



SVEUČILIŠTE U ZAGREBU



Fakultet  
elektrotehnike i  
računarstva

**Master Programme**  
**Computing**

Ac. year 2022/2023



# Advanced Architectures of Telecommunication Networks



## Lecture 9: 5G Service Based Architecture. Signaling and Session Management

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# The **core network**: the “heart” of a mobile network

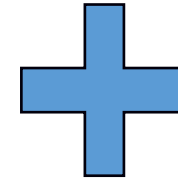
4G LTE → powered by the **Evolved Packet Core (EPC)**

Standalone 5G network → powered by the **5G Core (5GC)**

# Migration from 4G to 5G (reminder)

4G network

4G Radio  
Access  
Network  
(LTE)

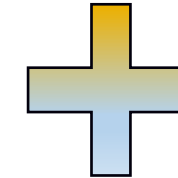


4G core  
(Evolved  
Packet  
Core, EPC)



5G Non-Standalone  
Architecture

5G Radio  
Access  
Network

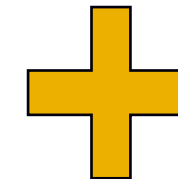


4G core  
(Evolved  
Packet  
Core, EPC)



5G Standalone  
Architecture

5G Radio  
Access  
Network

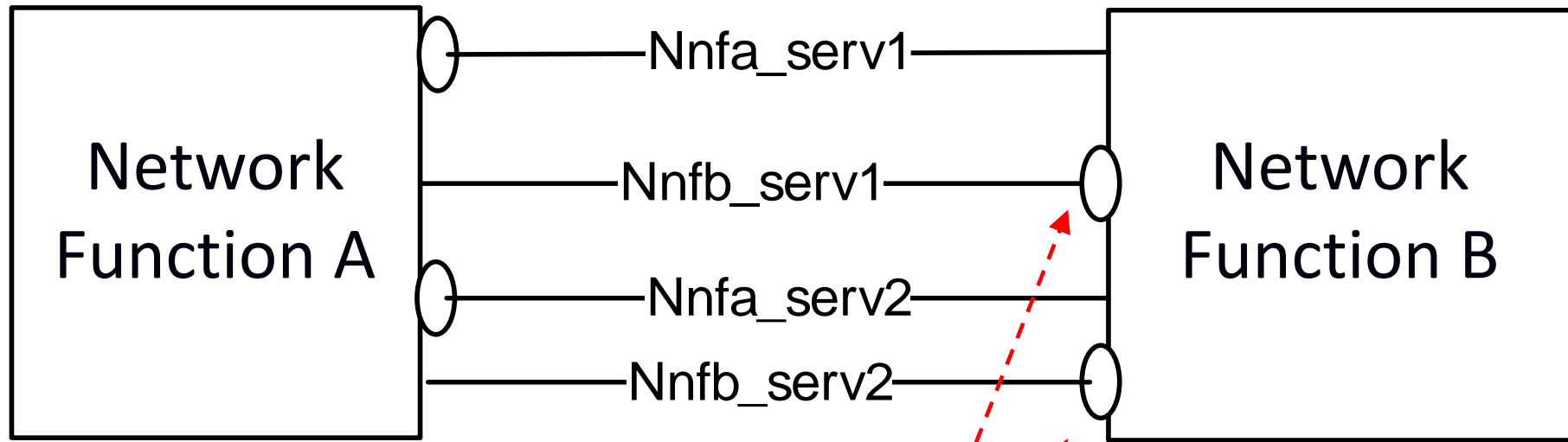


5G core  
(5GC)

# 5G Core: IT network principles + cloud-native design approach

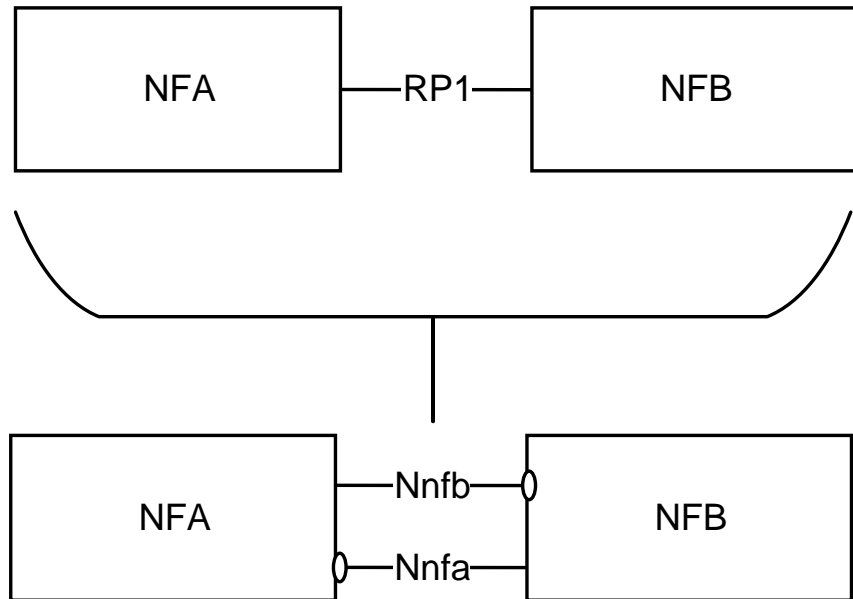
- Based on a **Service-Based Architecture (SBA)**
- A network function (NF) is formed by a combination of small pieces of software code called **microservices**.
  - Some microservices can be re-used for different NFs, making implementation more effective and facilitating independent life-cycle management
  - Allows upgrades and new functionalities to be deployed with zero impact on running services

Each network function (NF) offers one or more services to other NFs via Application Programming Interfaces (APIs)

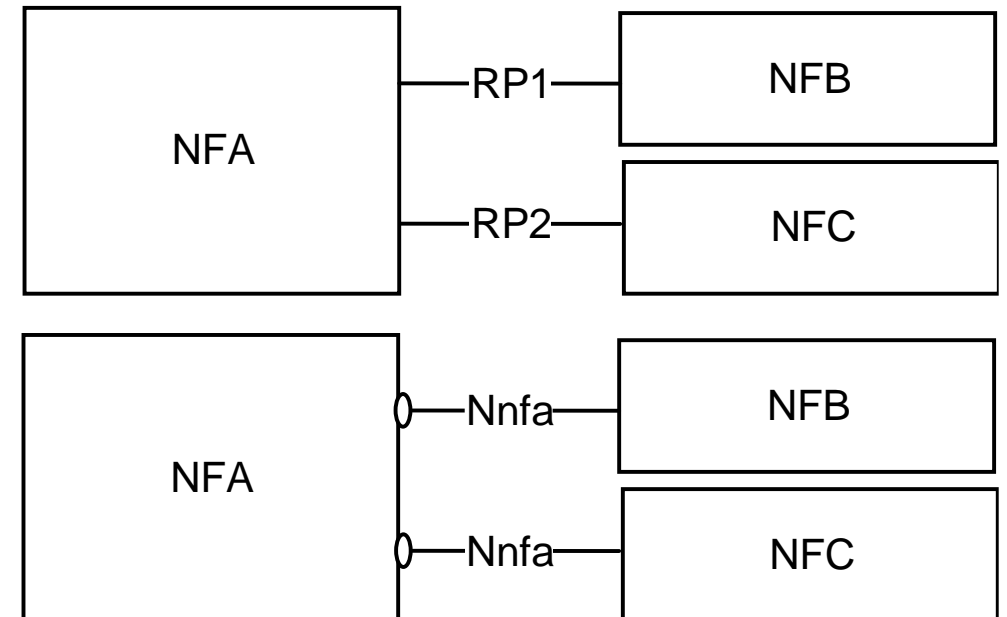


A NF may expose one or more services through  
**Service based interfaces**  
**(SBIs)**

