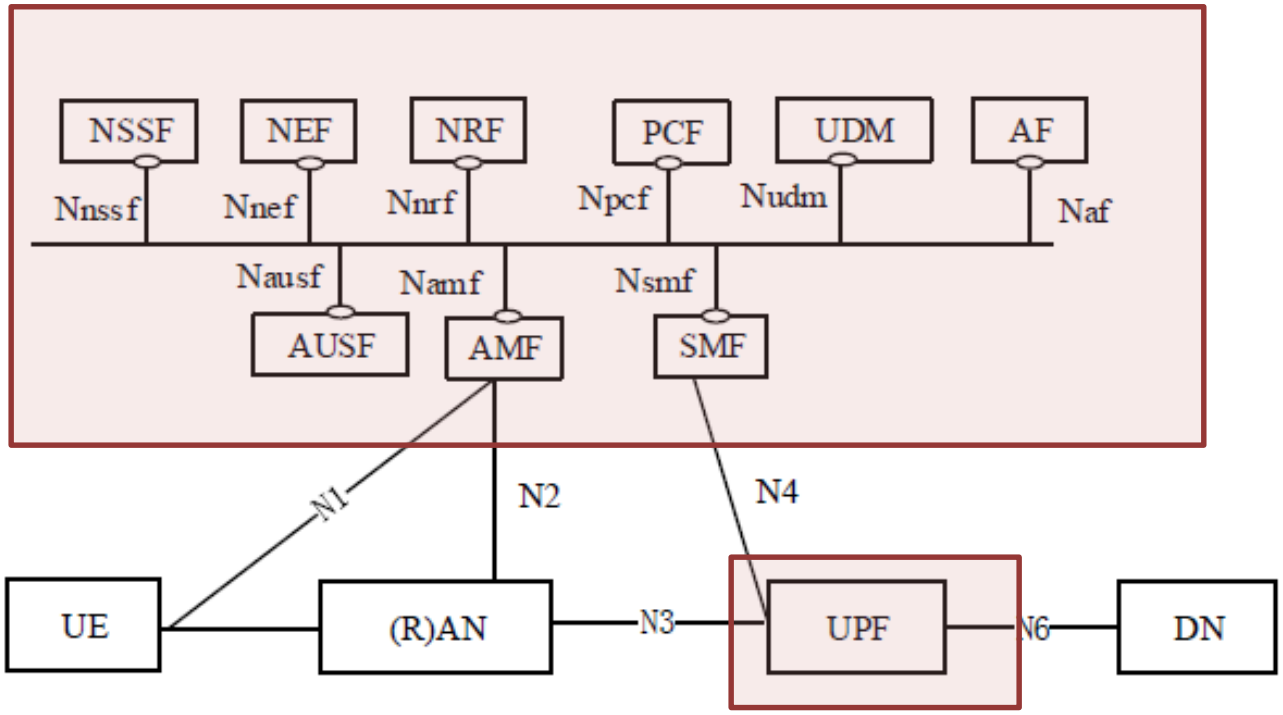
5G Core @ IIT Bombay

Mythili Vutukuru

Department of Computer Science and Engineering
IIT Bombay

5G Core: Overview

- Connects the UE / RAN to data networks



AMF (Access and Mobility Management Function)

SMF (Session Management Function)

AUSF (Authentication Server Function)

UDM (Unified Data Management)

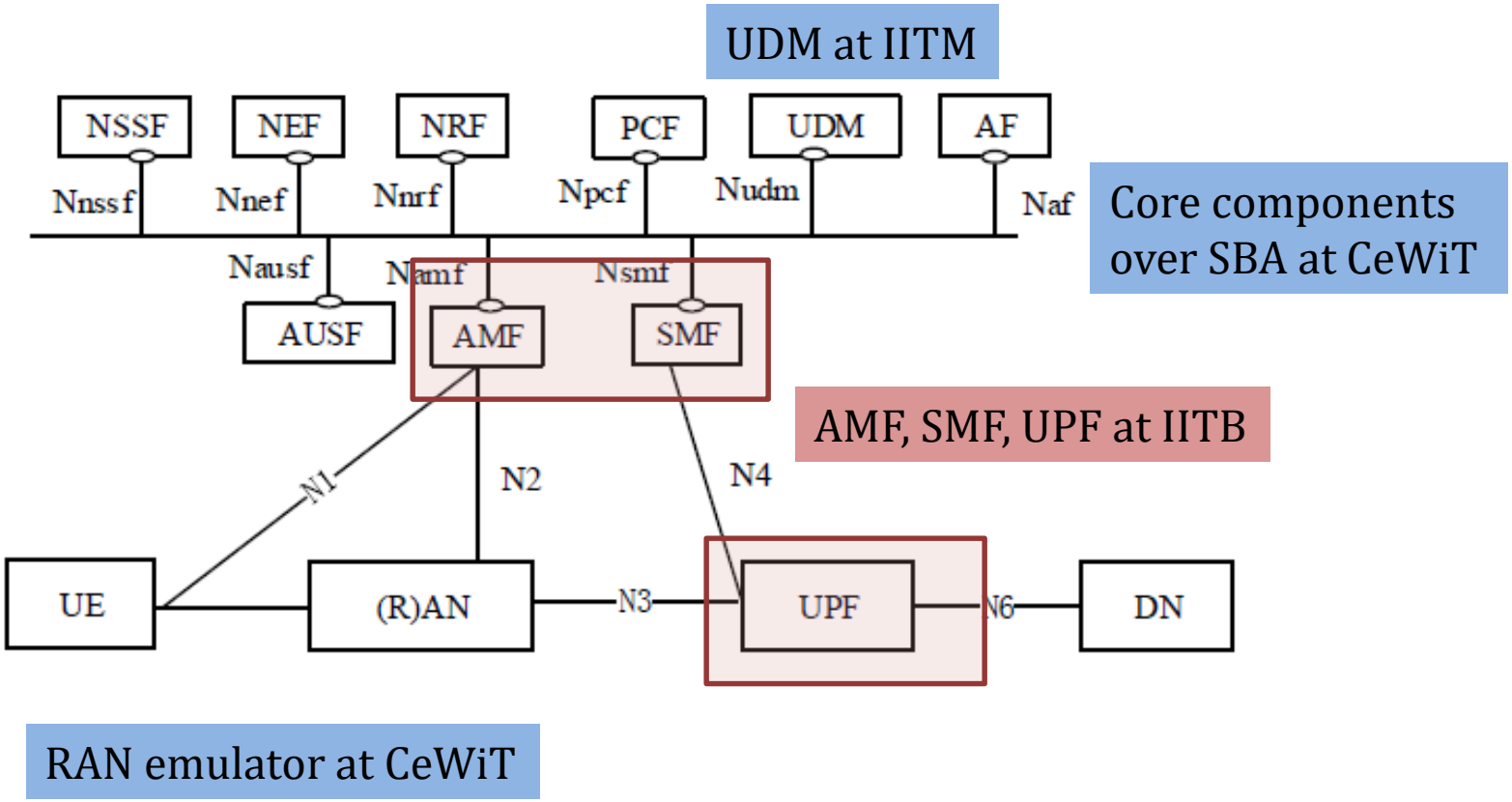
UPF (User Plane Function)

