Reduced TCO for Disaggregated RAN Using Qualcomm X100 5G RAN Accelerator Cards inside Dell PowerEdge XR8000s

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EXECUTIVE SUMMARY

The telecommunications industry is at the cusp of a revolution with the advent of disaggregated RAN (Open, Cloud and Virtualized RAN) architecture, which promises to reshape the landscape by introducing modularity and vendor diversity into radio access networks (RAN). This whitepaper delves into the total cost of ownership (TCO) benefits of deploying Qualcomm® X100 5G RAN Accelerator Cards in Dell PowerEdge XR8000, which off-load DU 5G High-PHY processing within this framework. By disaggregating traditional RAN components into modular units such as radios (RUs), centralized units (CUs), and distributed units (DUs) and linking them with fronthaul, midhaul, and backhaul connections, the disaggregated RAN architecture facilitates a more flexible and cost-efficient network.

The detailed analysis highlights the computational challenges, which are vital for modulation, demodulation, and error correction tasks, particularly within the Layer 1 and Layer 2 processing of the DU. These tasks are processor-intensive, driving up the capital expenditure (CapEx) and operational expenditure (OpEx) for network operators. The X-haul network requirements, comprising fronthaul, midhaul, and backhaul, further add to the complexity with their varied demands for bandwidth and latency.

Qualcomm X100 Accelerator Cards reduce server processing burdens leading to a reduction in server and operational expenses such as power and cooling. Our analysis shows that the use of Qualcomm X100 Accelerator Cards in Dell PowerEdge XR8000 offers considerable TCO savings across different network densities, particularly in high-density scenarios where the savings peak at 27%. The integration of Qualcomm X100 Accelerator Cards in Dell PowerEdge XR8000 can facilitate a more economical deployment of disaggregated RAN architectures, with lower initial investments and ongoing costs, aligning with the industry's goal of achieving more cost-effective, scalable, and flexible mobile networks.

Dell Detailed Analysis of Disaggregated RAN CU and DU Processing

Diving deeper into the technical architecture of disaggregated RAN, the traditional baseband unit (BBU) is effectively split into two distinct entities: the centralized unit (CU) and distributed unit (DU). This split enhances the flexibility and scalability of the network by allowing these components to be virtualized as vCU and vDU, which can run on standard commercial servers. Although this cloud-native approach supports a more versatile and cost-effective network infrastructure, it also presents challenges, particularly concerning the processing demands of the vDU.

The vDU is responsible for real-time baseband processing, which is inherently computationally intensive. The baseband processing encompasses two critical software layers: Layer 1 (L1) and Layer 2 (L2). L1, the physical layer, is concerned with the modulation and demodulation of signals, error correction, encryption, and the physical control of RF parameters. It is the most demanding in terms of processing power due to its real-time requirements for signal processing. L2, the data link layer, manages data transfer between the endpoint and the network, ensuring that data packets are distributed and addressed correctly. It is responsible for error detection and retransmission, which, while complex, is less demanding than L1 processing.

One of the most pressing issues with L1 processing is its extreme computational intensity, which necessitates a significant number of CPU cores for each radio cell. This high demand for cores increases the capital expenditure (CapEx) due to the need for more robust server hardware, operational expenditure (OpEx) and to the costs associated with running these servers, and overall power requirements for the DU servers.

Disaggregated RAN X-Haul Requirements and Challenges

The X-haul concept in disaggregated RAN encompasses the entirety of the RAN transport network, including fronthaul, midhaul, and backhaul. Fronthaul is particularly challenging because of its stringent requirements for high bandwidth and low latency necessary to facilitate the communication between the RU and DU. This drives the usage of expensive and sophisticated NICs that can handle the required 25GigE or 100GigE bandwidth with precise timing and latency specifications.

Although midhaul and backhaul do not require the same level of performance, resulting in less expensive NICs, they still play a vital role in the overall network structure. Midhaul connects the DU to the CU, while backhaul links the CU to the core network. The key to cost-effective network deployment lies in managing these varied requirements without compromising performance.

Qualcomm X100 Accelerator Card

Addressing the aforementioned challenges, Qualcomm Technologies, Inc., has introduced an innovative solution with the Qualcomm X100 Accelerator Card architecture. Traditional vDU configurations necessitate separate NICs for fronthaul and midhaul, with the fronthaul NICs being subject to strict latency and timing demands. Furthermore, the server CPU is heavily taxed, managing both L2 and the processor-intensive L1 high software layers.

