WDM and Hyperspectral MAC: Pathways to Optical Advantage in Short-Reach Systems

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The notion of an "optical advantage" arises naturally in domains where inputs or outputs are fundamentally optical, such as advanced displays, cameras, and optical spectroscopy. In the realm of data transmission, modern long-haul optical fiber communication has also universally triumphed over electronic alternatives, despite relying heavily on electronic I/O. This success is driven by the fundamentally low propagation loss of optical fibers over vast distances and the massive parallelism enabled by Wavelength Division Multiplexing (WDM), which effectively amortizes infrastructure costs by sharing a common physical medium.

However, as applications scale down to the short-reach regime—spanning intra-datacenter communications, chip-to-chip interconnects, and integrated computing architectures—it is less clear how this optical advantage can be practically sustained against highly optimized electronic systems. The critical question emerges: what specific physical properties and architectures can preserve or enable optical advantage in these highly constrained, localized environments

In this talk, we propose that the principles of WDM and hyperspectral multiply-accumulate (MAC) operations provide a robust pathway toward achieving this advantage. By enabling unprecedented parallelism and shared hardware resources, these architectures significantly improve data-processing throughput and hardware reutilization. We will illustrate these concepts through our recent experiments, demonstrating how harnessing the spectral dimension offers a definitive blueprint for the optical advantage in next-generation systems.