5G Core: Functionality

- Registration, authentication, security setup
- Setup data forwarding paths
- Forward user data from base station to external data networks
- Handle mobility across base stations
- Manage user state during active/idle transitions
- Billing, charging, policy

5G Core: Teams

- Development across IITB, CeWiT, IITM



5G Core: Team at IITB

- 5 full-time project engineers:
  - Current: Kapil Gokhale, Rohan Vardekar, Greeshma Vasudevan, Adeeba Thahsin, Omkar Prabhu
  - Ex-team members: Manasi Kolhe and Tejaswi Tanikella
- Several UG/PG students of CSE, IITB are also actively contributing to the project.

5G core: Versions

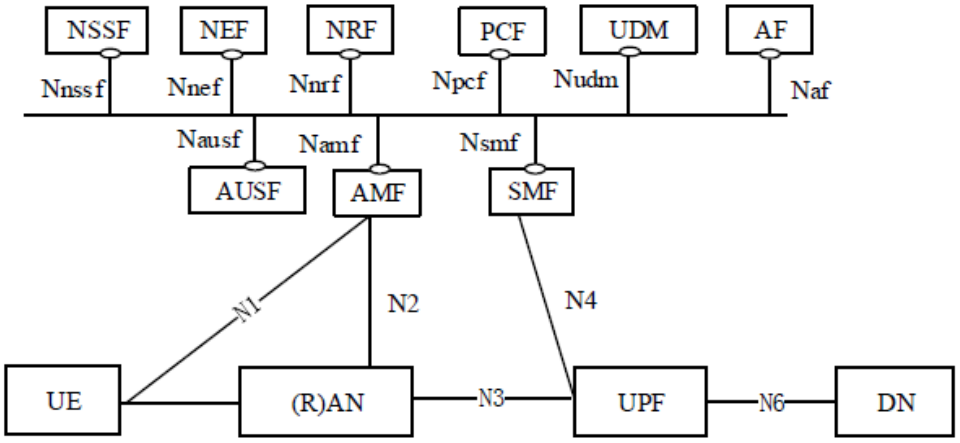
- Version 0: Basic user registration procedure
- Version 1: Registration, session setup, data forwarding
  - UE will be able to register, setup a session and transfer data to/from remote server via 5G core
  - End-to-end integration within testbed
- Version 2, Version 3: Mobility, active/idle transitions, and other advanced features.

5G Core: Testbed Setup

- 5G core follows principle of Network Function Virtualization (NFV)
  - Core functionality is being built as virtualized software functions that can run on commodity hardware
  - Software can be made available as source, binaries, VM images, and so on
- A complete testbed is not planned at IITB
  - IITB to make 5G core software available to locations hosting the end-to-end testbed

5G Core: Design Principles (1)

- Network Function Virtualization (NFV)
  - All components are software functions
  - Can be stateless, and scale on demand
  - Virtualized to run in VMs/containers on a cloud



Why NFV?

Hardware NFs

- Long hardware development cycles
- Difficult to scale: need to replace box when load increases
- Hardware functionality is harder to change
- Custom hardware is expensive

Software NFs

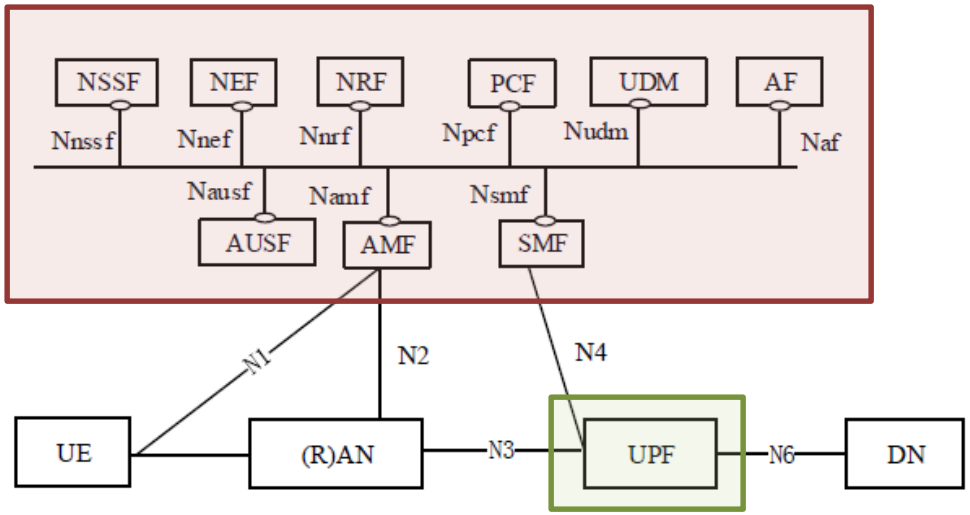
- Software development is faster
- Elastic scaling on demand: spawn new VMs as needed
- Greater flexibility in evolving to future needs
- Cheaper commodity hardware

Why NFV now?

