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APEX STANDARDS

Navigating the AI/ML Landscape: Insights from 3GPP Contributions

Artificial Intelligence (AI) and Machine Learning (ML) integration into 3GPP standardization for 5G and emerging 6G Radio Access Networks (RANs) has marked a significant evolution in mobile communications. This report provides an in-depth exploration of the evolution of AI and ML technologies within the framework of 3GPP. It highlights the critical role played by advanced tools such as the Apex Standards 3GPP TDoc Analysis Platform in propelling innovation forward. Additionally, the report sheds light on practical applications and real-life implementations of these technologies.

AI/ML in 3GPP Standardization: A Paradigm Shift Early Stage Pre-Rel-17

Network Data Analytics Function (NWDAF): Introduced in Rel-15, NWDAF began as a network slice analysis tool and expanded to cover data collection and exposure in the 5G core by Rel-16 and UE application data collection in Rel-17.
SON and MDT: These projects established data collection procedures for various NR features, setting the groundwork for subsequent AI/ML integration.

Rel-17 and Rel-18

AI-Enabled RAN Study: A RAN3-led study in Rel-17 investigated the principles of RAN intelligence enabled by AI, leading to the approval of a normative project on AI/ML for NG-RAN in Rel-18.
Rel-18 Focus Areas: Emphasis was placed on enhancing data collection, signaling, and operational efficiencies like Network Energy Savings and Mobility Optimizations.

The Role of Apex Standards 3GPP TDoc Analysis Platform

Apex Standards' platform revolutionizes the way professionals handle Temporal Documents (TDocs), shifting from traditional spreadsheet methods to a more efficient, dynamic system. This tool is particularly crucial for standardization delegates and IPR professionals, offering capabilities such as:

Intuitive Search Tools: Enhanced by keyword search, dynamic filtering, and focus on specific agenda items or text proposals.
TDoc Analysis and Relations: Allowing users to track negotiation details, source of disagreements, and company strategies.
Insightful Visualization: Facilitates quick, insightful analysis of TDocs, enhancing the efficiency of deriving insights.

Real-Life Applications and Impact

Cross-Vendor Interoperability: AI/ML technologies in 5G RAN, as detailed by Ericsson researchers Angelo Centonza and Ioanna Pappa, require precise rules to regulate communication and behavior among various system components.
RAN Optimization: AI/ML applications in load balancing, mobility optimization, and network energy saving are crucial.
Enhanced Network Management: AI/ML increases operational efficiency through automation and predictive analytics.

Rel-19 and Beyond

5G-Advanced and 6G: These future network generations will be AI-native, with AI deeply embedded across devices, radio, and RAN, as indicated in the 3GPP Release 18 work plan.
New AI/ML Use Cases: Expected developments include dynamic cell shaping and UE performance optimization.

Systematic Analysis

Efficient Tracking and Analysis: The platform enables quick identification of responsible working groups and concerned TS/TDocs, facilitating reverse look-up on affected technical clauses.
IPR and Standard Essential Patent Portfolio Developments: The tool aids in navigating the complex landscape of intellectual property in telecom standards.

Challenges and Opportunities in AI/ML for 3GPP Standardization

Interoperability and Standardization

Challenge: Ensuring AI/ML algorithms' outputs are understandable across vendors and systems is complex due to the diverse implementation methods and the 'black-box' nature of these technologies.
Opportunity: Standardizing AI/ML processes can enhance the efficiency of 5G/6G networks, leading to optimized system and elevated user experiences.
How Apex Standards Helps: The platform streamlines your access to the latest standards discussions and agreements. Our platform offers comprehensive analyses, proposal comparisons, historical insights, and evaluates the impact of new standards on your company's position. This empowers researchers and 3GPP delegates to stay abreast of evolving standards, contributing more effectively to the standardization process. *continued ►*

