**3GPP TSG-WG SA2 Meeting #165 *S2-2409638***

**14 - 18 October, 2024, Hyderabad, India**

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| *CR-Form-v12.2* |
| **CHANGE REQUEST** |
|  |
|  | **23.501** | **CR** | **5628** | **rev** | **-** | **Current version:** | **19.1.0** |  |
|  |
| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* |
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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***Proposed change affects:*** | UICC apps |  | ME |  | Radio Access Network |  | Core Network | **X** |

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| --- |
|  |
| ***Title:***  | Support of Energy Efficiency and Energy Saving |
|  |  |
| ***Source to WG:*** | China Mobile, Orange, SK Telecom, Rakuten Mobile, NEC, Tencent, TOYOTA MOTOR CORPORATION, LG Electronics, ETRI, Interdigital,NTT DOCOMO, KPN, China Unicom, KDDI, vivo?, ZTE?, Huawei, HiSilicon?, Samsung? |
| ***Source to TSG:*** | SA2 |
|  |  |
| ***Work item code:*** | EnergySys |  | ***Date:*** | 2024-10-04 |
|  |  |  |  |  |
| ***Category:*** | **B** |  | ***Release:*** | Rel-19 |
|  | *Use one of the following categories:****F*** *(correction)****A*** *(mirror corresponding to a change in an earlier release)****B*** *(addition of feature),* ***C*** *(functional modification of feature)****D*** *(editorial modification)*Detailed explanations of the above categories canbe found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | *Use one of the following releases:Rel-8 (Release 8)Rel-9 (Release 9)Rel-10 (Release 10)Rel-11 (Release 11)…Rel-16 (Release 16)Rel-17 (Release 17)Rel-18 (Release 18)Rel-19 (Release 19)* |
|  |  |
| ***Reason for change:*** | This paper provides the basic framework and function design to support energy related information collection, energy consumption information calculation, and exposure. New NF EECF is introduced to support the above functionality.The methods of calculation for the Energy consumption information of different granularities are provided.The Energy Consumption information of the different granularities are derived from user plane traffic transmission, i.e. the combination of Energy Consumption information in NG-RAN, I-UPF(s) and PSA-UPF(s), and the data volume is the main contributor. The Energy Consumption Assisted information include: Node-level energy consumption information, Node-level data volume, and data volume of the required granularities. This paper is merge version of S2-2409638, S2-2409847, S2-2409978, S2-2410302, S2-2410421, S2-2410576, S2-2410075 |
|  |  |
| ***Summary of change:*** | Add new NF EECF for architecture and function design to support energy consumption information collection and calculation. |
|  |  |
| ***Consequences if not approved:*** | The energy saving features cannot be supported. |
|  |  |
| ***Clauses affected:*** | 2; 3.2; 5.X;6.2.5;6.2.10; Annex(XX) |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** |  | **X** |  Other core specifications  | TS/TR ... CR ... |
| ***affected:*** |  | **X** |  Test specifications | TS/TR ... CR ... |
| ***(show related CRs)*** |  | **X** |  O&M Specifications | TS/TR ... CR ... |
|  |  |
| ***Other comments:*** |  |
|  |  |
| ***This CR's revision history:*** |  |

\* \* \* \* First change \* \* \* \*

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 22.261: "Service requirements for next generation new services and markets; Stage 1".

[3] 3GPP TS 23.502: "Procedures for the 5G System; Stage 2".

[4] 3GPP TS 23.203: "Policies and Charging control architecture; Stage 2".

[5] 3GPP TS 23.040: "Technical realization of the Short Message Service (SMS); Stage 2".

[6] 3GPP TS 24.011: "Point-to-Point (PP) Short Message Service (SMS) support on mobile radio interface: Stage 3".

[7] IETF RFC 7157: "IPv6 Multihoming without Network Address Translation".

[8] IETF RFC 4191: "Default Router Preferences and More-Specific Routes".

[9] IETF RFC 2131: "Dynamic Host Configuration Protocol".

[10] IETF RFC 4862: "IPv6 Stateless Address Autoconfiguration".

[11] ITU‑T Recommendation I.130: "Method for the characterization of telecommunication services supported by an ISDN and network capabilities of an ISDN".

[12] ITU‑T Recommendation Q.65: "The unified functional methodology for the characterization of services and network capabilities".

[13] 3GPP TS 24.301: "Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS): Stage 3".

[14] Void.

[15] 3GPP TS 23.228: "IP Multimedia Subsystem (IMS); Stage 2".

[16] 3GPP TS 22.173: "IMS Multimedia Telephony Service and supplementary services; Stage 1".

[17] 3GPP TS 23.122: "Non-Access-Stratum (NAS) functions related to Mobile Station in idle mode".

[18] 3GPP TS 23.167: "3rd Generation Partnership Project; Technical Specification Group Services and Systems Aspects; IP Multimedia Subsystem (IMS) emergency sessions".

[19] 3GPP TS 23.003: "Numbering, Addressing and Identification".

[20] IETF RFC 7542: "The Network Access Identifier".

[21] 3GPP TS 23.002: "Network Architecture".

[22] 3GPP TS 23.335: "User Data Convergence (UDC); Technical realization and information flows; Stage 2".

[23] 3GPP TS 23.221: "Architectural requirements".

[24] 3GPP TS 22.153: "Multimedia priority service".

[25] 3GPP TS 22.011: "Service Accessibility".

[26] 3GPP TS 23.401: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access".

[27] 3GPP TS 38.300: "NR; NR and NG-RAN Overall Description".

[28] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol Specification".

[29] 3GPP TS 33.501: "Security architecture and procedures for 5G system".

[30] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2".

[31] 3GPP TS 37.340: "Evolved Universal Terrestrial Radio Access (E-UTRA) and NR; Multi-connectivity; Stage 2".

