertake protective measures

i) Using Periodic TAU timer value sent by the HSS and/or UE provided low access priority indication (bullet h above), the MME can allocate a long periodic TAU timer value to the UE
   – A long periodic TAU timer is likely to slow down the rate at which a UE detects a network failure and thus it slows down the rate of movement of UEs from a failed network to other local competing networks

j) Mechanisms for the MME and P-GW to detect congestion associated with a particular APN

k) The addition of 'back off timers' to EMM and ESM signalling messages
   – These include some time randomisation to guard against a repeat of a load peak

l) Signalling that permits the P-GW to request the MME to generate the above ESM signalling with 'back off timers'

Standardised Indications and Mechanisms (Cont.)

m) An MME overload control mechanism to selectively limit the number of Downlink Data Notification requests the S-GW sends to the MME for downlink low priority traffic received for UEs in idle mode
n) UE configured for specific handling of the invalid USIM state, it remembers that the USIM is invalid and keeps the PLMN forbidden lists even if the UE is switched off and then switched on
o) When the UE has an activated PDN connection without low access priority or the UE is requested to establish such a PDN connection and the UE is configured with a permission for overriding low access priority, the UE doesn't provide a low access priority indication to the MME in NAS MM signalling and also not to the RAN in the RRC requests
p) When the UE has an activated PDN connection that is without low access priority or the UE is requested to activate such a PDN connection and the UE is configured with a permission for overriding Extended Access Barring, then the UE ignores any Extended Access Barring
q) The eNodeB may use the low access priority indication provided by the UE to steer UEs configured for low access priority to specific MMEs

Optimising periodic TAU Signalling

- To reduce network load from periodic TAU signalling and to increase the time until the UE detects a potential need for changing the RAT or PLMN (e.g. due to network problems) the longer values of the periodic TAU timer and Mobile Reachable timer shall be supported
- A long periodic RAU/TAU timer value may be locally configured at MME or may be stored as part of the subscription data in HSS
  - During Attach and TAU procedures the MME allocates the periodic RAU/TAU timer value as periodic TAU timer to the UE based on VPLMN operator policy, low access priority indication from the UE, periodic RAU/TAU timer value requested by UE and subscription information received from the HSS
- If MME receives a subscribed periodic RAU/TAU timer value from the HSS it allocates the subscribed value to the UE as periodic TAU timer
  - A visited PLMN MME may use subscribed periodic RAU/TAU timer value, if available, as an indication to decide for allocating a locally configured periodic RAU/TAU timer value to the UE

UE Configuration and Usage of Indicators

- A subscriber can by agreement with its operator be required to use UEs that are configured to support one or more of the following options
  - UE configured for low access priority; and/or
  - UE configured with a permission for overriding low access priority, which is only applicable for a UE that is also configured for low access priority; and/or
  - UE configured to perform Attach with IMSI at PLMN change; and/or
  - UE configured with a long minimum periodic PLMN search time limit; and/or
  - UE configured for specific handling of the invalid USIM state, the "forbidden PLMN list", the "forbidden PLMNs for attach in S1mode list" and the "forbidden PLMNs for GPRS service list"; and/or
  - UE configured for Extended Access Barring; and/or
  - UE configured with a permission for overriding Extended Access Barring, which is only applicable for a UE that is also configured for Extended Access Barring
- UEs can be configured for one or more of the above options
  - Post-manufacturing configuration of these options in the UE can be performed only by OMA DM or (U)SIM OTA procedures
  - UEs capable of the above options should support configuration of these options by both OMA DM and (U)SIM OTA procedures

High Latency Communication

- "High latency" refers to the initial response time before normal exchange of packets is established
  - That is, the time it takes before a UE has woken up from its power saving state and responded to the initial downlink packet(s)
- The High latency communication includes invoking extended buffering of MT data at the Serving GW when the UE is in a power saving state and not reachable
- For Control Plane CIoT EPS Optimisation, the High latency communication includes invoking the buffering of MT data at the Serving GW or the MME as specified in Mobile Terminated Data Transport in Control Plane CIoT EPS Optimisation with P-GW connectivity
- The High latency communication also includes sending event notifications to application servers that have requested "UE Reachability" or "Availability after DDN failure" monitoring events