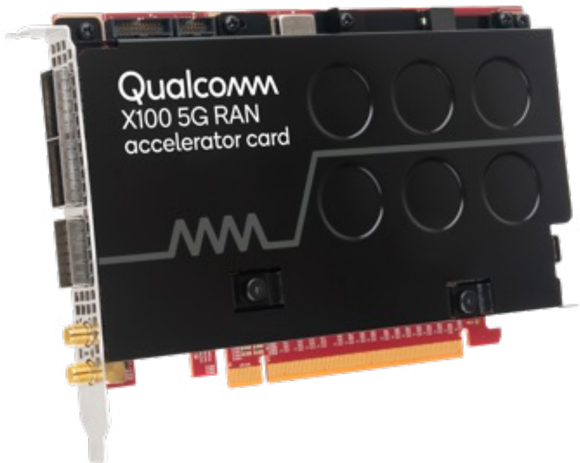

Figure 1. Qualcomm X100 Accelerator Card

Qualcomm X100 Accelerator Cards present a transformative approach. These Accelerator Cards are optimized and virtualized products with integrated hardware acceleration. Completely independent of CPUs, these cards are designed to deliver a high-performance, low-latency, power-efficient, and customizable turnkey solution for ease of deployment and to accelerate operator and infrastructure vendor adoption of Open RAN and Cloud RAN platforms. This solution is a PCIe inline accelerator card that is designed to seamlessly plug into standard commercial-off-the-shelf (COTS) servers to offload CPUs from latency sensitive and compute-intensive 5G baseband L1/physical layer functions, such as demodulation, beamforming, channel coding, and massive MIMO computation needed for high-capacity deployments. The Qualcomm X100 accelerator card comes with an integrated network interface card for fronthaul with high-PHY f unctions, everaging inline accelerator architecture. It integrates 25G Ethernet fronthaul capabilities with 12 X 25G Ethernet lanes to efficiently handle fronthaul operations. By reducing the core requirements of the server, the Qualcomm X100 Accelerator Card is designed to deliver significant cost savings and decreases in power consumption and cooling requirements for DU servers. An overview of the Qualcomm X100 Accelerator Card architecture is provided in Figure 2.

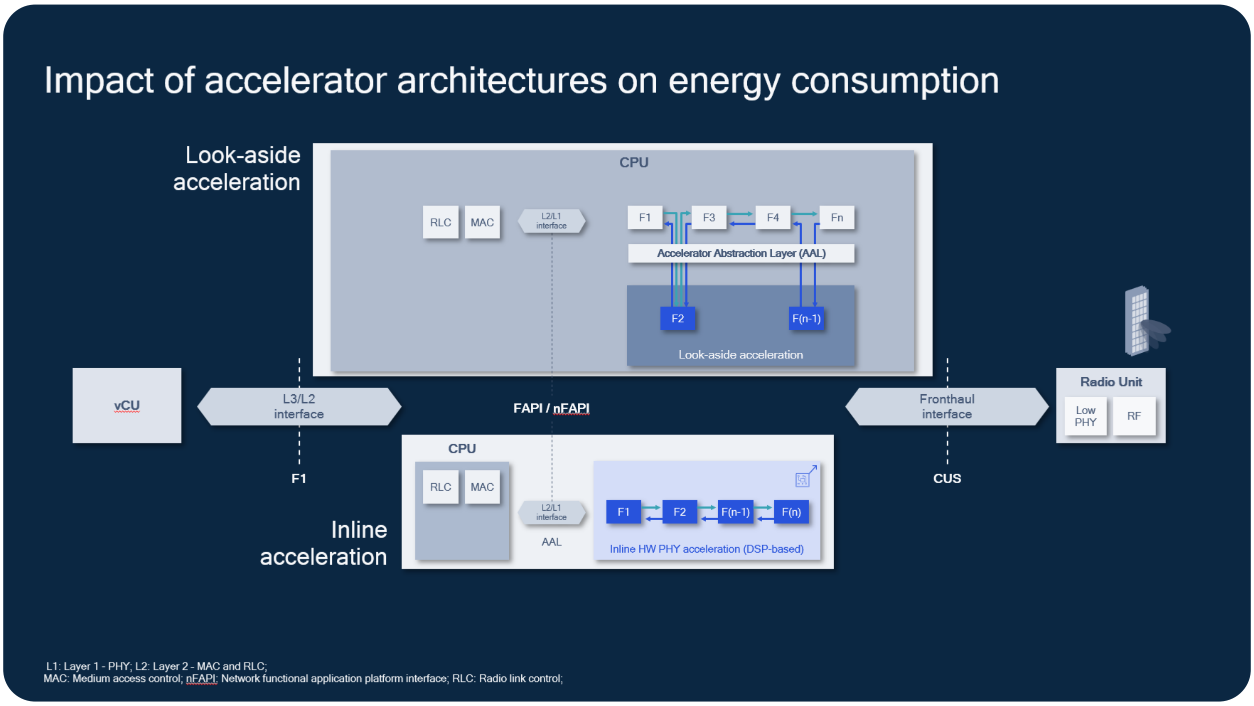

Figure 2. Qualcomm X100 Accelerator Card Architecture

The Qualcomm X100 Accelerator Card offers a tailored solution that is designed to address the high processing demands of the L1 layer of the vDU while also simplifying the fronthaul interface requirements. This paves the way for more economically viable Cloud RAN and Open RAN deployments, with lower upfront investments and operating costs. It is designed to stand as a critical enabler in the evolution of mobile networks toward a more cost-effective, scalable, and flexible future.

The Qualcomm X100 Accelerator Card's integration into the vDU architecture exemplifies the potential of targeted technological innovations to resolve specific challenges within the Disaggregated RAN ecosystem, particularly those associated with processing requirements and network interface costs. The Qualcomm X100 Accelerator Card also plays an important role when it comes to high capacity and energy efficiency requirements. Through such advancements, the telecommunications industry can look forward to more efficient network operations and the realization of the true promise of Cloud and Open RAN.