[32] 3GPP TS 23.214: "Architecture enhancements for control and user plane separation of EPC nodes; Stage 2".

[33] 3GPP TS 22.101: "3rd Generation Partnership Project; Technical Specification Group Services and Systems Aspects; Service aspects; Service principles".

[34] 3GPP TS 38.413: "NG-RAN; NG Application Protocol (NGAP)".

[35] 3GPP TS 33.126: "Lawful Interception Requirements".

[36] 3GPP TS 23.682: "Architecture enhancements to facilitate communications with packet data networks and applications".

[37] 3GPP TS 22.280: "Mission Critical Services Common Requirements (MCCoRe); Stage 1".

[38] 3GPP TS 23.379: "Functional architecture and information flows to support Mission Critical Push To Talk (MCPTT); Stage 2".

[39] 3GPP TS 23.281: "Functional architecture and information flows to support Mission Critical Video (MCVideo); Stage 2".

[40] 3GPP TS 23.282: "Functional architecture and information flows to support Mission Critical Data (MCData); Stage 2".

[41] 3GPP TS 32.240: "Charging management; Charging architecture and principles".

[42] 3GPP TS 38.401: "NG-RAN Architecture description".

[43] 3GPP TS 23.402: "Architecture enhancements for non-3GPP accesses".

[44] IETF RFC 4960: "Stream Control Transmission Protocol".

[45] 3GPP TS 23.503: "Policy and Charging Control Framework for the 5G System".

[46] 3GPP TS 23.041: "Public Warning System".

[47] 3GPP TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".

[48] 3GPP TS 24.502: "Access to the 5G System (5GS) via non-3GPP access networks; Stage 3".

[49] 3GPP TS 29.500: "5G System; Technical Realization of Service Based Architecture; Stage 3".

[50] 3GPP TS 38.304: "NR; User Equipment (UE) procedures in idle mode".

[51] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification".

[52] 3GPP TS 36.304: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode".

[53] Void.

[54] IETF RFC 4861: "Neighbor Discovery for IP version 6 (IPv6)".

[55] 3GPP TS 23.271: "Functional stage 2 description of Location Services (LCS)".

[56] 3GPP TS 23.060: "General Packet Radio Service (GPRS); Service description; Stage 2".

[57] IETF RFC 4555: "IKEv2 Mobility and Multihoming Protocol (MOBIKE)".

[58] 3GPP TS 29.510: "5G System: Network function repository services; Stage 3".

[59] 3GPP TS 29.502: "5G System: Session Management Services: Stage 3".

[60] IETF RFC 7296: "Internet Key Exchange Protocol Version 2 (IKEv2) ".

[61] 3GPP TS 23.380: "IMS Restoration Procedures".

[62] 3GPP TS 24.229: "IP multimedia call control protocol based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP); Stage 3".

[63] 3GPP TS 23.292: "IP Multimedia Subsystem (IMS) centralized services; Stage 2".

[64] 3GPP TS 23.222: "Functional architecture and information flows to support Common API Framework for 3GPP Northbound APIs".

[65] 3GPP TS 29.244: "Interface between the Control Plane and the User Plane Nodes; Stage 3".

[66] 3GPP TS 32.421: "Telecommunication management; Subscriber and equipment trace; Trace concepts and requirements".

[67] 3GPP TS 32.290: "5G system; Services, operations and procedures of charging using Service Based Interface (SBI)".

[68] 3GPP TS 32.255: "5G Data connectivity domain charging; Stage 2".

[69] 3GPP TS 38.306: "NR; User Equipment -UE) radio access capabilities".

[70] 3GPP TS 36.306: "Evolved Universal Terrestrial Radio Access -E-UTRA); User Equipment -UE) radio access capabilities".

[71] 3GPP TS 29.518: "5G System; Access and Mobility Management Services; Stage 3".

[72] Void.

[73] IETF RFC 2865: "Remote Authentication Dial In User Service (RADIUS)".

[74] IETF RFC 3162: "RADIUS and IPv6".

[75] 3GPP TS 29.281: "General Packet Radio System (GPRS) Tunnelling Protocol User Plane (GTPv1-U)".

[76] 3GPP TS 26.238: "Uplink streaming".

[77] 3GPP TR 26.939: "Guidelines on the Framework for Live Uplink Streaming (FLUS)".

[78] International Telecommunication Union (ITU), Standardization Bureau (TSB): "Operational Bulletin No. 1156"; http://handle.itu.int/11.1002/pub/810cad63-en (retrieved October 5, 2018).

[79] 3GPP TS 28.533: "Management and orchestration; Architecture framework".

[80] 3GPP TS 24.250: "Protocol for Reliable Data Service; Stage 3".

[81] IETF RFC 8684: "TCP Extensions for Multipath Operation with Multiple Addresses".

[82] IETF RFC 8803: "0-RTT TCP Convert Protocol".

[83] IEEE Std 802.1CB-2017: "IEEE Standard for Local and metropolitan area networks-Frame Replication and Elimination for Reliability".

[84] 3GPP TS 23.316: "Wireless and wireline convergence access support for the 5G System (5GS)".

[85] WiFi Alliance Technical Committee, Hotspot 2.0 Technical Task Group: "Hotspot 2.0 (Release 2) Technical Specification".

[86] 3GPP TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".

[87] 3GPP TS 23.273: "5G System (5GS) Location Services (LCS); Stage 2".

[88] 3GPP TS 23.216: "Single Radio Voice Call Continuity (SRVCC); Stage 2".

[89] CableLabs DOCSIS MULPI: "Data-Over-Cable Service Interface Specifications DOCSIS 3.1, MAC and Upper Layer Protocols Interface Specification".

[90] BBF TR-124 issue 5: "Functional Requirements for Broadband Residential Gateway Devices".