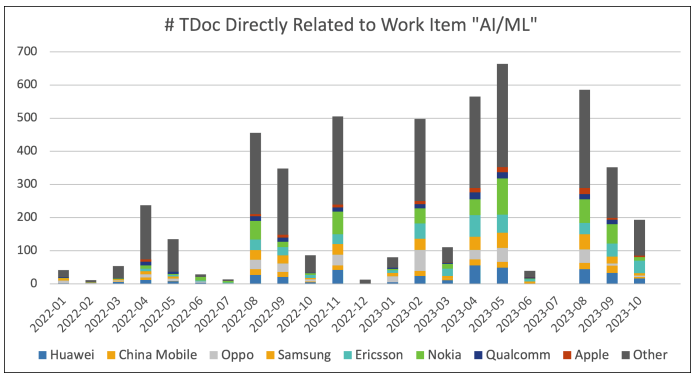

Figure Historical Construction. TDocs start to be formally linked with "AI/ML" Work Items since early 2022. Top contributors include Huawei, China Mobile, Oppo, Samsung, Nokia and Ericsson.

3GPP Related Work Item	C1	C3	C4	C6	CP	R1	R2	R3	R4	R5	RP	S1	S2	S3	S4	S5	S6	SP
AIML_MGT																258		2
AIML_MT												4						1
AIML_MT_Ph2												5						
AIMLsys		184	33		11			1					486					1
AIMLsys, eNA_Ph3		2											4					
AIMLsys, GMEC		1											1					
AIMLsys, NBI18		1																
eMDAS, AIML_MGT																2		
eNA_Ph3, AIMLsys		4											4					
FS_AIML														79				1
FS_AIML_MGMT																262		3
FS_AIML_MGMT, FS_eIDMS_MN																10		
FS_AIML_MGMT, FS_MANWDAF																2		
FS_AIML_MT												1						1
FS_AIML_MT_Ph2												89						3
FS_AIML_MT_Ph2, FS_Sensing												2						
FS_AIML_MT_Ph2,FS_Sensing												1						
FS_AIMLAPP																	47	
FS_AIMLsys												2	423		1			3
FS_MANWDAF, FS_AIML_MGMT																2		
FS_NR_AIML_Air						2092	379		131		33							
FS_NR_AIML_NGRAN_SEC														47				1
GMEC, AIMLsys													6					
NR_AIML_NGRAN-Core								542			13							
UPEAS, AIMLsys, eNA_Ph3													1					

Table 1 AI/ML Work Item-Working Group Matrix. AI/ML topics are relevant to nearly all working groups except CT1 and CT6 when viewed vertically. Horizontally, for instance, the "FS_NR_AIML_Air" Work Item is connected to 2,092 TDocs in RAN 1, 379 in RAN 2, and 131 in RAN 4, predominantly within the RAN TSG. In contrast, "AIMLsys" is broadly examined across multiple TSGs, with 184 TDocs in CT3, 1 in RAN3, and 486 in SA2.

3GPP WI-TS	22.261	22.837	22.874	22.876	23.288	23.501	23.502	23.503	23.700-80	23.700-82	28.105	28.541	28.864	28.908	28.912	29.122	29.503	29.508	29.510	29.513
AIML_MGT											254	1								
AIML_MT	3																			
AIML_MT_Ph2	5																			
AIMLsys					68	94	234	52								16	28	6	8	14
AIMLsys, NBI18																1				
eMDAS, AIML_MGT											2									
eNA_Ph3, AIMLsys																		2		
FS_AIML_MGMT											1		2	262	10					
FS_AIML_MGMT, FS_MANWDAF													2							
FS_AIML_MT_Ph2		2	2	88																
FS_AIML_MT_Ph2, FS_Sensing		1																		
FS_AIMLAPP										47										
FS_AIMLsys					1		2		402											
FS_AIMLsys, AIMLsys					1											1				
FS_eIDMS_MN															10					
FS_MANWDAF, FS_AIML_MGMT													2							
FS_NR_AIML_air																				
NR_AIML_NGRAN-Core																				

