Source:
https://daqscribe.com/wiki/case-studies/tap-monitoring-for-5g-o-ran-architectures/

Overview of 5G Open Radio Access Network (O-RAN)

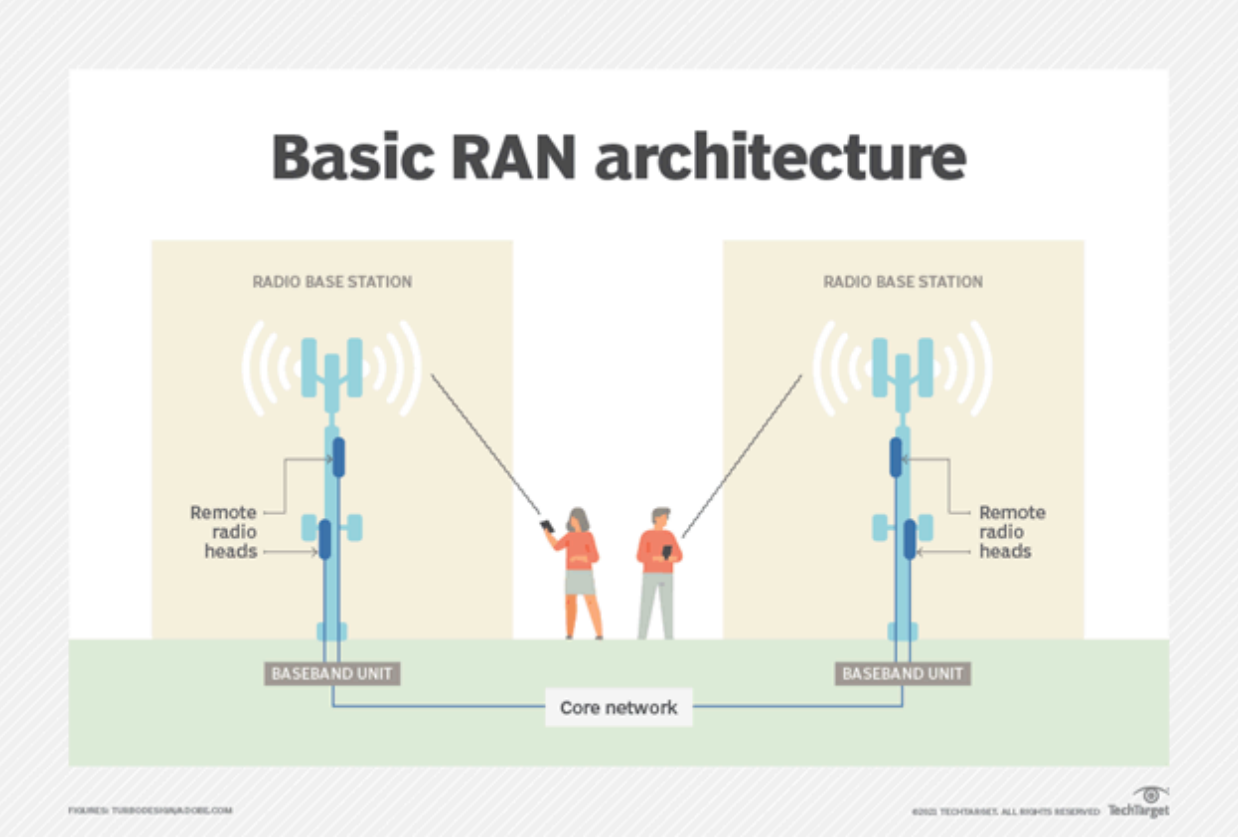
The 5G Open Radio Access Network (O-RAN) architecture brings greater efficiency, cost savings, and flexibility to mobile networks by introducing modular, interoperable components across the radio access layer. Unlike traditional, vendor-locked RAN systems, O-RAN promotes openness and standardization, enabling service providers to mix and match hardware and software from different vendors.

Disaggregated Architecture

O-RAN breaks down the traditional monolithic base station into three key components:

- **Radio Unit (RU):**
  Responsible for RF signal transmission and reception, the RU handles the lower layers of the PHY (physical) stack. It performs functions such as signal amplification, conversion, and digitization, and is typically integrated into or co-located with the antenna assembly.
- **Distributed Unit (DU):**
  The DU manages the upper PHY and MAC (Medium Access Control) layers. It executes real-time processing and controls the scheduling of radio resources. It is often co-located with the RU at the network edge to minimize latency.
- **Centralized Unit (CU):**
  Positioned closer to the operator's core network, the CU handles higher-layer

protocol processing and control functions. It implements the 3GPP-defined F1 interface to interoperate with the DU, facilitating user-plane and control-plane data management.



Source: Basic RAN Architecture.