[91] BBF TR-101 issue 2: "Migration to Ethernet-Based Broadband Aggregation".

[92] BBF TR-178 issue 1: "Multi-service Broadband Network Architecture and Nodal Requirements".

[93] BBF TR-456 issue 2: "AGF Functional Requirements".

[94] BBF WT-457: "FMIF Functional Requirements".

Editor's note: The reference to BBF WT-457 will be revised when finalized by BBF.

[95] Void.

[96] Void.

[97] IEEE Std 802.1AB-2016: "IEEE Standard for Local and metropolitan area networks -- Station and Media Access Control Connectivity Discovery".

[98] IEEE Std 802.1Q-2022: "IEEE Standard for Local and metropolitan area networks--Bridges and Bridged Networks".

[99] 3GPP TS 38.423: "NG-RAN; Xn Application Protocol (XnAP)".

[100] 3GPP TS 36.413: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP)".

[101] 3GPP TS 29.274: "Evolved General Packet Radio Service (GPRS) Tunnelling Protocol for Control plane (GTPv2-C); Stage 3".

[102] 3GPP TS 23.632: "User Data Interworking, Coexistence and Migration; stage 2".

[103] 3GPP TS 29.563: "5G System (5GS); HSS services for interworking with UDM; Stage 3".

[104] IEEE Std 802.1AS-2020: "IEEE Standard for Local and metropolitan area networks--Timing and Synchronization for Time-Sensitive Applications".

[105] 3GPP TS 22.104: "Service requirements for cyber-physical control applications in vertical domains".

[106] IEEE Std 802.11-2012: "IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications".

[107] IEEE Std 1588-2008: "IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems".

[108] 3GPP TS 28.552: "Management and orchestration; 5G performance measurements".

[109] 3GPP TS 24.193: "Access Traffic Steering, Switching and Splitting; Stage 3".

[110] 3GPP TS 24.526: "User Equipment (UE) policies for 5G System (5GS); Stage 3".

[111] 3GPP TS 22.186: "Enhancement of 3GPP support for V2X scenarios; Stage 1".

[112] 3GPP TR 38.824: "Study on physical layer enhancements for NR ultra-reliable and low latency case (URLLC)".

[113] IEEE: "Guidelines for Use of Extended Unique Identifier (EUI), Organizationally Unique Identifier (OUI), and Company ID (CID)", https://standards.ieee.org/content/dam/ieee-standards/standards/web/documents/tutorials/eui.pdf.

[114] 3GPP TS 32.256: "Charging Management; 5G connection and mobility domain charging; Stage 2".

[115] 3GPP TS 33.210: "Network Domain Security (NDS); IP network layer security".

[116] 3GPP TS 38.415: "PDU Session User Plane Protocol".

[117] 3GPP TS 24.535: "Device-side Time-Sensitive Networking (TSN) Translator (DS-TT) to network-side TSN Translator (NW-TT) protocol aspects; Stage 3".

[118] 3GPP TS 32.274: "Charging Management; Short Message Service (SMS) charging".

[119] 3GPP TS 23.008: "Organization of subscriber data".

[120] 3GPP TS 38.314: "NR; Layer 2 measurements".

[121] 3GPP TS 23.287: "Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services".

[122] 3GPP TS 29.503: "5G System; Unified Data Management Services; Stage 3".

[123] 3GPP TS 32.254: "Charging management; Exposure function Northbound Application Program Interfaces (APIs) charging".

[124] 3GPP TS 33.535: "Authentication and Key Management for Applications based on 3GPP credentials in the 5G System (5GS)".

[125] 3GPP TS 38.410: "NG-RAN; NG general aspects and principles".

[126] IEEE Std 1588: "IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems", Edition 2019.

[127] ST 2059-2:2015: "SMPTE Standard - SMPTE Profile for Use of IEEE-1588 Precision Time Protocol in Professional Broadcast Applications".

[128] 3GPP TS 23.304: "Proximity based Services (ProSe) in the 5G System (5GS)".

[129] 3GPP TS 23.247: "Architectural enhancements for 5G multicast-broadcast services".

[130] 3GPP TS 23.548: "5G System Enhancements for Edge Computing; Stage 2".

[131] IEEE Std 802.3: "Ethernet".

[132] 3GPP TS 29.561: "5G System; Interworking between 5G Network and external Data Networks; Stage 3".

[133] 3GPP TS 29.513: "Policy and Charging Control signalling flows and QoS parameter mapping; Stage 3".

[134] 3GPP TS 23.558: "Architecture for enabling Edge Applications (EA)".

[135] 3GPP TS 26.501: "5G Media Streaming (5GMS); General description and architecture".

[136] 3GPP TS 23.256: "Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking; Stage 2".

[137] GSMA NG.116: "Generic Network Slice Template".

[138] IETF RFC 3948: "UDP Encapsulation of IPsec ESP Packets".

[139] 3GPP TS 24.539: "5G System (5GS); Network to TSN translator (TT) protocol aspects; Stage 3".

[140] 3GPP TS 33.220: "Generic Authentication Architecture (GAA); Generic bootstrapping architecture".

[141] 3GPP TS 33.223: "Generic Authentication Architecture (GAA); Generic Bootstrapping Architecture (GBA) Push function".

[142] 3GPP TS 23.540: "Technical realization of Service Based Short Message Service; Stage 2".

[143] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification".

[144] 3GPP TS 29.525: "5G System; UE Policy Control Service; Stage 3".

[145] 3GPP TS 29.505: "5G System; Usage of the Unified Data Repository Services for Subscription Data; Stage 3".

[146] IEEE Std 802.1Qdj-2024: "IEEE Draft Standard for Local and metropolitan area networks - Bridges and Bridged Networks - Amendment XX: Configuration Enhancements for Time-Sensitive Networking".

