Communications of the Association for Information Systems

Volume 46 Article 25

5-2020

The Interaction of Virtual Reality, Blockchain, and 5G New Radio: Disrupting Business and Society

Aaron M. French
University of New Mexico, afrench@unm.edu

Marten Risius
University of Queensland

J. P. Shim
Georgia State University

Recommended Citation
French, A. M., Risius, M., & Shim, J. (2020). The Interaction of Virtual Reality, Blockchain, and 5G New Radio: Disrupting Business and Society. Communications of the Association for Information Systems, 46, pp-pp. https://doi.org/10.17705/1CAIS.04625

Communications of the Association for Information Systems

Panel Report DOI: 10.17705/1CAIS.04625 ISSN: 1529-3181

The Interaction of Virtual Reality, Blockchain, and 5G New Radio: Disrupting Business and Society

Aaron M. French
University of New Mexico
USA
afrench@unm.edu

Marten Risius
University of Queensland
Australia

J. P. Shim
Georgia State University
USA

Abstract:

The three cutting-edge technologies virtual reality, blockchain, and 5G have increasingly attracted public attention. While virtual reality became a popular concept in the 1990s, recent technological advances and decreased costs have created a resurgence in the technology. With significant funding and early adoption, blockchain and 5G have begun to make their mark on the world. Each technology alone may disrupt business and society, but, together, they provide multiple opportunities. In this paper, we summarize a 2018 Association for Information Systems Americas Conference on Information Systems (AMCIS) panel session with IS researchers and industry practitioners that tackled important topics related to these technologies. In particular, the panel made the case for IS research that focuses on topics that emerge when these technologies intersect. Each panelist presented their perspectives based on their experience and knowledge along with current issues and future directions. This topic has significant business implications as practitioners continue to note their advancements and develop strategies to adapt in a rapidly changing environment. The topic also has implications for future research as these technologies continue to become more prevalent.

Keywords: Blockchain, Virtual Reality, Augmented Reality, Mixed Reality, Extended Reality, 5G New Radio (NR), Societal Issues, Disruptive Technology.

This manuscript underwent editorial review. It was received 04/10/2019 and was with the authors for 5 months for 3 revisions. Christoph Peters served as Associate Editor.

1 Introduction

Rapid technical advances in virtual reality (VR), blockchain, and 5G technologies each provide disruptive power that affects industry and society, but, through technology integration, their impacts grow exponentially. These technologies can fuel each other's growth and potential while simultaneously creating impacts across economic and social boundaries. We shed light on these technologies to move public knowledge beyond the prevalent buzzword status and critically discuss their joint potential through technological integration. VR gained popularity in the late 1990s as the ubiquitous nomenclature to describe synthetic environments and augmented reality (Mills & Noyes, 1999). This technology galvanized researcher interest and stimulated numerous publications that evaluated VR's theoretical underpinnings ranging from gaming (Piekarski & Thomas, 2002) to medical training (Seymour et al., 2002). While VR demonstrated tremendous potential for organizations, universities, and individuals, few could adopt it at full scale due to high investment costs, low supply of technical expertise, and lack of mobility. However, various other technological advancements (e.g., affordable computing power, improved screen resolution, VR content platforms such as "Unity") have helped overcome these limitations. The current revival in VR interest may disrupt both business and society alike. However, when integrated with other emerging technologies, such as blockchain and 5G, these technologies gain capabilities that span beyond what anyone once theorized.

Blockchain and 5G NR are innovative technologies that complement each other and provide a foundation for new opportunities and advancements. These technologies individually have significant disruptive power, but, together, they provide multiple opportunities. Blockchain provides a platform that encapsulates independent nodes that store transactions on a distributed public ledger for increased data transparency and accuracy. Blockchain allows users to create a peer-to-peer network that cuts out the middle man and puts the power in their hands. With increased network speeds that 5G networks will bring, bandwidth and mobility limitations will be a thing of the past. Together, these technologies together will result provide ubiquitous access to information and services that connect everything and everybody. With cheaper VR hardware, advanced tools for development, and open source communities, VR may have a significant impact on society that will exponentially grow through its integration with blockchain and 5G.