Communication Interfaces

- **Open Fronthaul Interface (OFH):**
  The RU and DU are connected via the OFH, which commonly uses the enhanced Common Public Radio Interface (**eCPRI**) protocol over Ethernet. This standard enables flexible, high-throughput, and vendor-neutral communication between the radio and baseband components.
- **DU-CU Integration:**
  The DU and CU together form the logical base station, processing digitized RF signals and forwarding them toward the operator's 5G core for broader network routing and connectivity services.

Strategic Placement

- The **RU** is deployed at the antenna site for immediate radio access.
- The **DU**, often located at edge sites, ensures low-latency operation near users.
- The **CU** resides deeper in the network, closer to the 5G core, to efficiently manage centralized control and transport functions.

This open and modular design enables greater vendor diversity, accelerates innovation, and reduces both CAPEX and OPEX, making O-RAN a pivotal enabler of scalable and agile 5G deployment.

Test Access Points (TAP) Monitoring

TAP monitoring for 5G O-RAN is a crucial aspect of ensuring the performance, compliance, and interoperability of disaggregated 5G network components. In the context of O-RAN, TAP monitoring involves several key aspects:

1. Comprehensive testing: TAP monitoring for 5G O-RAN requires testing individual components such as radio units (RUs), distributed units (DUs), and centralized units (CUs), as well as end-to-end network validation.
2. Interoperability verification: With O-RAN's multi-vendor approach, TAP monitoring is essential to ensure seamless integration and communication between components from different vendors.
3. Performance assessment: TAP monitoring helps evaluate key performance indicators such as latency, throughput, and connection density, which are critical for 5G applications like ultra-reliable low-latency communications (URLLC).
4. Conformance testing: O-RAN components, particularly O-RUs, must conform to both 3GPP specifications and the O-RAN ALLIANCE's O-RAN.WG4.CONF specification for the fronthaul open interface.
5. Field trials and simulations: TAP monitoring includes conducting field trials and using emulation platforms to simulate real-world conditions and analyze network performance in diverse scenarios.

6. Continuous monitoring: Beyond initial testing, TAP monitoring for 5G O-RAN involves ongoing network assurance, optimization, and troubleshooting to maintain optimal performance.
7. Automation: Due to the asynchronous hardware and software releases of O-RAN elements, automated testing is crucial for comprehensive and efficient TAP monitoring.

By implementing thorough TAP monitoring practices, network operators can ensure the reliability, security, and optimal performance of their 5G O-RAN deployments while taking advantage of the flexibility and innovation potential offered by the open architecture.

Why Use TAP Monitoring Here?

1. Troubleshooting: Identify where packet loss, jitter, or latency occurs.
2. Performance Analysis: Track how efficiently RU and DU are communicating.
3. Synchronization Issues: Detect timing mismatches affecting radio performance.
4. Protocol Decoding: Examine eCPRI, RoE(Radio over Ethernet) ethernet frames.
5. Security & Compliance: Monitor for unexpected traffic patterns.

How It Works

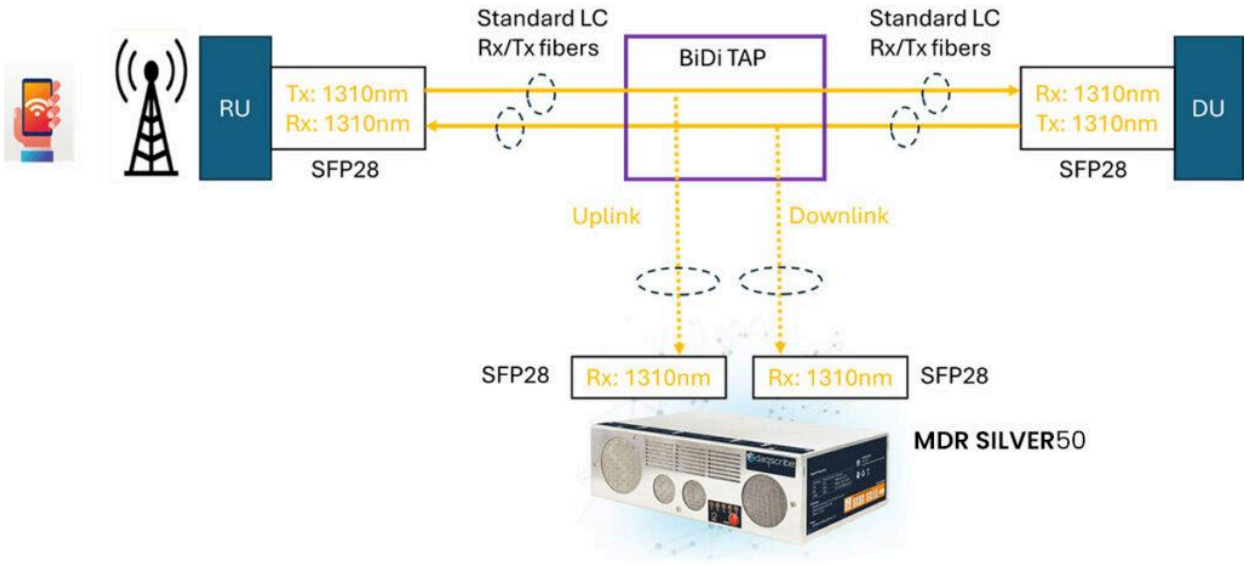
1. A TAP device is placed on the fronthaul link between RU and DU.
2. BiDi TAP capability ensures that both directions (RU → DU and DU → RU) are captured.
3. The TAP sends mirrored traffic to a monitoring probe, analyzer, or packet recording instrument.
4. Tools like Wireshark, can decode the protocols and give insights.

