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Metaverse Infrastructure: AI, IoT, Digital Twins, Teleoperation and Data Management with support from 5G and Beyond

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Abstracts

This research evaluates the technology and infrastructure supporting the evolving Metaverse, which Mind Commerce sees supporting a variety of applications and services including digital currency and assets, non-fungible tokens, gaming and simulations, next-generation social interactions and a completely on-net digital marketplace.

It analyzes key areas necessary to realize this vision including AI, IoT, the convergence of AI and IoT (AIoT), digital twins, teleoperation, and next generation data management. To realize the full capabilities of the Metaverse, there is a need for the aforementioned technologies as well as 5G and beyond. 5G and 6G technologies, along with edge computing, provide substantial bandwidth and low latency where needed as well as significantly lower latency for next virtual reality.

Select Research Findings:

The global market for IoT data collection solutions will reach $7.6B by 2027

The global market for IoT data-as-service solutions will reach $9.6.2B by 2027

Up to 93% of all IoT Platforms will contain some form of digital twinning capability by 2027

The global teleoperation and telerobotics market are poised to reach $83.7 billion by 2027

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Up to 93% of all IoT Platforms will contain some form of digital twinning capability by 2027

Teleoperations/telerobotics, and industrial automation will be leading 6G-enabled solutions

Important to the recent renaming of Facebook, Inc. to Meta Platforms, Inc. (or “Meta” for short), “Metaverse” refers to 3D worlds focused on social connection. Metaverse is partially derived from the adjective meta, which is something that refers to itself or the conventions of its genre. Something that is self-referential.

Virtual Reality and Mixed Reality in the Metaverse

Immersive technologies include augmented reality, haptic Internet, and virtual reality. The term `immersive` is used as this category embodies those technologies that facilitate a fully engrossing human experience, often including multiple senses as well as interaction with virtual objects and/or interaction between the real and virtual worlds.

Virtual Reality (VR) aims to create a new form of human-machine interaction allowing people to experience their sense of reality in a 3D computer-generated virtual environment. With VR, people are able to perform a series of actions and manipulation of objects as an integral part of a virtual environment. VR allows someone to fully immerse within a virtual environment through the exploration of their senses and create new patterns of communication and understanding.

The term mixed reality (MR) pertains to a form of hybrid reality in which physical and digital objects co-exist and interact in real-time. With MR, either virtual objects are digitally mixed into reality or real-world objects are merged into virtual worlds.

The latter case is sometimes referred to as augmented virtuality, and is one step closer to a VR environment in which real-world objects in a virtual world take on a sense of permanency with real objects, appearing to actually exist within the virtual world.

Adding to this sense of permanency, real-world objects in a virtual world may be digitally controlled. Conversely, MR may also support manipulation of virtual objects permanently placed in the real-world. In either scenario, MR will be an important aspect of teleoperations and vice versa.

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Internet of Things in the Metaverse

The Internet of Things (IoT) is poised to fundamentally transform communications, global IT support systems, automation and business processes in virtually every industry vertical. IoT originally was manifested in machine-to-machine communications primarily for asset monitoring and logistics within a few industries such as gas and electric utilities, vending, and fleet management.

IoT is evolving to incorporate increasingly greater aspects of the business ecosystem. The greatest value will be realized through leveraging data obtained to derive useful insights and decision-making support of process improvement, automation, and development of new products and services.

IoT Platforms can be defined as a convergence of software and hardware solutions to interconnect “things” (people, things, objects, spaces, processes, data, etc.). These platforms may act as a bridge between the real world and the virtual world, enabling various “things” to communicate and interact with each other.

Important IoT platform functions include continuously collecting, sharing, and utilizing data about users and for users. Users may be communication service providers, consumer, enterprise, and industrial or government entities. One of the key purposes for this data exchange within the Metaverse is to support physical-to-cyber communications and interactions between the real-world and virtual worlds.

Artificial Intelligence of Things in the Metaverse

The combination of Artificial Intelligence (AI) and the Internet of Things (IoT) has the potential to dramatically accelerate the benefits of digital transformation for consumer, enterprise, industrial, and government market segments.

Artificial Intelligence of Things (AIoT) is transformational for both technologies as AI adds value to IoT through machine learning and decision making and IoT adds value to AI through connectivity and data exchange. The AIoT market constitutes solutions, applications, and services involving AI in IoT systems and IoT support of AI solutions.

As IoT networks proliferate throughout every major industry vertical, there will be an increasingly large amount of unstructured machine data. The growing amount of human-oriented and machine generated data will drive substantial opportunities for AI support of unstructured data analytics solutions.

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Data generated from IoT supported systems will become extremely valuable, both for internal corporate needs as well as for many customer-facing functions. This will be especially true in the Metaverse as virtual world data becomes monetized as well as the linkage between virtual and real worlds.