# Examples: Reference Points vs SBIs

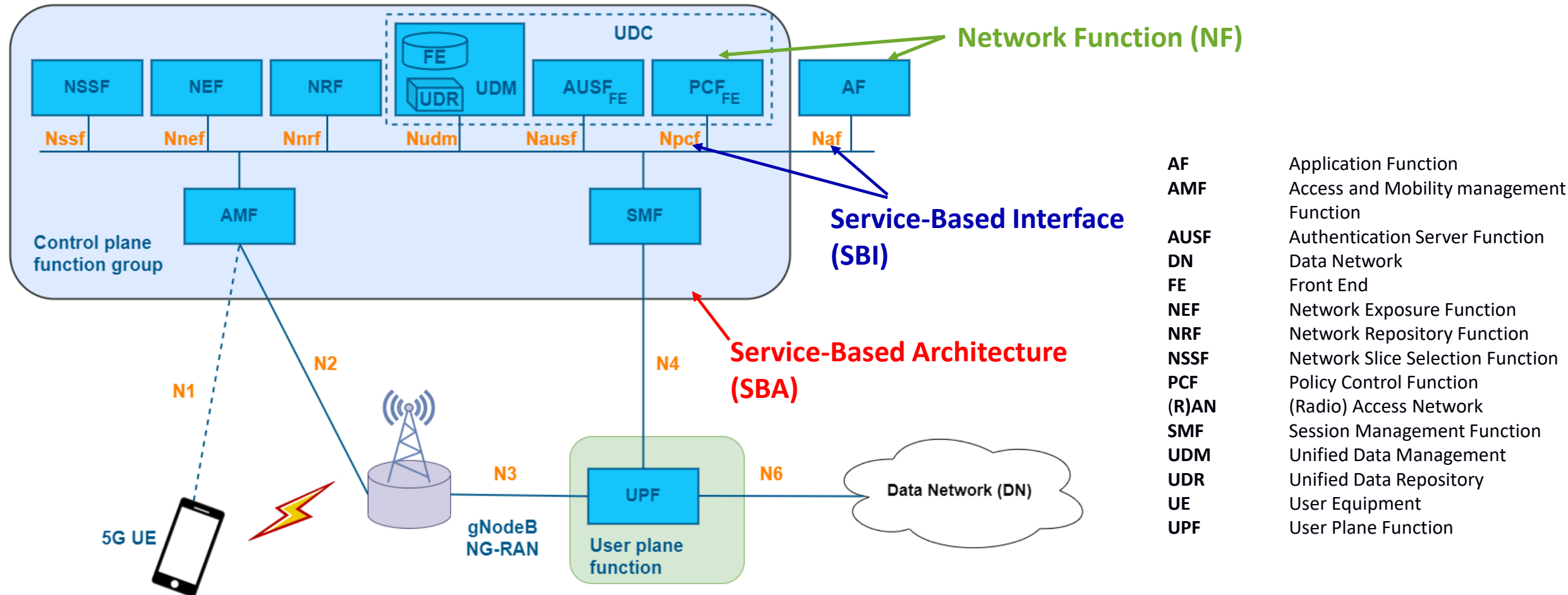


Reference Point (RP) replaced by two Service based Interfaces



Reference Points vs. Service-based Interfaces: representation of equal functionality on the interfaces

# 5G Service-Based Architecture (SBA) (*reminder*)

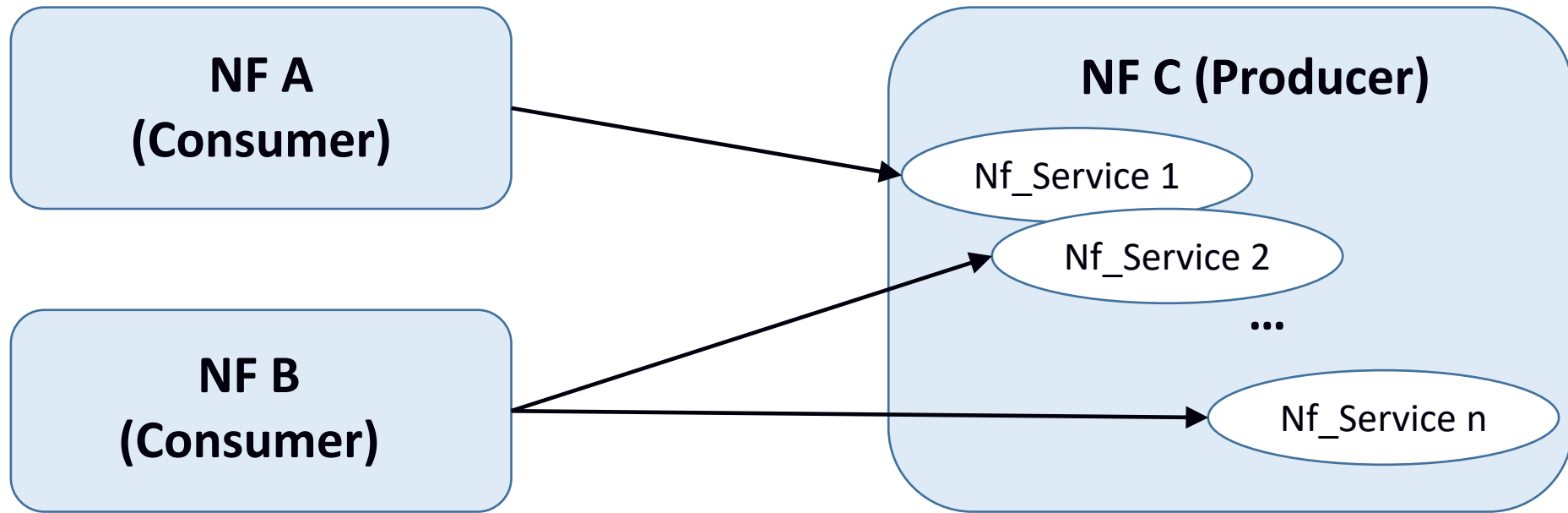


- All interactions are abstracted as: *Request-Response, Subscribe-Notify*
- System procedures are described as a sequence of NF service invocations

# Network functions

- Each entity in the architecture = **Network Function (NF)**
- Entities of the SBA:
  - Each of the interfaces to the NFs is a **Service-Based Interface (SBI)**, e.g. Nsmf
  - Each NF supports one or more Network Function Services exposed via its SBI
  - Each Network Function Service supports one or more Operations
- Operations can be invoked by other entities (Consumers)
- Defined procedures (interactions between NFs) as services : registration, connection establishment, location update, detach, etc.