Support for Non-IP Data Delivery (NIDD)

The support of Non-IP data is part of the CIoT EPS Optimisations

- A PDN Type "Non-IP" is used for Non-IP data
  - The Non-IP data delivery to SCS/AS (Service Capability Server/Application Server) is accomplished by one of two mechanisms
    - Delivery using SCEF (Service Capability Exposure Function)
    - Delivery using a Point-to-Point (PtP) SGi tunnel
  - The Reliable Data Service is defined in TS 23.682
    - When the Reliable Data Service is not used, Non-IP data in-sequence delivery cannot be guaranteed and data PDUs may be lost requiring higher protocol layers to ensure guaranteed delivery when needed
- The SMS service may also be used to deliver data without use of the IP protocol
  - The SMS service is always supported for CIoT EPS Optimisations, i.e. can be used simultaneously with Non-IP and IP data. When only the SMS service is needed, an attach without PDN connection establishment can be used
- Dedicated bearers are not supported for the Non-IP data

Service Gap Control

- Service Gap Control is an optional feature intended for MTC/CIoT UEs to control the frequency at which these UEs can access the network
  - Intended to be used for "small data allowance plans" for MTC/CIoT UEs where the applications are tolerant to service latency
  - Service Gap Time is a subscription parameter used to set the Service Gap timer and is enforced in the UE and in the MME on a per UE level
- Service Gap Control requires the UE to stay in ECM-IDLE mode for at least the whole duration of the Service Gap timer before triggering Mobile Originated user data transmission
  - The Service Gap timer is not stopped upon ECM-IDLE state to ECM-CONNECTED state transition
- The MME may enforce the Service Gap timer by rejecting connection request for MO user plane data, MO control plane data, or MO SMS when a Service Gap timer is running
  - The UE shall not initiate connection requests for MO user plane data, MO control plane data, or MO SMS when a Service Gap timer is running
  - The UE shall also not initiate Attach Requests when a Service Gap timer is running, unless it is Attach Request without PDN connectivity or Emergency Attach which are allowed

TS23.501 Clause 5.31 Support for Cellular IoT

- 5.31.1 General
- 5.31.2 Preferred and Supported Network Behaviour
- 5.31.3 Selection, steering and redirection between EPS and 5GS
- 5.31.4 Control Plane CIoT 5GS Optimisation
- 5.31.5 Non-IP Data Delivery (NIDD)
- 5.31.6 Reliable Data Service
- 5.31.7 Power Saving Enhancements
- 5.31.8 High latency communication
- 5.31.9 Support for Monitoring Events
- 5.31.10 NB-IoT UE Radio Capability Handling
- 5.31.11 Inter-RAT idle mode mobility to and from NB-IoT
- 5.31.12 Restriction of use of Enhanced Coverage
- 5.31.13 Paging for Enhanced Coverage
- 5.31.14 Support of rate control of user data
- 5.31.15 Control Plane Data Transfer Congestion Control
- 5.31.16 Service Gap Control
- 5.31.17 Inter-UE QoS for NB-IoT
- 5.31.18 User Plane CIoT 5GS Optimisation
- 5.31.19 QoS model for NB-IoT
- 5.31.20 Category M UEs differentiation

5.31.1 General

- This clause provides an overview about 5GS optimisations and functionality for support of Cellular Internet-of-Things (Cellular IoT, or CIoT) according to service requirements described in TS 22.261
  - Cellular IoT is in earlier 3GPP releases also referred to as Machine Type Communication (MTC)
  - In this Release Control Plane CIoT 5GS Optimisations (clause 5.31.4) and User Plane CIoT 5GS Optimisations (clause 5.31.18) are only supported over E-UTRA
- CIoT functionality is *provided* by the visited and home networks when the networks are configured to support CIoT
  - It applies to both the non-roaming case and the roaming case and some functionality may be dependent upon the existence of appropriate roaming agreements between the operators
- Some of the CIoT functions are *controlled* by subscriber data
  - Other CIoT functions are based on indicators sent by the UE to the network
  - CIoT functionality is performed by UEs that are configured to support different options as described in clause 5.31.2