IoT and Digital Twins in the Metaverse

A “digital twin” represents a virtual item that is mapped to a physical thing such as equipment, robot, or virtually any connected personal or business asset. This mapping of the digital world to real-world assets is facilitated by IoT platforms and software that is leveraged to create a digital representation of the physical asset.

The digital twin of a physical asset can provide data about its status such as its physical state and disposition. Conversely, a digital object may be used to manipulate and control a real-world asset by way of teleoperation. This form of cyber-physical connectivity, signaling, and control will be a key capability to realize the vision for Industry 4.0 to fully digitize production, servitization, and the “as a service” model for products.

IoT will enable “Smart Objects” as depicted above, facilitating many new business models and opportunities based on new feature/functionality such as the following:

Virtual-to-Real (V2R): Virtual objects that can be provisioned and administered to interface with real objects for many purposes including monitoring and control.

Real-to-Virtual (R2V): Real-objects provide feedback, alerts, and even control of virtual objects (software programs via Software Defined Networks) and platforms (hardware and software put in place to orchestrate IoT networks and assets).

Virtual-to-Virtual (V2V): This represents simulation and testing for IoT networks, including end-nodes and assets. IoT is new, and potentially dangerous (e.g. control and security issues), necessitating platforms for IoT V2V.

The above scenarios will be employed singularly and in combination across different industry verticals in accordance with their overall IoT operational readiness as well as physical-to-cyber integration on a product-by-product and/or service-by-service basis.

IoT enabled digital twin technology will facilitate dramatic changes in a wide range of

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consumer, enterprise, and industrial products and services. Impacted areas cover a wide range including everything from marketing and advertising to operations and product lifecycle management.

Advanced IoT systems will utilize digital twin technology to enable next-generation teleoperation. The implementation of digital twins will also enable distributed remote control of assets, which will drive a market need for IoT identity management, authentication, and authorization.

Data Management in the Metaverse

Identity Management in the Metaverse

Managing identities and access control for enterprise applications remains one of the greatest challenges facing IT today. The future of ICT (and Metaverse in particular) will include many identity-related issues and challenges that pertain to non-human activities such as those autonomous actions that occur on behalf of humans as a result of IoT.

There will be a growing need for Identity of Things (IDoT) management solutions to support communications between otherwise disparate IoT systems and networks. These solutions will evolve to include critical support functionality such as IDoT verification, permissions management, and discovery that will be provided by a combination of premise-based and cloud-based infrastructure.

Closely associated with Thing Identity is Authentication, Authorization, and Accounting (AAA) functions relied upon to verify 'Thing Identity' and allow things to engage in various communications and actions. However, AAA requires the availability of reliable identity information associated with IoT network elements, devices, actors, and data.

The implementation and operation of IDoT and related AAA systems will become especially important in the Metaverse as the prospect of 'virtual identity theft becomes a real concern. Accordingly, 'thing identity' will become increasingly important as well as related areas such as IoT authentication.

Big Data in the Metaverse

Data that is uncorrelated and does not have a predefined data model and is not organized in a predefined manner requires special handling and analytics techniques. The common industry term, big data, represents unstructured data sets that are large,

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complex, and prohibitively difficult to process using traditional management tools.

The sheer volume and unstructured nature of most IoT data will drive significant opportunities for big data solutions. This will be especially true in the Metaverse as massive quantities of data will be required to support the environment as well as volumes of data that grow exponentially large as user interactions generate data at an ever-increasing velocity.

Edge Computing in the Metaverse

Real-time and distributed unstructured data processing will become increasingly important, especially with the anticipated accelerations of IoT networks and applications. This is because there will be many distributed points of data access such as sensors, wearable technology, and various other consumer and industrial devices.

By its very nature, most of the data collected in the Metaverse will be unstructured (Big) data and in very large quantities. Therefore, distributed intelligence is necessary to decide in real-time what data is relevant for immediate action and what data should be stored or archived in the cloud.

There is a close association here with a hybrid cloud network topology in which some data is passed to a more centralized storage and processing area while other data is processed locally at the edge of networks.

AI further enhances the ability for big data analytics and IoT platforms to provide value to each other. The use of AI for decision making in IoT and data analytics will be crucial for efficient and effective decision making, especially in the area of streaming data and real-time analytics associated with edge computing networks.

Data Visualization in the Metaverse

Data visualization is viewed by many as a modern equivalent of visual communication. One of the primary goals of data visualization is to communicate information clearly and efficiently to users via the statistical graphics, plots, information graphics, tables, and charts selected.

Effective visualization helps users in analyzing and reasoning about data and evidence. Next generation visualization will entail a combination of advanced UI methods as well as new data models that involve data as a service.

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