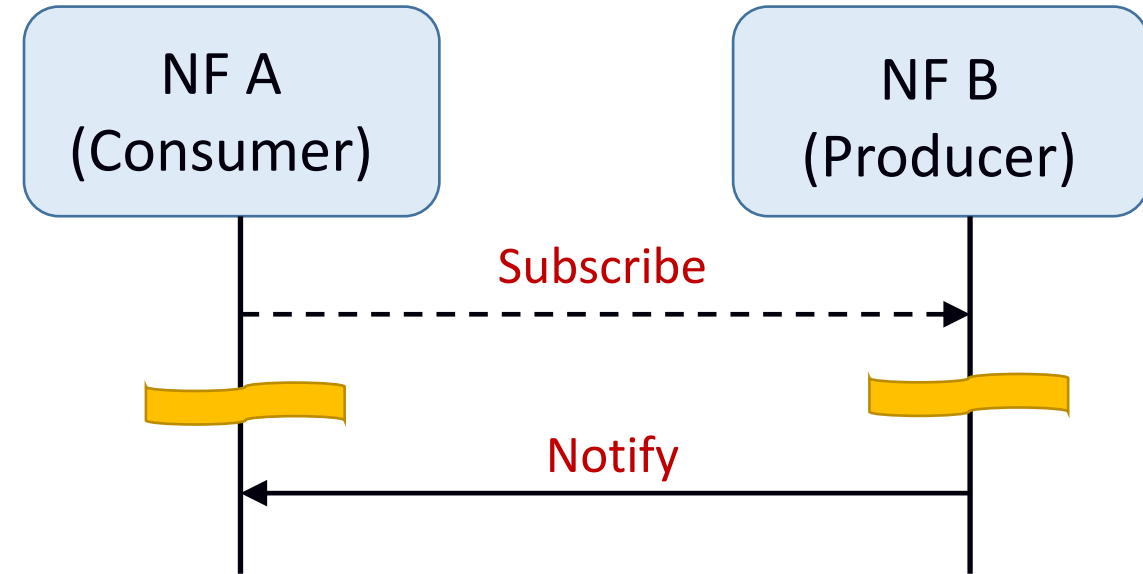
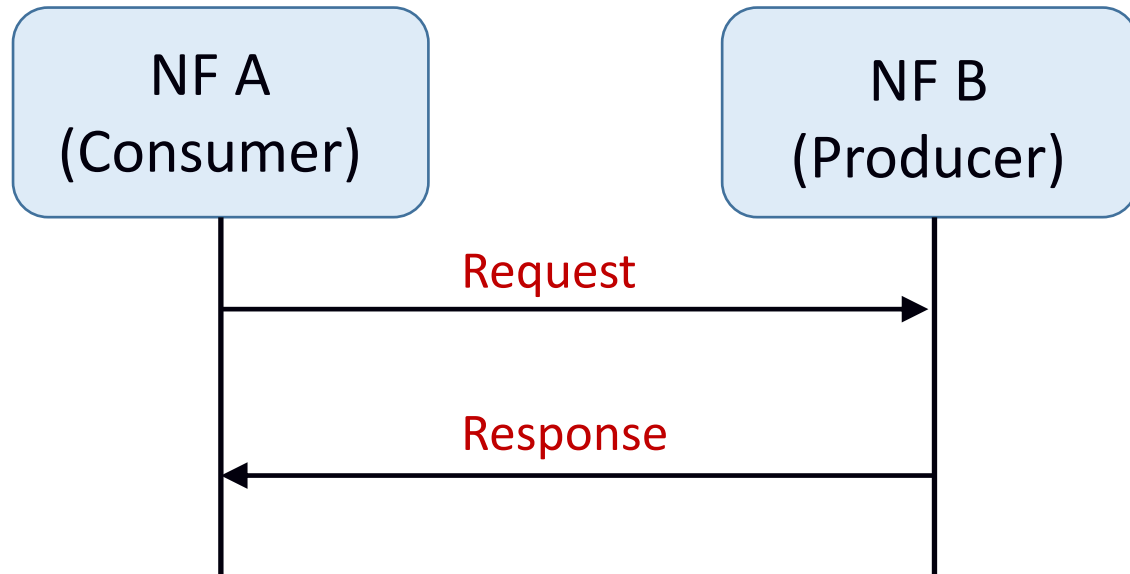
When two NFs communicate they take on two distinct roles:

- **Service Consumer** – sends a request
- **Service Producer** – offers a service and triggers some action based on the request; after completed action, responds back to the Service Consumer

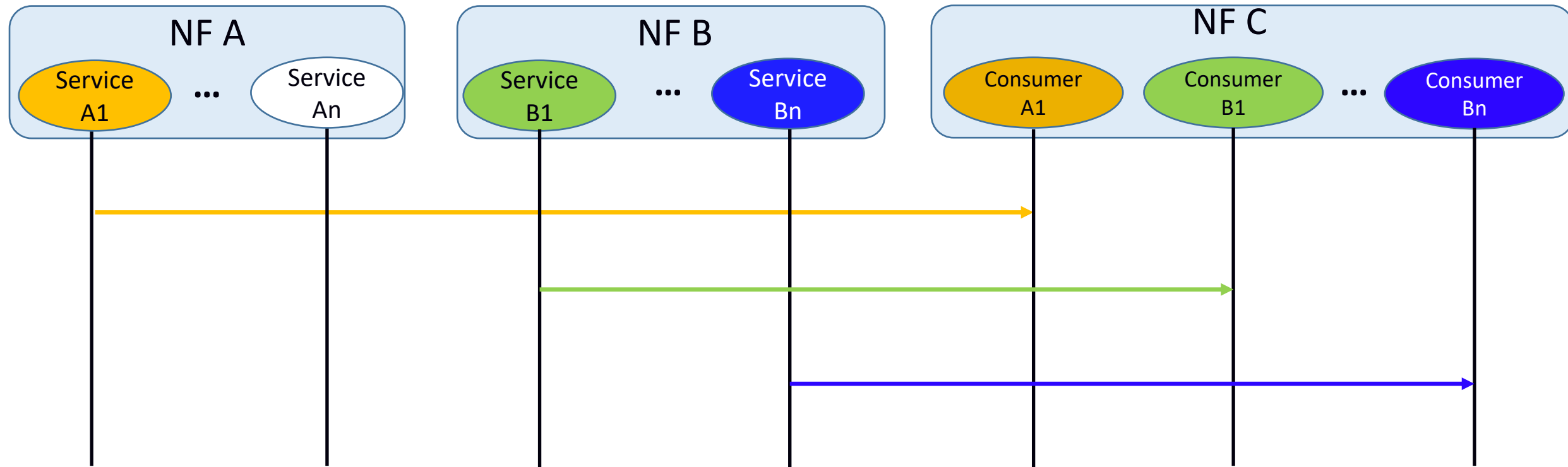
An **NF Service** is one type of capability exposed by an NF (NF Service Producer) to other NFs (NF Service Consumers). The service is:

