DOCUMENT

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About 5G nFAPI

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www.smallcellforum.org

Small Cell Forum develops the technical and commercial enablers to accelerate small cell adoption and support the digital transformation of enterprises and communities.

Broad roll-out of small cells will make high-grade mobile connectivity accessible and affordable for industries, enterprises and for rural and urban communities. That, in turn, will drive new business opportunities for a widening ecosystem of service providers.

Those service providers are central to our work program. Our operator members establish the requirements that drive the activities and outputs of our technical groups.

We have driven the standardization of key elements of small cell technology including Iuh, FAPI, nFAPI, SON, services APIs, TR-069 evolution and the enhancement of the X2 interface. These specifications enable an open, multivendor platform and lower barriers to densification for all stakeholders.

Today our members are driving solutions that include:

- 5G Components, Products, Networks
- Dis-aggregated 5G Small Cells
- Planning, Management and Automation
- 5G regulation & safety
- Neutral Hosts & Multi-operator
- Private and Public Network coexistence
- Edge compute with Small Cell Blueprint
- End to end orchestration

The Small Cell Forum Release Program website can be found here: www.scf.io

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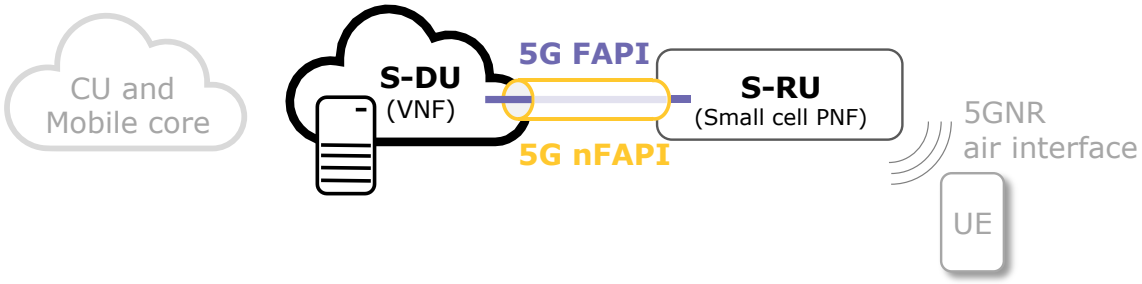
Executive summary

5G nFAPI Overview

As the industry moves towards a more open and disaggregated RAN, several different functional split options have been shortlisted by MNOs (mobile network operators) as candidates for further evaluation. MNOs have requested standards development of selected split options to enable further evaluation, and SCF has developed specifications for split Option 6 named nFAPI (network Functional API).

5G nFAPI is a network interface which leverages the widely adopted FAPI system-on-a-chip PHY API used in the vast majority of the world's SoC based small cells [SCF222]. The first release of the nFAPI specification, 5G nFAPI 1.0, was published September 2020 and enables early implementations for evaluation by mobile operators and other small cell deployers.

'5G nFAPI', release 1.0 Sep 2020, Small Cell Forum, www.scf.io/doc/225



5G nFAPI 1.0 adds a network transport wrapper around the 5G FAPI PHY API [SCF222] to create the split option-6 interface between S-RU and S-DU network nodes.

- **The S-RU (SCF Remote Unit)** is the small cell or physical network function (PNF).
- **The S-DU (SCF Distributed Unit)** can be a virtual network function (VNF), or could be physical.
- **A CU (Central Unit)** may or may not be co-located with the S-DU. Along with mobile core network aspects, the CU is out of scope for this first release.

In this informative companion document to the normative specification we provide an overview of the specification's application, a roadmap for ongoing feature implementation and ecosystem support, and an FAQ.

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1. FAPI vs nFAPI

It is important to understand the differences between FAPI and nFAPI:

FAPI is a set of APIs for small cell components, so *internal* interfaces for small cells. It is defined by component suppliers and adopted by software stack vendors and small cell integrators. It is applicable for both integrated and disaggregated base stations for all split options.

nFAPI 'wraps' these APIs to make them transportable over network connections. nFAPI is therefore an *external* network interface between S-RU and S-DU network nodes. It is defined by small cell component and system suppliers, for use by deployers and operators in building open RAN small cell networks.

2. nFAPI Details

The S-RU is not virtualized and is termed a PNF (Physical Network Function). Within the context of nFAPI, the PNF device is the physical radio unit (also called S-RU), which contains a number of PHY instances with associated RF chains within the PNF device. nFAPI resides between a VNF, including 5G NR L2/L3 software, and a separate PNF, including the L1 PHY. The nFAPI P5 interface configures the PNF device at the PNF device level and at the static PHY instance level. The nFAPI P7 interface operates the PHY instance for the slot procedures.