Dell PowerEdge XR8000 Server

Dell XR8000 servers are designed to simplify and optimize deployments of disaggregated RANs. Dell's latest telco servers deliver a significant boost in network performance and simplified operations to reduce the total cost of ownership (TCO). Dell PowerEdge XR8000s have the following benefits that directly reduce network TCO:

- Improved RAN network performance and throughput
- Dell smart cooling design reduces power consumption, thereby minimizing OpEx and CapEx and contributing to ESG/green data center goals
- Smart, modular designed for telco environment reduces labor expenses and truck roll expenses
- New telco edge servers support deployments in existing telco environments (cell site, central office, and datacenter), which reduces OpEx and CapEx associated with upgrading power and cabinet infrastructure
- Dell has extended support (up to 11 years) to increase longevity of infrastructure

Figure 3. Dell XR8000 Servert

TCO Model Assumptions

Our TCO model compares two scenarios:

1. Dell PowerEdge XR8000 DU servers with Qualcomm X100 Accelerator Cards
2. Dell PowerEdge XR8000 DU servers without Qualcomm X100 Accelerator Cards

Our model calculates the CapEx and OpEx of RAN network deployments for both scenarios. We focus on disaggregated RAN deployments using TDD 100MHz carrier and 32T32R M-MIMO Cat. B radio units. In this model we consider three types of cell sites: low, medium, and high density as depicted in Table 1.

Cell Site Dens	# Cells	MHz x Layers	Radio Unit
Low	3	2400MHz x Layers	32T32R
Medium	6	4800MHz x Layers	32T32R
High	12	9600MHz x Layers	32T32R

Table 1. Cell Site Densities and Configurations

In our TCO model we use Dell XR8620 servers in two scenarios with and without Qualcomm X100 Accelerator Cards. We use the following assumptions for X-haul requirements:

- Each 100MHz 32X32 carrier requires 2 X 25G fronthaul interfaces
- We use a NIC with 4 X 25G fronthaul ports in the scenario without Qualcomm X100 Accelerator Cards
- Qualcomm X100 Accelerator Cards have three QSFP ports and uses breakout cables to provide 12 X 25G ports, which is accounted for in the scenario with Qualcomm X100 Accelerator Cards
- For midhaul we use an internal Ethernet port in the XR8620 server so no extra NICs are required

We also make a conservative assumption that the Qualcomm X100 Accelerator Card reduces the CPU processing load in the XR8620 by 50%. In practice we expect higher reductions in processing loads. The key assumptions for server configurations in each type of cell site is provided in Table 2.

		Without X100				With X100			
Cell Site Density	Fronthaul Interfaces	Server Cores	Server	Watts	4 Port Fronthaul NICs	Server Cores	Server	Watts	X100 Cards
Low Density	6	32	XR8620 1 sled	449	2	20	XR8620 1 sled	408	1
Medium Density	12	32	XR8620 1 sled	454	3	20	XR8620 1 sled	429	1
High Density	24	64	XR8620 2 sleds	708	6	32	XR8620 1 sled	598	2

Table 2. Assumptions for XR8620 Server Configurations in Low-Density, Medium-Density, and High-Density Cell Sites

Network Dimensions

In our TCO model for each Qualcomm X100 Accelerator Card scenario (with and without Qualcomm X100 Accelerator Card) we compare three network configurations. The first configuration mixes low-density, medium-density and high-density cell sites. We also compare each type of cell site density separately to show the TCO differences based on cell site density. For all the network configuration we grow the cell sites from zero to 10,000 over five years. The network configurations are presented in Table 3.

Cell Site Density	Mixed Configuration	Low Density	Medium Density	High Density
Low	10,000	10,000	0	0
Medium	10,000	0	10,000	0
High	10,000	0	0	10,000

Table 3. Network Configuration Compared with and without Qualcomm X100 Accelerator Card Scenarios

TCO Results

We compare the TCO for each of the configurations specified in Table 3 for the with and without Qualcomm X100 Accelerator Card scenarios. We consider both CapEx and OpEx. CapEx consists of the acquisition expenses for the DU server that includes:

- Dell XR8620t servers
- CPUs with the cores specified in Table 2
- Fronthaul NICs (for the without Qualcomm X100 Accelerator Card scenario)
- Qualcomm X100 cards (for the with Qualcomm X100 Accelerator Card scenario)

Figure 4. Dell and Qualcomm Equipment

OpEx consists of:

- Annual vendor support and maintenance expenses for the servers
- Power and cooling expenses

A summary of the TCO results is presented in Table 4. The drivers for the savings are evident in the configurations presented in Table 2. The largest savings is in the high-density configuration because an XR8620 with two sleds are required for the without Qualcomm X100 Accelerator Card scenario and six front-haul NICs are required for this scenario. With the Qualcomm X100 Accelerator Card scenario a single sled XR8620 can be used with only two Qualcomm X100 Accelerator Cards, which results in significant CapEx reductions as well as lower vendor support, power, and cooling expenses. The detailed results for each network configuration are presented in the following sections of this report.

