Tech Report C20003158 Historical Construction Unclassified

20 Dec 2023

APEX STANDARDS 3GPP NTN Store and Forward: A Timeline from Inception to 5G Integration

tore and Forward (S&F) operations have become an essential functionality within 5G communication frameworks, especially for User Equipment (UEs) that rely on satellite connectivity. This

feature is tailored to ensure service continuity. This where satellite links are irregular or temporarily unavailable, for instance, during periods when satellites lack a direct feeder link connection or when communication between satellites through Inter-Satellite Links (ISL) is not established. The S&F capability is particularly crucial for services that can tolerate delays in data transmission, maintaining a flow of communication despite the inherent challenges of satellite-based networks.

Inception of the S&F Idea

The history of the S&F feature within the 3GPP standards reflects an ongoing evolution to meet the dynamic needs of network operations and management. Initially brought to the table by Ericsson on February 26, 2014 (S5-140287), the focus was on managing network performance while adhering to user privacy constraints, specifically in the context of Self-Organizing Networks (SON). This foundational work addressed the complexities of correlating anonymized data for network optimization without compromising individual identities, a key concern in the increasingly privacy-aware telecommunications.

Huawei's involvement, noted on January 30, 2015 (S2-150468), marked a shift towards a practical application of S&F functions, proposing a mechanism that leveraged network monitoring capabilities to store data for User Equipments (UEs) that were temporarily unreachable due to power-saving modes or sporadic connectivity. This proposal underscored the S&F feature's potential for reducing latency and enhancing data delivery efficiency in various network scenarios.

Qualcomm also contributed to the discourse on December 2, 2014 (RP-141992), emphasizing the need for network enhancements to support extended Discontinuous Reception (DRX) in Long Term Evolution (LTE), where S&F functionality could be critical for efficient network paging and data services.

Five-Year Dormancy Followed by Renewed Presentation in the 5G NTN Scenario

After this initial flurry of activity, the topic did not see much discussion until it was revisited by China Mobile Commu-

nications Corporation on May 24, 2020 (S6-200908), in the burgeoning context of 5G. This revival in SA6 signified the increasing importance of S&F, particularly for messaging services, reflecting the industry's pivot towards the next generation of mobile communications.

The relevance of S&F functions continued to grow with the involvement of companies like Sateliot (RP-210434) and Novamint, as evidenced by discussions and documents through 2021. These companies highlighted the significance of S&F in the Non-Terrestrial Networks (NTN) and IoT domains, proposing the development of satellite constellations that could support delay-tolerant services through S&F architectures.

Most recently, a broad consortium of entities, including Novamint, Nokia, ETRI, Sateliot, Gatehouse, CATT, China Telecom, JSAT and LGE, further solidified the feature's role by agreeing on consolidated requirements for S&F operations in S1-232533 on August 27, 2023. This consensus illustrated the widespread industry acknowledgment of S&F's function in enabling flexible communication solutions, particularly in satellite operations where constant connectivity cannot be guaranteed.

The S&F feature's journey through the 3GPP discussions thus mirrors the telecommunications industry's broader trends: from enhancing privacy and network management to supporting the advanced functionalities required by 5G and satellite technologies.

The S&F operation can be categorized into two scenarios:

Single Satellite Operation: This involves a scenario where the satellite stores data received from the UE when both the service and feeder links are unavailable. Once the feeder link becomes available, the satellite forwards the stored data to the ground network. This process is crucial in maintaining communication continuity in areas where direct, consistent satellite connectivity is not feasible.

Multiple Satellites Operation via Inter-Satellite Links: In this scenario, a satellite (Satellite A) stores data received from the UE. If both the service and feeder links of all satellites in the group are unavailable, Satellite A retains the data. The data is then forwarded either when Satellite A's feeder link is available or to another satellite (Satellite B) in the group that has an operational feeder link to the ground network, enhancing the resilience and coverage and ensuring data delivery across vast and remote areas. Implementing S&F operations in 5G systems is vital for remote monitoring services using IoT devices worldwide, in areas with limited mobile coverage. These devices, often in remote locations, rely on satellite communication. The S&F operation allows consistent data transmission to application servers, overcoming challenges of intermittent satellite connectivity.

The 3GPP TS 22.261 document requires 5G systems to provide services via satellite, focusing on low-power Machine-type Internet of Things (MIoT) communications. However, it falls short in addressing the needs of delay-tolerant, non-real-time IoT services using Non-Geostationary Orbit (NGSO) satellites. To improve this, S&F mechanisms are proposed to enhance NGSO satellite constellations' cost-effectiveness. Implementing S&F in 5G satellite operations requires additional parameters such as data retention periods, storage quotas, and Quality of Service (QoS) configurations. This ensures efficient management of S&F operations and reliable IoT service delivery in satellite networks. Current industry trends emphasize the importance of IoT NTN, offering a cost-effective solution by reducing both capital (CAPEX) and operational expenditures (OPEX) in satellite communications.