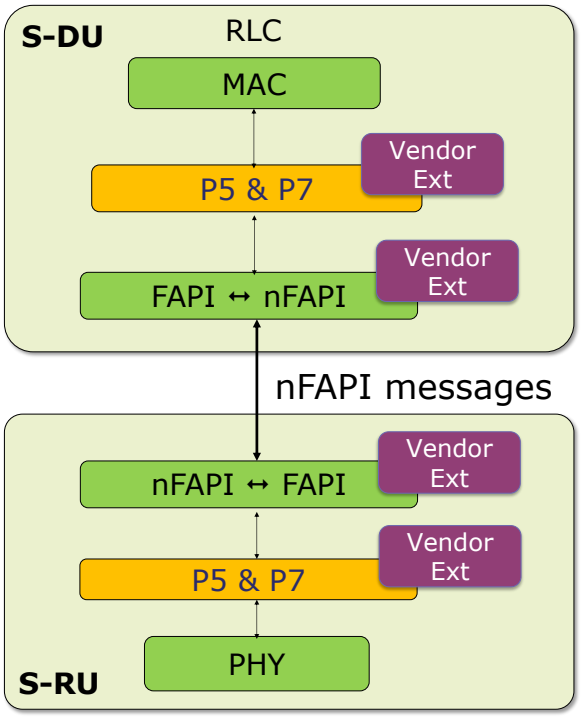


Figure 2–1 The relationship between FAPI and nFAPI

2.1.1 P5 and P7 interface and protocol stacks

The transport layer for nFAPI P5 (PHY mode control) is required to ensure reliable message transfer, so Stream Control Transmission Protocol (SCTP) is used as the transport protocol.

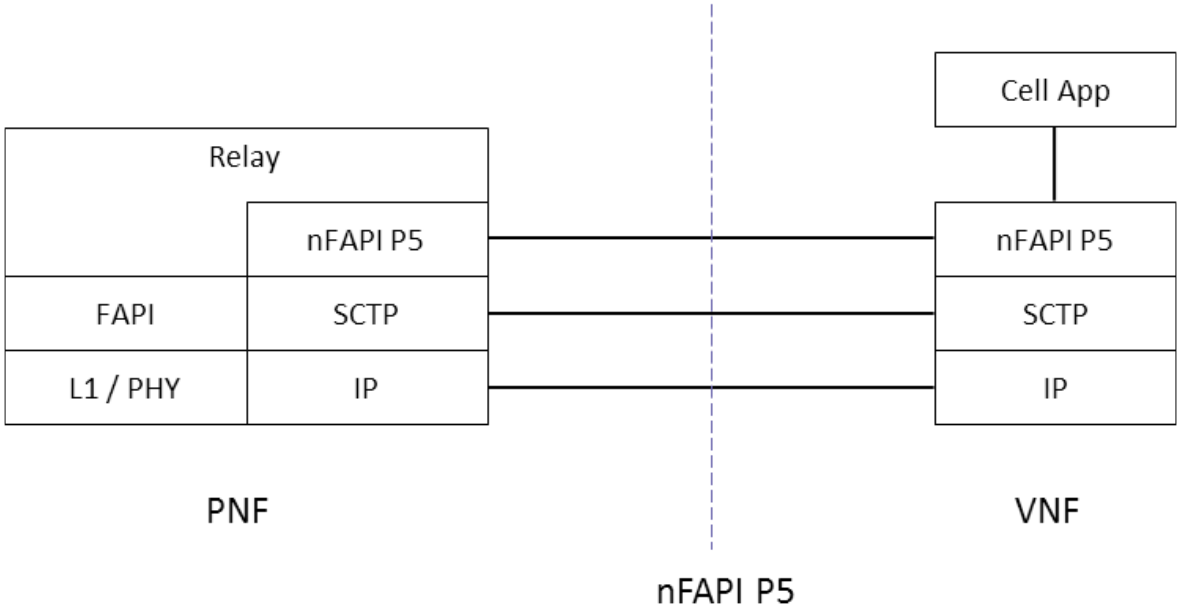


Figure 2–2 nFAPI P5 Protocol Stack

The P7 (main data path) interface uses UDP transport for data transfer and the P7 messages provide the ability to identify and handle the case of lost packets.