1.1 The Panel

Following the theme for AMCIS 2018 ("digital disruption"), a panel of industry and academic experts on VR, blockchain, and 5G technology discussed the disruptive potential on industry and society through their integration. In this paper, we summarize that discussion. In recent history, several technologies have made revolutionary impacts on society such as the Internet in the 1990s, social networking in the 2000s, and smartphones and smart technologies in the 2010s. VR, blockchain, and 5G represent the next technologies that may soon make their mark on business and society (Shim et al., 2017). The panel addressed these topics through two discussion rounds. In the first round, the panelists introduced and summarized the technologies and benefits of technological integration. In the second round, the panelists discussed VR's, blockchain's, and 5G's impacts and disruptive potential, their integration, and their organizational and societal impacts. The panel concluded with a question and answer (Q&A) session with the audience and insights from the panel members on research implications and future recommendations.

1.2 Panel Report Organization

We format this panel report according to the panel discussion that took place. Thus, in Section 2, we summarize the discussion on disruptive technologies. In Section 3, we highlight their potential through technological integration. In Section 4, we describe these technologies' disruptive power, their societal effects, and regulation and compliances issues. Finally, in Section 5, we discuss research implications and recommendations.

2 Overview of Disruptive Innovations

In this section, we summarize blockchain, 5G, and VR to provide background information about their current status, capabilities, and potential. We use this background as a foundation for the following sections in which we describe how they complement one another and, thus, how their integration turns them into disruptive technologies for business and society.

2.1 Virtual Reality and Augmented Reality

While researchers and practitioners have discussed and theorized VR over the past several decades, new advances in the technology and its widespread adoption have renewed interest in it and warrant new discussions. VR constitutes one of the most pervasive extended realities (XR), a relatively new umbrella term that refers to the full spectrum of VR, AR, mixed reality (MR), and 360-degree video (Scribani, 2019). VR artificially creates a three-dimensional digital egocentric environment that fully immerses its users. It typically comprises several different technical components, such as visual and aural systems, manual control objects, a central coordinating processing and software system, and some input device that can capture users' movement (Bidgoli, 2017). VR's fully immersive digital nature distinguishes it from related XR technologies such as AR or mixed reality that superimpose computer-generated images on or merge them into, respectively, a user's view of the world (Intel, 2018). Originally, one created VRs through stationary displays such as a cave automatic virtual environment (CAVE), a cube-shaped room with walls that served as holographic rear-projection screens (Cruz-Neira, Sandin, & DeFanti, 1993). Today, VR commonly uses head-mounted displays that range in complexity from simple viewers with a smartphone dock (e.g., Google Cardboard) to more complex discrete devices that interface with personal computers and gaming consoles (e.g., Oculus Rift, HTC Vive, Samsung Gear VR, or Sony's PlayStation VR) (Intel, 2018). Augmented reality adds digital elements to a live view by using a smartphone's or device's camera. Typical AR examples include the Skully Technologies motorcycle helmet or games such as Pokemon Go.

VR applications have various promising fields such as virtual prototyping, architectural walkthroughs, data visualization, training and education, entertainment, virtual collaborations and meetings, and medical or therapeutic measures (Craig, Sherman, & Will, 2009). Walmart, Boeing, UPS, and other Fortune 500 companies currently use VR as a training tool (Morris, 2018). While VR inspires great hope and demonstrates substantial potential, current pitfalls limit its general applicability: it can easily create a sense of motion sickness for untrained and even experienced users, VR devices' weight and poor air-conditioning restricts long-term usage, and the devices do not suit many locations because they shield users away from their immediate environment. However, considering the great investments that organizations have made in VR technologies (Merel, 2018), we expect that they will overcome these limitations. As network speeds increase and new infrastructures (e.g., blockchain and 5G) provide additional capabilities, VR's capabilities will expand beyond stationary use adding mobility with ubiquitous access to VR environments. VR will become as pervasive as mobile phones, which will require new research from both design science and behavior science perspectives.

