Metaverse and Other Technology Bundles for UN SDGs – Opportunities and Challenges

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Abstract

This policy brief goes beyond AI and suggests that metaverse is a much more powerful technology bundle that could usher unprecedented opportunities but could also expose us to unimaginable challenges. This brief starts with an overview of Metaverse as a Technology Bundle that integrates AI, Blockchains, IoTs, Cloud, Web3.0 and AR/VR to possibly accelerate the progress in key SDGs. Additional technology bundles that could further accelerate global B2B trade and other targeted SDGs are also introduced. Challenges and appropriate policies and approaches are recommended for the benefit of multiple SDGs.

Introduction to Technology Bundles and Metaverse

Digital technology bundles have collectively fuelled the digital revolution since the early 1990s. For example, excel spreadsheets coupled with a simple web page still serve as the starter bundle for most startups, especially in the developing countries. Simple databases with online purchasing support ecommerce sites and social media services supported by web2.0 strengthened e-business and B2B trade around 2000. More recent developments in generative AI, blockchains, IoTs and cloud technologies are now transforming businesses, global supply chains and information exchanges. Emergence of metaverse technology bundles is supporting next generation enterprises in public and private sectors. This evolution of smart enterprises, in the public and private sectors, can be visualized by an approximate stage model displayed in Figure 1:

- X axis represents the use of digital technologies for business specific operations such as marketing, sales and customer support (from eBusiness 0.0 to eBusiness 4.0 and beyond)
- Y axis represents the use of digital technologies for industry specific operations (from Industry 0.0 to Industry 4.0 and beyond)

Special CaseA represents a scenario where the business operations use latest digital technologies but the factories (e.g., textile mills) rely on the 18th century steam engines. CaseB represent an opposite scenario (e.g., US AirForce using cutting edge technologies in command and control systems but legacy systems in business operations). Decision makers need to balance the two.

Figure 1. Stage Model for Digital Transformations (Extension of Umar [4, 5])
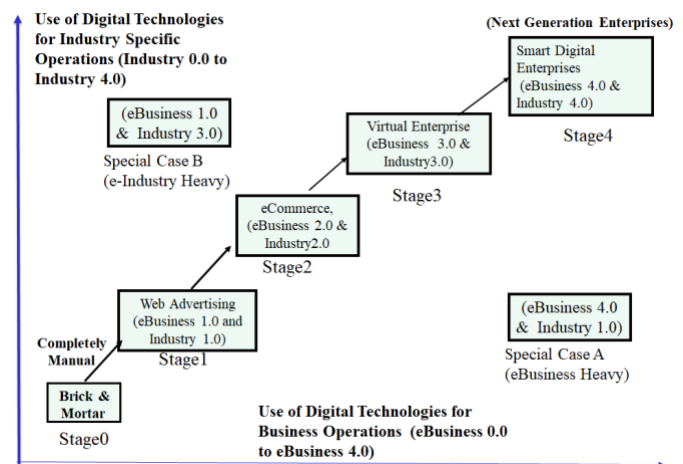
Stages 0 to 4 are introduced in this model to roughly represent any organization in any part of the world as it evolves from Brick and Mortar to a Next Generation Enterprise that exploits the latest "bundle" of technologies. Our main interest is in the Metaverse, a bundle of digital technologies that supports a virtual world envisioned in 1992 by the science fiction novelist Neal Stephenson [1]. Metaverse only exists on the internet and the concept has morphed into a bundle of the following highly interdependent technologies that support the virtual world of metaverse which is not limited by the physical world:

- AI (Artificial Intelligence that emulate the behavior of smart human beings). AI has progressed through several stages where it can now generate code, diagrams and even videoclips.
- Blockchains (a digital ledger that cannot be modified) and NFTs (Non-Fungible Tokens) -- a non-interchangeable unit of data stored on a blockchain that can be sold and traded.
- Web 3.0 (semantic web content that can be understood by other machines and is stored on a

blockchain) – every web page can be a block on the blockchain.
- AR/VR (Augmented Reality that is a mixture of real artifacts that are enhanced by Virtual Reality).
- Additional technologies such as the Databases (e.g., graph and vector databases) and cloud technologies also support the metaverse.

These technologies are at the core of metaverse bundle and can be represented by a simple ten-dimensional model shown in Figure2 that identifies specific digital technologies for enterprises to progress through the Stage Model. For each dimension, a set of values, {Low, Medium, High}, based on an informal estimation, indicate the adoption. Thus, the inner circle depicts a stage1 organization and the outermost circle represents a metaverse organization. Thus as organizations gradually progress from inner circle to the metaverse circle, they encounter new challenges and need new policies to address the challenges. These two models are used in a toolset discussed in Annex3.