- self-contained
- reusable
- managed independently of other NF services offered by the same NF

## Two types of primitive operations:



System procedures: built by invocation of a number of NF services



# HTTP REST Interfaces

- uses message syntax from the widely used HTTP protocol
- relies on the concept of Resource Modeling → a distributed software application can be addressed through Uniform Resource Identifiers (URIs)
- important aspect: all communication must include the full set of information needed for a specific processing action. Does not rely on previous messages → **stateless!**

## Main HTTP methods used:

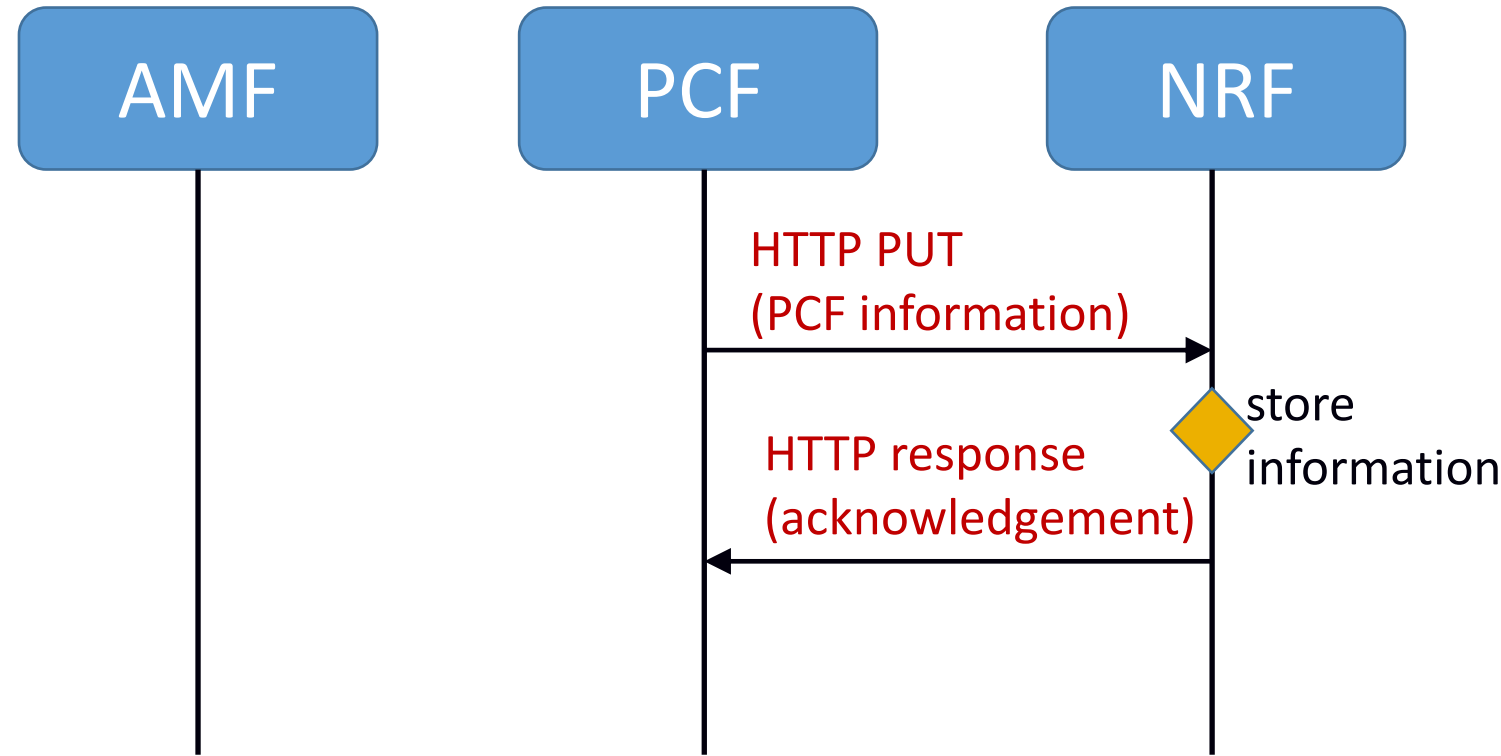
- **GET**—used to fetch data from a server; does not change any data.
- **POST**—used to send data to a server
- **PUT**— also used to send data to a server, but it replaces existing data
- **DELETE**—used to remove data from a server

# Service registration and discovery

- Service Discovery: provides a mechanism for Service Consumers to locate and contact Service Producers
- In 5GC, service discovery is done via a dedicated NF referred to as the **Network Repository Function (NRF)**
- NRF: keeps track of all available services of all NFs in the network
  - each NF is configured with the address of one or more NRFs, but it does NOT have addresses to other NFs!