2.2 Blockchain

A blockchain refers to a distributed database that stores transactions in cryptographically linked blocks, which creates an immutable ledger (Glaser, 2017). By enabling automated, immediate, and verifiable transactions between peers, blockchain technologies constitute the backbone of the transition from the collaborative Web 2.0 to Web 3.0 (also referred to as the "Internet of value") (The Economist, 2018). We commonly distinguish three blockchain archetypes that can serve different purposes (see Figure 1): public blockchains (open source blockchains that anyone can use or develop), private blockchains (blockchains that an approved entity develops and controls), and consortium blockchains (blockchains that various entities—typically similar or partnering companies—own and use to create transparency for all participating members). R3 Bank exemplifies a consortium blockchain that contains a global network of partners that create innovative apps to support finance and commerce. Like former discussions about social media's worth (Kane, Palmer, Phillips, & Kiron, 2014), industry and academia have begun to assess blockchain technologies' value (Avital, Beck, King, Rossi, & Teigland, 2016).

In this regard, blockchain technologies offer considerable benefits compared to established databases or intermediary systems. Most prominently, one cannot easily or cheaply manipulate blockchains, which explains why many refer to them as immutable logs (Xu et al., 2017). In a public blockchain, for example, every node stores the entire blockchain, which not only provides access to all recent transactions but also keeps an entire history of all the transactions that have been completed and stored on the database at any time in history (Xu et al., 2017). Depending on the context, blockchain systems also have increased transparency since all nodes have read access to the database (Glaser, 2017). Further, smart contracts enable parties to manage transactions automatically. Since parties can immediately exchange assets and verify their legitimacy through a blockchain, they can save time through swift consensus (Christidis & Devetsikiotis, 2016; Raskin, 2016; Zhang & Wen, 2015). Lastly, by enabling validated peer-to-peer transactions, blockchain technologies can replace traditional intermediaries and, thereby, help reduce

associated overhead costs (Risius & Spohrer, 2017). Thus, blockchain technologies offer considerable benefits to the economy and society.

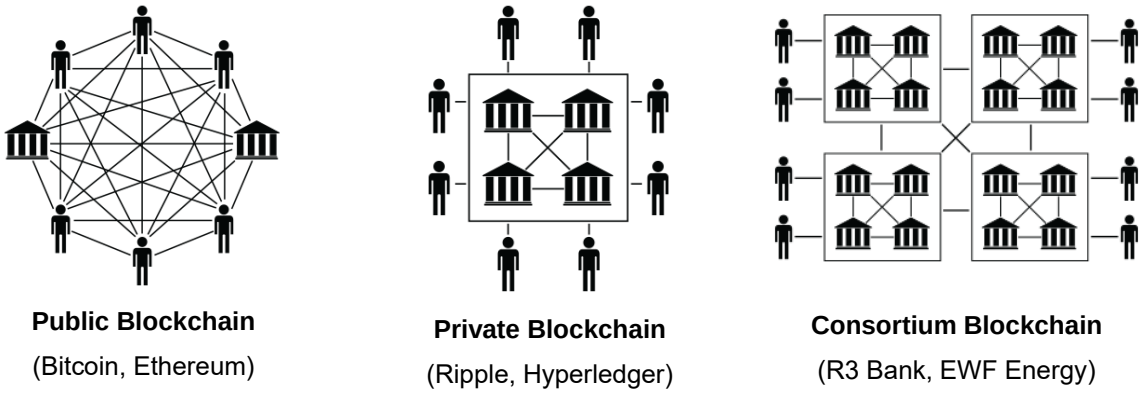

Figure 1. Types of Blockchains

However, despite the various benefits that blockchain technology offers, it also has several drawbacks that one must consider when deploying a blockchain system. The most prominent downside concerns limited scalability. Beck, Stenum Czepluch, Lollike, and Malone (2016) argue that scalability issues, costs, and volatility in the transaction currency can constrain widespread adoption and utilization throughout the economy. Privacy can also be a concern in public blockchain applications since they can create legal uncertainty related to privacy. While nodes in a blockchain have asymmetrically encrypted identities, de-anonymization attacks have shown that one can analyze transaction patterns to identify nodes (Meiklejohn et al., 2013; Ron & Shamir, 2013). At the same time, we lack reliable know-your-customer solutions that abide by legal regulations while preserving blockchain's potential for privacy protection and decentralization. In order to integrate blockchain with other systems, we require standards that also determine, for example, liability (Risius & Spohrer, 2017).