- Improved performance of commodity hardware
  - Processors are getting better
  - NICs (network interface cards) are getting smarter
- New techniques for high performance I/O
  - E.g., Intel Data Plane Development Kit (DPDK) can directly transfer packets from NIC to user software, bypassing kernel overheads
- NFV is the default design for 5G core

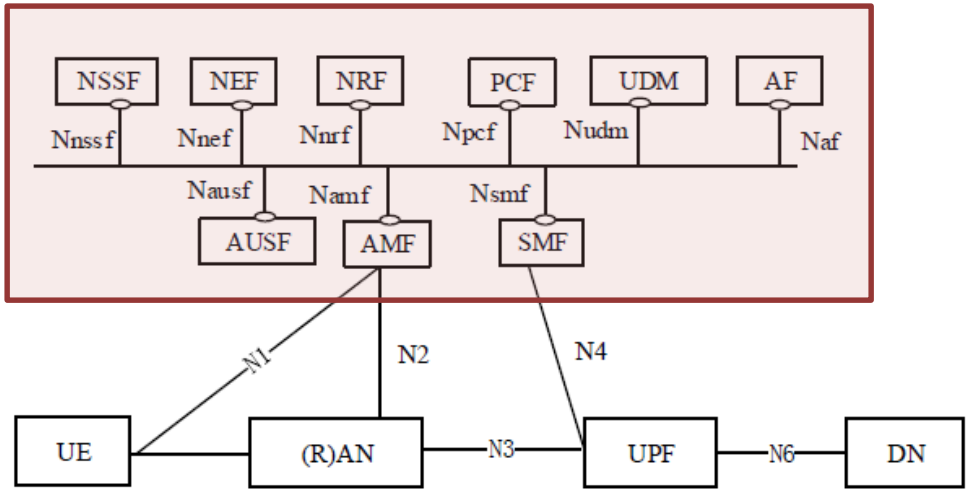
5G Core: Design Principles (2)

- Control User Plane Separation (CUPS)
  - Control (AMF, SMF, …) separate from data plane
  - Independent scaling and provisioning
  - Data plane can move closer to user for low latency



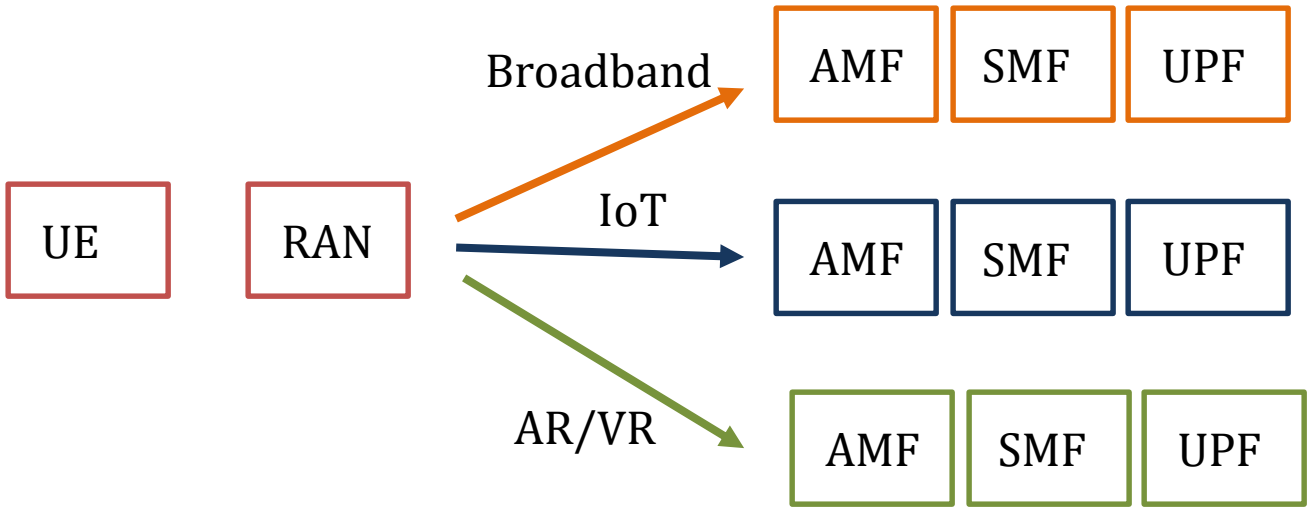
5G Core: Design Principles (3)

- Service Based Architecture (SBA)
  - Control plane components talk over HTTP
  - RESTful APIs between components
  - Reuse frameworks for scalable HTTP servers



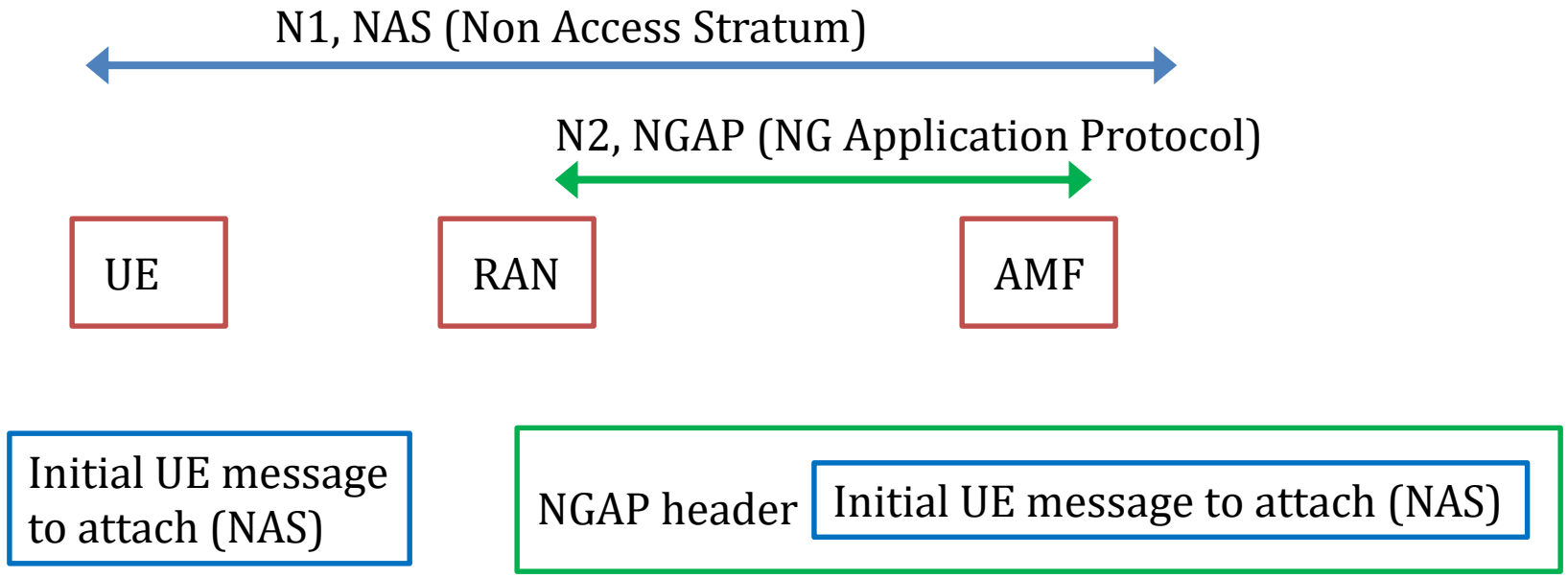
5G Core: Design Principles (4)