[147] Void.

[148] 3GPP TS 28.557: "Management and orchestration; Management of Non-Public Networks (NPN)".

[149] 3GPP TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM)".

[150] IETF RFC 8655: "Deterministic Networking Architecture".

[151] IETF RFC 8343: "A YANG Data Model for Interface Management".

[152] IETF RFC 8344: "A YANG Data Model for IP Management".

[153] IETF RFC 7224: " IANA Interface Type YANG Module".

[154] IETF draft-ietf-detnet-yang: "Deterministic Networking (DetNet) YANG Model".

Editor's note: The reference to draft-ietf-detnet-yang will be revised to RFC when finalized by IETF.

[155] IETF RFC 6241: "Network Configuration Protocol (NETCONF)".

[156] IETF RFC 8040: "RESTCONF Protocol".

[157] IETF RFC 8939: "Deterministic Networking (DetNet) Data Plane: IP".

[158] IETF RFC 5279: "A Uniform Resource Name (URN) Namespace for the 3rd Generation Partnership Project (3GPP)".

[159] IETF RFC 9330:"Low Latency, Low Loss, Scalable Throughput (L4S) Internet Service: Architecture".

[160] IETF RFC 9331: "Explicit Congestion Notification (ECN) Protocol for Very Low Queuing Delay (L4S)".

[161] IETF RFC 9332: "Dual-Queue Coupled Active Queue Management (AQM) for Low Latency, Low Loss, and Scalable Throughput (L4S)".

[162] IETF RFC 6603: "Prefix Exclude Option for DHCPv6-based Prefix Delegation".

[163] IETF RFC 8415: "Dynamic Host Configuration Protocol for IPv6 (DHCPv6)".

[164] ITU‑T Recommendation G.810: "Definitions and terminology for synchronization networks".

[165] 3GPP TS 38.470: "NG-RAN; F1 general aspects and principles".

[166] IETF RFC 9000: "QUIC: A UDP-Based Multiplexed and Secure Transport".

[167] IETF RFC 9001: "Using TLS to Secure QUIC".

[168] IETF RFC 9002: "QUIC Loss Detection and Congestion Control".

[169] IETF RFC 9221: "An Unreliable Datagram Extension to QUIC".

[170] IETF RFC 9298: "Proxying UDP in HTTP".

[171] IETF RFC 9114: "Hypertext Transfer Protocol Version 3 (HTTP/3)".

[172] IETF RFC 9297: "HTTP Datagrams and the Capsule Protocol".

[173] IETF RFC 9220: "Bootstrapping WebSockets with HTTP/3".

[174] draft-ietf-quic-multipath: "Multipath Extension for QUIC".

Editor's note: The above document cannot be formally referenced until it is published as an RFC.

[175] 3GPP TS 28.530: "Management and orchestration; Concepts, use cases and requirements".

[176] 3GPP TS 28.531: "Management and orchestration; Provisioning".

[177] 3GPP TS 23.434: "Service Enabler Architecture Layer for Verticals (SEAL); Functional architecture and information flows".

[178] IEEE Std 802.1CBdb-2021: "Amendment 2: Extend Stream Identification Functions".

[179] 3GPP TS 26.522: "5G Real-time Media Transport Protocol Configurations".

[180] 3GPP TS 23.586: "Architectural Enhancements to support Ranging based services and Sidelink Positioning".

[181] 3GPP TS 23.542: "Application layer support for Personal IoT Network".

[182] IETF RFC 8415: "Dynamic Host Configuration Protocol for IPv6 (DHCPv6)".

[183] 3GPP TS 29.571: "5G System; Common Data Types for Service Based Interfaces; Stage 3".

[184] 3GPP TS 23.289: "Mission Critical services over 5G System; Stage 2".

[185] IETF RFC 3550: "RTP: A Transport Protocol for Real-Time Applications".

[186] IETF RFC 3711: "The Secure Real-time Transport Protocol (SRTP)".

[187] IETF RFC 6184: "RTP Payload Format for H.264 Video".

[188] IETF RFC 7798: "RTP Payload Format for High Efficiency Video Coding (HEVC) ".

[189] IETF RFC 8285: "A General Mechanism for RTP Header Extensions".

[190] 3GPP TS 28.405: "Quality of Experience (QoE) measurement collection; Control and configuration".

[191] 3GPP TS 37.355: " LTE Positioning Protocol (LPP)".

[192] 3GPP TS 32.422: "Telecommunication management; Subscriber and equipment trace; Trace control and configuration management".

[193] IETF RFC 3168: "The Addition of Explicit Congestion Notification (ECN) to IP".

[194] 3GPP TS 33.503: "Security Aspects of Proximity based Services (ProSe) in the 5G System (5GS)".

[195] 3GPP TS 38.414: "NG-RAN; NG data transport".

[196] 3GPP TS 38.799: "Study on Additional Topological Enhancements for NR".

[196] 3GPP TS 28.554: "Study on Additional Topological Enhancements for NR".

[Y] 3GPP TS 28.554: "Management and orchestration; 5G end to end Key Performance Indicators (KPI)".

[x] 3GPP TS 28.310: "Management and orchestration; Energy efficiency of 5G".