3GPP WI-TS	29.514	29.517	29.519	29.520	29.522	29.543	29.552	29.591	33.877	33.898	37.483	38.133	38.300	38.401	38.413	38.420	38.423	38.473	38.843
AIML_MGT																			
AIML_MT																			
AIML_MT_Ph2																			
AIMLsys	4	15	9	54	51	20	5	11											
AIMLsys, NBI18																			
eMDAS, AIML_MGT																			
eNA_Ph3, AIMLsys				2															
FS_AIML_MGMT									48										
FS_AIML_MGMT, FS_MANWDAF																			
FS_AIML_MT_Ph2																			
FS_AIML_MT_Ph2, FS_Sensing																			
FS_AIMLAPP																			
FS_AIMLsys										79		3							
FS_AIMLsys, AIMLsys				2															
FS_eIDMS_MN																			
FS_MANWDAF, FS_AIML_MGMT																			
FS_NR_AIML_air												3							24
NR_AIML_NGRAN-Core											8		35	13	5	6	93	5	

Table 2 AI/ML Work Item-TS Matrix. Having a comprehensive overview is essential, particularly for researchers focusing on specific work items (WIs) due to professional assignments or upstream requirements. This enables them to swiftly identify relevant Technical Specifications (TS) to progress their work. For instance, some WIs like AIMLsys are associated with a broad spectrum of TS. In contrast, others, such as AIML_MT, currently link solely to TS 22.261. Conversely, when researchers start with a specific TS, it's beneficial to trace back and explore which WIs are connected, facilitating a reverse-engineering approach to understand the underlying WIs driving these specifications.

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Lifecycle Management of AI/ML Models

Challenge: Managing the lifecycle of AI/ML models, including the development, deployment, and maintenance, is critical. This involves handling complex data, ensuring accuracy, and updating models in response to evolving network conditions.
Opportunity: Effective lifecycle management ensures AI/ML applications remain efficient and relevant, improving network performance and adapting to changing network environments.
How Apex Standards Helps: The platform's advanced search and analysis capabilities can assist in tracking the evolution of discussions related to AI/ML model lifecycle management. It provides a comprehensive view of ongoing work, including various approaches and methodologies being considered within 3GPP.

Sustainability and Trustworthiness

Challenge: AI/ML solutions must be evaluated for their energy efficiency and ethical implications. This includes considering the total energy footprint of AI/ML operations and ensuring AI/ML models are transparent and fair.
Opportunity: By focusing on sustainable and trustworthy AI/ML solutions, the telecom industry can lead in responsible innovation, ensuring that advancements are beneficial.
How Apex Standards Helps: By providing access to the latest research and discussions on sustainability and ethics in AI/ML, the platform helps innovators and researchers align their work with these crucial aspects. It allows for a thorough understanding of the industry's direction regarding sustainable and ethical AI/ML development.

How Apex Standards 3GPP TDoc Analysis Platform Drives Innovation

Finding Relevant Information

Method: The platform offers sophisticated filtering and search tools that sift through vast amounts of data to identify relevant TDocs, discussions and decisions.
Impact: Researchers, inventors, and 3GPP delegates can quickly locate the information they need, saving time and resources that can be better spent on innovation.

Performing High-Quality Analysis

Method: With features like visualization tools and comprehensive data categorization, the platform enables deep analysis of trends, patterns, and relationships of TDocs.
Impact: This level of analysis can reveal insights into technology trends, standardization progress, and potential areas for innovation, guiding inventors and researchers towards productive and impactful areas of development.

Facilitating Collaboration and Consensus

Method: By offering an overview of various stakeholders' positions and arguments, the platform improves understanding of different perspectives in 3GPP.
Impact: This understanding is crucial for building consensus, essential for successful standardization and the adoption of new technologies in the industry.

