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XR & Edge Computing: Is it time for Operational Teams to get exponential value?

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Extended Reality (XR) devices, which include virtual reality (VR), augmented reality (AR), and mixed reality (MR), have continued drawing attention as powerful tools for delivering immersive and interactive experiences, especially to Operational teams.

However, the current XR landscape faces latency, bandwidth, security, and real-time interaction challenges. This is where Software-Defined Edge (SD-EDGE) computing comes into play, offering a technical framework that can revolutionize the XR experience.

Edge computing can be very beneficial for XR (Extended Reality) devices. In this paper, we cover the intersection of XR & Edge Computing - from both technical & a practical business application (use case perspective). We also share our observations on industries that have benefitted the most with Edge computing.

Technology Benefits:

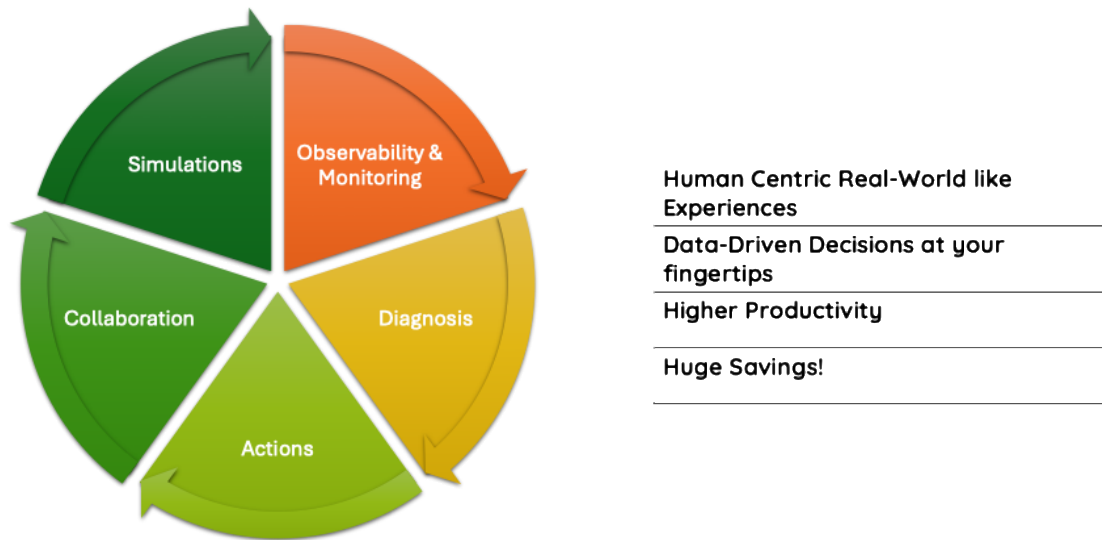
- **Latency Minimization:** Achieving optimal XR experiences requires minimizing latency to ensure a fluid and captivating user encounter. Employing edge processing, which involves handling data in close proximity to the user's position, offers a substantial reduction in the time lag between a user's input and the subsequent reaction within the XR setting. This factor is pivotal not only in averting motion sickness but also in crafting XR interactions that feel instinctive and true to life.
- **Efficient Bandwidth Utilization:** Within XR applications, substantial data volumes are often produced, ranging from high-resolution video streams to intricate 3D models. By handling this data either on the device itself or at an edge server, the necessity to transmit the entirety of this data to a distant data center can be mitigated. This approach intelligently streamlines bandwidth consumption, consequently alleviating network strain.
- **Seamless Real-Time Engagement:** Many XR applications center around real-time engagements with the physical world or fellow users. By leveraging edge computing, these interactions can be processed with heightened speed, guaranteeing swift responsiveness of virtual components to the user's inputs.
- **Content Personalization:** With the utilization of edge computing, localized analysis of user interactions and preferences becomes feasible. This empowers the provision of personalized XR content suggestions and experiences, minimizing dependence on cloud-centric processing for achieving customization.
- **Optimal Resource Management:** XR devices, particularly standalone units, frequently possess constrained computational capabilities in contrast to robust data centers. By delegating specific processing tasks to edge servers, device resources can be conserved effectively, leading to prolonged battery life and judicious management of available resources.
- **Uninterrupted Operation in Low-Connectivity Environments:** Through the implementation of edge computing, XR applications can maintain their functionality even in situations where the device lacks online access or has restricted connectivity to cloud resources. This capability proves particularly advantageous in XR contexts characterized

by sporadic connectivity, such as outdoor augmented reality adventures or training simulations conducted in remote locations.