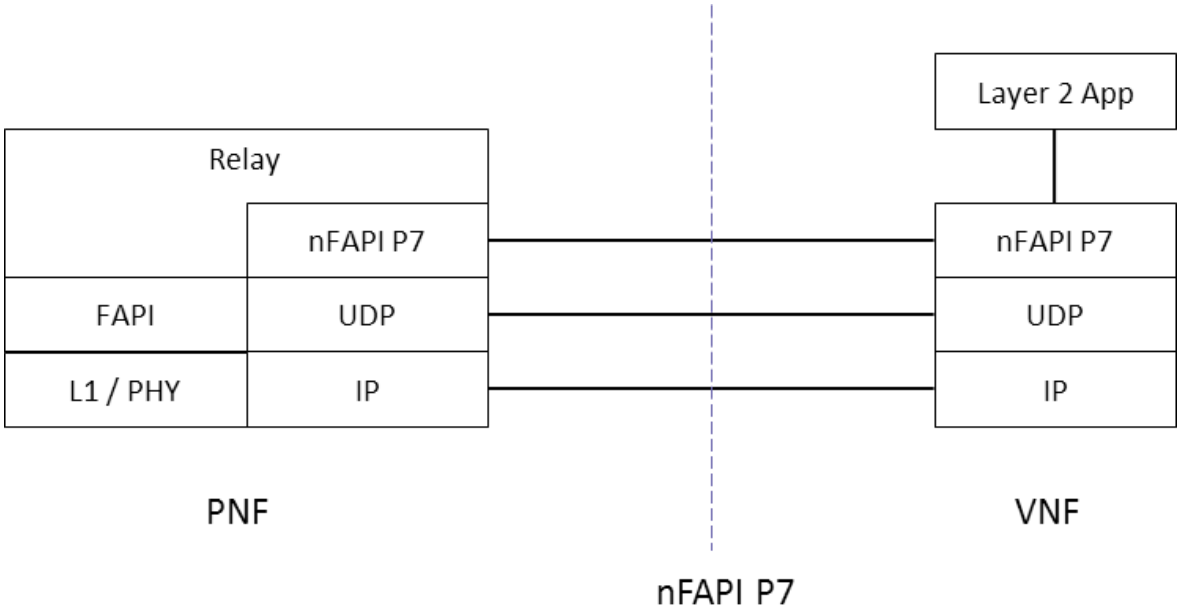


Figure 2–3 nFAPI P7 Protocol Stack

2.1.2 5G nFAPI message types

The nFAPI protocol carries three types of messages:

- **Dedicated nFAPI messages**: These are messages defined solely in the nFAPI protocol, e.g., PNF_XXX messages
- **Transparent messages**: These are messages that are defined in the 5G FAPI specification, and carried by the nFAPI protocol, as is. That is the nFAPI only provides a transport of these messages and does not modify these messages.
- **Combined messages**: These messages are defined by the 5G FAPI specification, but the nFAPI specification adds new values and TLVs to these messages.

3. 5G nFAPI Roadmap

5G nFAPI 1.0 is the first release of the specification. It enables early implementations for evaluation by mobile operators, other deployers and the open source community

5G nFAPI 1.0 specifies:

- nFAPI definitions
- P5 interface
- PNF procedures
- PHY procedures
- P7 interface
- Node Sync procedures
- Slot procedures
- Timing & Sync recommendations (informative)
- Signaling call flows (informative)
- RF configuration (informative)

The following items are planned in the future release(s) of 5G nFAPI:

- nFAPI framework robustness enhancements
- Support for P19 (Front end control) and P4 (Network Monitor Mode)
- P7 transport enhancements

Ongoing developments are planned to enhance the 5G nFAPI specification, as well as provide ecosystem support as follows:

3.1 P19 Front End Unit Control

The P19 API enables tighter control of the front end needed for 5G NR to support rich configuration, shorter symbol times and analogue beamforming. The API specification can be found in [SCF223] and a video overview can be found here: https://www.smallcellforum.org/5g-fapi-suite/