5.31.2 Preferred and Supported Network Behaviour

- At registration, a UE includes its 5G Preferred Network Behaviour indicating the network behaviour the UE can support and what it would prefer to use
- The 5G Preferred Network Behaviour signalled by the UE includes the following information in the 5GMM Capability IE:
  - Whether Control Plane CIoT 5GS Optimisation is supported
  - Whether User Plane CIoT 5GS Optimisation is supported
  - Whether N3 data transfer is supported
  - Whether header compression for Control Plane CIoT 5GS Optimisation is supported
- And the following 5G Preferred Network Behaviour in other IEs
  - Whether Control Plane CIoT 5GS Optimisation or User Plane CIoT 5GS Optimisation is preferred

Preferred and Supported Network Behaviour – Support of UEs

- If the UE indicates support of User Plane CIoT 5GS Optimisation then it shall also indicate support of N3 data transfer
  - If N3 data transfer is supported is indicated by the UE, the UE supports data transfer that is not subject to CIoT 5GS Optimisations
- If the AMF indicates support of User Plane CIoT 5GS Optimisation then it shall also indicate support of N3 data transfer
  - If the UE and AMF indicate support for User Plane CIoT 5GS Optimisation, the AMF indicates support of User Plane CIoT 5GS Optimisation support for the UE to NG-RAN
- For NB-IoT UEs that only support Control Plane CIoT 5GS Optimisation, the AMF shall include support for Control Plane CIoT 5GS Optimisation in the Registration Accept message
- A UE that supports the NB-IoT shall always indicate support for Control Plane CIoT 5GS Optimisation
- A UE that supports WB-E-UTRA shall always indicate support for N3 data transfer

5.31.3 Selection, Steering and Redirection between EPS and 5GS

- The UE selects the core network type (EPC or 5GC) based on the broadcast indications for both EPC and 5GC, and the UE's EPC and 5GC Preferred Network Behaviour
  - Networks that support NB-IoT shall broadcast an indication whether N3 data transfer is supported or not in system information
  - When the UE performs the registration procedure it includes its Preferred Network Behaviour (for 5G and EPC) in the Registration Request message and the AMF replies with the 5G Supported Network Behaviour in the Registration Accept message
- In networks that support CIoT features in both EPC and 5GC, the operator may steer UEs from a specific CN type due to operator policy
  - To redirect a UE from 5GC to EPC, when the UE sends a Registration Request, the AMF sends a Registration Reject with an EMM cause value indicating that the UE should not use 5GC
    - The UE disables N1 mode and re-enables S1 mode, if it was disabled
  - To redirect a UE from EPC to 5GC, when the UE requests an Attach or TAU procedure, the MME sends a reject message with an EMM cause indicating the UE should not use EPC
    - The UE disables S1 mode and re-enables N1 mode, if it was disabled

Selection, Steering and Redirection between EPS and 5GS (Cont.)

- To redirect a UE from 5GC to EPC
  - When the UE sends a Registration Request, the AMF sends a Registration Reject with an EMM cause value indicating that the UE should not use 5GC
  - The UE disables N1 mode and re-enables S1 mode, if it was disabled. The UE then performs either an Attach or TAU in EPC
- To redirect a UE from EPC to 5GC
  - When the UE requests an Attach or TAU procedure, the MME sends a reject message with an EMM cause indicating the UE should not use EPC
  - The UE disables S1 mode and re-enables N1 mode, if it was disabled. The UE then registers with 5GC
- When determining whether to redirect the UE
  - The AMF/MME takes into account the UE support of S1/N1 mode, respectively, and
  - The UE's Preferred Network Behaviour and the Supported Network Behaviour of the network the UE is being redirected towards
- If after redirection the UE cannot find a cell supporting connectivity, the UE may re-enable the disabled N1/S1 mode and then perform Registration, Attach or TAU

5.31.4 Control Plane CIoT 5GS Optimisation

- The Control Plane CIoT 5GS Optimisation is used to exchange user data between the UE and the SMF as payload of a NAS message in both uplink and downlink directions
  - Avoiding the establishment of a user plane connection for the PDU Session
- The UE and the AMF perform integrity protection and ciphering for the user data by using NAS PDU integrity protection and ciphering
  - For IP and Ethernet data, the UE and the SMF may negotiate and perform header compression
- UE and AMF negotiate support and use of Control Plane CIoT 5GS Optimisation
  - When the Control Plane CIoT 5GS Optimisation feature is used and the PDU session type is unstructured, the SMF selects either NEF or UPF based on information in the UE's subscription