- **Enhanced Privacy and Security:** Certain XR applications handle sensitive data, including live video feeds from a user's surroundings. Opting for local or edge-based processing can significantly bolster user privacy and security, curtailing the need to transmit sensitive information to the cloud thereby reducing potential exposure risks.

From a technical perspective, SD-EDGE integrates software-defined networking principles to facilitate dynamic resource allocation and management. This capability enables the streamlined distribution of processing tasks across edge servers, fine-tuning workload allocation and upholding uniform performance levels across a diverse range of XR applications.

From a business perspective, we get into a lot of interesting use cases on how customers are looking at this to solve their operational challenges. Broadly we see applications across the following categories:



Illustrative use cases:

- **Remote Assistance for Field Service:** Workers in the field can use XR devices to view augmented instructions, diagrams, and guidance. With Edge computing, these devices can quickly process local data and conditions without needing to communicate with a central server, enabling quicker responses and troubleshooting. This has always been one of the dreams edge computing – to help people in the field manage incidents quickly and effectively
- **Security Monitoring:** Security personnel in conjunction with XR devices can monitor locations, with AI-driven alerts for any anomalies & incidents. By processing video feeds, telemetry data from sensors locally through Edge devices, there's quicker incident recognition and response.

- **Emergency Response and Rescue:** In situations like fires, natural disasters, or accidents, XR can provide first responders with augmented overlays of critical data (like structural weaknesses or the location of individuals). Edge computing ensures that these data streams are processed instantly, which is critical in life-threatening situations.
- **Medical Emergencies:** Medical personnel can receive augmented information about a patient's vitals, medical history, or guidance on emergency procedures. Edge processing can analyze data from medical sensors in real-time, giving instant feedback to the medical staff.
- **Industrial Incident Management:** In manufacturing facilities or industrial plants like Oil & Gas, Energy sector, it can be used to alert workers to malfunctions, leaks, or failures. Edge computing can process data from a plethora of sensors in the facility, triggering alarms or actions based on real-time inference.
- **Traffic Management:** For smart cities, provide traffic controllers with a real-time augmented view of traffic flows, accidents, or congestion. Edge computing could analyze data from cameras, IoT devices, and sensors across the city, enabling quick adjustments to traffic signals, rerouting, etc.
- **Retail stores:** Store managers can be alerted to incidents like potential shoplifting, stock discrepancies, customer congestion or dwell times. Edge devices process data from in-store cameras and sensors, with the manager receiving real-time insights through their XR device.
- **Training and Simulation:** XR can be used for training simulations, especially for critical incidents. For example, training firefighters with virtual scenarios. Edge computing ensures the training environment reacts in real-time to the trainee's actions.
- **Infrastructure Maintenance:** For teams inspecting infrastructure (like bridges, dams, or tunnels), XR can overlay historical data, structural analysis, or stress points. Edge devices can process data from on-site sensors, ensuring inspectors have the most up-to-date information.
- **Agricultural Incident Management:** Farmers or agricultural managers can use XR to get insights about crop diseases, pest infestations, or irrigation issues. Edge devices could process data from soil sensors, drones, or cameras, providing immediate feedback about any issues.

For all these use cases, the combination of XR and Edge computing ensures that the required data processing occurs close to the data source, ensuring swift decision-making and action based on real-time insights.

To sum up, the integration of edge computing has the potential to elevate the performance, responsiveness, security, and holistic user experiences with XR devices. Achieved by processing data in proximity to the user, this approach seamlessly aligns with the requisites of immersive and interactive XR applications.