IOWN GLOBAL FORUM™

IOWN GLOBAL FORUM: KEY VALUES AND TECHNOLOGY EVOLUTION ROADMAP

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1. IOWN Global Forum Key Values

The Innovative Optical and Wireless Network Global Forum, or the IOWN Global Forum, is focused on driving the development of future communications and computing infrastructure to create a more connected and efficient society. Its innovative structure and collaborative approach imbue the Forum with unique characteristics that allow it to deliver multiple distinct benefits to the market, including:

- **A holistic approach:** The IOWN Global Forum approaches technological development holistically, concentrating on enabling a new generation of communications and computing infrastructure with deterministic QoS, high energy efficiency, and extreme performance capabilities. The Forum also provides design guidance on how to apply IOWN networking and computing technologies in various use case scenarios, including mobile fronthaul, cloud computing, cyber-physical systems, and AI-integrated communications.
- **Implementation-driven:** The Forum's technology is primarily driven by practical implementation and deployment needs of future communication and computing infrastructure. The forum encourages and guides engineering experiments, through which technology gaps are identified and new technologies are developed.
- **System and architectural solutions-focused:** The IOWN Global Forum focuses on system-level engineering solutions by integrating device/component-level advancements developed by member companies or other fora.
- **Global leader:** Being a global leader in networking and computing technologies, the IOWN Global Forum advises and informs the industry on developing and running advanced networking and computing systems for various use case scenarios and works to promote solutions for next-generation systems.
- **Collaboration:** The IOWN Global Forum is a collaborative initiative that brings together industry professionals from many sectors, including telecommunications, electronics, and photonics, to exchange experiences, use cases, and technologies for developing new ideas and solutions.

- **Concrete deliverables:** The IOWN Global Forum delivers technical reports, reference implementation models, and specifications. The Forum also provides valuable inputs to relevant standards organizations and fora.

The IOWN Global Forum provides value by focusing on two key technology segments: IOWN Networking and IOWN Computing.

IOWN Networking: This area of focus spans technologies with the ability to connect endpoints while achieving deterministic Quality of Service (QoS) and high-energy efficiency

- QoS is characterized by throughput, latency, bandwidth, jitter, availability, packet loss, and security.
- Endpoints are application entities. Ultimately, they should be the processors' local memories. However, during their evolution, they may serve as gateways of computing clusters. Endpoints can communicate dynamically with guaranteed bandwidth end-to-end with other endpoints. Implementers can choose any granularity of these endpoints as their system requires
- High energy efficiency should be achieved even when demands are varying and unpredictable.

IOWN Computing: This endeavor focuses on moving and processing data while satisfying extreme performance requirements and high-energy efficiency

- Extreme requirements may be data bandwidth, computational complexity, execution time bound, security/privacy/confidential requirements.
- High-energy efficiency should be achieved even when workloads are varying and unpredictable.

2. IOWN Global Forum Technology Evolution Roadmap

The evolution of IOWN Global Forum technology continuously aims to optimize both the networking and computing domains. It is important to note that the development of these two technology tracks is interconnected and mutually influential. As IOWN Computing evolves, it introduces new advancements and demands that impose subsequent requirements on IOWN Networking. Conversely, the evolution of IOWN Networking facilitates infrastructure upgrades that can elevate IOWN Computing to new heights. The interplay between these two tracks creates a symbiotic relationship where advancements in one domain drive progress in the other.

Collaboration is essential for attaining combined IOWN Networking and Computing optimizations. The importance of this collaborative and interconnected approach is recognized by the Forum, which actively promotes cooperation across computer and networking technologies. Working together maximizes the possibility of synergistic advancements and optimizations.

IOWN Global Forum endeavors to link networking and computing innovations, guaranteeing they complement and strengthen one another. This collaborative approach lays the path for a more efficient and interconnected environment where both areas' advantages may be fully realized.

2.1. IOWN Computing Evolution Roadmap

Table 1 depicts the timeline for the progress of IOWN Computing, showing the expected advancements by 2030. The primary goal is to accomplish fine-grained computing resource allocation at the computing device level, resulting in considerable gains in computing resource utilization, energy efficiency, and scalability.

To minimize data movement and optimize performance, the roadmap includes implementing direct memory access and copy among any processing unites (XPU), reducing the need for data transfer between different processing units. Additionally, the cache coherence memory space is projected to expand from the current Commercial Off-The-Shelf (COTS)-scale to rack-scale using Compute Express Link (CXL) technology.

The roadmap envisages achieving remote direct memory access at the inter-datacenter scale by using the potential of all-photonics networks. This functionality allows efficient and fast data access and sharing across geographically dispersed data centers.