Network Configuration	CapEx Savings	OpEx Savings	TCO Savings
Mixed Configuration	20%	17%	20%
Low Density	15%	13%	15%
Medium Density	14%	12%	14%
High Density	28%	24%	27%

Table 4. Summary of TCO Results

Mixed Network Configuration

The overall five-year cumulative TCO results for the mixed configuration are presented in Table 5, which shows a five-year cumulative 20% TCO savings for Dell PowerEdge XR8000 servers using the Qualcomm X100 Accelerator Cards. An annual OpEx and CapEx comparison of the scenarios with and without the Qualcomm X100 Accelerator Card are compared in Figure 5 and Figure 6, respectively. CapEx is driven by server acquisition expenses, and OpEx is driven by vendor support, power, and cooling expenses. The vendor support and maintenance is a percentage of the overall server acquisition expense so these expenses are reduced as a result of lower overall server pricing. Power and cooling expenses are reduced as a result of the Qualcomm X100 Accelerator Card which has lower power consumption as compared to the alternative servers with processors with more cores and fronthaul NIC cards.

Indicators	Without Qualcomm X100 Accelerator Card	With Qualcomm X100 Accelerator Card	Savings	% Savings
TCO	$907.5M	$730.36M	$177.14M	20%
CapEx	$683.5M	$545.0M	$138.5M	20%
OpEx	$224.0M	$185.36M	$38.64M	17%

Table 5. Five-Year TCO Results for the Mixed Configuration of Low-Density, Medium-Density, and High-Density Cell Sites

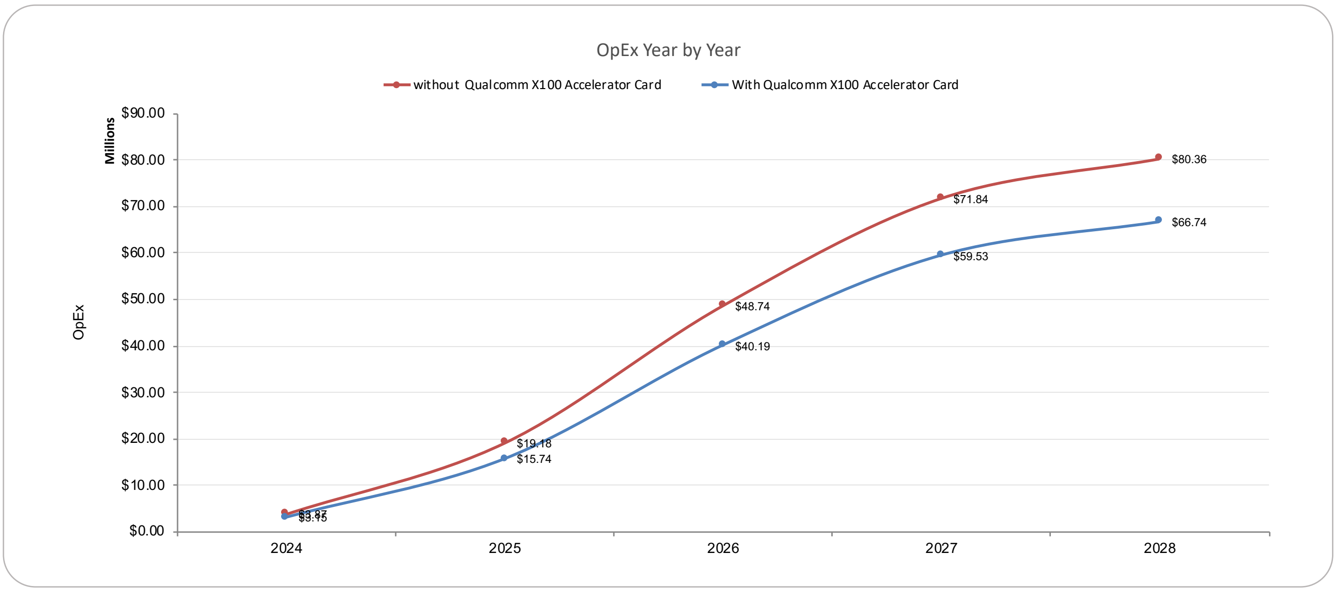

Figure 5. Annual OpEx Comparison for the Mixed Configuration of Low-Density, Medium-Density, and High-Density Cell Sites