5.31.5 Non-IP Data Delivery (NIDD)

- Functions for NIDD may be used to handle Mobile Originated (MO) and Mobile Terminated (MT) communication for unstructured data (also referred to as Non-IP). Such delivery to the AF is accomplished by one of the following two mechanisms:
  - Delivery using the NIDD API
  - Delivery using UPF via a Point-to-Point (PtP) N6 tunnel
- NIDD is handled using an Unstructured PDU session to the NEF
  - The UE may obtain an Unstructured PDU session to the NEF during the PDU Session Establishment procedure
- The NEF also supports distribution of Mobile Terminated messages to a group of UEs based on the NIDD API
  - If an External Group Identifier is included in the MT NIDD request, the NEF uses the UDM to resolve the External Group Identifier to a list of SUPIs and sends the message to each UE in the group with an established PDU Session
- The Protocol Configuration Options (PCO) may be used to transfer NIDD parameters to and from the UE (e.g. maximum packet size)
  - The PCO is sent in the 5GSM signalling between UE and SMF. NIDD parameters are sent to and from the NEF via the N29 interface

5.31.6 Reliable Data Service

- The Reliable Data Service (RDS) may be used between the UE and NEF or UPF when using a PDU Session of PDU Type ‘Unstructured’
  - The service provides a mechanism
    - for the NEF or UPF to determine if the data was successfully delivered to the UE and
    - for the UE to determine if the data was successfully delivered to the NEF or UPF
  - When a requested acknowledgement is not received, the Reliable Data Service retransmits the packet
    - The service is enabled or disabled based on DNN and NSSAI Configuration per SLA
- The UE indicates its capability of supporting RDS in the Protocol Configuration Options (PCO) and the SMF negotiates RDS support with the NEF or UPF
- The protocol uses
  - a packet header to identify if the packet
    - requires no acknowledgement,
    - requires an acknowledgement, or
    - is an acknowledgment and to allow detection and elimination of duplicate PDUs at the receiving endpoint
  - Port numbers in the header are used to identify the application on the originator and to identify the application on the receiver
    - RDS supports both single and multiple applications within the UE

5.31.7 Power Saving Enhancements

- To enable UE power saving and to enhance MT reachability while using MICO mode, e.g. for CIoT, the following features are specified in the following clauses
  - Extended Discontinuous Reception (DRX) for CM-IDLE and CM-CONNECTED with RRC-INACTIVE
  - MICO mode with Extended Connected Time
  - MICO mode with Active Time
  - MICO mode and Periodic Registration Timer Control
- If a UE requests via NAS to enable both MICO mode with Active Time and extended idle mode DRX, the AMF may decide to enable MICO mode with or without Active Time, extended idle mode DRX or both
  - e.g. based on
    - local configuration
    - Expected UE Behaviour, if available
    - UE requested Active Time value
    - UE subscription information and n
    - network policies etc

5.31.8 High latency communication

- "High latency" refers to the initial response time before normal exchange of packets is established
  - That is, the time it takes before a UE has woken up from its power saving state and responded to an initial downlink packet or signal
- High latency communication is supported by extended buffering of downlink data in the UPF, SMF or NEF when a UE is using power saving functions in CM-IDLE state and the UE is not reachable
  - For UPF anchored PDU sessions the SMF configures during AN release the UPF with user data Forwarding Action Rule and user data Buffering Action Rule according to TS 29.244
    - The rules include instructions whether UPF buffering applies or the user data shall be forwarded to the SMF for buffering in the SMF
  - For NEF anchored PDU sessions only extended buffering in the NEF is supported in this release of the specification
  - the AMF provides an Estimated Maximum Wait Time to the SMF if the SMF indicates the support of extended buffering
    - During the Network Triggered Service Request procedure or Mobile Terminated Data Transport procedures when using Control Plane CIoT 5GS Optimisation
    - The SMF determines the Extended Buffering Time based on the received Estimated Maximum Wait Time or local configuration

