

APEX STANDARDS

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

Sore 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 in scenarios 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.

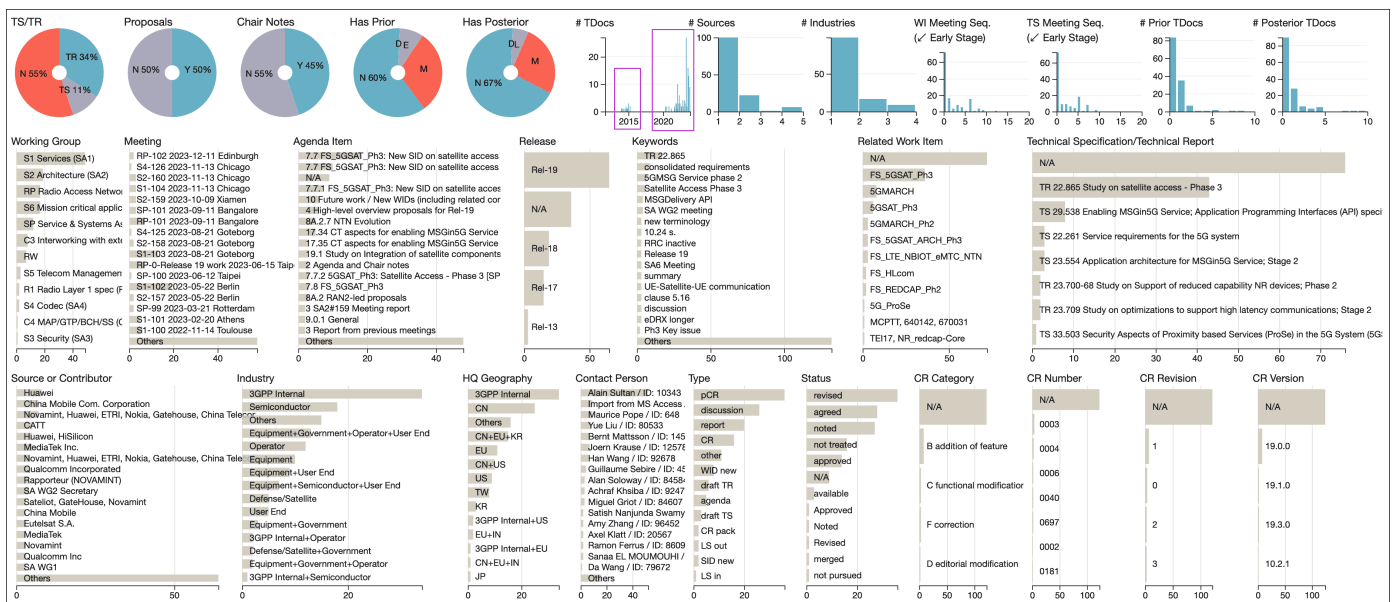
Multiple Satellites Operation via Inter-Satellite Links: In this scenario, a satellite (Satellite A) stores data received from the UE. If both the service and feeder links of all satellites in the group are unavailable, Satellite A retains the data. The data is then forwarded either when Satellite A's 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.



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).