- Network Slicing
  - Separate instances of core components for different applications
  - Isolation, customized implementations



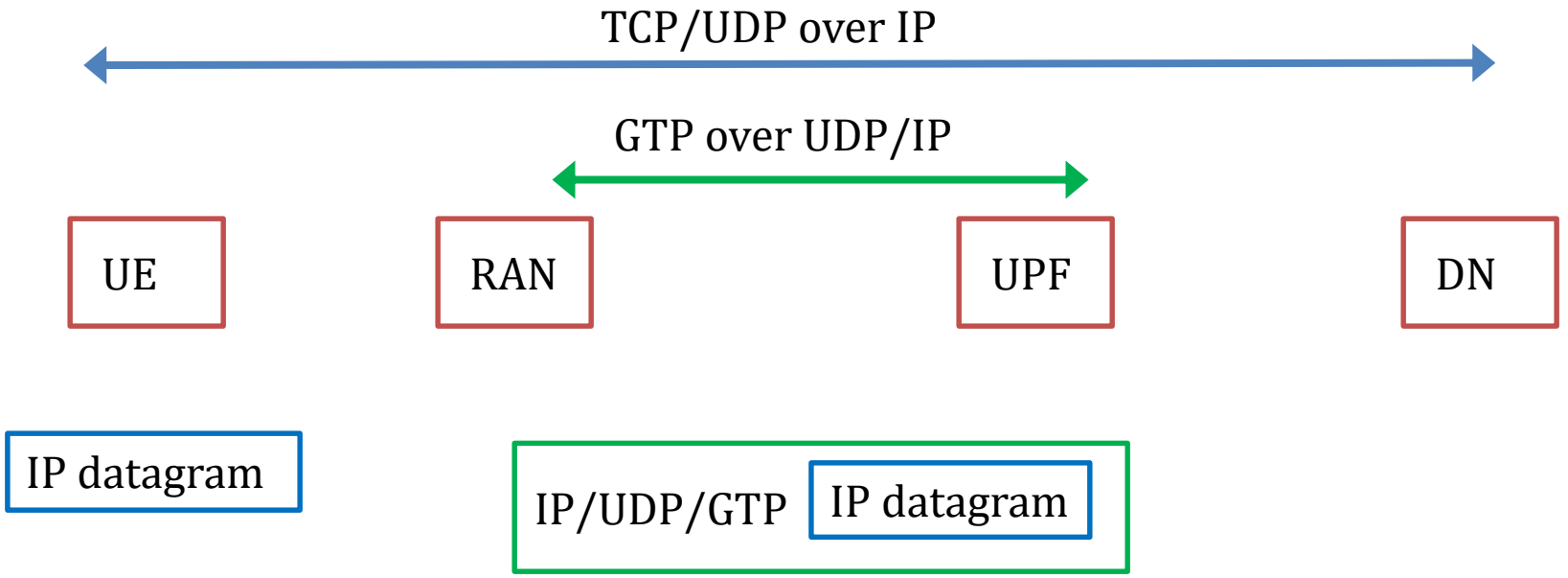
5G Core: Control Plane Stack

- UE and AMF exchange NAS msgs over N1
- RAN and AMF exchange NGAP msgs over N2

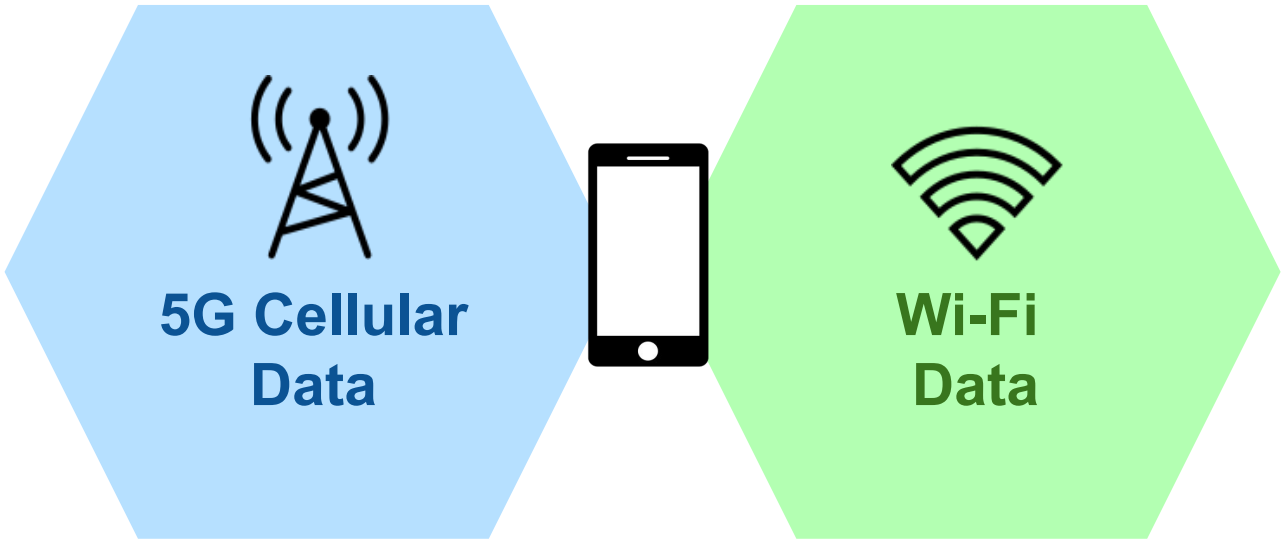


5G Core: Data Plane Stack

- UE generates IP datagrams to external data networks
- RAN and UPF use GTP over UDP