TS	Affected Versions	Affected Clauses Corresponding to TS Sections	TDoc Contributor	TDoc Change Request Details	Related Work Item
23.288	17.6.0	2 References	Samsung	S2-2210600 Rev: 0 CR Num: 0575 S2-2211180 Rev: 0 CR Num: 0575 S2-2211330 Rev: 2 CR Num: 0575	AIMLsys
23.288	17.6.0	6.14.3 Output Analytics	Ericsson	S2-2210268 Rev: 0 CR Num: 0555	AIMLsys
23.288	17.6.0	6.2.9 User consent for analytics	Huawei	S2-2210634 Rev: 0 CR Num: 0579	AIMLsys
23.288	17.6.0	6.6.1 General	Huawei	S2-2210426 Rev: 0 CR Num: 0566 S2-2211183 Rev: 1 CR Num: 0566 S2-2211331 Rev: 2 CR Num: 0566	AIMLsys
23.501	17.6.0	7.2.4 PCF Services	Huawei, OPPO	S2-2210632 Rev: 0 CR Num: 3796 S2-2211185 Rev: 1 CR Num: 3796 S2-2211333 Rev: 2 CR Num: 3796	AIMLsys
23.502	17.6.0	4.15.6.6 Setting up an AF session with required QoS procedure 4.15.6.6a AF session with required QoS update procedure	Intel	S2-2210808 Rev: 0 CR Num: 3647	AIMLsys
23.502	17.6.0	4.15.6.6 Setting up an AF session with required QoS procedure 4.15.6.6a AF session with required QoS update procedure	Samsung	S2-2210570 Rev: 0 CR Num: 3627	AIMLsys
23.502	17.6.0	5.2.13.2.4 Nbsf_Management_Discovery service operation	Intel	S2-2210811 Rev: 0 CR Num: 3648	AIMLsys
23.502	17.6.0	5.2.5.1 General	Huawei, OPPO	S2-2210633 Rev: 0 CR Num: 3630 S2-2211186 Rev: 1 CR Num: 3630 S2-2211334 Rev: 2 CR Num: 3630 S2-2211426 Rev: 3 CR Num: 3630	AIMLsys
23.503	17.6.0	6.1.1.2.2 The Binding Support Function (BSF)	Samsung	S2-2210569 Rev: 0 CR Num: 0778	AIMLsys
28.105	17.3.0	6.1 General 6.2.1 Description 6.2.2.1 ML training requested by consumer 6.2.2.2 ML training initiated by producer 6.2.2.3 ML model and and ML entity selection 6.2.2.4 Managing ML training processes 6.2.2.5 Handling errors in data and ML decisions 6.2.3 Requirements for ML training	Nokia, TELUS	S5-233947 Rev: 0	AIML_MGT
37.483	17.5.0	8.1 List of E1AP Elementary Procedures	Samsung	R3-233943 Rev: 0 CR Num: 0070	NR_AIML_NGRAN-Core
37.483	17.1.0	8.2.9.2 Successful Operation	Samsung	R3-224855 Rev: 0 CR Num: 0036	NR_AIML_NGRAN-Core
38.300	17.1.0	15.5.1.1 General	Huawei	R3-224891 Rev: 0	NR_AIML_NGRAN-Core
38.300	17.1.0	15.5.1.2 Load reporting for intra-RAT and intra-system inter-RAT load balancing	Huawei	R3-224891 Rev: 0	NR_AIML_NGRAN-Core
38.300	17.1.0	15.5.1.4 Adapting handover and/or reselection configuration	Huawei	R3-224891 Rev: 0	NR_AIML_NGRAN-Core
38.300	17.1.0	15.5.1.5 Load reporting for inter-system load balancing	Huawei	R3-224891 Rev: 0	NR_AIML_NGRAN-Core
38.401	17.1.1	7.0 General 7.1 NG-RAN sharing 7.10 Support of RAN visible QoE measurement 7.2 Remote Interference Management 7.3 Cross-Link Interference Management 7.4 Support for Non-Public Networks 7.5 RACH Optimisation Function 7.6 Positioning 7.7 Support for NR MBS 7.7.1 Support of dynamic PTP and PTM switching 7.8 PCI Optimisation Function 7.9.1 General 7.9.2 OAM requirements 7.9.3 Dynamic coverage configuration changes	CMCC	R3-225058 Rev: 1 CR Num: 0253	NR_AIML_NGRAN-Core
38.420	17.2.0	3.1 Definitions	CATT	R3-235954 Rev: 0 CR Num: 0036	NR_AIML_NGRAN-Core
38.420	17.2.0	3.1 Definitions	CATT, Nokia	R3-237027 Rev: 0 CR Num: 0036	NR_AIML_NGRAN-Core