Figure 2. Dimensional View of Digital Technologies (Extension of Umar [4, 5])
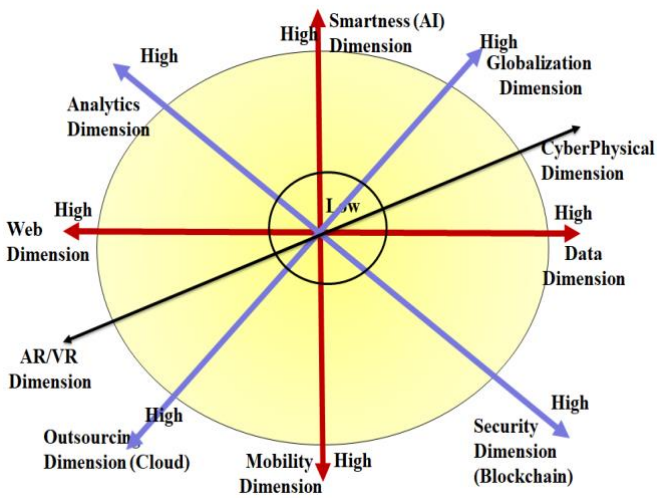
Although each of these Meta Technologies is strong enough in its own right, but when integrated together, they support a virtual environment where avatars provide government services in a metaverse city. Metaverse could also be used to support the UN SDGs [a1, a2, a3]. Annex 2 displays some use cases that highlight how the metaverse technologies collaborate with each other to accelerate UN SDGs. We are only showing significant use cases that span poverty reduction, food and agriculture, healthcare, education, gender equality, water and sanitation, energy, economic growth, industrialization and innovation, inequality, safe and smart cities, climate change, conservation of oceans, sustainable terrestrial ecosystems, peaceful societies and global partnerships to achieve all of the above.

Additional Technology Bundles and Policy Implications

Besides the Metaverse Technology bundle, many other technology bundles have emerged that integrate multiple technologies for specific use. A common example is the bundle that integrates AI, Blockchain and the Cloud (dubbed the "ABC" bundle) to trigger tremendous economic development around the globe. Similar bundles for global health & human services and digital banking services are becoming common. In addition, there are UN created regional/economic/special interest "bundles" (e.g., OECD, SIDS, LDCs, UN-Habitat, UN-South to South, etc) with different technologies for different needs.

There are also some sustainability studies that are pointing to very interesting interdependencies between all of the above that could be of value to the policy makers. For example, SIDS (Small Islands and Developing States) may need a "SIDS Technology Bundle" that could be of high value to SIDS because it would integrate Blue Economies and Disaster Resilience capabilities with other solutions to deliver high value to SIDS.

Due to space limitations, this brief will only consider three technology bundles (Metaverse, ABC and SIDS). Others will be investigated in the future. Table1 (Annex1) is a summary of our analysis: it shows the key SDGs supported by Metaverse, ABC and SIDS bundles.

Challenges and Policy Issues [A1-A6]

Metaverse technologies have transformative potential in significantly accelerating SDG progress, but these technologies, especially AR/VR are major energy consumers. However, as mentioned in Table1 (Goal7), Metaverse could reduce travel related emissions due to the increase in remote work. Another concern is that Metaverse requires expensive lenses, CPUs, and very fast networks -- these limit the potential users of metaverse to only affluent populations and countries.

Real concerns exist regarding security complexities and data privacy due to increased sharing of sensitive and personal data or continuous surveillance by numerous cameras leading to privacy violations and data misuse. Ethical concerns abound thus possibly impeding SDG 10 progress. It will be also important to protect children's emotional wellbeing if they cannot distinguish real artifacts from virtual. Proposed

Metaverse cities such as Seoul use closed circuit TV (CCTV) to watch and record all movements of its citizens in Seoul. This has triggered serious criticism [26].

Bad actors may take advantage of metaverse's reality-altering capabilities to inject political or dangerous messages or trigger false alarms and disasters that look very real. In addition, new laws will be needed to grapple with new situations such as NFTs and ownership rights. In addition, machine-generated content by Web3.0 could challenge frameworks such as the General Data Protection Regulation (GDPR) [10]. It seems that there is a need for "Responsible Metaverse" that is similar to "Responsible AI".

Expert systems of the past are morphing into digital avatars that look and behave like us. This creates numerous legal and social issues. Could "Avatar Lawyers" emerge to offer services like company incorporation and arbitrating use of digital land for unlawful activities (some law firms have already established offices in the metaverse [30]). Basically, metaverse could enable a new wave of "Meta-Crime" that would need a new breed of lawyers with "Meta-Forensics" skills and Policy makers will need to update their skills accordingly.