Integrating WLAN with the 5G Core Network



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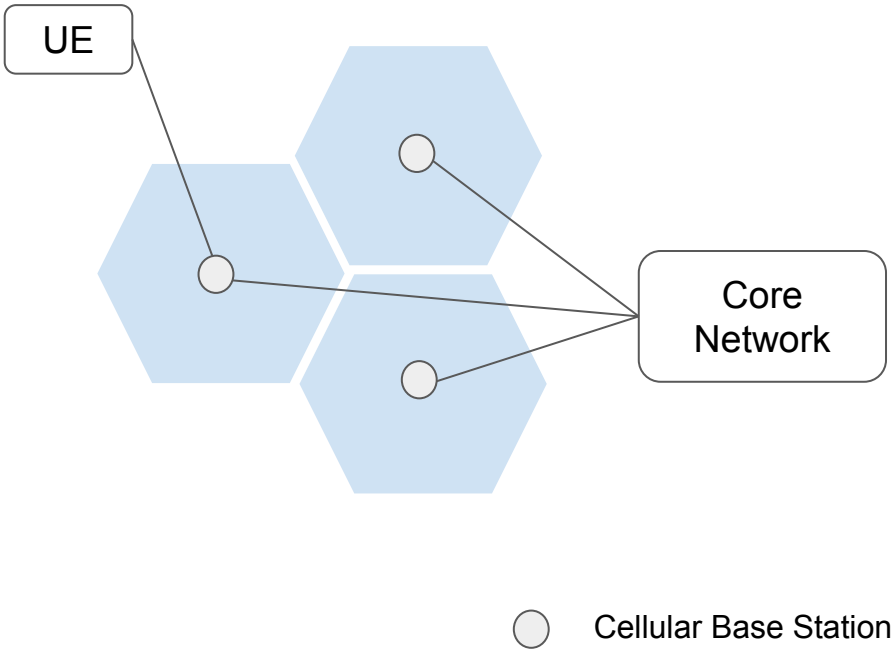
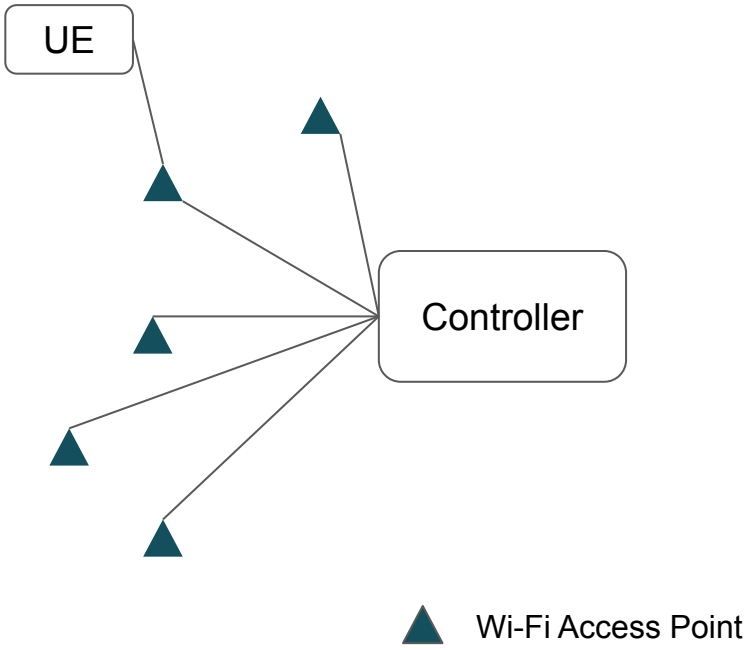
Access Network

