Expression of Interest

Position on Intelligent Edge IoT Technologies and Applications

Motivation

The next generation of the Cloud-Edge-IoT continuum is expected to be more intelligent, autonomous, and collaborative, enabling more efficient and effective data processing and new applications and services. Autonomy at the edge is enabled by advances in artificial intelligence (AI), machine learning (ML), edge AI, intelligent connectivity, immersive technologies, digital twins, and other related technologies. Some critical aspects of this evolution that generate new research challenges and the need for innovative solutions to address these challenges are listed below:

- More intelligent edge devices: Edge devices such as sensors, gateways, and edge servers are becoming more intelligent and capable of processing and analysing data locally. They can perform advanced data analytics, predictive modelling, and decision-making, enabling real-time and context-aware data processing at the edge.
- Distributed Intelligence: Instead of relying only on centralised cloud-based intelligence, the next generation of the edge IoT continuum processing is expected to have distributed intelligence, with AI and ML algorithms deployed across the continuum, from the cloud to the IoT edge devices. This will enable more efficient and effective data processing, analytics, and decision-making and more secure and resilient systems.
- Autonomous decision-making: Edge IoT devices will have more autonomy and decision-making capabilities, enabled by AI and ML algorithms, to allow them to respond to events and changes in the environment without relying on centralised control. This will reduce the latency and bandwidth requirements of transmitting data to the cloud and enable faster and more efficient responses to local events.
- Edge-to-Edge collaboration: The next generation of the IoT edge continuum will enable more collaboration and communication between IoT edge devices, enabling them to work together to perform complex tasks, share data, and coordinate actions. This will allow more efficient and effective data processing and improve the system's overall performance.

Current Status

The intelligent edge IoT technologies and applications field is rapidly evolving, with many exciting developments and innovations underway. As the ecosystem matures, it is expected to see more efficient, secure, and intelligent IoT edge devices and systems that enable new applications and services in various industrial domains.

IoT Edge Computing Platforms enable developers to deploy code and algorithms to edge devices and enable efficient data processing and analytics at the edge. Many edge computing platforms are available in the market.

Meta-operating system development addresses a unified operating system that can seamlessly integrate multiple edge IoT devices, applications, and services across different platforms and domains. In the context of industrial IoT and immersive technologies at the edge, meta-operating system can play a key role in enabling more intelligent and autonomous systems that can adapt to changing conditions and demands in real-time.

AI and ML algorithms are increasingly being deployed at the edge to enable intelligent data processing and decision-making. Edge IoT devices can perform real-time image recognition, natural language processing, and predictive analytics without relying on cloud-based processing.

Security and privacy are critical concerns in edge IoT systems, and there is a growing focus on building secure and resilient edge devices and systems. Techniques such as hardware-based security, trusted execution environments, and blockchain-based data sharing are being explored to enhance the security and privacy of edge IoT systems.

There are many applications of intelligent edge IoT technologies in various domains, such as healthcare, manufacturing, transportation, and agriculture.

Standardisation and interoperability are essential issues in the edge IoT ecosystem, as there are many different devices, platforms, and protocols in use. Efforts are underway to develop standard interfaces and protocols to enable seamless communication and interoperability between edge devices and platforms.

Research Challenges

Few future research challenges that need to be addressed to advance meta-operating system towards new web and immersive edge technologies are listed below:

- The meta-operating system must be scalable and interoperable, allowing it to integrate many devices, applications, and services across different platforms and domains. This requires the development of standardised interfaces and protocols that can be used to enable seamless communication and collaboration between various components of the system.
- Data management must be adapted to the new distributed edge IoT architectures. The meta-operating system must effectively store, process, and analyse large amounts of data from multiple sources while ensuring data quality, privacy, and security. This requires new data management techniques, such as distributed databases, data mining, machine learning, and new programming models for processing and analysing data.
- New intelligent resource management techniques must be developed considering that the meta-operating system can dynamically allocate and manage resources across multiple intelligent edge IoT devices and applications based on real-time data and performance metrics. This requires using edge AI techniques, such as machine learning and reinforcement learning, to optimise resource allocation and management in real-time.
- Edge IoT immersive technologies need to be supported by meta-operating systems, which requires the development of new architectures and programming models that can support high-performance computing and low-latency communication across multiple intelligent edge IoT devices and platforms.
- Machine-to-machine, human-to-machine hybrid interaction must be enabled by the meta-operating systems enabling natural and intuitive interaction between intelligent edge IoT devices and humans, allowing humans to interact with and control the behaviour of edge IoT devices and applications seamlessly and intuitively. This requires natural language processing, gesture recognition, and other human-computer interaction techniques.
- Security and privacy concerns become more critical as meta-operating systems integrate more intelligent edge IoT devices and applications which interact in real-time with humans. Meta-operating systems must be designed to be secure and resilient against attacks and to protect sensitive data and user privacy.

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