\* \* \* \* Second change \* \* \* \*

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

5GC 5G Core Network

5G DDNMF 5G Direct Discovery Name Management Function

5G LAN 5G Local Area Network

5GS 5G System

5G-AN 5G Access Network

5G-AN PDB 5G Access Network Packet Delay Budget

5G-EIR 5G-Equipment Identity Register

5G-GUTI 5G Globally Unique Temporary Identifier

5G-BRG 5G Broadband Residential Gateway

5G-CRG 5G Cable Residential Gateway

5G GM 5G Grand Master

5G NSWO 5G Non-Seamless WLAN offload

5G-RG 5G Residential Gateway

5G-S-TMSI 5G S-Temporary Mobile Subscription Identifier

5G VN 5G Virtual Network

5QI 5G QoS Identifier

ADRF Analytics Data Repository Function

AF Application Function

AI/ML Artificial Intelligence/Machine Learning

AKMA Authentication and Key Management for Applications

AnLF Analytics Logical Function

AMF Access and Mobility Management Function

AoI Area of Interest

AS Access Stratum

ATSSS Access Traffic Steering, Switching, Splitting

ATSSS-LL ATSSS Low-Layer

AUSF Authentication Server Function

BMCA Best Master Clock Algorithm

BSF Binding Support Function

CAG Closed Access Group

CAPIF Common API Framework for 3GPP northbound APIs

CH Credentials Holder

CHF Charging Function

CN PDB Core Network Packet Delay Budget

CP Control Plane

CQRCI Clock Quality Reporting Control Information

DAPS Dual Active Protocol Stacks

DCCF Data Collection Coordination Function

DCS Default Credentials Server

DetNet Deterministic Networking

DL Downlink

DN Data Network

DNAI DN Access Identifier

DNN Data Network Name

DRX Discontinuous Reception

DS-TT Device-side TSN translator

EAC Early Admission Control

EECF Energy Efficiency and Consumption Function

ePDG evolved Packet Data Gateway

EBI EPS Bearer Identity

EUI Extended Unique Identifier

FAR Forwarding Action Rule

FL Federated Learning

FN-BRG Fixed Network Broadband RG

FN-CRG Fixed Network Cable RG

FN-RG Fixed Network RG

FQDN Fully Qualified Domain Name

GBA Generic Bootstrapping Architecture

GEO Geostationary Orbit

GFBR Guaranteed Flow Bit Rate

GIN Group ID for Network Selection

GMLC Gateway Mobile Location Centre

GPSI Generic Public Subscription Identifier

GUAMI Globally Unique AMF Identifier

HMTC High-Performance Machine-Type Communications

HR Home Routed (roaming)

IAB Integrated access and backhaul

IMEI/TAC IMEI Type Allocation Code

IPUPS Inter PLMN UP Security

I-SMF Intermediate SMF

I-UPF Intermediate UPF

LADN Local Area Data Network

LBO Local Break Out (roaming)