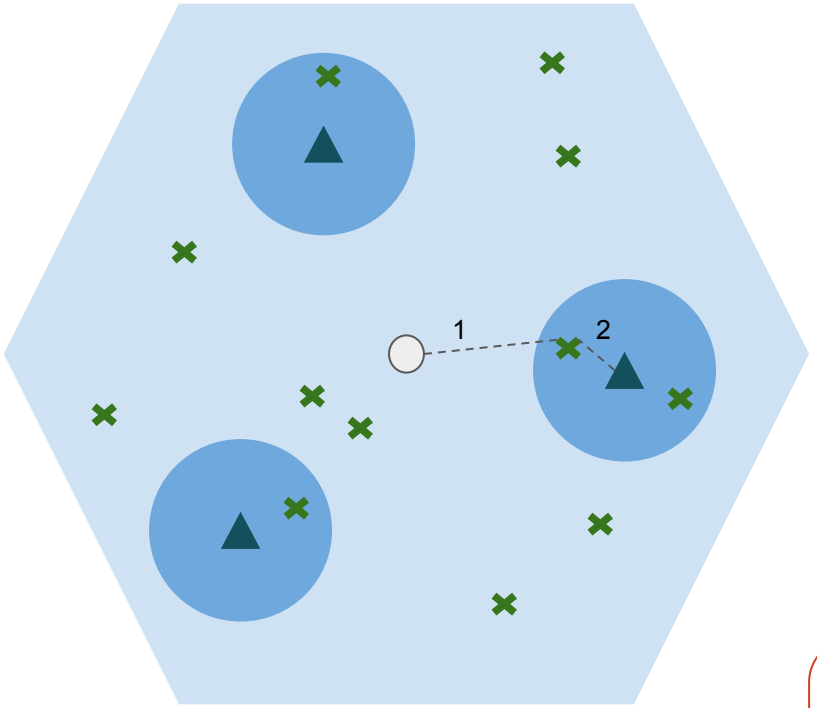


Cellular Network



WLAN Network

Cellular Network with WLAN



Users

Cellular Base Station

Wi-Fi Access Point

Random Deployment

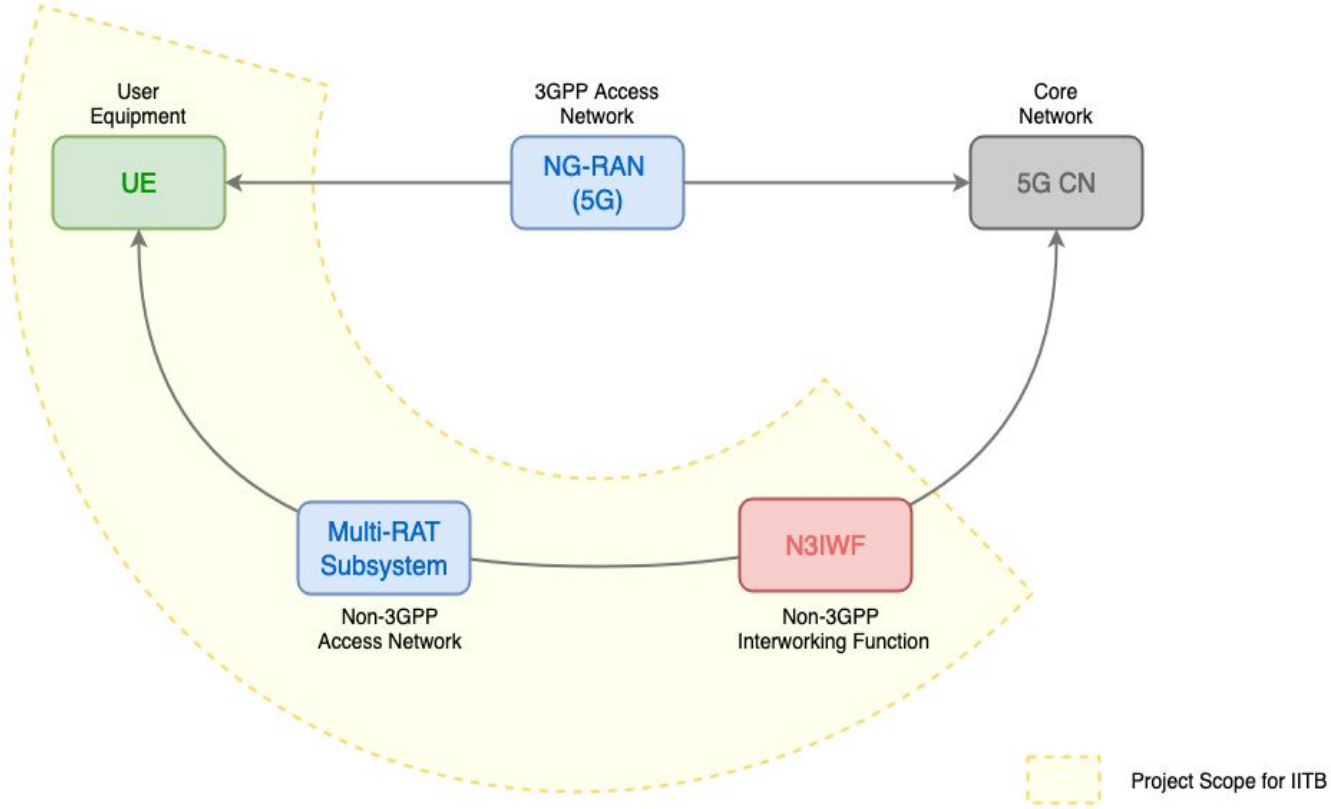
Alternate Access to Data Network

Better User Experience

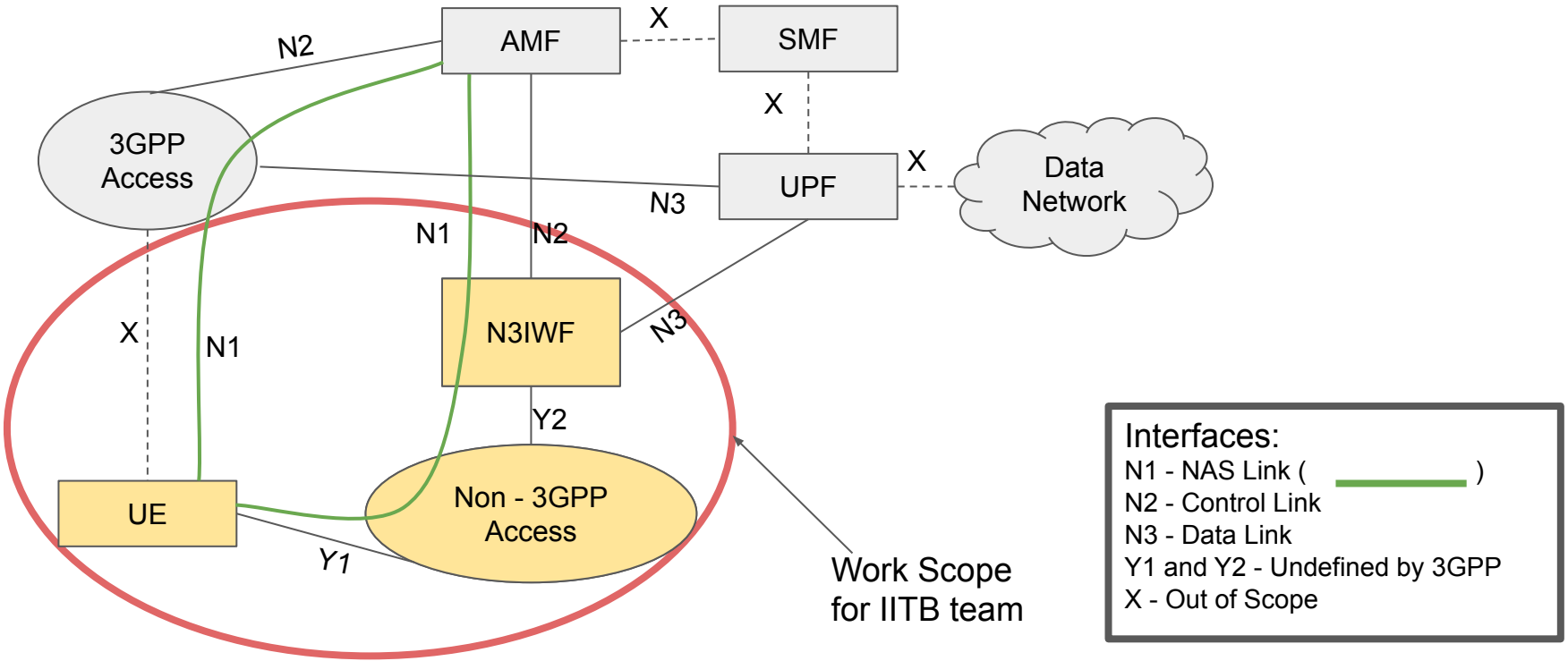
Traffic Offloading

