SOLiD

Case Study

SK Telecom deploys 5G-PON fronthaul to maximize fiber utilization, simplify operations and reduce costs

This case study explores the evolution of SK Telecom's mobile network for cell site connectivity, from 3G backhaul to 4G centralized RAN and through to 5G fronthaul. A key aspect is the fiber network architecture that connects cell sites to the central office, which evolved from point-to-point (3G), to active hub-and-spoke (4G), then to PON hub-and-spoke (5G).

Implementation of the 5G-PON architecture helped realize several important objectives for SKT:

- Overcome the limitations in fiber plant capacity
- Simplify operations by eliminating active WDM equipment from cell sites, while maintaining optical ring protection
- Minimize transport delay in order to support URLLC (Ultra-Reliable Low-Latency Communication) applications and services¬
- Accelerate cell site installations with colorless, semi self-tuning optics that minimizes wavelength planning and transceiver stocking logistics
- Achieve significant cost savings

Cell Densification: Fiber Connectivity to More Sites

3G ushered in data; 4G saw the rise of mobile streaming; 5G adds higher speeds, greater capacity, lower latency, and cloud architectures that promise to unlock transformational applications and use cases across multiple industries. Cell densification has been a fundamental strategy throughout. The smaller the cell, the stronger the RF signal at the cell edge, the higher the modulation rate, and hence higher peak speeds and greater cell throughput. New wireless spectrum adds another dimension: mmWave (high-band) cells operate at higher frequencies with higher losses, resulting in a cell radius less than 150 meters, while 700 MHz (low-band) cells reach further with a radius well over 1 km in urban environments. The density of high-band cells is projected to be 10 to 20 times that of low-band cells.

CRAN: Sites Require Increasing Bandwidth

Not only is more fiber needed to connect new sites, but the fiber has to carry more traffic. 3G backhaul predominantly operated at T1/E1 speeds. The introduction of the CPRI interface in 4G enabled Centralized Radio Access Network (CRAN), in which the BBU was not longer deployed at the cell site and co-located with the RRH, but rather deployed in a pool of BBUs at the central office. Fiber connected the BBUs to the RRHs, and the CPRI link operated at up to 10 Gbps – several orders of magnitude faster than T1/E1. In 5G the maximum CPRI speed further increased to 25 Gbps.

SK telecom

SK Telecom (SKT) is South Korea's leading ICT company, driving innovations in the areas of mobile communications, media, security, commerce and mobility.

SKT boasts unrivaled leadership in the South Korean mobile market with over 30 million subscribers, nearly 50 percent of the market. The company has 49 ICT subsidiaries and annual revenues approaching KRW 18.6 trillion ($15.5 billion USD).

SKT is a 5G early adopter and fast mover. Two years after launching the world's commercial, country-wide 5G service in April 2019, SKT's 5G subscribers totaled 7.7 million – in a country with a population of 51 million. With median download speeds above 600 Mbps and latency of 40 ms in major cities1, SKT quickly established itself as a world leader in 5G network performance and excellence.

Impact of 5G-PON at SKT

50%

lower fiber costs compared to dark fiber

26%

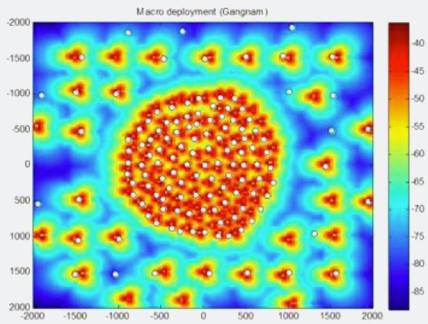
reduction in fronthaul TCO compared to 4G

SOLiD

"In order to support 1000 times more traffic than LTE, it is essential to increase network capacity through significantly improved cell split … this means 5G systems need ultra-dense small cell network of which the cell density is more than the level discussed in LTE-A HetNet … Accordingly, 5G network needs to secure differentiated small cell O&M technologies and expand relevant ecosystem with high performance/low-cost small cell, cost-effective backhaul/relay technologies."

SK Telecom 5G White Paper

SK Telecom's View on 5G Vision, Architecture, Technology, Service, and Spectrum



Latency in 5G: The Final Factor

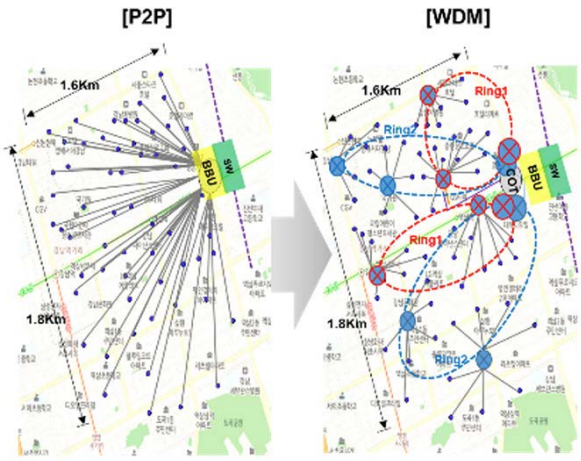
5G is architected to support Ultra-Reliable Low-Latency Communications (URLLC). Applications include:

- Autonomous Vehicles (V2X) and drones
- Smart Factories, Robotics, and Industrial Automation (Industry 4.0)
- Telemedicine
- Assisted Reality (AR) and Virtual Reality (VR)

Most applications require end-to-end packet latency of 1-10 milliseconds, and some demanding use cases require sub-millisecond latency. Thus it is vitally important that the RAN, including fiber fronthaul/backhaul from the RU to the DU/CU, introduce the minimum possible delay. Cloud architectures such as Multi-access Edge Computing (MEC) further reduce device-to-server latency by bringing application servers from the data center out to the edge. Often these are co-located with the RAN CU/DU servers.

From 3G to 4G

SKT commercially launched 4G LTE service in July 2011 and achieved nationwide coverage by April 2012. The CRAN architecture was adopted from the start as it would substantially reduce the total cost of ownership, and future-proof the network by enabling RAN virtualization and disaggregation of network functions. A hub-and-spoke fiber topology was implemented (see adjacent figure).

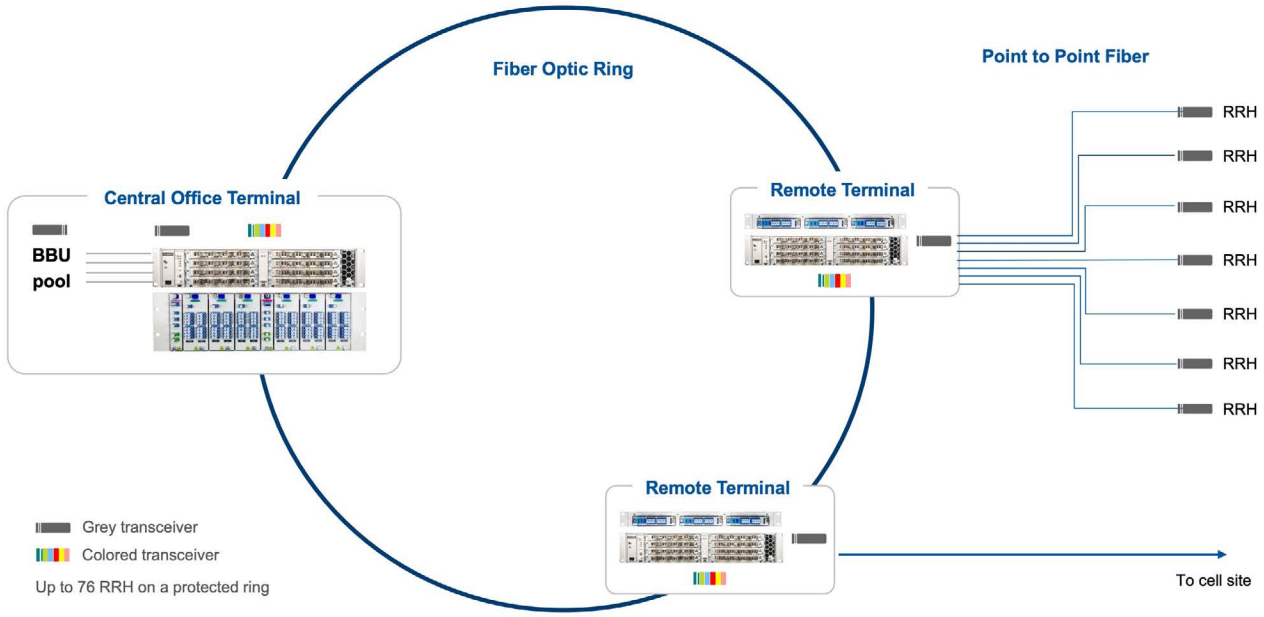


BBUs located in the central office are served by a fiber COT (central office terminal). This is connected via protected fiber rings to the RT (remote terminals). A single RT serves multiple RRHs located at different cell sites, which are connected via point-to-point fiber to the RT.

The hub-and-spoke ring topology lowered fiber connectivity costs by using short fiber spans from cell sites to the RTs. The optical rings linking the RTs to the COT adds wavelength rerouting and protects against fiber cuts and node failures, thereby improving network resilience.

4G: The WDM Solution

The Active WDM solution combined CWDM and DWDM to support up to 76 RRHs in a single protected ring. The configuration is shown below:



Demarcation and WDM management

The solution supports a clear demarcation between radios and WDM equipment (i.e. wireless and optical domains) since the active central office terminal (COT) and the active remote terminal (RT) perform performance monitoring of all wavelengths. An element management system (EMS) is used to manage and operate the terminals and colored transceivers. Instead of colored optics, grey transceivers are used at the BBU and the RRHs.