The S&F feature in satellite communications is indispensable for ensuring continuous and reliable data transmission in 5G networks, especially in scenarios where direct and constant connectivity to satellites is not available. This feature not only facilitates robust communication in remote and challenging environments but also expands the scope and reliability of satellite-based communication services.

DISCLAIMER An in-depth examination of technology's historical development offers strategic insights by exploring its evolution, past milestones, and impact on driving innovation and influencing policy. This analysis also projects future technological trends and provides a detailed evaluation of intellectual property portfolios, particularly in the context of standardization, while considering economic and societal factors. This sample report is strictly based on the keyword match "Store and Forward", without considering similar terminologies like "Save and Transmit," "Preserve and Send," or "Receive and Relay," etc. For more extensive and customized research on select topics, Apex Standards offers high quality due diligence services, available upon request.

TS/TR	Proposals Chair N	Notes Has Prior	Has Posterior	# TDocs	# Sources	# Industries		TS Meeting Seq.	# Prior TDocs	# Posterior TDocs	
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Working Group	Meeting	Agenda Item	Release	Keywords		Related We	ork Item	Technical Specificatio	on/Technical Report		
S1 Services (SA1) S2 Architecture (SA2) RP Radio Access Netw	S2-159 2023-10-09 Xiamen	7.7 FS_5GSAT_Ph3: New SID on satellit 7.7 FS_5GSAT_Ph3: New SID on satellit N/A 7.7.1 FS_5GSAT_Ph3: New SID on satel 10 Future work / New WIDs (including re	lite access Rel-19	5GMSG	ated requirements Service phase 2 Access Phase 3	N/A FS_5GSA 5GMARC	н	N/A TR 22.865 Study on se	atellite access - Phase 3		
SP Service & Systems		4 High-level overview proposals for Rel- 8A.2.7 NTN Evolution 17.34 CT aspects for enabling MSGin50 17.35 CT aspects for enabling MSGin50	3 Service	new term 10.24 s.	SA WG2 meeting new terminology 10.24 s. BRC inactive	5GMARC	5GSAT_Ph3 5GMARCH_Ph2 FS 5GSAT_ARCH_Ph3		TS 29.538 Enabling MSGin5G Service; Application Programming Interfaces (API) speci TS 22.261 Service requirements for the 5G system		
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S4 Codec (SA4)	(c S1-102 2023-03-22 Berlin SP-99 2023-03-21 Rotterdam (c S1-101 2023-02-20 Athens S1-100 2022-11-14 Toulouse	7.8 FS_5GSAT_Ph3 8A.2 RAN2-led proposals 3 SA2#159 Meeting report 9.0.1 General 3 Report from previous meetings	Rel-13	clause 5.16 discussion eDRX longer Ph3 Key issue		FS_REDCAP_Ph2 5G_ProSe MCPTT, 640142, 670031	TR 23.709 Study on optimizations to support high latency communications; Stage 2				
S3 Security (SA3)	Others	Others		Others	15500	TEI17, NF	R_redcap-Core	TS 33.503 Security As	pects of Proximity based	Services (ProSe) in the 5G System (5G	
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Source or Contributor	Industry	У	HQ Geography	Contact Person	Туре	Status	CR Category	CR Number	CR Revision	CR Version	
Huawei China Mobile Com. Cor Novamint, Huawei, ETF CATT		P Internal conductor rs	3GPP Internal CN Others	Alain Sultan / ID: 1034 Import from MS Acces Maurice Pope / ID: 648 Yue Liu / ID: 80533	S. discussion	revised agreed noted	N/A	N/A	N/A	N/A	
Huawei, HiSilicon MediaTek Inc.	Opera I, Nokia, Gatehouse, China Tele Equip		CN+EU+KR EU CN+US	Bernt Mattsson / ID: 14 Joern Krause / ID: 125 Han Wang / ID: 92678 Guillaume Sebire / ID:	45 CR 78 other	not treated approved	B addition of feature	0004	1	19.0.0	
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Apex Standards 3GPP TDoc Analysis Platform, which is used to meticulously scan the TDoc database spanning from 1999 to 2023 for the term "Store and Forward," reveals its earliest recorded mention in 2014 within Ericsson's document S5-140287. This initial reference was subsequently followed by mentions in Huawei's S2-150468 and Qualcomm's RP-141992, under slightly different contexts. After a five-year hiatus, the term resurfaced in China Mobile's document S6-200908 in 2020. Since then, there has been a growing trend of various companies acknowledging the significance of Store and Forward (S&F), leading to the integration and standardization of related operational features into the pertinent Technical Specifications (TS) and Technical Reports (TR).