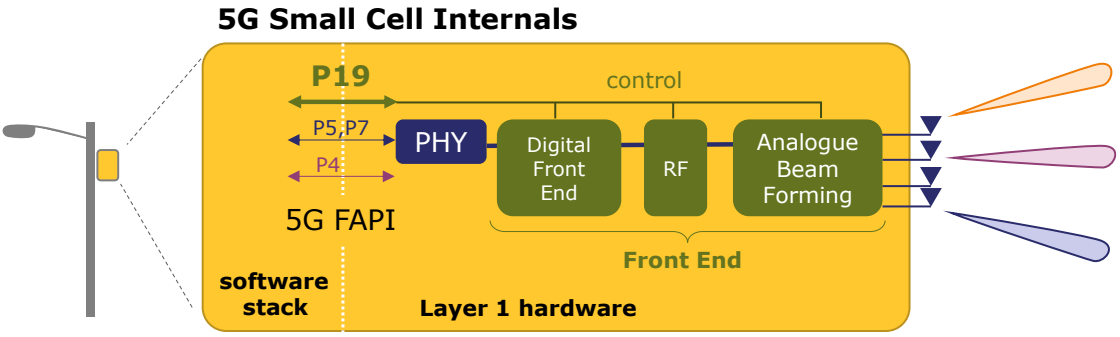


Figure 3–1 P19 Front End Unit Control

The P19 API is specified as a hardware API for use in products with co-located MAC and PHY. Support for P19 over nFAPI will be added in the next release of the specification, enabling S-DUs to have tight control of front end units in S-RUs. An illustrative (not normative) approach to handle these parameters is included as an Appendix in the 5G nFAPI specification [SCF222]

3.2 P4 Network Monitor Mode

Network monitor mode enables small cells to 'listen' to the surrounding network like a UE, to assist in self configuration and ongoing self-organizing networks (SON). The API specification can be found in [SCF224], and an overview found here: https://www.smallcellforum.org/5g-fapi-suite/. Support of this API over nFAPI interface will be added in a future release.

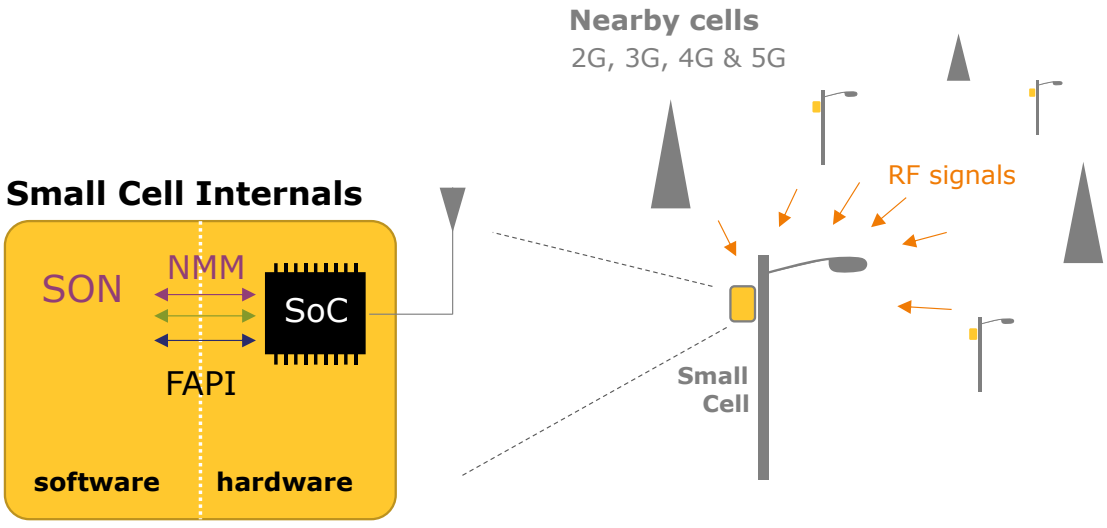
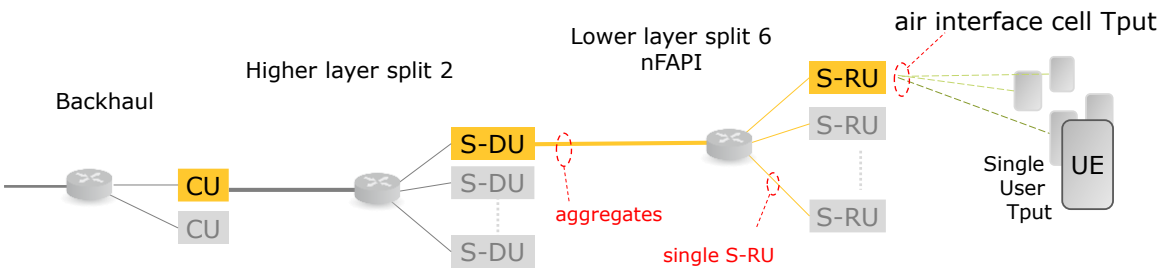


Figure 3–2 P4 Network Monitor Mode

3.3 Transport Network Requirements



S-DUs will connect to one or more S-RUs over transport networks. Performance requirements for such networks in terms of bandwidth and latency are being developed and will be shared to help deployers plan and evaluate the busines case for split 6 disaggregation of the 5G RAN.