5.31.9 Support for Monitoring Events

- The Monitoring Events feature is intended for monitoring of specific events in the 3GPP system and reporting such Monitoring Events via the NEF
  - The feature allows NFs in 5GS to be configured to detect specific events and report the events to the requested party
- For CIoT, the list of supported monitoring events is specified in Table 4.15.3.1-1 of TS 23.502
- Support for Monitoring Events can be offered via AMF, UDM and SMF, and can be reported via the NEF

5.31.11 Inter-RAT idle mode mobility to and from NB-IoT

- Tracking Areas are configured so that they do not contain both NB-IoT and other RATs' cells, so when the UE is changing RAT type to or from NB-IoT while remaining registered with 5GC, the UE will perform the Mobility Registration Update procedure
- When the UE is changing RAT type to or from NB-IoT and moving between 5GC and EPC, during the Registration, Attach or TAU procedure the RAT type change is determined
- PDU session handling is controlled by "PDU Session continuity at inter RAT mobility" in the UE's subscription data, which indicates per DNN/S-NSSAI
- The AMF informs the SMF at an inter-RAT idle mobility event, e.g. to or from NB-IoT connected to 5GC about the RAT type change in the Nsmf_PDUSession_UpdateSMContext message during the Registration procedure
- During inter-RAT idle mode mobility to NB-IoT, if a PDU session has more than one QoS rule, the SMF shall initiate a PDU session modification procedure as described in TS 23.502 [3] to remove any non-default QoS rule, and maintain only the default QoS rule

5.31.12 Restriction of use of Enhanced Coverage

- The usage of Enhanced Coverage requires use of extensive resources (e.g. radio and signalling resources)
  - For eMTC, the Enhanced Coverage Restricted information indicates whether CE mode B is restricted for the UE, or both CE mode A and CE mode B are restricted for the UE, or both CE mode A and CE mode B are not restricted for the UE
  - For NB-IoT, the NB-IoT Enhanced Coverage Restricted information indicates whether the Enhanced Coverage is restricted or not for the UE
- If the UE includes the support for restriction of use of Enhanced Coverage, the AMF sends Enhanced Coverage Restricted information to the UE in the Registration Accept message
  - The AMF receives Enhanced Coverage Restricted information from the UDM during the Registration procedure
- The UE indicates its capability of support for restriction of use of Enhanced Coverage to AMF in the Registration procedure for the RAT it is camping on
  - A UE that supports Enhanced Coverage shall also support restriction of the Enhanced Coverage
- The UE shall assume that restriction for use of Enhanced Coverage is the same in the equivalent PLMNs

5.31.13 Paging for Enhanced Coverage

- Support of UEs in Enhanced Coverage is specified in TS 36.300
- Whenever N2 is released and Paging Assistance Data for CE capable UE is available for the UE, the NG-RAN sends it to the AMF
- The AMF stores the received Paging Assistance Data for CE capable UE and, if Enhanced Coverage is not restricted for the UE, then the AMF includes it in every subsequent Paging message for all NG-RAN nodes selected by the AMF for paging

5.31.14 Support of rate control of user data

- The rate of user data sent to and from a UE (e.g. a UE using CIoT 5GS Optimisations) can be controlled in two different ways
  - Serving PLMN Rate Control
  - Small Data Rate Control
- Serving PLMN Rate Control is intended to allow the Serving PLMN to protect its AMF and the Signalling Radio Bearers in the NG-RAN from the load generated by NAS Data PDUs
- Small Data Rate Control is intended to allow HPLMN operators to offer customer services such as "maximum of Y messages per day"
- The SMF in the Serving PLMN may send the Small Data rate control parameter for an emergency PDU session