38.420	17.2.0	6.2.1 Mobility management procedures 6.2.10 IAB procedures 6.2.11 MBS Management procedures 6.2.12 Small data transmission procedures 6.2.13 QMC support procedures 6.2.2 Dual Connectivity procedures 6.2.3 Global procedures 6.2.4 Interface Management procedures 6.2.5 Energy saving procedures 6.2.6 Resource coordination procedures 6.2.7 UE Tracing procedures 6.2.8 Load management procedures 6.2.9 Data exchange for self-optimisation procedures	CATT, CMCC	R3-230255 Rev: 0	NR_AIML_NGRAN-Core
38.423	17.2.0	3.2 Abbreviations	Ericsson	R3-226495 Rev: 0	NR_AIML_NGRAN-Core
38.423	17.4.0	8.1 Elementary procedures	Ericsson	R3-231133 Rev: 4 CR Num: 0959 R3-232523 Rev: 5 CR Num: 0959	NR_AIML_NGRAN-Core
38.423	17.4.0 17.5.0	8.1 Elementary procedures	Ericsson, Nokia	R3-233535 Rev: 6 CR Num: 0959 R3-233756 Rev: 7 CR Num: 0959 R3-234786 Rev: 8 CR Num: 0959	NR_AIML_NGRAN-Core
38.423	17.2.0	8.1 Elementary procedures	Samsung	R3-225705 Rev: 0 CR Num: 0920	NR_AIML_NGRAN-Core
38.423	17.2.0	8.2.1.2 Successful Operation	Ericsson, InterDigital, Verizon	R3-225512 Rev: 0 CR Num: 0912 R3-226508 Rev: 0 CR Num: 0948	NR_AIML_NGRAN-Core
38.423	17.2.0	8.2.1.2 Successful Operation	Samsung	R3-225706 Rev: 0 CR Num: 0921	NR_AIML_NGRAN-Core
38.423	17.1.0	8.4.10.2 Successful Operation	Huawei	R3-224892 Rev: 0 CR Num: 0894	NR_AIML_NGRAN-Core
38.423	17.1.0 17.2.0	8.4.10.2 Successful Operation	Samsung	R3-224853 Rev: 0 CR Num: 0889 R3-225704 Rev: 0 CR Num: 0919	NR_AIML_NGRAN-Core
38.473	17.2.0	8.1 List of F1AP Elementary procedures 8.10.0 General 8.10.1.1 General 8.10.1.2 Successful Operation 8.10.1.3 Abnormal Conditions 8.10.1.A Unsuccessful Operation 8.10.2.1 General 8.10.2.2 Successful Operation 8.10.2.3 Abnormal Conditions 8.10.2.B Unsuccessful Operation 8.10.3.1 General 8.10.3.2 Successful Operation 8.10.3.3 Abnormal Conditions 8.10.3.C Unsuccessful Operation 8.10.4.1 General 8.10.4.2 Successful Operation 8.10.4.3 Unsuccessful Operation 8.10.4.4 Abnormal Conditions 8.11.1.1 General 8.11.1.2 Successful Operation	Huawei	R3-225849 Rev: 0 CR Num: 1067 R3-226615 Rev: 0 CR Num: 1099	NR_AIML_NGRAN-Core
38.473	17.1.0	8.2.10.2 Successful Operation	Huawei	R3-224893 Rev: 0 CR Num: 1026	NR_AIML_NGRAN-Core
38.473	17.1.0	8.2.10.2 Successful Operation	Samsung	R3-224854 Rev: 0 CR Num: 1023	NR_AIML_NGRAN-Core

Table 3 Intellectual Property Rights. Companies may submit Change Requests (CRs) to influence existing standards, especially if they own patents related to the proposed changes. Once a patented method becomes part of a standard, the company may benefit from licensing it, creating a sustainable innovation cycle. For example, Huawei submitted two CRs, R3-225849 and R3-226615, seeking sweeping changes to existing standards in TS 38.473 starting in Version 17.2.0, affecting a total of 20 section clauses, including 8.1, 8.10, and 8.11 subsections.

The Apex Standards 3GPP TDoc Analysis Platform is more than just an efficient tool for retrieving information; it's a catalyst for 5G/6G innovation. By addressing key challenges for AI/ML integration, we empower stakeholders to drive forward-looking R&D, fostering a future in telecommunication more interconnected and beneficial to human life.

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