# Example: Phase 1 - Service registration

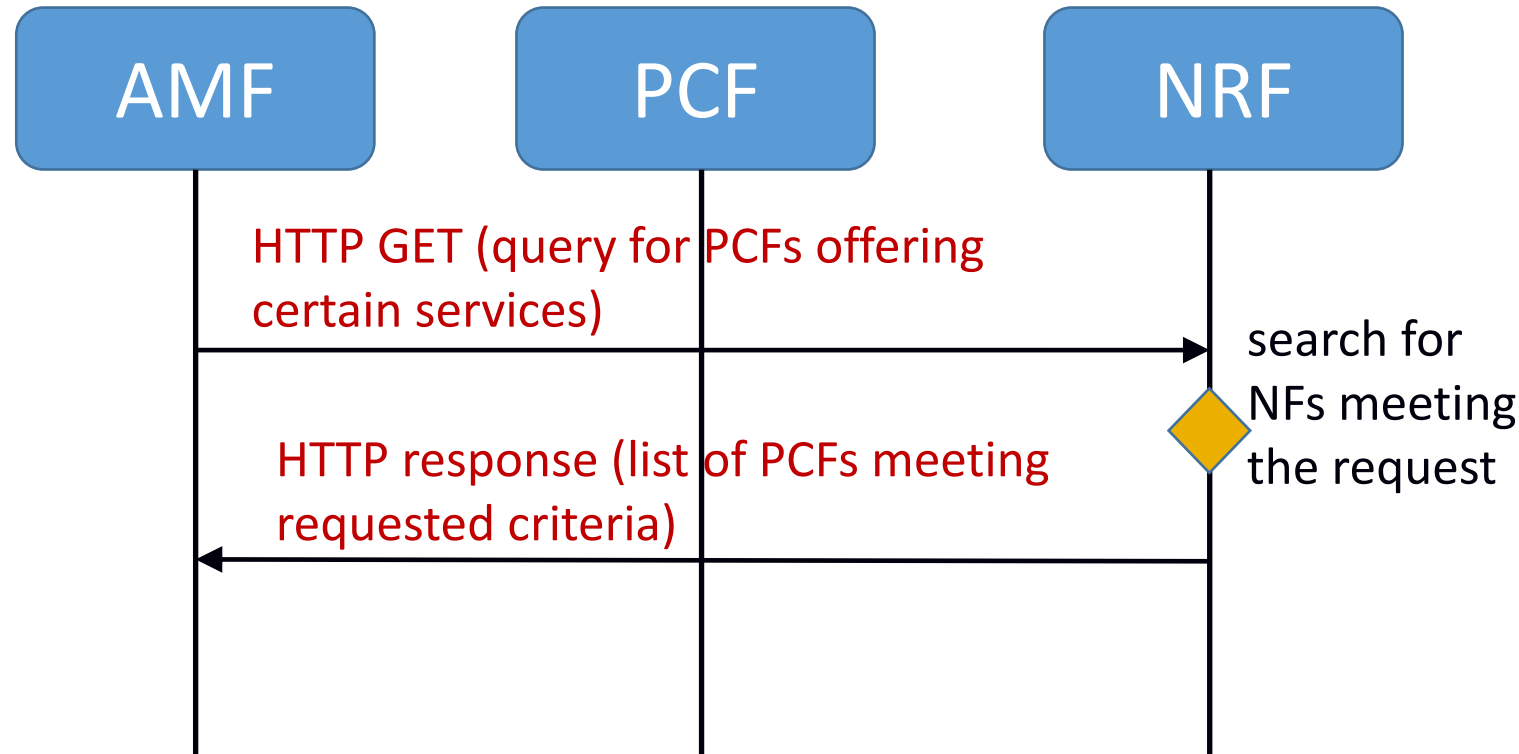
- Example: the NF PCF wants to register its services
- PCF registers with the NRF using an HTTP PUT message: includes info about PCF, such as available services, IP address, ID
- NRF: verifies request, stores data, and ACKs PCF registration with an HTTP response
- PCF services now available to other NFs through querying the NRF



<b>AMF</b>	Access and Mobility management Function
<b>NRF</b>	Network Repository Function
<b>PCF</b>	Policy Control Function

# Example: Phase 2 - Service discovery

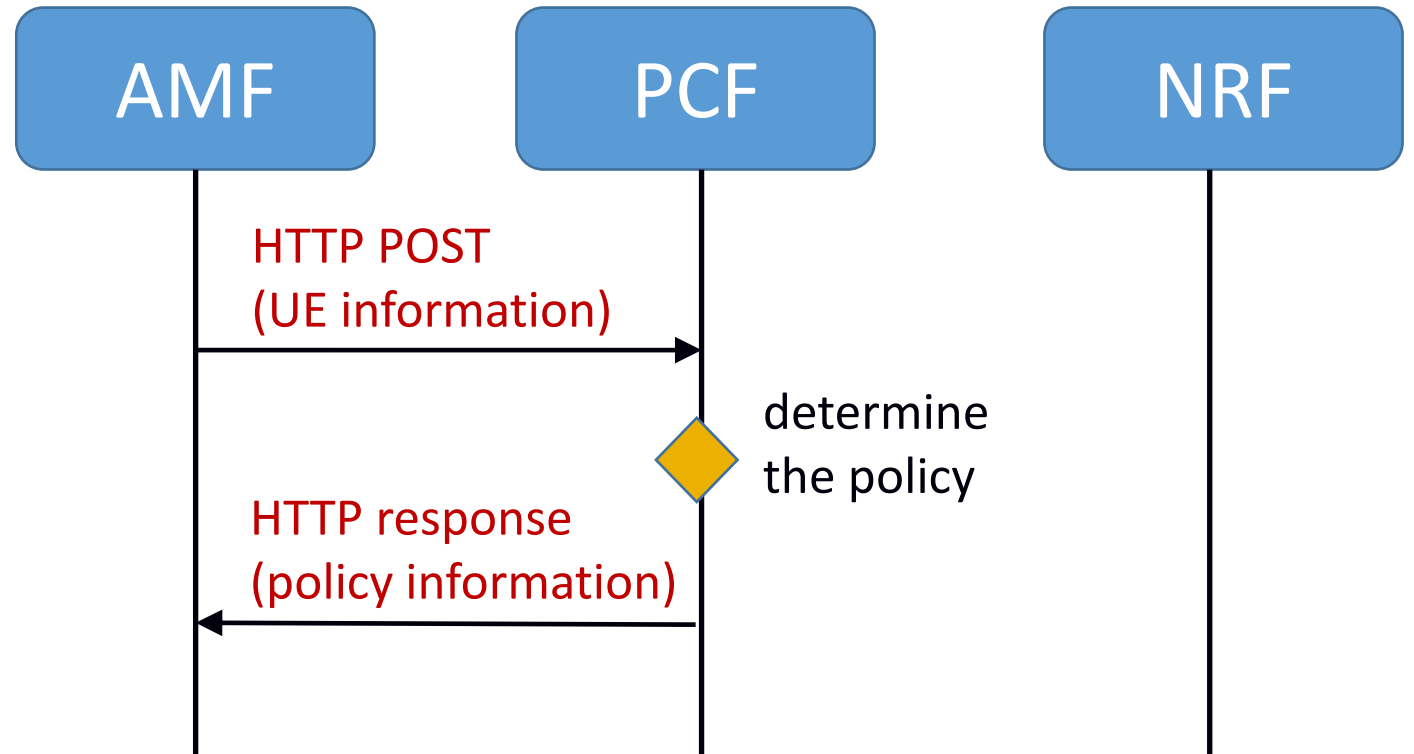
- Another NF (e.g., the AMF) wants to use services of the PCF
- AMF: queries the NRF using HTTP GET for a list of PCFs offering these services
- NRF: filters out NFs registered as providing requested service, and responds back to AMF



<b>AMF</b>	Access and Mobility management Function
<b>NRF</b>	Network Repository Function
<b>PCF</b>	Policy Control Function

# Example: Phase 3 - Service request

- AMF selects a PCF
- AMF contacts selected PCF with a Service Request using HTTP POST
- PCF determines applicable policy (more on this later!) and sends an HTTP response