LEO Low Earth Orbit

LMF Location Management Function

LoA Level of Automation

LPP LTE Positioning Protocol

LRF Location Retrieval Function

L4S Low Latency, Low Loss and Scalable Throughput

MBS Multicast/Broadcast Service

MBSF Multicast/Broadcast Service Function

MBSR Mobile Base Station Relay

MBSTF Multicast/Broadcast Service Transport Function

MB-SMF Multicast/Broadcast Session Management Function

MB-UPF Multicast/Broadcast User Plane Function

MEO Medium Earth Orbit

MFAF Messaging Framework Adaptor Function

MCX Mission Critical Service

MDBV Maximum Data Burst Volume

MFBR Maximum Flow Bit Rate

MICO Mobile Initiated Connection Only

MINT Minimization of Service Interruption

ML Machine Learning

MPQUIC Multi-Path QUIC

MPS Multimedia Priority Service

MPTCP Multi-Path TCP Protocol

MTLF Model Training Logical Function

MWAB Mobile gNB with wireless access backhauling

N3IWF Non-3GPP InterWorking Function

N3QAI Non-3GPP QoS Assistance Information

N5CW Non-5G-Capable over WLAN

NAI Network Access Identifier

NAT Network Address Translation

NCR Network Controlled Repeater

NCR-MT NCR Mobile Termination

NEF Network Exposure Function

NF Network Function

NGAP Next Generation Application Protocol

NID Network identifier

NPN Non-Public Network

NR New Radio

NRF Network Repository Function

NS-AoS Network Slice Area of Service

NSAC Network Slice Admission Control

NSACF Network Slice Admission Control Function

NSAG Network Slice AS Group

NSI ID Network Slice Instance Identifier

NSSAA Network Slice-Specific Authentication and Authorization

NSSAAF Network Slice-specific and SNPN Authentication and Authorization Function

NSSAI Network Slice Selection Assistance Information

NSSF Network Slice Selection Function

NSSP Network Slice Selection Policy

NSSRG Network Slice Simultaneous Registration Group

NSWO Non-Seamless WLAN offload

NSWOF Non-Seamless WLAN offload Function

NW-TT Network-side TSN translator

NWDAF Network Data Analytics Function

ONN Onboarding Network

ON-SNPN Onboarding Standalone Non-Public Network

PCF Policy Control Function

PDB Packet Delay Budget

PDR Packet Detection Rule

PDU Protocol Data Unit

PDV Packet Delay Variation

PEGC PIN Element with Gateway Capability

PEI Permanent Equipment Identifier

PEMC PIN Element with Management Capability

PER Packet Error Rate

PFD Packet Flow Description

PIN Personal IoT Network

PINE PIN Element

PLR Packet Loss Rate

PNI-NPN Public Network Integrated Non-Public Network

PPD Paging Policy Differentiation

PPF Paging Proceed Flag

PPI Paging Policy Indicator

PSA PDU Session Anchor

PSDB PDU Set Delay Budget

PSER PDU Set Error Rate

PSIHI PDU Set Integrated Handling Information

PTP Precision Time Protocol

PVS Provisioning Server

QFI QoS Flow Identifier

QMC QoE Measurement Collection

QoE Quality of Experience

RACS Radio Capabilities Signalling optimisation

(R)AN (Radio) Access Network

RG Residential Gateway

RIM Remote Interference Management

RQA Reflective QoS Attribute

RQI Reflective QoS Indication

RSN Redundancy Sequence Number

RTT Round Trip Time

SA NR Standalone New Radio

SBA Service Based Architecture

SBI Service Based Interface

SCP Service Communication Proxy

SD Slice Differentiator

SEAF Security Anchor Functionality

SEPP Security Edge Protection Proxy

SF Service Function

SFC Service Function Chain

SMF Session Management Function

SMSF Short Message Service Function

SN Sequence Number

SNPN Stand-alone Non-Public Network

S-NSSAI Single Network Slice Selection Assistance Information

SO-SNPN Subscription Owner Standalone Non-Public Network

SSC Session and Service Continuity

SSCMSP Session and Service Continuity Mode Selection Policy

SST Slice/Service Type

SUCI Subscription Concealed Identifier

SUPI Subscription Permanent Identifier

SV Software Version

TA Tracking Area

TAI Tracking Area Identity

TNAN Trusted Non-3GPP Access Network

TNAP Trusted Non-3GPP Access Point

TNGF Trusted Non-3GPP Gateway Function

TNL Transport Network Layer

TNLA Transport Network Layer Association

TSC Time Sensitive Communication

TSCAC TSC Assistance Container

TSCAI Traffic Assistance Information

TSCTSF Time Sensitive Communication and Time Synchronization Function

TSN Time Sensitive Networking

TSN GM TSN Grand Master

TSP Traffic Steering Policy

TSS Timing Synchronization Status

TT TSN Translator

TWIF Trusted WLAN Interworking Function

UAS NF Uncrewed Aerial System Network Function

UCMF UE radio Capability Management Function

UDM Unified Data Management

UDR Unified Data Repository

UDSF Unstructured Data Storage Function

UL Uplink

UL CL Uplink Classifier

UPF User Plane Function

URLLC Ultra Reliable Low Latency Communication

URRP-AMF UE Reachability Request Parameter for AMF

URSP UE Route Selection Policy

VID VLAN Identifier

VLAN Virtual Local Area Network

W-5GAN Wireline 5G Access Network

W-5GBAN Wireline BBF Access Network

W-5GCAN Wireline 5G Cable Access Network

W-AGF Wireline Access Gateway Function

\* \* \* \*Third change (all new text) \* \* \* \*

## 5.X Support of Energy Efficiency and Energy Saving

### 5.X.1 General

This clause provides an overview of 5GS functionalities to support of energy related information collection, energy consumption information calculation, and exposure. Based on the UE subscription and Energy Consumption information, the 5GS may perform energy saving policies, NF discovery and (re-)selection, and UP path adjustment.

- The 5GS supports energy related information collection, energy consumption information calculation and exposure, which are specified in clause 5.X.2;

- The UE subscription and policy control with considering Energy Consumption information is described in clause 5.X.3;

- Enhancements of NF discovery and (re-)selection considering energy-related information are described in clause 5.X.4;

- The user plane path adjustment for a PDU session(s) based on Energy Consumption information are described in clause 5.X.5;

### 5.X.2 Energy Consumption Information calculation and exposure

#### 5.X.2.1 General

The Energy Efficiency and Consumption Function (EECF) is defined to collect and store the Energy Consumption Assisted information, calculate the Energy Consumption information, and expose the Energy Consumption information to the authorized consumer NF(s) subject to operator’s policy.

 NOTE 1: The EECF can be deployed standalone or co-located with NWDAF.

When the authorized consumer is AF, the granularities of Energy Consumption information include: per UE, per UE per application, per PDU session. When the authorized consumer NF is a 5GC NF (e.g., NWDAF, PCF), the granularities of Energy Consumption information include: per UE, per-UE-per-QoS flow, per PDU session.

NOTE 2: In this release, the EECF only supports to determine the energy-related information for user plane communication (not control plane signalling) of the UE.

NOTE 3: The collection of renewable energy information is to be coordinated with SA WG5.

AF or 5GC NF (e.g., NWDAF, PCF) may subscribe the EECF for Energy consumption information of the above granularities, with providing parameters including e.g., UE GPSI, UE IP address(es), Flow description(s), Area of Interest (AOI), Application ID, DNAI(s), Energy related criteria (e.g. maximum/minimum/average /variance value for Energy Consumption), reporting frequency, reporting threshold, as described in clause 5.2.X in TS 23.502[x]

Editor’s note: Whether and how the renewable energy is exposed is FFS.

The Energy Consumption information of the above granularities are derived from user plane traffic transmission, i.e. the combination of Energy Consumption information in NG-RAN, I-UPF(s) and PSA-UPF(s), and the data volume is the main contributor.

The Energy Consumption Assisted information include: Node-level energy consumption information, Node-level data volume, and data volume of the required granularities. The Node-level Energy Consumption Assisted information received from OAM and SMF/UPF, could be used by EECF for all the UEs serving by the NF Node.

* EECF requests OAM to provide the NG-RAN and UPF Node-level energy consumption information, NG-RAN and UPF Node-level data volume, based on a measurement time period T (e.g., with including start/end time) as specified in SA5 TS 28.554.
* EECF gets the data volume of the granularities e.g., QoS flow or PDU session, from SMF/UPF. And for the same QoS flow or PDU session, the data volume in NG-RAN and UPF(s) are the same.
* When the gNB and/or the (I-)UPF(s) which serving the UE are changed, the serving gNB ID and UPF ID will be sent to the new functionality through AMF/SMF as described in clause 4.3.5.X in TS 23.502[x].

NOTE 4: It is assumed that the measurement time period T is aligned over the UPF/NG-RAN nodes for which information is collected, i.e. the start/stop of the time periods is time-synchronized.

EECF calculates the Energy Consumption information of certain granularity for the UE by adding the Energy Consumption information of the corresponding granularity at the UPF(s) and gNB serving the UE.

Editor’s NOTE: Details of OAM expose Node level Energy Consumption information to EECF needs the coordination with SA WG2 and SA WG5.