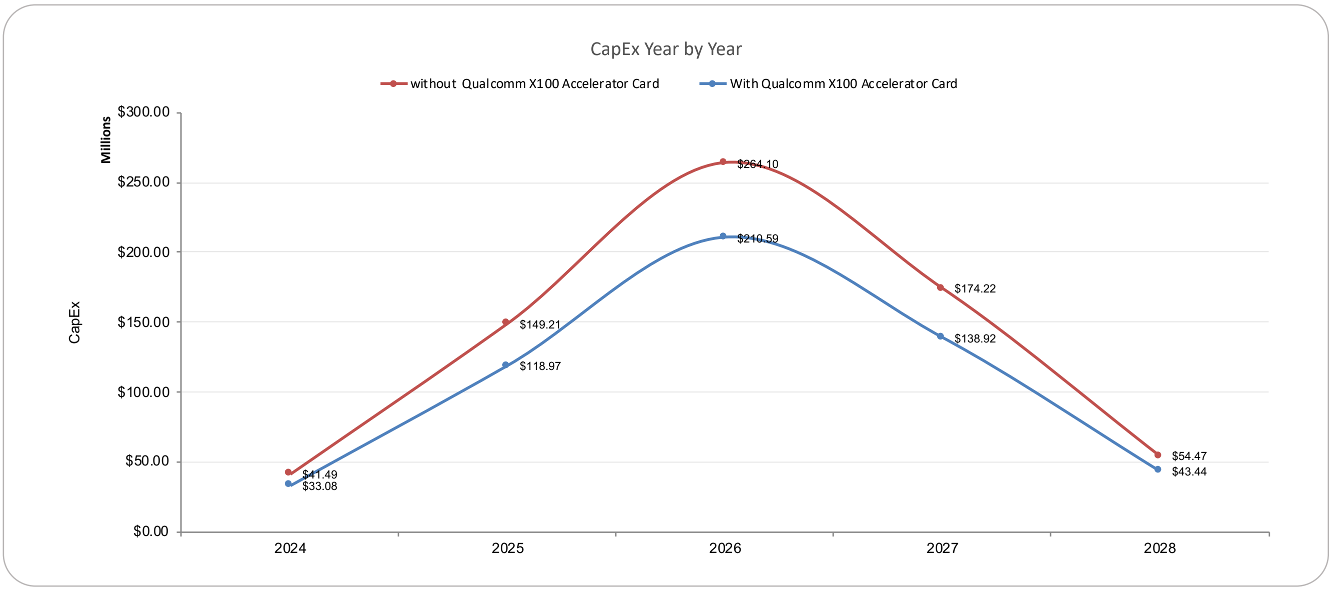

Figure 6. Annual CapEx Comparison for the Mixed Configuration of Low-Density, Medium-Density, and High-Density Cell Sites

Low Density

The overall five-year cumulative TCO results for the low-density configuration are presented in Table 6, which shows a five-year cumulative 15% TCO savings for DU servers using the Qualcomm X100 Accelerator Cards. An annual OpEx and CapEx comparison of the scenarios with and without the Qualcomm X100 Accelerator Card are compared in Figure 7 and Figure 8, respectively.

Indicators	Low density without Qualcomm X100 Accelerator Card	Low density with Qualcomm X100 Accelerator Card	Savings	% Savings
TCO	$251.39M	$213.83M	$37.56M	15%
CapEx	$189.25M	$160.0M	$29.25M	15%
OpEx	$62.14M	$53.83M	$8.31M	13%

Table 6. Five-Year TCO Results for the Low-Density Cell Sites

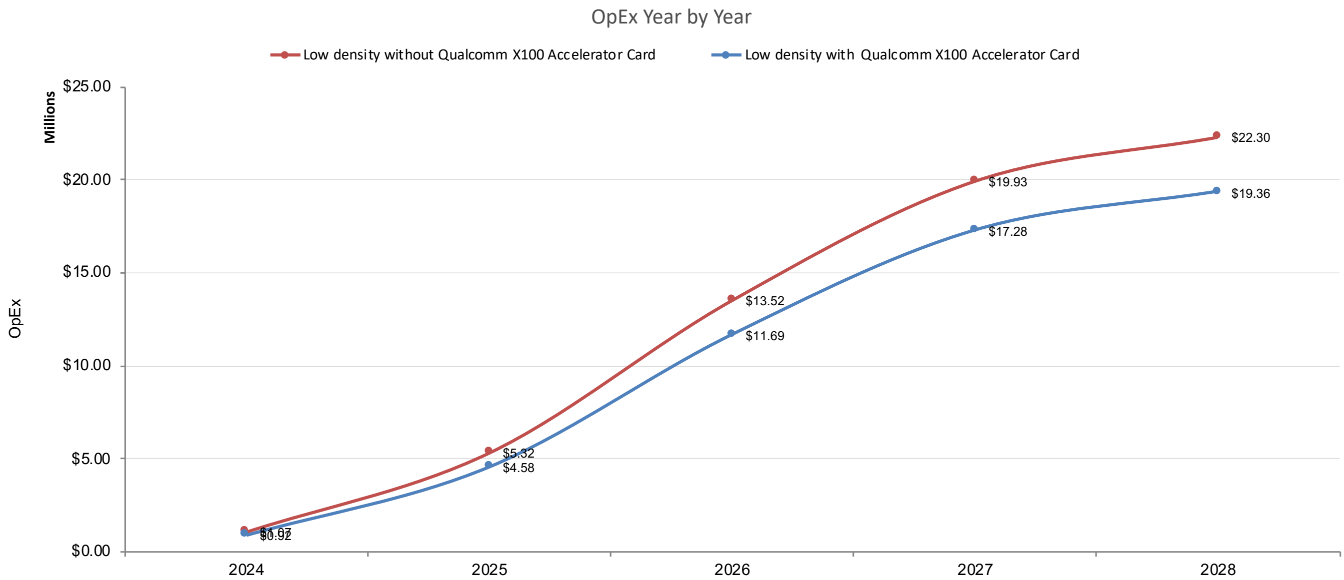

Figure 7. Annual OpEx Comparison for the Mixed Configuration Low-Density Cell Sites