Requirements for integrated 3G and 4G small cells can be found in [SCF049], and requirements for 4G nFAPI can be found in [SCF169]

3.4 Management models

NETCONF/YANG based models for Option 6 provide a standardized way of configuring and managing a 5G small cells. SCF will adopt an O&M approach aligned with 3GPP and O-RAN.

3.5 Sync and timing design

The 5G nFAPI 1.0 specification summarises relevant timing alignment requirements from 3GPP. A broader study of sync requirements for small cells in general is underway.

3.6 Test and Measurement support

SCF has initiated the work with small cell vendors and test equipment manufacturers to develop interoperability and conformance test scenarios and test tool capabilities.

The nFAPI interface can be used to drive 3GPP TS38.141 conformance, design verification and manufacturing test automation of nFAPI based RAN products including S-RU and S-DU.

- For S-RU testing the 5G nFAPI 1.0 interface can be used to configure the PHY for DL test models and UL reference channels, and to control the RF parameters for RF channels.
- Full conformance testing takes place for the whole gNB over the small cell network of S-RU, S-DU and CU.
- End to end testing is also supported by the current 5G nFAPI 1.0 interface
- Test optimised nFAPI support will be targeted in the nFAPI roadmap for future releases including P19 support and UL receiver measurements.
- The nFAPI interface can also be used to test the S-DU from UE/S-RU emulators.

4. Frequently Asked Questions

1. What does the 5G nFAPI 1.0 release provide?
5G nFAPI release 1.0 specifies the Option 6 split deployment architecture and defines configuration procedures over a P5 interface, and data transfer and sync procedures over a P7 interface. Release 1.0 also contains timing and synchronization recommendations for small cell deployments.

2. How does 5G nFAPI help industry adoption of 5G small cells?
The 5G FAPI suite of specifications are a part of the initiative from Small Cell Forum to promote widespread adoption of small cells for different deployment scenarios. The 5G nFAPI specification enables vendors providing base station and radio solutions for small cells to adopt a distributed and disaggregated architecture by introducing a network interface between L2+ layers and a radio unit hosting PHY and RF components.

3. What are the changes in 5G nFAPI 1.0 compared to LTE nFAPI?
The 5G nFAPI specification is an evolution of LTE nFAPI protocol to accommodate the needs of 5G NR. nFAPI concepts, framework and interfaces remain the same. The underlying FAPI procedures on P5 and P7 interfaces have been enhanced for 5G to optimize signalling messages and ensure low latency data transfer for 5G NR numerologies.

4. What are the changes expected in future releases of 5G nFAPI?
Further releases of 5G nFAPI are planned to address messages specific to P19 (RF and digital front end control) and P4 (network monitor mode) interfaces. The FAPI suite of specifications will also be updated to support 3GPP Rel. 16 features. There are further optimizations envisioned for the user plane in the future releases.

5. Can LTE and 5G nFAPI implementations coexist?
Implementations of LTE nFAPI and 5G nFAPI can co-exist by using different ports. The P5 and P7 interfaces are similar but messages are different.

6. What aspects of 5G nFAPI are aligned with the O-RAN architecture?
Small Cell Forum, through its liaison with O-RAN, will align management of small cells with the approach of O-RAN and 3GPP, by specifying appropriate data models and management interface definitions. This alignment will allow the mapping of appropriate configuration parameters for L2 and PHY layers.

7. How are the timing and synchronization aspects addressed in 5G nFAPI?
Small Cell Forum is developing a paper that includes recommendations on timing architecture and synchronization for 5G small cell networks. The nFAPI specification contains a summary of recommendations.

8. What does SCF recommend for RF parameter configuration before P19 is included in nFAPI specification?
An illustrative (not normative) approach to handle these parameters is included as an Appendix in the 5G nFAPI specification. A normative specification for P19 will be available in the next release of 5G nFAPI.

9. **What are SCF's plans to promote testing and interoperability of nFAPI implementations?**

SCF is working with partners in the wider disaggregated and open RAN ecosystem to promote testing and interoperability of 5G nFAPI. Test equipment upgrades to verify conformance and interoperability are expected following the specification release.