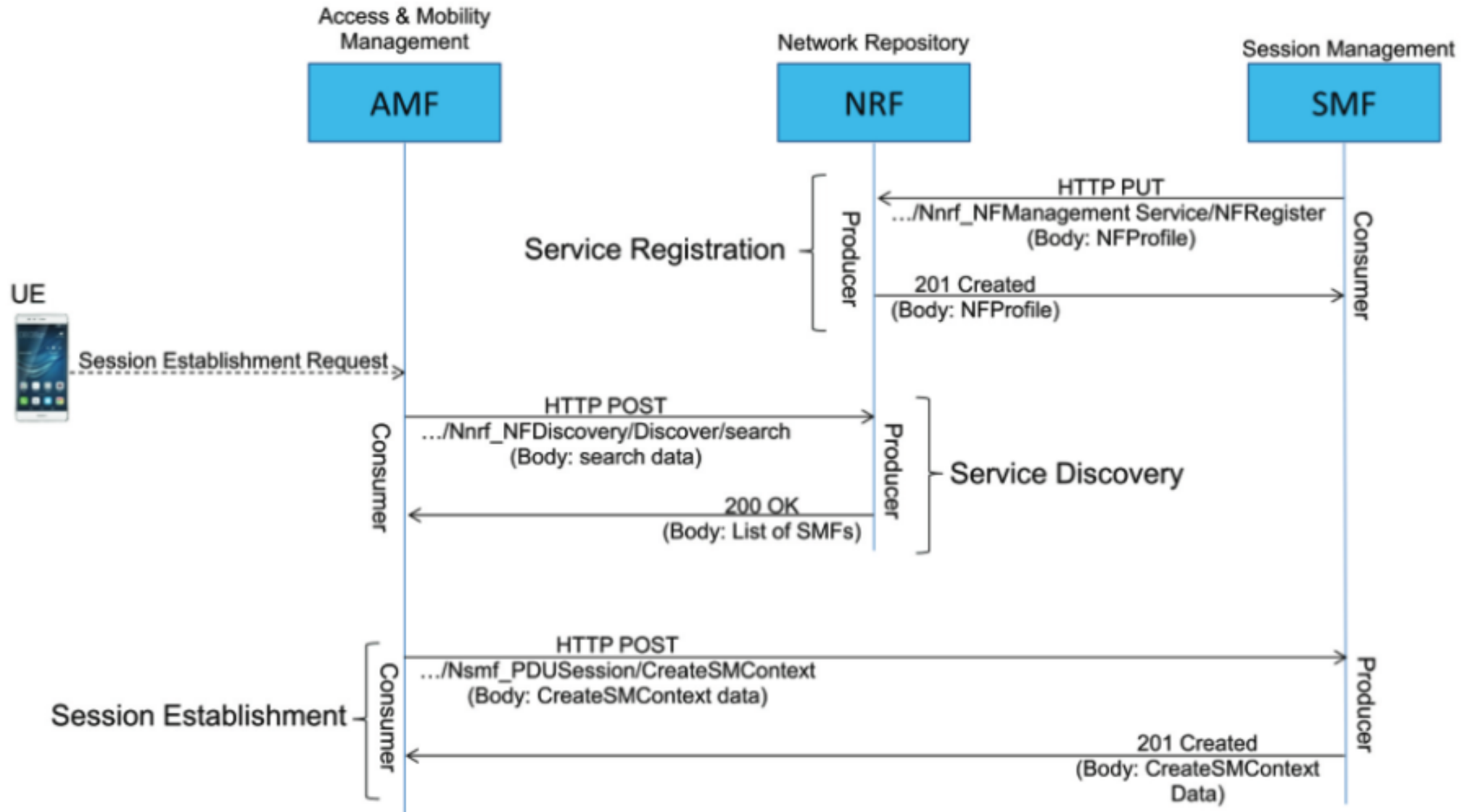
<b>AMF</b>	Access and Mobility management Function
<b>NRF</b>	Network Repository Function
<b>PCF</b>	Policy Control Function
<b>UE</b>	User Equipment



Note: these three phases (**service registration**, **service discovery**, and **service request**) do not usually happen in direct sequence.

A Network Function typically registers with the NRF when it is put into service, while the service discovery and service requests may for example take place when a device connects to the network

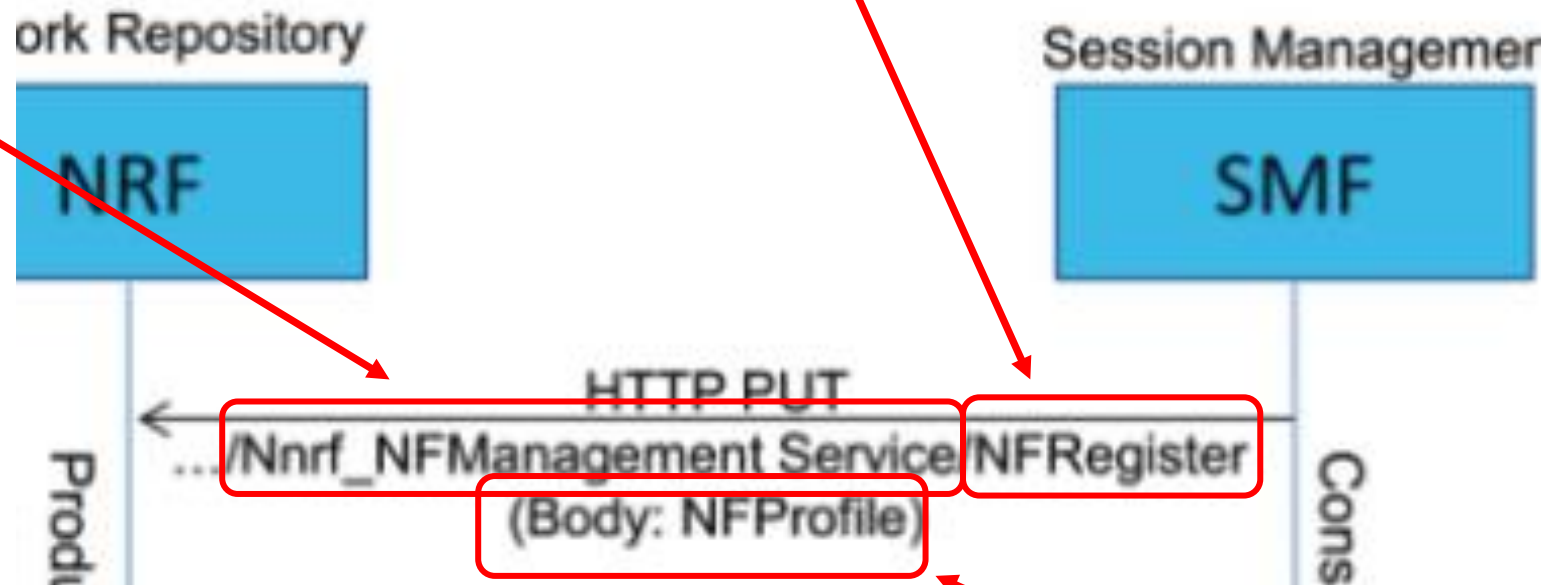
# Simplified API calls for example SBA procedure