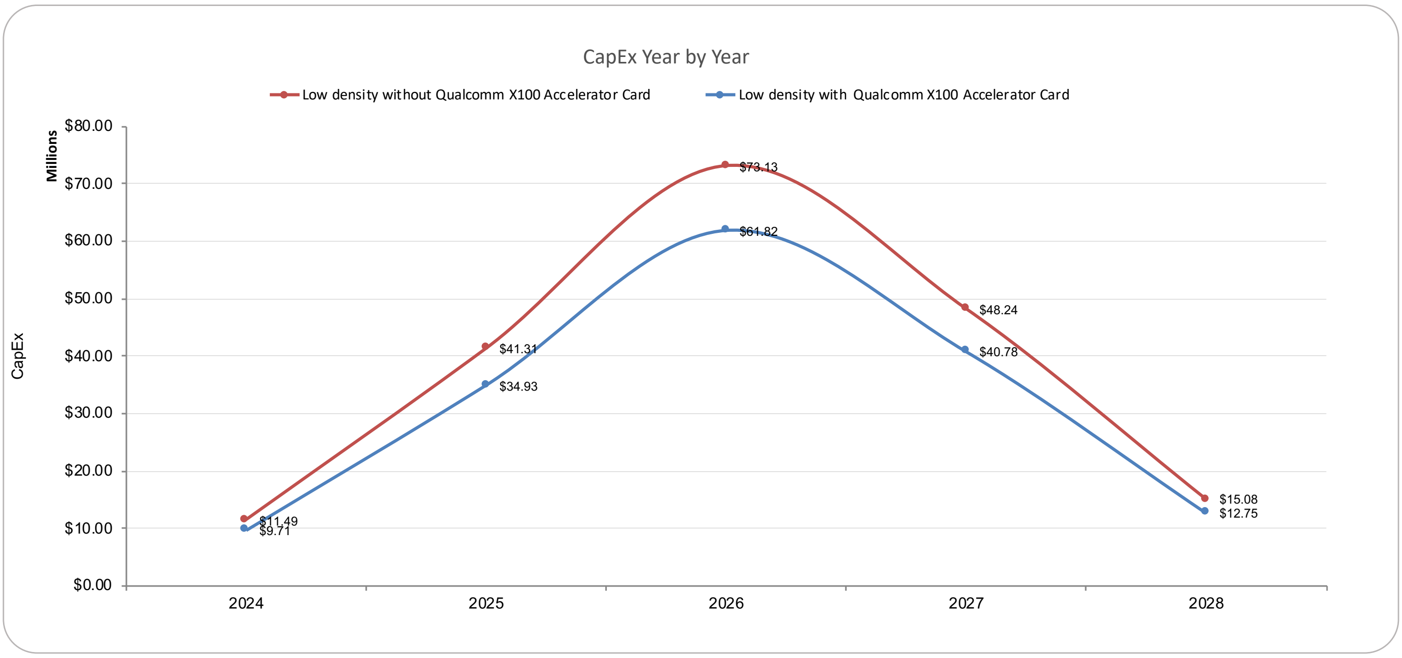

Figure 8. Annual CapEx Comparison for Low-Density Cell Sites

Medium Density

The overall five-year cumulative TCO results for the medium-density configuration are presented in Table 7, which shows a five-year cumulative 14% TCO savings for DU servers using the Qualcomm X100 Accelerator Cards. An annual OpEx and CapEx comparison of the scenarios with and without the Qualcomm X100 Accelerator Card are compared in Figure 9 and Figure 10, respectively.

Indicators	Medium density without Qualcomm X100 Accelerator Card	Medium density with Qualcomm X100 Accelerator Card	Savings	% Savings
TCO	$269.96M	$233.11M	$36.85M	14%
CapEx	$204.25M	$175.0M	$26.25M	14%
OpEx	$65.71M	$58.11M	$7.6M	12%