The main advantage of the ABC bundle is that it eliminates the extra cost and energy utilization of metaverse. ABC also reduces the aforementioned privacy and ethical concerns introduced by AR/VR. However, it excludes many appealing applications of metaverse in tourism, education, agriculture, healthcare, and climate change modelling.

The SIDS bundle primarily uses AI, Blockchains, and IoTs and is thus very beneficial large number of developing states. However, some advanced technologies specific to Blue Economy and Climate Change could be provided through partnerships with developing countries.

Concluding Remarks and a Path Forward

This brief fully recognizes the transformative impact of AI on sustainable development. However, it also contends that AI alone is not enough. AI when bundled with equally transformative digital technologies such as Blockchains, IoTs, Web3.0, Augmented Reality, Virtual Reality, Vector Databases and Globally Distributed Cloud Environments offers significantly more compelling outcomes. Metaverse could usher unprecedented opportunities but could also expose us to unimaginable challenges. This brief has examined Metaverse as a Technology Bundle that could possibly accelerate the progress in key SDGs. Additional technology bundles that could further accelerate global B2B trade and other targeted SDGs are also reviewed and some challenges have been identified.

Unfortunately, recommendation of viable policies that could be actually implemented and sustained in a rapidly changing technology landscape is a daunting task. Annex 3 presents an alternative approach -- a computer aided planning, engineering and management platform that handles the complex task of recommending appropriate actions, including policies and implementation details for different technology bundles, in different locations and industry sectors. A basic version of this platform is currently operational.

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Annex 1. [Table] Highlights of Key SDGs Supported by Metaverse, ABC and SIDS Bundle

Type of Bundle	Key SDGs Supported (Please see Annex I for Detailed Discussion)
Metaverse (Technologies in the Bundles - AI, Blockchains, IoTs, Cloud, Web3.0 and AR/VR) [a1. a2, a3, a5, a6]	Goal1 and 2 (End poverty and hunger) could be affected due to increased cottage industries and possibly huge impact due to Meta-based indoor farming Goal3 (Ensure healthy lives , education and energy): "MetaHealth" with convergence of AI, AR/VR, IoTs, quantum computing, and robotics could revolutionize healthcare; immersive tutorials, gamifications and simulations for educating diverse populations Goal7 (Ensure access to energy): Metaverse will definitely consume more energy but it could greatly limit travel emissions because white-collar workers would not need to commute to work every day. Goals 8, 9 and 10 (Economic growth, resilient infrastructure and sustainable smart cities) will significantly benefit from metaverse. Please see AnnexI for more details. Goals 13 to 16 (combat climate change, terrestrial ecosystems, and vital institutions) will be strengthened through peaceful use of AI and other meta technologies such as AR/VR, IoTs, global-cloud-based systems and vector databases. (see Annex2I for more information).
ABC BundleI (AI, Blockchains, IoTs and the Cloud) [a4]	The emphasis of this technology bundle is to set aside the AR/VR and Web3.0 capabilities of metaverse and focus on supporting smart cities, B2B exchanges for global ecommerce. For example, a typical architecture of this bundle to support a smart city, e.g., LA, has the following layers: End User Layer of devices at homes in LA to Edge Computing that supports the end users in LA and Fog Computing to collect the data being produced by US cities. This data is sent to the main cloud servers located, say, in Singapore. Many variations of this architecture can be envisioned.
SIDS (AI, Blockchains, and IoTs plus technologies specific to Blue Economy and Climate Change)	This bundle specifically addresses the following needs of SIDS: • Most organizations are in stage 0, 1 and 2 of Figure1. Thus they need pre-integrated solutions that provide spreadsheets, simple databases and website functionalities. Microsoft Office is an example. • Most SIDS rely on the Blue Economies (economies based on the sea) to survive. These economies are supported by a wide range of cyber-physical solutions such as web portals, mobile apps, IoTs, robots and drones. These solutions need to be customized for different geographical locations with different capabilities and should be produced quickly and at massive scales to meet the specific demands of the SIDS and other countries. To complicate matters further, several government policies and industry guidelines regulate the deployment and use of many solutions. It is virtually impossible to handcraft the needed solutions individually and manually. See [ITMC'11 Template (ict4sids.com)] for details. • Climate change is a major challenge for SIDS because it results in many disasters such as floods and changing shore lines. UNDRR (www.undrr.org) is the lead *UN* agency for the coordination of *disaster risk reduction.*

Annex 2. Impact of Metaverse & Other Bundles on SDGs

SDG 1. End poverty: Metaverse advertisements to promote cottage industries and entrepreneurship [8, 18]. In addition, disasters and climate change are major contributors to poverty and Metaverse can help in this area (see Goal13).