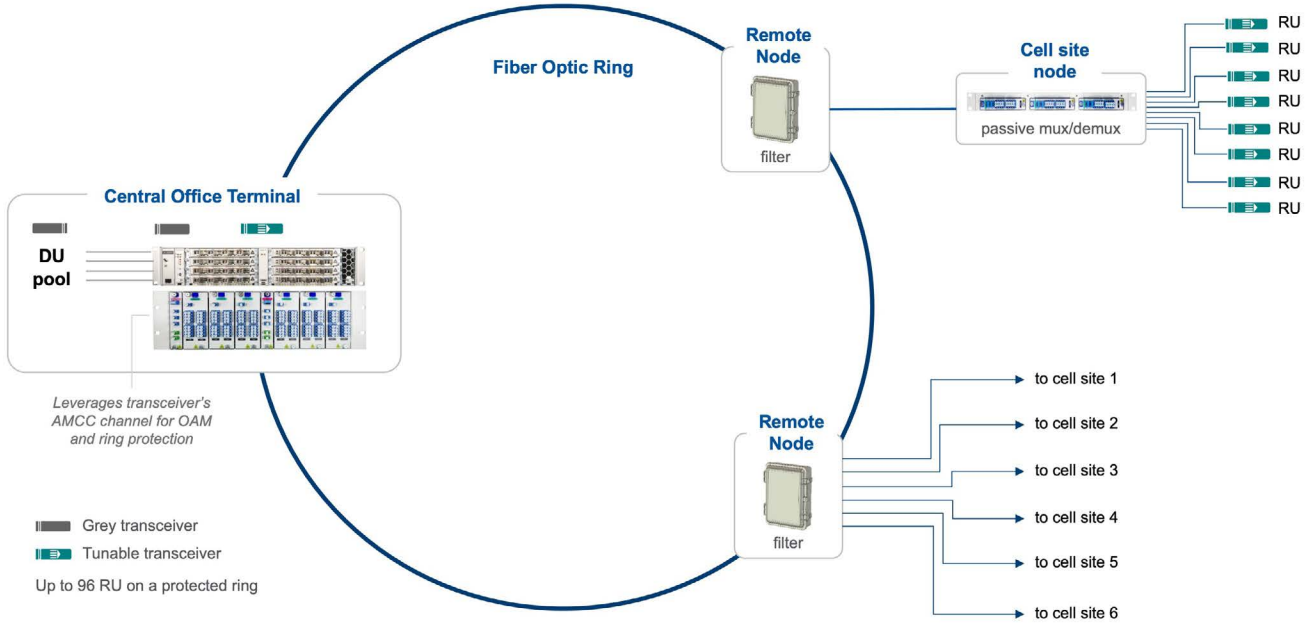
Network Resilience with Optical Ring Protection

At the central and remote terminals, optical wavelengths are converted from grey optics to WDM for transport over the optical ring. In case of a fiber cut, the wavelengths are rerouted in the opposite direction. Optical channels are not reused between fiber spans, so half the capacity on the fiber ring is reserved to accommodate rerouting scenarios.

> The 4G network consists of approximately 12,000 base station nodes and 80,000 RRH. Deployment took approximately 12 months. Building the network with new fiber (either leased or new construction) would have taken three years or longer.

5G-PON: The New Architecture

In 2018, in preparation for 5G, SKT began deployment of their second generation CRAN fronthaul solution named 5G-PON as shown below.



The optical fiber ring remains the same and is still protected, but some important enhancements were made:

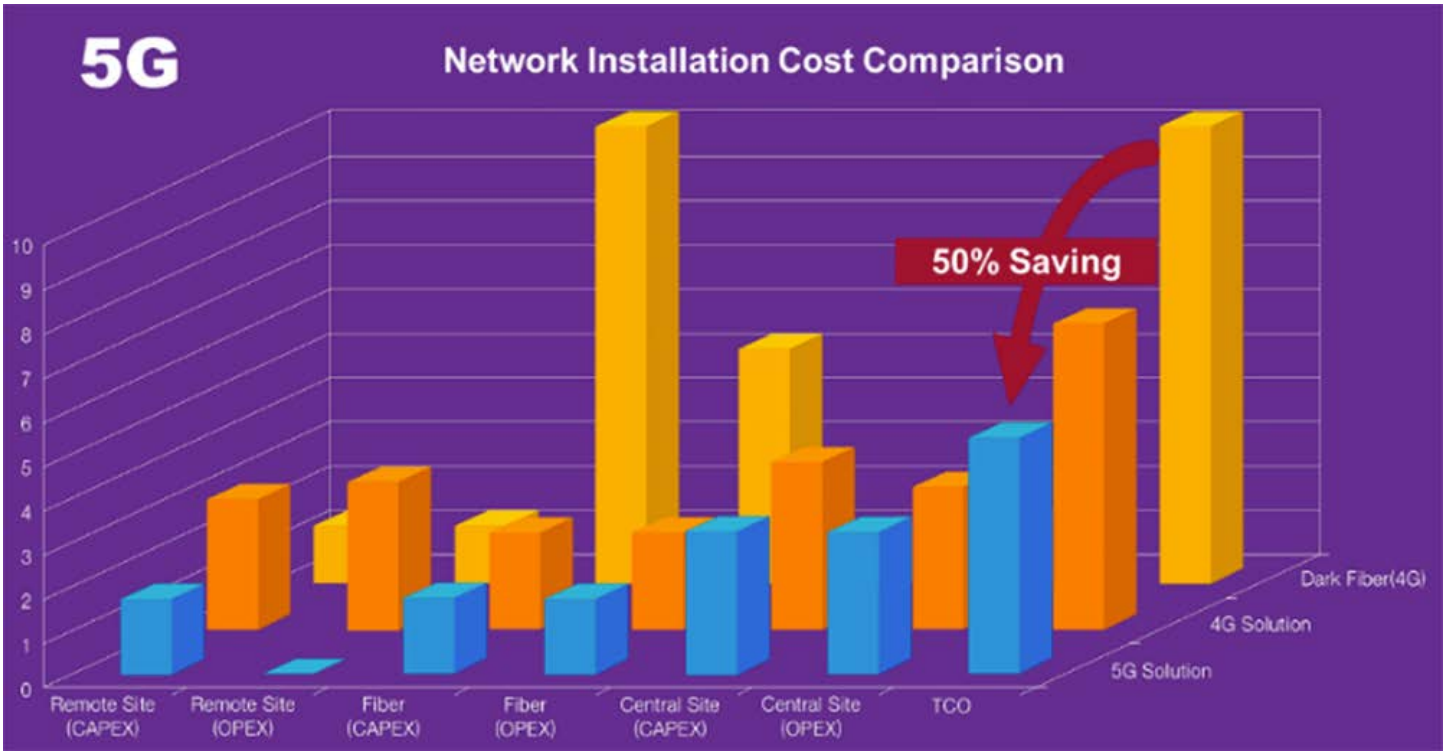
- **The RT, now called the Remote Node (RN) is completely passive**. All active electronics and transceivers have been replaced by a passive optical band-pass filter and mux/demux. With no need for power plus a smaller footprint, site acquisition becomes easier and site OPEX (electricity, cooling, maintenance) is reduced. Latency is now significantly reduced since traffic passing through the passive RN remains untouched and does not undergo optical-electrical-optical conversion (as it did in 4G with grey/colored optics conversion).
- **A multi-stage PON architecture for fiber distribution to the RUs** was implemented to provide greater flexibility for site acquisition, and shorter fiber runs to new sites, thereby reducing site CAPEX.
- **The RU uses tunable transceivers instead of grey transceivers**, as does the other end of the link at the COT. The COT leverages the Auxiliary Management and Control Channel (AMCC) to communicate with RU transceiver, and analyzes the Digital Diagnostic Monitoring Information (DDMI) for remote transceivers' performance monitoring. Furthermore, a Multi-Source Agreement (MSA) defining interoperability standards was implemented with industry vendors to ensure a diverse supply chain and a competitive marketplace for the transceivers. The transceivers are semi self-tuning: at the COT their wavelength is configured by the EMS; at the RU the wavelength is automatically configured by the COT, making them as quick and easy to install as grey transceivers.

By taking active equipment out of the field and transferring critical functions to software on the COT and transceivers, the 5G-PON solution is saving SKT 26% compared to the 4G active WDM solution.

A High-Performance Fiber Transport Network Delivers Significant Cost Savings

SKT's 5G-PON architecture and the tunable WDM PON solution from SOLiD delivered impressive time and cost savings while reducing fronthaul latency. The key benefits experienced by SKT were:

1. Greatly improved fiber utilization with proven optical hardware and smart management.
2. Simultaneous reduction of both CAPEX and OPEX by eliminating active equipment in the field
3. Rapid field deployment – with minimal technician training and reduction in the number of transceiver models to be stocked – due to the use of semi self-tuning transceivers enables to reduce SKU numbers and make installation easy and fast



EDGE CONNECTIVITY. SOLiD COVERAGE.

The efficient use of fiber optic assets is the foundation of a 5G world. The data transmission capacity demanded by 5G networks increases as new bands and larger channel bandwidths enable massive wireless data. Providing the necessary bandwidth to the edge cannot happen without fiber-optic infrastructure.

To learn more about our unmatched optical transport solutions, contact us at optical.support@solid.co.kr