Table 7. Five-Year TCO Results for the Medium-Density Cell Sites

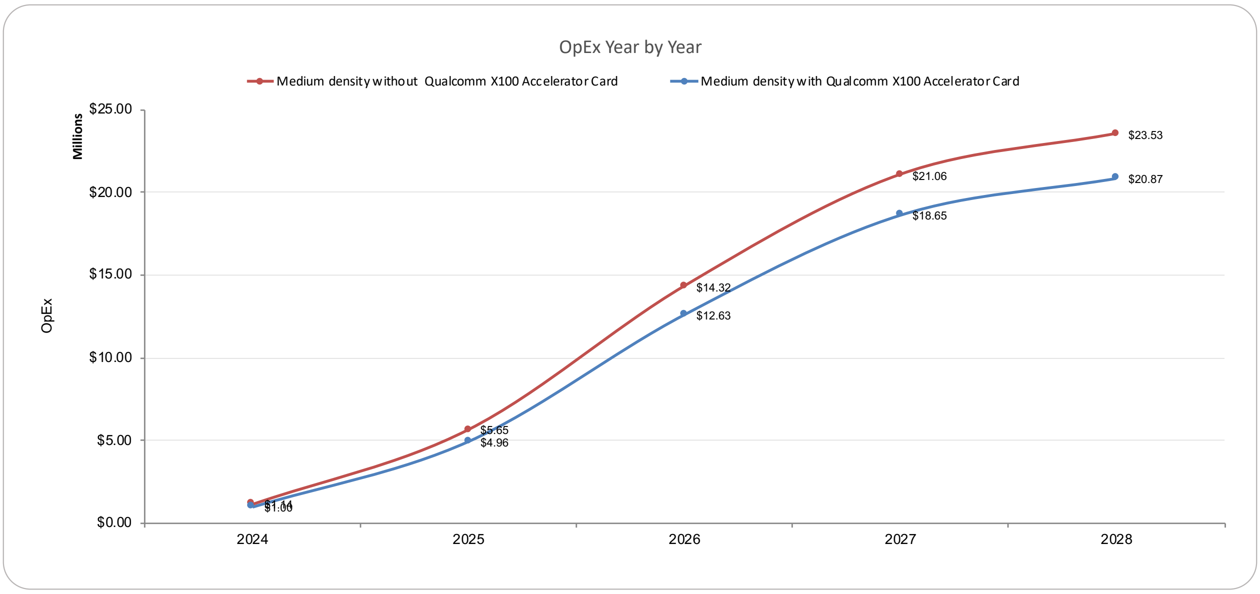

Figure 9. Annual OpEx Comparison for Medium-Density Cell Sites

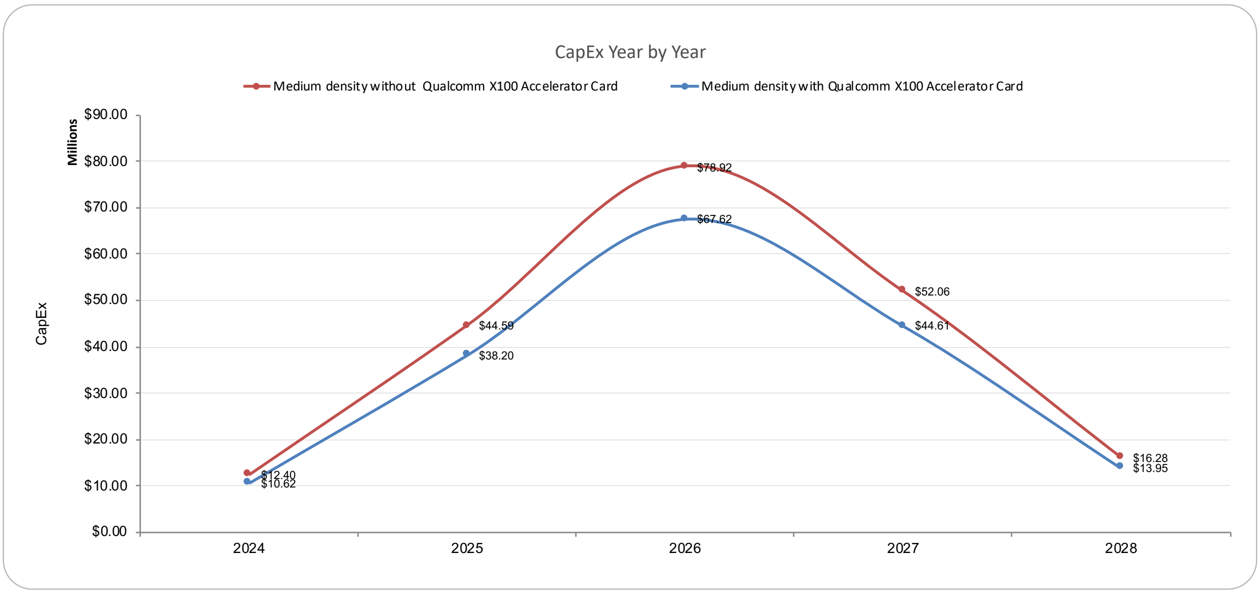

Figure 10. Annual CapEx Comparison for the Mixed Configuration of Medium-Density Cell Sites

High Density

The overall five-year cumulative TCO results for the high-density configuration are presented in Table 8, which shows a five-year cumulative 27% TCO savings for DU servers using the Qualcomm X100 Accelerator Cards. An annual OpEx and CapEx comparison of the scenarios with and without the Qualcomm X100 Accelerator Card are compared in Figure 11 and 12, respectively.

Indicators	High density without Qualcomm X100 Accelerator Card	High density with Qualcomm X100 Accelerator Card	Savings	% Savings
TCO	$386.15M	$283.42M	$102.73M	27%
CapEx	$290.0M	$210.0M	$80.0M	28%
OpEx	$96.15M	$73.42M	$22.73M	24%