#### 5.X.2.2 Energy Consumption information for UPF(s)

To enable the calculation of Energy Consumption information per UPF(s) in the given granularity level, the EECF needs to get the UPF Node-level energy consumption information from OAM, the Node-level data volume from OAM, and the data volume of the required granularities (as described in 5.X.2.1) from SMF/UPF.

The data volume of the required granulairities (as described in 5.X.2.1) are obtained as follows:

* Case A) For per UE granularity, the consumer NF (e.g., AF or NWDAF) provides UE ID to EECF, and EECF subscribes the UDM through Nudm\_UECM\_Get service operation to retrieve the SMF ID(s) which serving the UE. Then EECF gets the UE’s traffic data volume through invoking Nsmf\_EventExposure service. SMF requests the corresponding UPF(s) which serving the UE to report the data volume of the UE.
* Case B) For per PDU session granularity, the consumer NF (e.g., AF or NWDAF) provides UE address to EECF. EECF reaches the PCF as described in clause 4.3.6.4 in TS23.502[x] and PCF reports the SMF ID to EECF. The EECF finds the SMF serving the PDU session from UDM. Then EECF gets the PDU session’s traffic data volume through invoking Nsmf\_EventExposure service. SMF requests the corresponding UPF(s) which serving the PDU session to report the data volume of the PDU session. If there is I-SMF and/or I-UPF, the SMF request I-SMF to report the data volume with the traffic filter at the I-UPF.
* Case C) For per-UE-per-QoS flow or per-UE-per-application, the consumer NF (e.g., NWDAF or AF) provides UE address, Flow Description(s) to EECF. EECF reaches the PCF as described in clause 4.3.6.4 in TS23.502[x] and PCF reports the SMF ID to EECF. EECF gets the per-UE-per-QoS flow or per-UE-per application data volume through invoking Nsmf\_EventExposure service. SMF requests the corresponding UPF(s) which serving the PDU session to report the data volume of the PDU session. If there is I-SMF and/or I-UPF, the SMF request I-SMF to report the data volume with the traffic filter at the I-UPF..

EECF requests the UPF node-level energy consumption information and node-level data volume from OAM based on the UPF node ID reported from SMF.

When (I-)UPF is relocated, the SMF gets the new (I-)UPF ID and update to EECF.

NOTE 1: For example, the potential formula for Energy Consumption of UE in UPF(s) over a time period T is
,

where are all (I-)UPFs used by the UE in a time period T, and is the energy consumption the UE in i-th UPF. One potential approach to estimate is

Where is the total energy consumption of the UPF (provided by OAM) over a time period T, is the data volume correspond to the UE in the i-th UPF and is the total data volume transmitted for all UEs at the i-th UPF.

#### 5.X.2.3 Energy Consumption information for gNB

Energy Consumption information at the given granularity level per gNB is calculated based on the gNB Node-level energy consumption information from OAM, gNB Node-level data volume from OAM, and the data volume of the required granularities (as described in 5.X.2.1) which are assumed to be the same value as the data volume in the UPF.

The EECF gets the SMF ID(s) based on the Case A-C, and requests the SMF(s) to report the gNB ID which serving the UE. During the handover, the target gNB ID will be updated in SMF and SMF reports this new gNB ID to EECF.

The EECF requests the OAM to report the Node-level data volume and the Node-level Energy Consumption information with providing the gNB ID.

NOTE: For example, one potential formula for Energy Consumption of UE in gNB over a time period T is ,

where are all gNBs used by the UE a time period T, and is the energy consumption the UE in i-th gNB. One potential approach to estimate it is

Where is the total energy consumption of the gNB (provided by OAM) over a time period T, is the data volume correspond to the UE in the i-th gNB and is the total data volume transmitted for all UEs at the i-th gNB.

Editor’s NOTE: It is based on RAN WGs decision whether the NG-RAN support to report UE level energy consumption information.

\* \* \* \* Forth change (all new text) \* \* \* \*

## 5.X.3 Policy control with considering energy-related information

Editor’s Note: This clause will specify the enhancements in the policy controls considering energy-related information.

\* \* \* \* Fifth change (all new text) \* \* \* \*

## 5.X.4 NF (re)selection with considering energy-related information

Editor’s Note: This clause will specify the enhancements in NF selection and reselection considering the energy-related information.

\* \* \* \* Sixth change (all new text) \* \* \* \*

## 5.X.5 UP Path Adjustment with considering energy-related information

Editor’s Note: This clause will specify adjustment of UP path of PDU sessions considering the energy-related information.

\* \* \* \* Seventh change \* \* \* \*

### 6.2.5 NEF

#### 6.2.5.0 NEF functionality

The Network Exposure Function (NEF) supports the following independent functionality:

- Exposure of capabilities and events:

 NF capabilities and events may be securely exposed by NEF for e.g. 3rd party, Application Functions, Edge Computing as described in clause 5.13.

 NEF stores/retrieves information as structured data using a standardized interface (Nudr) to the Unified Data Repository (UDR).

- Secure provision of information from external application to 3GPP network:

 It provides a means for the Application Functions to securely provide information to 3GPP network, e.g. Expected UE Behaviour, 5G-VN group information, time synchronization service information and PDU Set handling service specific information. In that case the NEF may authenticate and authorize and assist in throttling the Application Functions.

- Translation of internal-external information:

 It translates between information exchanged with the AF and information exchanged with the internal network function. For example, it translates between an AF-Service-Identifier and internal 5G Core information such as DNN, S-NSSAI, as described in clause 5.6.7.

 In particular, NEF handles masking of network and user sensitive information to external AF's according to the network policy.

- Redirecting the AF to a more suitable NEF/L-NEF e.g. when serving an AF request for local information exposure and detecting there is a more appropriate NEF instance to serve the AF's request.