To maintain robust data security, the roadmap includes post-quantum security solutions that address data security in use and at rest. These developments strengthen defenses against upcoming quantum-based assaults and weaknesses.

Agile computing resource configuration and reconfiguration are highlighted as key objectives, with a target provisioning time of seconds. This rapid adaptability allows dynamic adjustments to computing resources based on workload demands, optimizing resource allocation and overall system efficiency.

The roadmap also emphasizes support for time-sensitive applications with millisecond-level time sensitivity. This capability enables the execution of real-time and latency-critical tasks, catering to a diverse set of applications such as autonomous vehicles, telecommunications, and industrial automation.

Moreover, the evolution of IOWN Computing aims to facilitate nationwide data sharing and access. This scalable and interconnected infrastructure allows seamless data exchange and collaboration across diverse geographical regions.

By following this roadmap, IOWN Computing aims to revolutionize computing capabilities, ushering in a future of highly efficient, secure, and flexible computing systems that support a wide range of applications and requirements.

Table 1 IOWN Computing evolution roadmap

Metrics	Phase 1 (Now)	Phase 2 (3-5 years)	Phase 3 (by 2030)
Computing resource allocation unit	Server level	Computing device level	Computing device level
Energy efficiency	Measured and best effort Independent from workloads/events/traffic	Precisely measured and controlled Closely match with workloads/events/traffic	Strive for order-of-magnitude Reduction as compared to Phase 2
Data copy/movement cost	Host-assisted data path	XPU-direct data path	XPU-direct data path
Cache coherence memory space	COTS-scale	Rack scale (via CXL)	Rack scale (via CXL)
Direct memory access memory space	Intra-datacenter scale (e.g., by RDMA, NVMe)	Inter-datacenter (by RDMA over APN)	Inter-datacenter with APN (by RDMA over APN)
Logical server composability	Server-level	Module card-level (e.g., PCIe card, CXL card)	Chip-level

Metrics	Phase 1 (Now)	Phase 2 (3-5 years)	Phase 3 (by 2030)
Security	Classic (e.g., by RSA, DH)	Post-quantum security for data in use and at rest	Post-quantum security for data in use and at rest and its management with a zero-trust concept
Agility of computing resource reconfiguration	In hours	In minutes	In seconds
Capability in supporting time-sensitive/deterministic workloads	Not supported	ms-level deterministic	ms-level deterministic
Storage/data mobility	Local-level	Regional-level	National-level

2.2. IOWN Networking Evolution Roadmap

The evolution of IOWN Global Forum Networking metrics is depicted in Table 2, showcasing the roadmap for future advancements. By 2030, the network is poised to expand the endpoints of all-optical connections, transitioning from site-to-site connectivity to memory-to-memory integration, as depicted in Figure 1. This expansion will drive different vectors. For example, it is expected to significantly increase the bandwidth per endpoint, surpassing 10 Tbps. Despite the increased granularity and dynamicity of endpoints, network operators strive for reduced latency between them to ensure effective communication. Furthermore, the system will detect and handle system failures, alleviating users of the burden of dealing with such issues. The addition of more all-optical connection endpoints will also help to limit jitter, improving overall network performance.

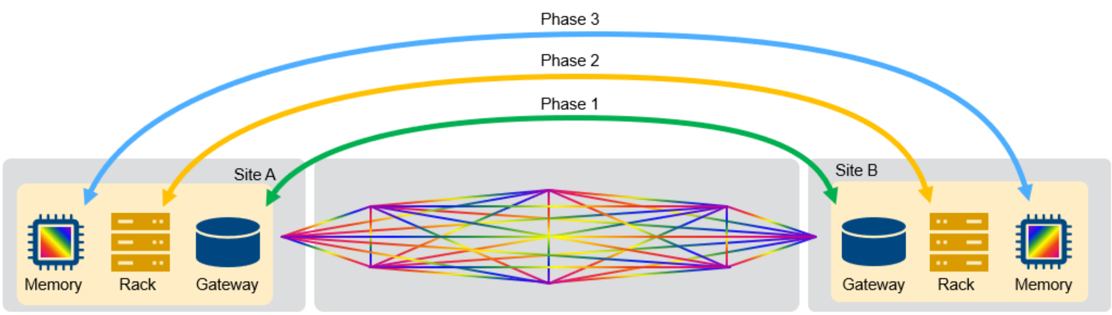

Figure 1 Evolving from site-to-site endpoints to memory-to-memory endpoints

The network will deploy post-quantum security methods to improve data security during transport. This ensures not only in rest data confidentiality and integrity but also equally for inflight data. In addition, a more flexible cost model, allowing for a pay-per-volume approach rather than the current pay-per-endpoint method, will be developed. This change in pricing structure gives consumers more flexibility and cost-effectiveness.