Centralized Control

3GPP 5G System Architecture

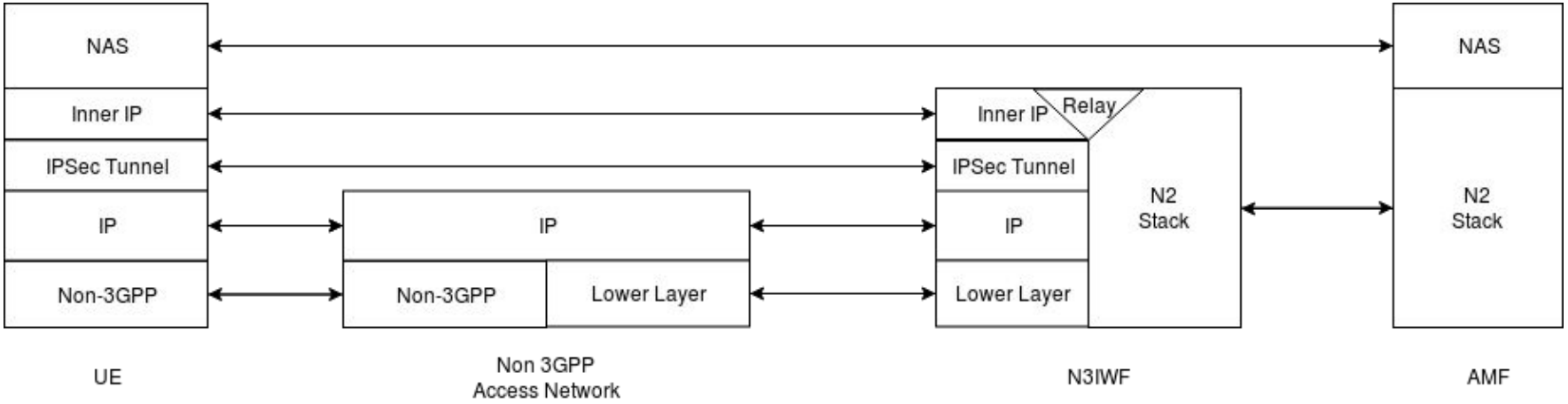


WLAN Access (Non-3GPP Access) for 5G Core



Courtesy: 3GPP

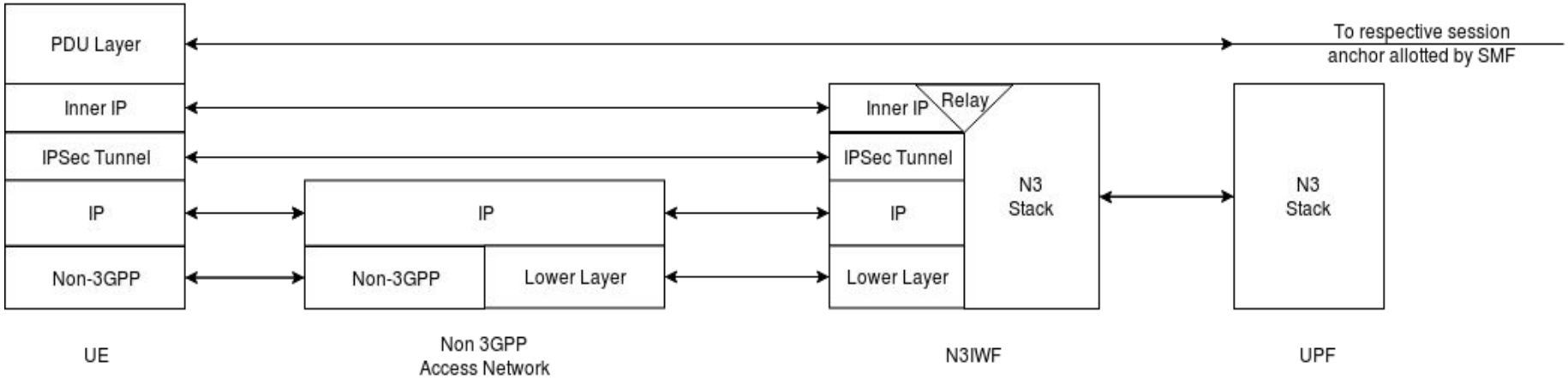
Signaling Relay by N3IWF (Control Plane)



Entities	Interfaces
UE - AMF	NAS Link
UE - N3IWF	IPSec Tunnel
N3IWF - AMF	N2 Link (SCTP,NGAP)