10. **Will open source implementations be available anytime soon?**

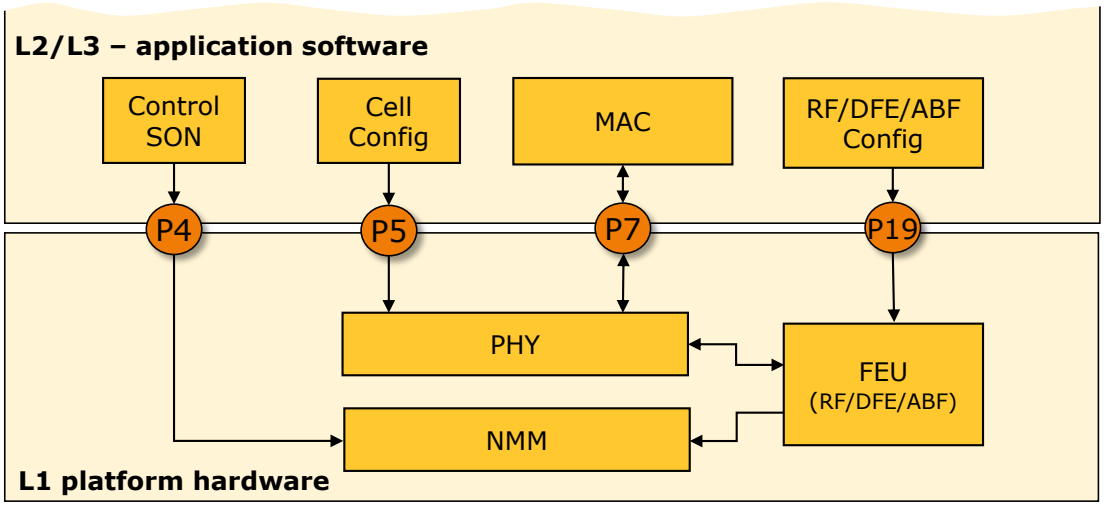
SCF will tap into the existing community of open source RAN development to foster an open source nFAPI implementation.

5. SCF's FAPI Suite

The functional application platform interface (FAPI) is an initiative within the small cell industry released by the Small Cell Forum, which establishes interoperability and innovation among suppliers of platform hardware, platform software and application software by providing a common API around which suppliers can create a competitive ecosystem. In doing this, we support a long and distinguished engineering tradition of providing an 'interchangeability of parts' to ensure that the systems vendors can take advantage of the latest innovations in silicon and software with minimum barriers to entry, and the least amount of custom re-engineering. Hence the specification helps support an innovative and competitive ecosystem for vendors of 5G small cell hardware, software and equipment.

For 5G, the FAPI suite comprises specification documents covering the following APIs:

- '5G FAPI: PHY API' - main data path (P7) and PHY mode control (P5) interface [SCF222]
- '5G FAPI: RF and Digital Front End Control API' – (P19) for Frontend Unit control [SCF223]
- '5G FAPI: Network Monitor Mode API' - (P4) for 2G/3G/4G/5G [SCF224]
- '5G FAPI: network FAPI', transport wrapper to convert APIs into network interfaces [SCF225]



SON (Self Organising Networks), MAC (Medium Access Control), NMM (Network Monitor Mode)
FEU (Front End Unit) including DFE (Digital Front End) and ABF (Analog Beam Forming)

Figure 5–1 Small cell internal architecture

The full FAPI family of 3G, 4G and 5G API are as follows:

New for 5G

Brand name		3GPP RAT Type [TS29.274]	SCF FAPI Support				
			PHY API	network monitor mode	RF/Digital Front End	network FAPI (PHY/MAC split)	small cell (PNF/S-RU) management model
2G	GSM	GERAN		[SCF224]			
3G	UMTS	UTRAN	[SCF048]	[SCF224]			
3G	HSPA	HSPA Evolution	[SCF048]	[SCF224]			
4G	LTE	EUTRAN (WB-E-UTRAN)	[SCF082]	[SCF224]		[SCF082]	[SCF167]
4G	LTE-NB-IoT	EUTRAN-NB-IoT	[SCF082]	[SCF224]		[SCF082]	[SCF167]
4G	LTE-M	LTE-M	[SCF082]	[SCF224]		[SCF082]	[SCF167]
5G	5G NR	NR	[SCF222]	[SCF224]	[SCF223]	[SCF225]	[SCF227]*

*in progress

Table 5–1 Full suite of SCF specifications

Further details can be found here: https://www.smallcellforum.org/5g-fapi-suite/