**Protocols of control and user plane and their functions**

In the 5G network architecture, different protocols handle control and user plane operations, each with specific roles and functions. Here’s an overview of the key protocols used in both the control plane and user plane:

**Control Plane Protocols**

The control plane in a 5G network manages signaling and control functions related to user sessions, mobility, and access. Key protocols in the control plane include:

1. **NG Application Protocol (NGAP)**
   * **Function**: Handles the signaling between the User Equipment (UE) and the Access and Mobility Management Function (AMF).
   * **Key Tasks**:
     + UE registration and authentication.
     + Connection setup, modification, and release.
     + Mobility management and handover procedures.
     + Interactions with the Session Management Function (SMF) for session-related tasks.
2. **Service Communication Proxy (SCP) Protocol**
   * **Function**: Facilitates secure and efficient communication between different network functions (NFs).
   * **Key Tasks**:
     + Manages communication and data exchange between NFs, such as between AMF and SMF or between SMF and UPF.
     + Ensures security and integrity of signaling messages.
3. **Session Management Protocol (SMP)**
   * **Function**: Manages session establishment, modification, and release between the Session Management Function (SMF) and other network elements.
   * **Key Tasks**:
     + Coordinates with the AMF to manage sessions.
     + Interacts with the UPF to set up and manage user plane paths.
4. **Network Function (NF) Interface Protocols**
   * **Function**: Various protocols facilitate communication between network functions.
   * **Key Tasks**:
     + NF-2-NF communication (e.g., AMF to PCF, SMF to UDM).
5. **Access and Mobility Management (AMF) Protocols**
   * **Function**: Provides control and signaling for access and mobility management.
   * **Key Tasks**:
     + Manages the UE's connection and mobility across the network.

**User Plane Protocols**

The user plane in a 5G network is responsible for the actual transfer of user data between the UE and the external network. Key protocols in the user plane include:

1. **GPRS Tunneling Protocol for User Data (GTP-U)**
   * **Function**: Carries user data between the User Plane Function (UPF) and the Serving Gateway (SGW) or between other user plane elements.
   * **Key Tasks**:
     + Encapsulates and transports user data packets.
     + Ensures proper routing and QoS enforcement.
2. **User Datagram Protocol (UDP)**
   * **Function**: Used for transporting user data in many scenarios due to its low overhead and simplicity.
   * **Key Tasks**:
     + Provides a connectionless transport layer for user data.
     + Suitable for applications requiring fast, real-time data transmission with minimal latency.
3. **Internet Protocol (IP)**
   * **Function**: Handles the addressing and routing of user data packets across the network.
   * **Key Tasks**:
     + Provides logical addressing and routing for data packets.
     + Supports both IPv4 and IPv6 addressing.
4. **Quality of Service (QoS) Protocols**
   * **Function**: Ensures that data traffic is handled according to specified QoS requirements.
   * **Key Tasks**:
     + Enforces QoS rules and parameters defined by the PCF and SMF.
     + Manages traffic prioritization, bandwidth allocation, and latency requirements.
5. **Multiprotocol Label Switching (MPLS)**
   * **Function**: Often used in backbone networks to direct user data traffic efficiently.
   * **Key Tasks**:
     + Provides efficient data forwarding based on labels.
     + Supports traffic engineering and QoS.

In the 5G network, control plane protocols like NGAP, SMP, and SCP manage signaling and control functions, while user plane protocols such as GTP-U, UDP, and IP handle the actual data transfer. The combination of these protocols ensures that the network can manage user connections and data traffic effectively, delivering the high performance and flexibility required by modern applications and services.