- The Network Exposure Function receives information from other network functions (based on exposed capabilities of other network functions). NEF stores the received information as structured data using a standardized interface to a Unified Data Repository (UDR). The stored information can be accessed and "re-exposed" by the NEF to other network functions and Application Functions, and used for other purposes such as analytics.

- A NEF may also support a PFD Function: The PFD Function in the NEF may store and retrieve PFD(s) in the UDR and shall provide PFD(s) to the SMF on the request of SMF (pull mode) or on the request of PFD management from NEF (push mode), as described in TS 23.503 [45].

- A NEF may also support a 5G-VN Group Management Function: The 5G-VN Group Management Function in the NEF may store the 5G-VN group information in the UDR via UDM as described in TS 23.502 [3].

- Support management of ECS Address Information.

- Support management of relationship between DNAI and EAS Address Information.

- Exposure of analytics:

 NWDAF analytics may be securely exposed by NEF for external party, as specified in TS 23.288 [86].

- Retrieval of data from external party by NWDAF:

 Data provided by the external party may be collected by NWDAF via NEF for analytics generation purpose. NEF handles and forwards requests and notifications between NWDAF and AF, as specified in TS 23.288 [86].

- Support of Non-IP Data Delivery:

 NEF provides a means for management of NIDD configuration and delivery of MO/MT unstructured data by exposing the NIDD APIs as described in TS 23.502 [3] on the N33/Nnef reference point. See clause 5.31.5.

- Charging data collection and support of charging interfaces.

- Support of Member UE selection assistance functionality:

- NEF may provide one or more list(s) of candidate UE(s) (among the list of target member UE(s) provided by the AF) and additional information to the AF based on the parameters contained in the request from the AF as described in clause 5.46.2. NEF supports the translation of the member UE selection filtering criteria parameters received from the AF to the corresponding event or analytics filters that can be understood by the 5GC NFs for events or analytics related data collection. NEF interacts with 5GC NFs using existing services in order to collect the corresponding data and then derive the list(s) of candidate UE(s) and other assistance information as described in clause 4.15.13 of TS 23.502 [3].

- Support of Multi-member AF session with required QoS for a set of UEs identified by a list of UE addresses:

- Details are specified in clause 4.15.6.13 of TS 23.502 [3].

- Support of UAS NF functionality:

 Details are defined in TS 23.256 [136].

- Support of EAS deployment functionality:

 Details are defined in TS 23.548 [130].

- Support of SBI-based MO SM transmit for MSISDN-less MO SMS:

 Details are defined in TS 23.540 [142].

- Support PDU Set Handling as defined in clause 5.37.5.

- Support management of common EAS and common DNAI:

 Details are defined in TS 23.548 [130].

- Support request and exposure of energy related information as defined in clause 5.x.A specific NEF instance may support one or more of the functionalities described above and consequently an individual NEF may support a subset of the APIs specified for capability exposure.

NOTE: The NEF can access the UDR located in the same PLMN as the NEF.

The services provided by the NEF are specified in clause 7.2.8.

For external exposure of services related to specific UE(s), the NEF resides in the HPLMN. Depending on operator agreements, the NEF in the HPLMN may have interface(s) with NF(s) in the VPLMN.

When a UE is capable of switching between EPC and 5GC, an SCEF+NEF is used for service exposure. See clause 5.17.5 for a description of the SCEF+NEF.

#### 6.2.5.1 Support for CAPIF

When an NEF is used for external exposure, the CAPIF may be supported. When CAPIF is supported, an NEF that is used for external exposure supports the CAPIF API provider domain functions. The CAPIF and associated API provider domain functions are specified in TS 23.222 [64].

\* \* \* \* Eighth change \* \* \* \*

### 6.2.10 AF

The Application Function (AF) interacts with the 3GPP Core Network in order to provide services, for example to support the following:

- Application Function influence on traffic routing (see clause 5.6.7);

- Application Function influence on Service Function Chaining (see clause 5.6.16.2);

- Accessing Network Exposure Function (see clause 5.20);

- Interacting with the Policy and charging control framework (see clause 5.14);

- Time synchronization service (see clause 5.27.1.8);

- IMS interactions with 5GC (see clause 5.16).

- Support PDU Set Handling as defined in clause 5.37.5.

- Support request and exposure of energy related information as defined in clause 5.x.

Based on operator deployment, Application Functions considered to be trusted by the operator can be allowed to interact directly with relevant Network Functions.

Application Functions not allowed by the operator to access directly the Network Functions shall use the external exposure framework (see clause 7.3) via the NEF to interact with relevant Network Functions.

The functionality and purpose of Application Functions are only defined in this specification with respect to their interaction with the 3GPP Core Network.

\* \* \* \* Ninth change \* \* \* \*

Annex XX (informative):
Network Energy consumption information calculation

XX.1 general

This Annex provides examples on how to calculate the energy consumption.

XX.2 per PDU session Energy consumption calculation

For a certain time window, the Energy consumption of a PDU session is:

1. 

gNBi, i=1,,,m is a list of gNB serving the PDU session in the time window

UPFj, i=1,,,n is a list of UPF (including I-UPF) serving the PDU session in the time window

For each gNB serving UE in the time window (i.e. gNBi in the above formula), the EC of PDU session is:

1. 

For each UPF (i.e. UPFj) involving the PDU session of UE in the time window, the EC of the UPFj is:

1. 

The UPFs in this formula includes A-UPF and involved I-UPFs.

The EECF obtains , , ,  in a time windows from OAM.

The EECF obtains , from SMF serving the PDU session.

XX.3 per UE Energy consumption calculation

For a certain time window, the energy consumption of the UE is the sum of the energy consumption of all PDU sessions (see Annex XX.2) of the UE.

\* \* \* \* End of changes \* \* \* \*