Standard TAPs vs BiDi TAPs

Standard TAPs and BiDi TAPs are both network monitoring devices, but they have distinct characteristics and use cases:

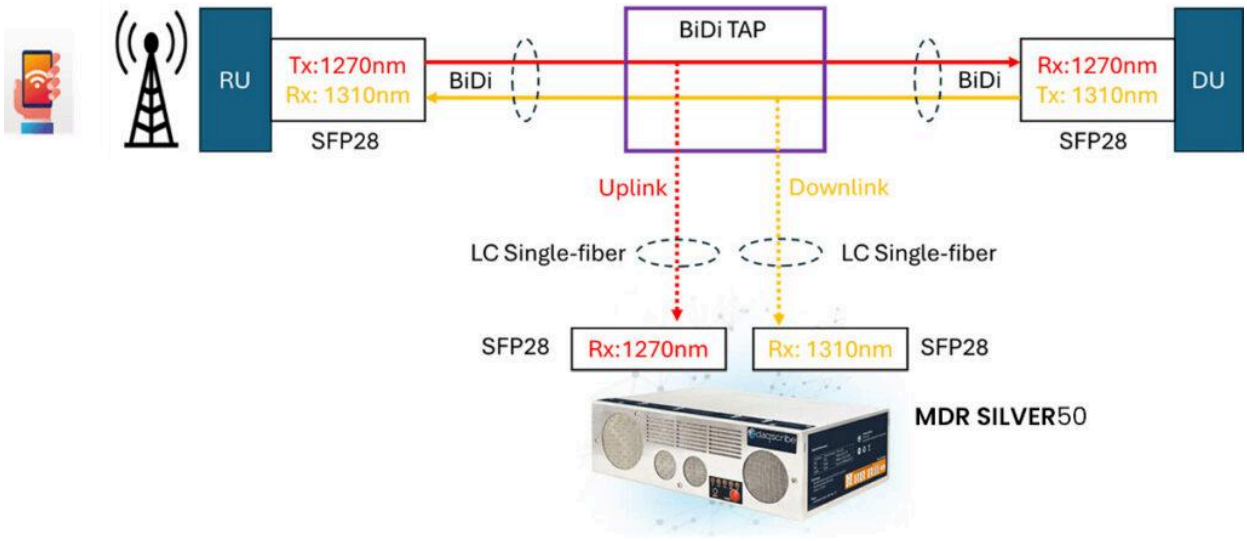
Standard TAPs

1. Fiber usage: Typically require separate fibers for transmitting and receiving data.
2. Compatibility: Work with traditional optical links using separate wavelengths for each direction.
3. Cost: Generally less expensive than BiDi TAPs.
4. Deployment: Suitable for most network environments using standard optical technology.



BiDi TAPs

1. Single fiber utilization: Support bidirectional traffic over a single fiber using wavelength division multiplexing (WDM).
2. Compatibility: Specifically designed for Cisco Bi-directional Optical Technology and other BiDi links.
3. Cost efficiency: Enable 25Gb(40Gb/100Gb) connectivity over existing multimode fiber infrastructure, reducing overall deployment costs.
4. Space optimization: Ideal for high-density environments due to reduced fiber cabling requirements.



Key Differences

1. Technology support: BiDi TAPs are essential for monitoring BiDi links, which standard TAPs cannot effectively handle.
2. Wavelength handling: BiDi TAPs can isolate and capture multiple wavelengths on a single fiber, unlike standard TAPs.
3. Insertion loss: BiDi TAPs often use advanced splitter technology to reduce insertion loss compared to traditional splitters.
4. Density: BiDi TAPs can offer higher port density, with some models supporting up to 24 BiDi links in a 1U chassis.

In summary, while standard TAPs are suitable for most traditional network setups, BiDi TAPs are specialized devices designed to provide visibility into bidirectional optical links, offering unique advantages in terms of fiber utilization, cost-effectiveness, and compatibility with modern high-speed networks using BiDi technology.