Courtesy: 3GPP

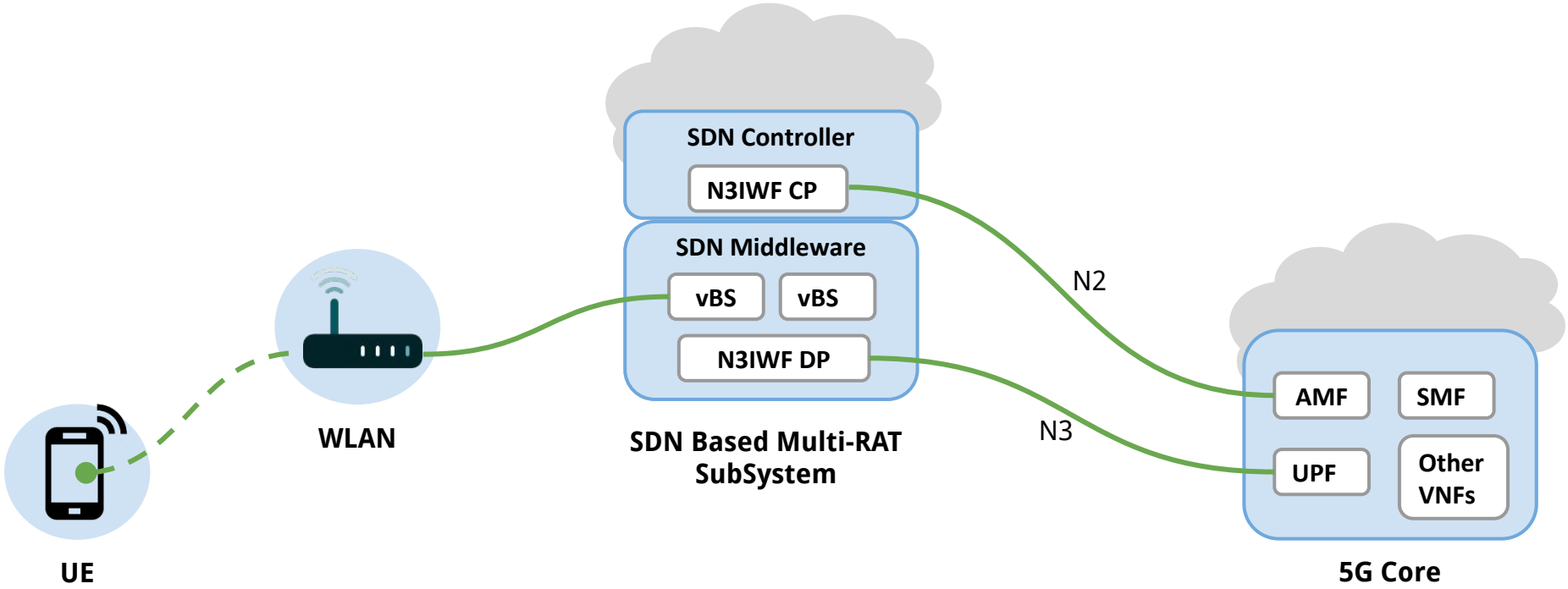
Data Relay by N3IWF (Data Plane)



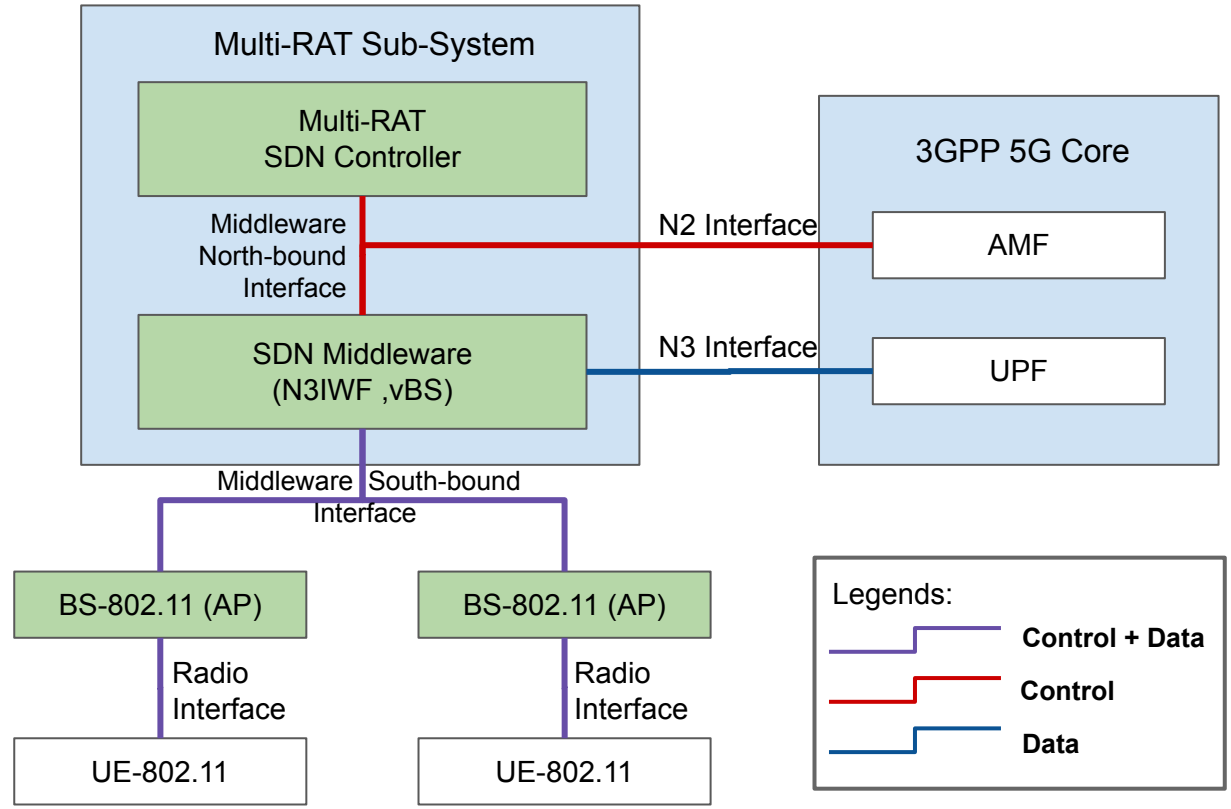
- IPSec Tunnel between UE and N3IWF and N3 link between N3IWF and UPF.
- Non 3GPP Access Network responsible for just forwarding the packets.

Courtesy: 3GPP

WLAN InterWorking with 5G Core - SDN based Architecture (1/2)



WLAN InterWorking with 5G Core - SDN based Architecture (2/2)



Multi-RAT SDN Controller responsible for managing WiFi APs in vendor agnostic manner.

SDN Middleware comprises of N3IWF, Virtual Base Station.

Courtesy: Adapted from IEEE P1930.1 standard initiative being led by IITB