Table 8. Five-Year TCO Results for the High-Density Cell Sites

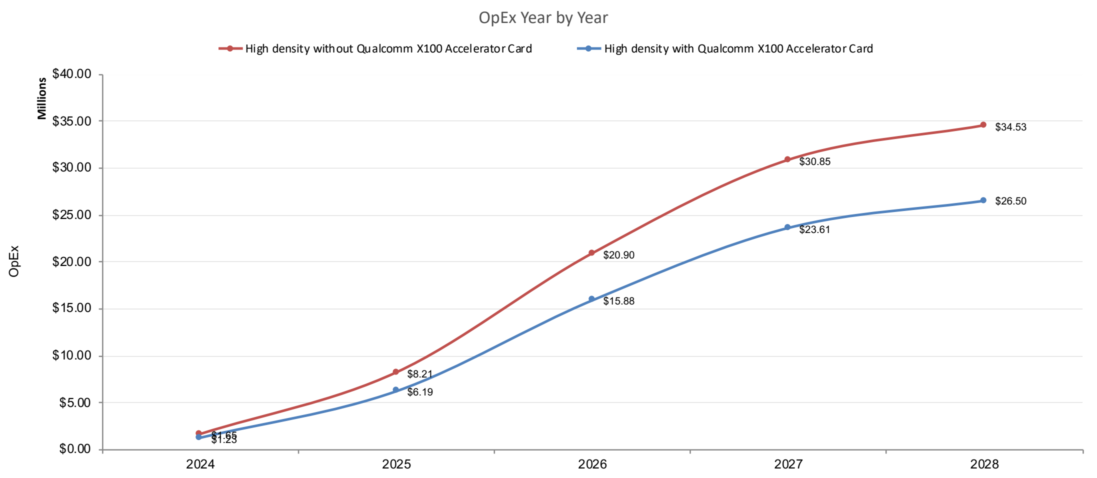

Figure 11. Annual OpEx Comparison for High-Density Cell Sites

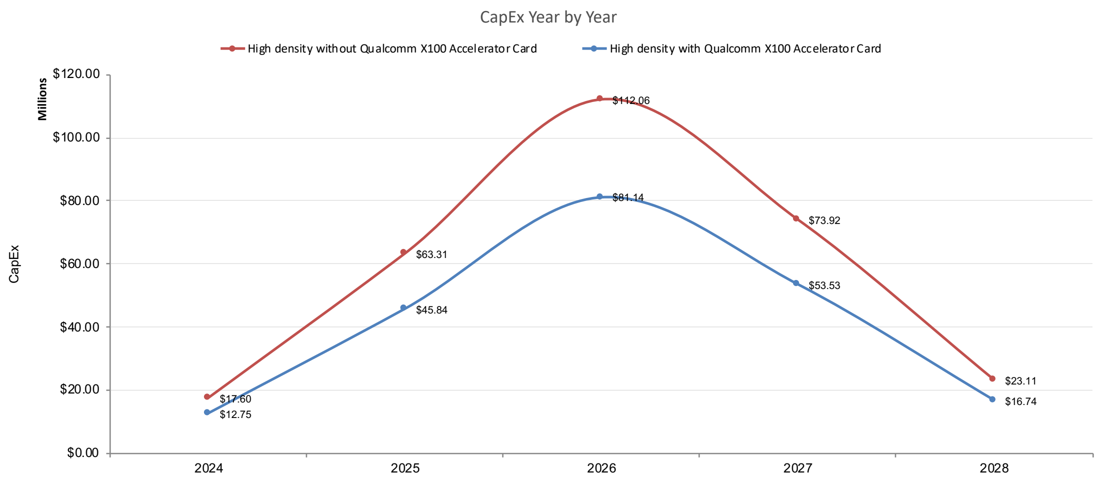

Figure 12. Annual CapEx Comparison for the Mixed Configuration of High-Density Cell Sites

Conclusion

The comprehensive analysis underscores the economic impact of offloading DU workloads onto Qualcomm X100 Accelerator Cards in Dell PowerEdge XR8000. The Qualcomm X100 Accelerator Card emerges as a pivotal technology in addressing the processing challenges of the L1 layer of the DU and simplifying the fronthaul interface requirements. By alleviating the need for additional cores and reducing NIC expenses, the Qualcomm X100 Accelerator Cards in Dell PowerEdge XR8000 card is capable of enabling a leaner, more efficient network design.

Our TCO model, grounded in a comparison between DU servers with and without Qualcomm X100 Accelerator Cards, demonstrates the financial advantage of incorporating Qualcomm Technologies and Dell's solution. With TCO savings up to 27% in high-density scenarios, the Qualcomm X100 Accelerator Card not only optimizes network performance, but also paves the way for substantial reductions in both CapEx and OpEx.

In the rapidly evolving landscape of mobile networks, where cost efficiency and performance are paramount, the Qualcomm X100 Accelerator Cards[1] in Dell PowerEdge XR8000 stands out as an essential enabler for the successful deployment of vRAN and O-RAN architectures. Its role in the network transformation aligns with the industry's pursuit of innovation, scalability, and flexibility, promising a new era of RAN that is both economically and technically advanced.

[1] Qualcomm branded products are products of Qualcomm Technologies, Inc. and/or its subsidiaries.

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Peter Fetterolf, Ph. D. is an expert in network technology, architecture and economic analysis. He is responsible for financial modeling and whitepapers as well as software development of the ACG Research Business Analytics Engine. Dr. Fetterolf has a multidisciplinary background in the networking industry with over thirty years of experience as a management consultant, entrepreneur, executive manager, and academic. He is experienced in economic modeling, business case analysis, engineering management, product definition, market validation, network design, and enterprise, and service provider network strategy.