5.31.16 Service Gap Control

- Service Gap Control is an optional feature intended for CIoT UEs to control the frequency at which these UEs can access the network
  - Service Gap Control is intended to be used for "small data allowance plans" for MTC/CIoT UEs where the applications are tolerant to service latency
- Service Gap Time is a subscription parameter used to set the Service Gap timer and is enforced in the UE and in the AMF on a per UE level
  - The UE indicates its capability of support for Service Gap Control in the Registration Request message to the AMF
  - The AMF passes the Service Gap Time to the UE in the Registration Accept message for a UE that has indicated its support of the Service Gap Control
- Service Gap Control requires the UE to stay in CM-IDLE mode for at least the whole duration of the Service Gap timer before triggering Mobile Originated user data transmission, except for procedures that are exempted
  - The Service Gap timer shall be started each time a UE moves from CM-CONNECTED to CM-IDLE
  - When a Service Gap timer expires, the UE is allowed to send a connection request again
- The AMF may enforce the Service Gap timer by rejecting connection requests for MO user plane data, MO control plane data, or MO SMS when a Service Gap timer is running

5.31.17 Inter-UE QoS for NB-IoT

- To allow NG-RAN to prioritise resource allocation between different UEs accessing via NB-IoT when some of the UEs are using Control Plane CIoT 5GS Optimisation, NG-RAN may, based on configuration, retrieve from the AMF the subscribed NB-IoT UE Priority for any UE accessing via NB-IoT by using the UE's 5G-S-TMSI as the identifier
- In order to reduce signalling load on the AMF, NG-RAN may be configured to request the NB-IoT UE Priority from the AMF
  - e.g. only when the NG-RAN's NB-IoT load exceeds certain threshold(s) or when the NG-RAN needs to cache the QoS profile

5.31.18 User Plane CIoT 5GS Optimisation

- User Plane CIoT 5GS Optimisation enables transfer of user plane data from CM-IDLE without the need for using the Service Request procedure to establish Access Stratum (AS) context in NG-RAN and UE
  - UE and AMF negotiated support User Plane CIoT 5GS Optimisation (see clause 5.31.2) over NAS
  - the UE has indicated support of User Plane CIoT 5GS Optimisation in the UE radio capabilities as defined in TS 36.331
  - AMF has indicated User Plane CIoT 5GS Optimisation support for the UE to NG-RAN
  - the UE has established at least one PDU session with active UP connection, i.e. AS context is established in NG-RAN and the UE

then the RRC connection can be suspended by means of the Connection Suspend Procedure

5.31.19 QoS model for NB-IoT

5GC QoS model applies to NB-IoT with the following requirements:

- The default QoS rule shall be the only QoS rule of a PDU Session for a UE connected to 5GC via NB-IoT
  - There is only one QoS flow (corresponding to the default QoS rule) per PDU session
- Reflective QoS is not supported over NB-IoT
- For NB-IoT, there is a 1:1 mapping between the QoS flow corresponding to the default QoS of a PDU session and a Data Radio Bearer when user plane resources are active for that PDU session
- A maximum of two Data Radio Bearers are supported over NB-IoT
  - Therefore, at most two PDU sessions can have active user plane resources at the same time

5.31.20 Category M UEs differentiation

- When the UE has provided a Category M indication to the NG-RAN during RRC Connection Establishment, the NG-RAN shall provide an LTE-M Indication to the AMF in the Initial UE Message
- When the AMF receives an LTE-M Indication from NG-RAN in an Initial UE Message or from an MME during EPS to 5GS handover, the AMF shall store the LTE-M Indication in the UE context, consider that the RAT type is LTE-M and signal it accordingly to the SMSF during registration procedure for SMS over NAS, to the SMF during PDU Session Establishment or PDU Session Modification procedure
  - The PCF will also receive the RAT Type as LTE-M, when applicable, from the SMF during SM Policy Association Establishment or SM Policy Association Modification procedure
- The NFs generating CDRs shall include the LTE-M RAT type in their CDRs
- Upon AMF change or inter-system mobility from 5GS to EPS, the source AMF shall provide the "LTE-M Indication" to the target AMF or MME as part of the UE context
- During EPS to 5GS Mobility Registration Procedure, the AMF shall
  - Disregard any "LTE-M Indication" received from the MME in the UE context, and
  - Take into account the "LTE-M Indication" received from NG-RAN

Summary

- 3GPP proposed three MTC architectural models either roaming or non-roaming
  - Direct model, indirect, model and hybrid model
- MTC functionalities as well as standardized indications and mechanisms are introduced
- 3GPP 5GS supports for cellular IoT are described
  - Around twenty techniques including Non-IP data delivery, NB-IoT, etc.