# Simplified API calls for example SBA procedure

a service offered  
by the NRF

*NFRegister* is an operation supported by  
the *Nnrf\_NFManagement Service*  
(in this example, the SMF is asking to  
register itself and its services in the NRF)



a profile document (JSON) with  
info about the NF, in this case SMF

# Resource (service) identification

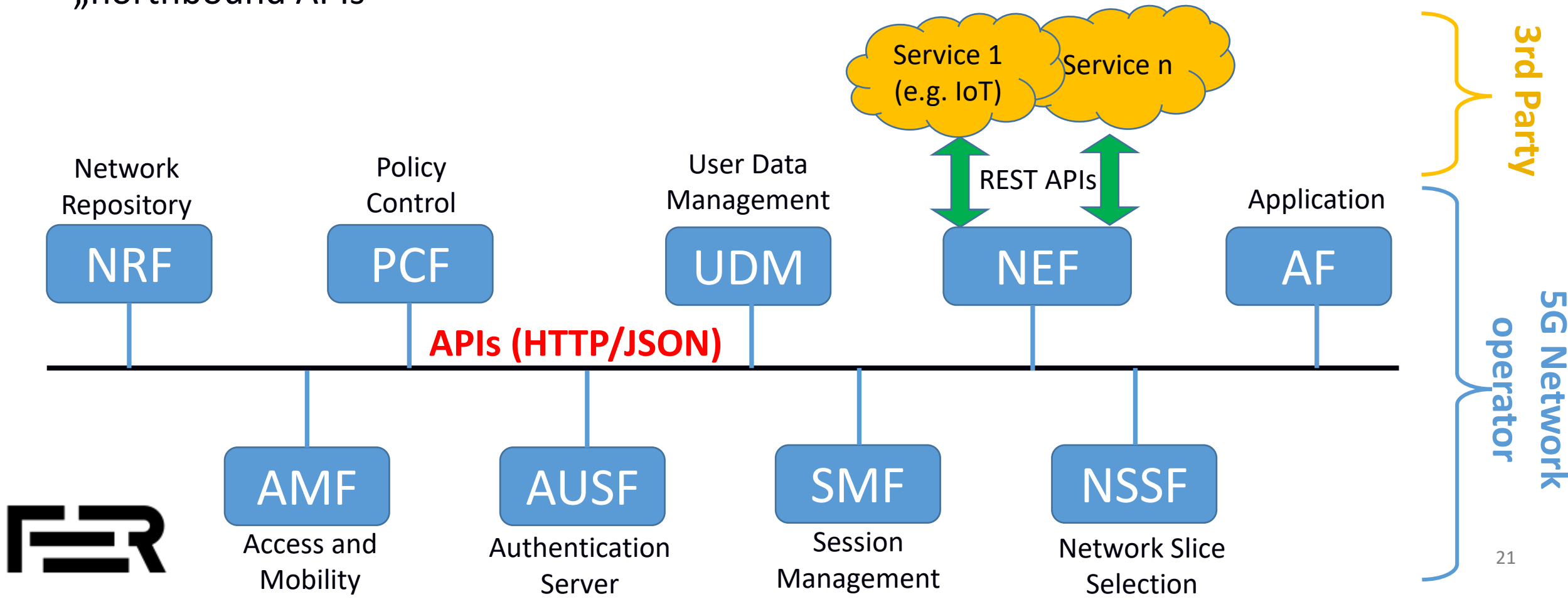
- Each service has a unique address (URI)
- the URI addresses the resource (service), not a specific server

`{apiRoot} / {apiName} / {apiVersion} / {apiSpecificResourceUriPart}`

*more on this in the scope of Lab 3!*

# Capability exposure to 3rd parties

- main idea: make 5G Core Network functionalities available to 3rd parties such as service providers and vertical industries outside the operator's domain
- provided by the Network Exposure Function (NEF) and based on RESTful APIs → „northbound APIs“



# Mandatory components of a 5G architecture

- **AMF (Access and Mobility Management Function):**
  - manages all UE related functions
  - establishes a signaling connection towards the UE
- **SMF (Session Management Function):**
  - sets up connectivity for the UE towards data networks
  - manages the User Plane for the connectivity
  - establishes, modifies, and releases sessions; allocation of IP addresses per session
- **UPF (User Plane Function)**
  - processes and forwards user data; connects to external IP networks
  - controlled by the SMF

# Mandatory components of a 5G architecture

- **NRF (Network Repository Function)**
  - a repository of profiles of the NFs available in the network
- **AUSF (Authentication Server Function)**
  - handles authentication in the home network
  - provides security parameters
- **UDM (Unified Data Management)**
  - a front-end for user subscription data stored in the UDR
- **UDR (Unified Data Repository)**
  - database where various types of data is stored (e.g., subscription data, data defining various types of network or user policies)

# Session Management



# Session management

Task: provide the UE with data connectivity toward a Data Network (DN)  
→ for example the Internet, a dedicated factory network, etc.

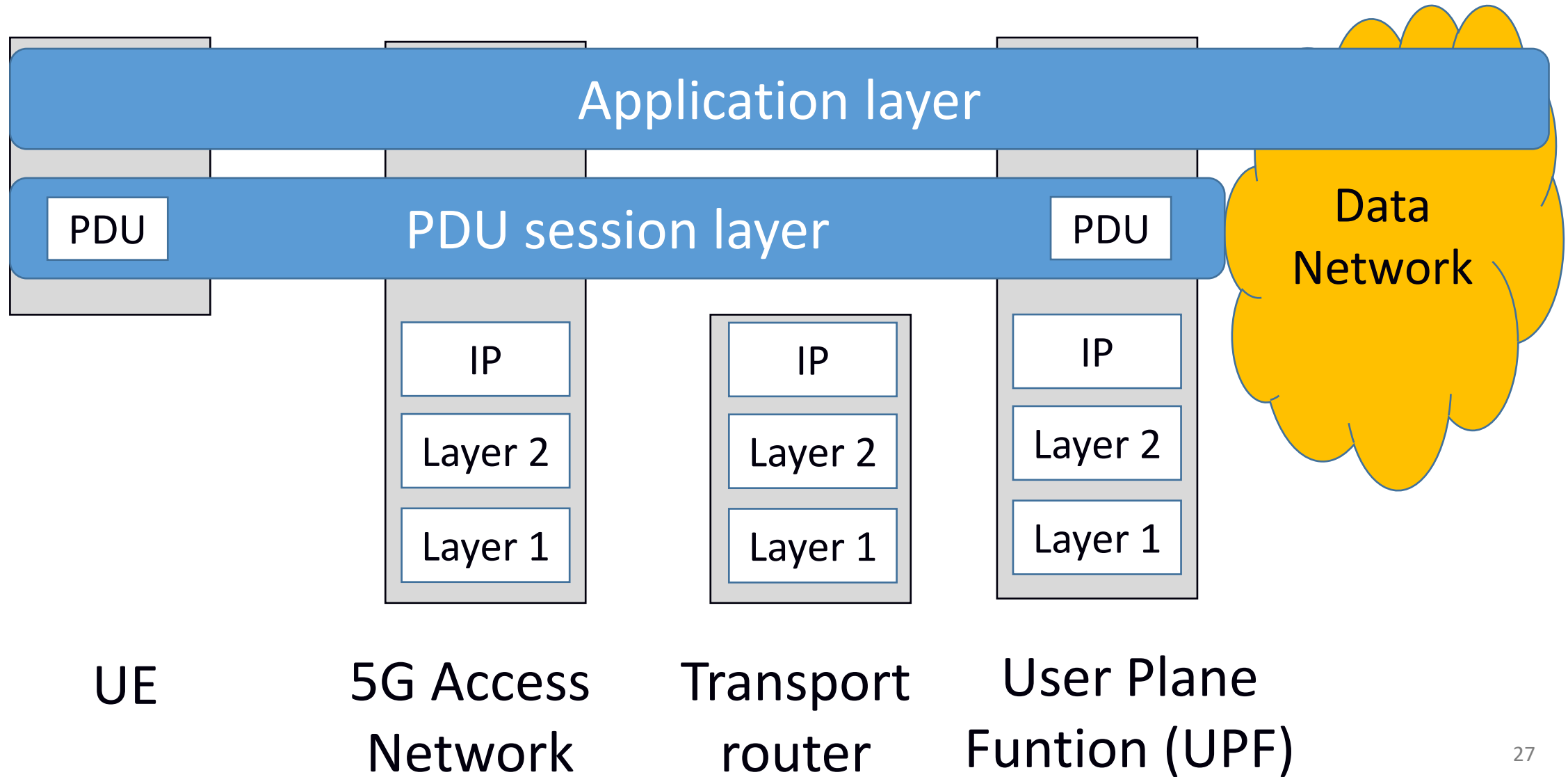
Session Management functionality → key responsibilities include:

- setting up connectivity for the UE toward Data Networks,
- managing the User Plane for that connectivity.

# Connecting to a Data Network (DN)

- To connect to a Data Network, the UE requests the establishment of a **PDU Session**
  - PDU Session: provides a logical connection (association) between the UE and a specific DN
- **PDU (Protocol Data Unit)**: the basic end-user protocol type carried by the PDU Session (e.g., IP packets, Ethernet frames);
  - depends on the PDU Session type
- During PDU Session Establishment, the corresponding User Plane connection between the UE and the DN is activated
- The User Plane connection provides transport of PDUs.

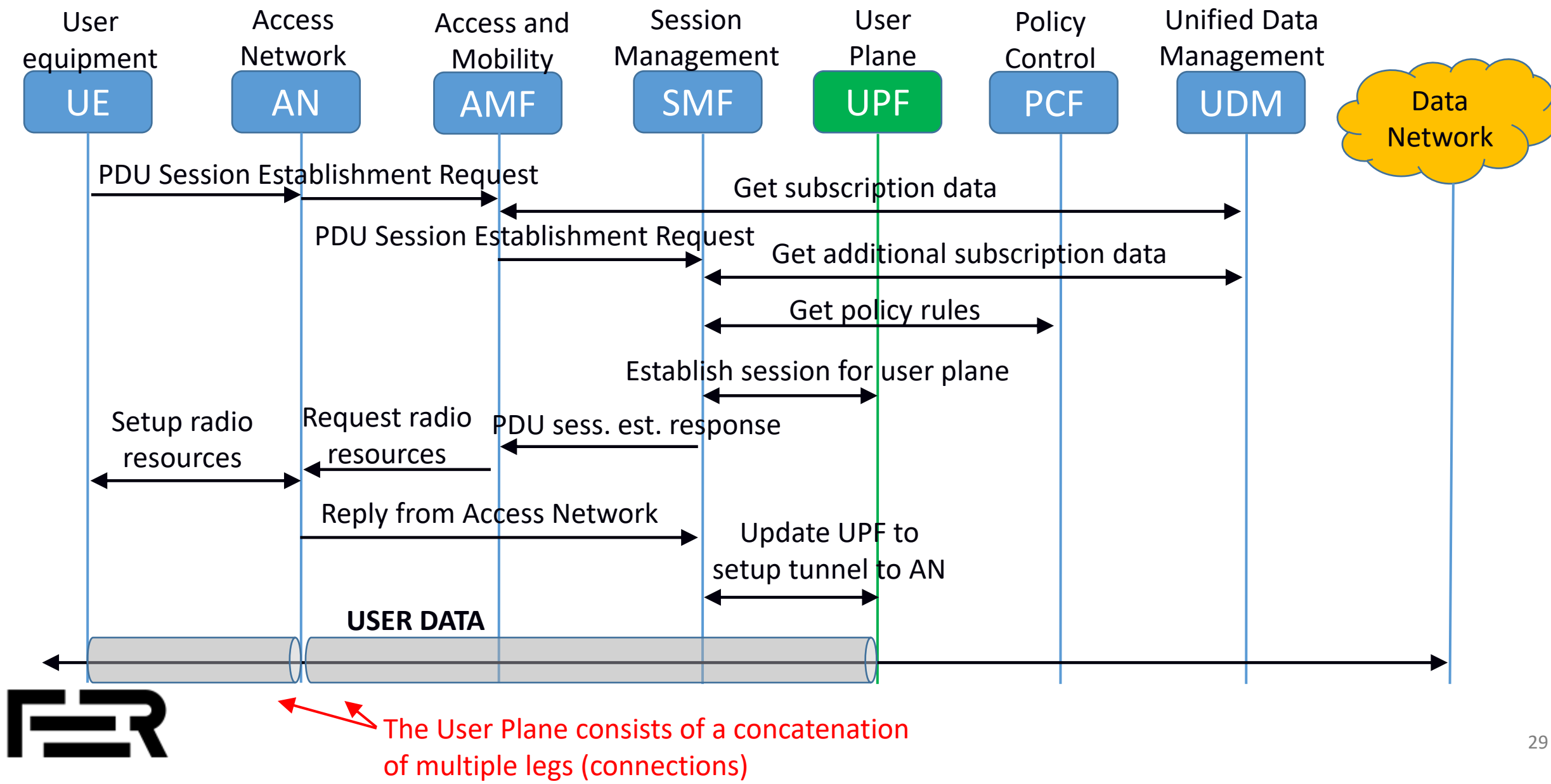
# Connecting to a Data Network (DN)



# Connecting to a Data Network (DN)

- The 5G system is concerned with the “PDU Session Layer”
- PDUs (e.g., IP packets) in general carry application traffic (e.g., HTTP, FTP, SMTP)
- User data is transported:
  - between the UE and the 5G Access Network (New Radio, NR) over an underlying radio connection
  - between the 5G Access Network and the UPF over an underlying transport network
- The User Plane connection (the PDU Session) is **separated** from the actual transport connection between the network nodes
  - The User Plane is **tunneled over a transport network** to provide per-user security, mobility, charging, QoS etc.
  - Idea: decouple the end-user PDU Session “layer” from the underlying transport and allow operators to deploy any transport technology (e.g., MPLS, Ethernet, wireless links) independently of the end-user “PDU layer”.

# Simplified PDU Session Establishment procedure



More details on  
various aspects of  
the 5G system  
architecture  
(560+ pages!)



<https://www.3gpp.org/specifications/specifications>