SDG 2. End hunger, achieve food security and promote sustainable agriculture: A huge impact of Metaverse could be on indoor farming because the indoor farmers are investing in the latest technologies for sustainable and hassle-free agriculture [19]. Also, AR/VR tutorials for complex and expensive agriculture machinery and blockchains for secure storage and distribution of food. This could strengthen the Agriculture hubs in rural areas with precision agriculture and food safety capabilities. Also use of IoT technologies to increase, protect, and optimize crop production, as well as improve the storage and distribution of food [8, 9, 10, 11]

SDG 3. Ensure healthy lives: Meta-enabled healthcare services that integrate e-learning, e-health and e-administration to offer healthcare to remote populations. The "MetaHealth" is rapidly gaining traction with convergence of AI, AR/VR, IoTs, quantum computing, and robotics are expected to change the healthcare delivery and improve patient outcomes. In addition, digital robots (avatars) for aging and disabled populations for routine household tasks. [9, 17, 20]

SDG 4. Ensure quality education: Immersive tutorials, gamifications and simulations for educating diverse populations that include students with disabilities. Metaverse has the ability to bring online learning environments to life with tremendous flexibility. The tutorials for adult education could be provided through capacity building centers [8, 9, 21]

SDG 7. Ensure access to energy: Metaverse will definitely consume more energy. However, extensive use of Meta Technologies (IoTs, AI, Big Data, and Blockchains) is needed to manage and control energy consumption. Another consideration is that a successful Metaverse could greatly limit travel emissions on both local and global levels because white-collar workers would not need to commute to work every day. [22]

SDG 8. Promote economic growth: Extensive use of metaverse to support tourism, fisheries, entrepreneurship and cottage industries in different geographical areas. AR/VR could produce very attractive virtual tours that are of great economic value to developing countries [8, 9, 23].

SDG 9. Build resilient infrastructure and promote sustainable industrialization and innovation: Aggressively exploit innovative applications of all metaverse technologies to promote and support Industry4.0 and Manufacturing4.0. There are numerous opportunities for innovative digital twins in industrial settings.Many entrepreneurs can support the planning engineering and management tasks of Metaverse. [8, 24], SDG9 (Industry, Innovation, and Infrastructure) has many 41% of cases exemplifying the role of AI in fostering urban sustainability (STI).

SDG 11. Make cities and human settlements inclusive, safe, resilient and sustainable. Meta-Role: Smart cities, towns and communities can use metaverse extensively. See, for example, the Seoul Metaverse City initiative that will allow citizens to request and receive almost all government services through avatars without leaving their homes. Large number of use exemplifying the role of AI in fostering urban sustainability.

SDG 13. Combat climate change and its impacts: Use metaverse for sophisticated models for climate change and to detect and measure changes in ocean waves and weather conditions, and detect earthquakes, These models could integrate sensors, BI and Big Data with Meta Technologies. Metaverse could reduce the need for travel and be good for climate change due to less emissions [8, 10, 26]

SDG 15. Protect, restore and promote sustainable use of terrestrial ecosystems. Meta-Role: Use connected alarm systems and AI/ML capabilities across high density urban areas to notify residents of fast-moving fires and also use sophisticated Metaverse models to predict and detect wildfires quickly.

SDG 16. Peace, Justice, and Strong Institutions. Very large number of use cases illustrating the potential of AI to enhance governance and institutional capacities [Habitat]

Annex 3. SPACE (Strategic Planning, Architecture, Controls PACE) Platform for Next Generation Enterprises

SPACE is a Training, Research and Consulting Platform that supports graduate education and research at MS/PhD levels and a consulting and advising practice for the UN ICT4SIDS Partnership and public/private enterprises around the globe. At the core of this platform is an eFactory and a Lab that enables the users to launch successful digital enterprises and initiatives in any sector anywhere in the world and then pursue other scenarios, displayed in Figure 3, if needed. For the purpose of this policy brief, we are thinking of the following experiment:

- Start with Scenario2 (Digital Transformation) by selecting any country from any sector (e.g., SDGs). Lets say it is a telemedicine center in Samoa.
- Select the current and future stage of the center by using the Figure1 stage model.
- Choose a technology bundle by using the Figure 2 ten dimensional model to select a *suitable* bundle (e.g,, SIDS, ABC, Metaverse or something else). SPACE issues warnings to help the users.
- SPACE produces Promises and Pitfalls (e.g., challenges, possible policy considerations)
- The user then proceeds to Scenario3 and Scenario4 for implementation, deployment & management considerations. A Sandbox is also available for extensive hands-on experiments.

Figure 3. An eFactory and Lab for Strategic Planning of Smart Digital Enterprises (See 2.5 Minute Videoclip)