Network automation will be important in reducing provisioning times to seconds. The network will use automated techniques to speed the provision of services and resources, eliminating delays and enhancing overall efficiency. Furthermore, with unique workloads, events, and traffic patterns in mind, energy efficiency will be extensively examined and controlled. This precision allows for more efficient resource allocation and eliminates waste.

Table 2 IOWN Networking evolution roadmap

Metrics	Phase 1 (Now)	Phase 2 (3-5 years)	Phase 3 (by 2030)
Endpoint Granularity	Site-to-Site	Rack-to-Rack	Memory-to-Memory
Bandwidth per endpoint device	25-400 Gbps	More than 1.6 Tbps (note 1) With Dynamic Allocation (note 2)	More than 3.2 Tbps With Dynamic Allocation
Latency between endpoints	5 usec/km + X (note 3)	5 usec/km + X + Y (note 4)	Less than 3.5 usec/km + X + Y (note 5)
Robustness to system failure	User Effort to address system failure	Infrastructure Service for addressing system failure	Infrastructure Service for addressing system failure
Jitter	Bounded	Bounded	Bounded
Security	Classic	Post quantum security for data in motion with crypto agility	Post quantum security for data in motion with crypto agility and its management with a zero-trust concept
Cost model	Fixed high cost per endpoint	Fixed low cost per endpoint + Variable cost per volume	Fixed low cost per endpoint + Variable cost per volume
Provisioning lead time	Days	Minutes	Seconds
Energy efficiency	Measured and best effort Independent from workloads/events/traffic	Precisely measured and controlled Closely match with workloads/events/traffic	Strive for order-of-magnitude reduction as compared to Phase 2
Service awareness	Not aware	Service-aware transport	Service-aware transport

Notes:

1. Inter-datacenter rack-to-rack
2. The bandwidth can be dynamically allocated between endpoints. Bandwidth can be assigned and retired based on demand.

3. X is the latency in an optical transceiver such as those due to FEC and DSP. X can be 4 to 5 usec for example [19].
4. Y is the latency for packet processing. the additional packet switch latency
5. Hollow-core fiber has the potential to decrease latency to less than 3.5 usec per km.

3. Status

The IOWN Global Forum has been working on a variety of advanced technologies and architectures in order to deliver the IOWN Networking and IOWN Computing roadmaps. These are summarized in Table 3.

Table 3 IOWN Global Forum existing technologies in addressing IOWN Networking and Computing metrics

Technologies	Main features	Addressed IOWN Networking metrics	Addressed IOWN Computing Metrics
Open All-photonics network (Open APN) [1]	• End-to-end lambda connection • Dynamic optical path provisioning/control • Energy efficient transport • Multi-operator environment • Computing-networking convergence • Automated networking, including MANO, resource reallocation, service assurance, performance management • Format-free optical communication • Intelligent monitoring • Extended wavelength availability	Endpoint granularity, bandwidth per endpoint, cost model, latency between endpoints, jitter, provision lead time, energy efficiency	

Technologies	Main features	Addressed IOWN Networking metrics	Addressed IOWN Computing Metrics
Mobile fronthaul over APN [2] [3]	• Optical-switch based elastic load balancing • Packet-switch based elastic load balancing	Bandwidth per endpoint, robust to system failure, energy efficiency	
Fiber sensing for Open APN [4] [5]	• Distributed fiber sensing technologies in Open APN • Sensing data utilization	Robustness to system failure	
Data-centric infrastructure (DCI) [6]	• Disaggregated and heterogenous computing infrastructure • Optimized for data movement and access • Composable logical service node • Accelerator pooling and sharing • Remote direct memory access		Computing resource allocation unit, energy efficiency, data copy/movement cost, cache coherence memory space, direct memory access memory space, composability, agility of computing resource reconfiguration, capability in supporting time-sensitive/deterministic workloads, storage/data mobility
IOWN data hub [7]	• Data management and sharing infrastructure for fast and trusted data processing, usage exchange among multiple parties or locations		Storage/data mobility
IOWN security [8]	• Post quantum security for data in transport, in use and at rest with crypto agility	Security	Security

By applying IOWN Global Forum technologies, reference implementation models were developed for a variety of use cases, including area management security, interactive live music entertainment, and remote-controlled robotic inspection [9]-[11]. Proof of concept (PoC) reference documents were also developed to guide verifications of IOWN Global Forum technologies [12] - [18].

The Forum has issued a Call For Proposal (CFP) to gather its members' new ideas to enhance IOWN networking and computing technologies and to apply the IOWN technologies to various use cases. New Study/Work Items are to be finalized by the end of 2023 to make further advances toward the realization of the targets described above.

4. References

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