Application Note

Smart xHaul Time-Sensitive Networking (TSN) Solution

How fast is 5G?
A simple question with a not-so-simple answer: it depends on amount of wireless spectrum, the chipset used in the mobile phone, how cluttered the path is between the phone and the cell site radio, and many other factors. As deployments ramp up, mobile network operators achieve new download speed records – and then break them just as quickly.

Stress on the transport network
This multiplication of bandwidth compared to 4G is compounded by Cloud RAN (C-RAN) and fronthaul architectures, in which the baseband processing is performed remotely at a central hub, not at the cell site. CPRI (or packetized eCPRI) is the protocol used to carry traffic between the radios and the hub. For an IP traffic rate of 600 Mbps (i.e. the backhaul bandwidth), the CPRI line rate is 10 Gbps. This is because the CPRI link carries digitized baseband RF traffic, the ‘raw’ information which once processed, supports a host of advanced features.

Fiber exhaustion
The sheer amount of bandwidth a cell site requires (tens or even over a hundred Gbps) can rapidly lead to fiber exhaustion. Dedicating a fiber to each radio (4G and 5G) or service is neither scalable nor feasible: any viable solution must maximize the capacity of existing fiber plant.

Multiplexing several wavelengths on the same fiber is a possibility, but the associated transponders, filters, and associated rack space comes at a cost. Real estate at the cell site is also limited. To overcome these limitations, Fujitsu introduces the flexiHaul M6424 TSN Switch, a solution based on IEEE 802.1CM Time-Sensitive Networking for Fronthaul.

Time-Sensitive Networking (TSN)
The IEEE 802.1CM standard combines the deterministic performance and reliability of circuit-switched transport with the speed and scale of Ethernet switching. Compared to active WDM-based offerings, the flexiHaul M6424 TSN-based solution can reduce the total cost of ownership with up to 50% lower capital costs, 90% turn-up time savings, and 75% footprint reduction. Ancillary benefits include reduced network complexity, and simplified spares and inventory management.

The first proven, commercially available TSN fronthaul solution in the market.

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Application Benefits
- Simplicity: a compact 1RU transport switch that aggregates CPRI, eCPRI and Ethernet traffic onto 100 GbE links
- Open & standards-based: implements IEEE 802.1CM Time-Sensitive Networking (TSN) for Fronthaul and IEEE 1914.3 Radio over Ethernet (RoE) for CPRI encapsulation to maximize interoperability
- Precision time protocol (PTP) for 5G radios supplied by the network, instead of by GPS at the cell site

Functional Elements
- flexiHaul™ M6424 TSN Switch
Aggregate traffic from the cell site, without WDM optics

**Macro Cell Sites**

- 4G RRH CPRI
- 5G RU eCPRI
- Ethernet

**Central Location**

- CPRI
- Ethernet
- 4G
- 5G
- Internet

**TSN mobile fronthaul: flexiHaul M6424 aggregates cell site traffic, without WDM optics**

**Aggregating traffic from the cell site**

The flexiHaul M6424 is a member of the Fujitsu Smart xHaul family of solutions. The M6424 is a hardened, 1RU TSN transport switch that connects cell site radios to the 4G baseband unit or 5G DU/CU at the central hub. It aggregates and transports multiple traffic types:

- 4G CPRI up to 10 Gbps through Ethernet encapsulation using IEEE 1914.3 Radio over Ethernet (RoE)
- 5G eCPRI up to 25 Gbps with grooming for hub site interconnect port reduction to DU/DU-CU
- Ethernet up to 25 Gbps for business or Wi-Fi access points, delivered over a converged network infrastructure
- Alarms, environmental monitoring, and OAM (operations, administration, maintenance) traffic from the cell site to the network operations center (NOC)

The flexiHaul M6424 provides 24x multi-function ports with operation up to 25 Gbps (SFP28) and 4x 100 Gbps network uplink ports (QSFP28), with a total 800 Gbps switching capacity – packed in an temperature hardened, 1RU chassis.

**Frame Pre-emption**

Combining time sensitive CPRI/eCPRI traffic with native Ethernet traffic on the same uplink requires sophisticated traffic management. While packet prioritization, queuing, buffering, and scheduling techniques are already common in Ethernet networks, the IEEE 802.1CM standard adds Interspersing Express Traffic (IEEE 802.3br) and Frame Pre-emption (802.1Qbu) in order to meet the strict tolerances for packet latency and jitter. These two protocols allow time sensitive CPRI and eCPRI express traffic to pre-empt Ethernet traffic in order to maintain time sensitive latency budgets. Pre-empting jumbo frames over 9,000 bytes is especially useful. Without pre-emption these jumbo frames would impact time sensitive express traffic.

**Precision Time Protocol (PTP)**

While 4G radios in the US predominantly use GPS clocks located at the cell site for synchronization, 5G radios will mostly use IEEE 1588v2 Precision Time Protocol (PTP) for timing and synchronization. Clock sources will be more centralized, and the transport network will distribute timing and synchronization information to cell site radios. The flexiHaul M6424 TSN Switch can operate as a telecom boundary clock (T-BC), processing and passing on timing information, correcting errors, and synchronizing traffic accordingly. Timing interfaces include 1 PPS (SMA), 10 MHz (SMA), and ToD (RJ-45). Synchronous Ethernet (SyncE) is also supported.
Maximize your fiber capacity and lower your total cost of ownership

Summary
The Smart xHaul TSN Solution aggregates 4G, 5G, and Ethernet traffic from a cell site onto one or more 100 GbE uplinks. By maximizing fiber capacity, fiber exhaustion can be avoided despite the large bandwidth demanded by CPRI/eCPRI. Since active WDM optics are not used, the solution significantly lowers TCO.

The 5G era is just beginning. More advanced and mission-critical applications (autonomous vehicles, industrial automation, remote surgery, and others) are still on the horizon. The transport network will continue to evolve, and will require a comprehensive toolkit to address different challenges as they arise. TSN technology is a key tool that puts the transport network into position for future growth.