2.3 5G New Radio (NR)

According to several recent global mobile industry reports, such as the 3rd Generation Partnership Project (3GPP), the 5G wireless standard is 100 times faster than the 4G LTE standard currently available. As Figure 2 shows, 3GPP Release-15 (Rel-15) establishes a solid foundation for 5G NR, especially for enhanced mobile broadband and beyond. 5G New Radio (NR) evolves the OFDM of 4G into a flexible and scalable waveform framework. It is well known from 4G that multicarrier OFDM is advantageous compared to single carrier modulation for throughput (GSMA, 2018; Smee, 2018; Shim et al., 2020). eMBB, URLLC, and mMTC are three generic services with heterogeneous requirements that 5G network slicing supports.

5G speeds and low latencies (i.e., 5G mobile sysetms, mobile terminal device with MIMO antenna array multi gigabit downlink speeds and latencies as low as 1 millisecond) are essential to meet the increasing connectivity requirements. These connectivity requirements include aspects such as virtual reality, augmented reality, extended reality, autonomous vehicles, and drones. With increased network speeds from 5G mobile systems, VR/AR will be able to expand beyond stationary systems into ubiquitous mobile environments.

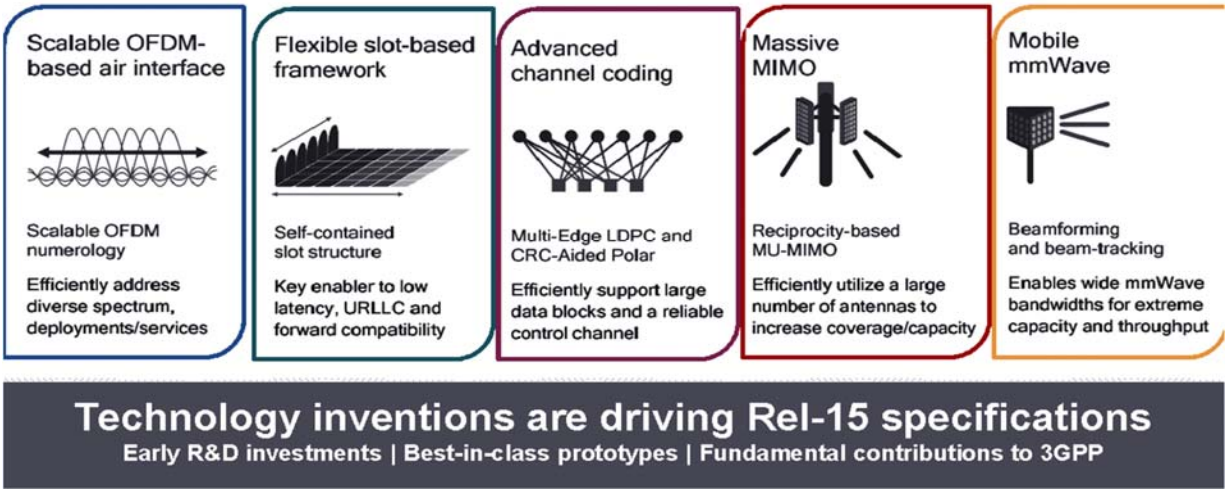

Figure 2. 3GPP Rel-15 Establishes a Solid Foundation for 5G NR (Smee, 2018)

3 Technological Integration of Disruptive Technologies

Blockchain, 5G, and VR remain at different development and deployment stages. While virtual reality has decades of research and development behind it, blockchain remains in its infancy, and 5G NR has entered preparation for its launch. Even so, these technologies offer complementary benefits through blockchain's backend applications, 5G NR's network speeds, and VR's front-end applications. Figure 3 depicts how we conceptualize how these technologies converge, which opens up potential use cases that we discuss throughout this section. VR has overcome its previous price limitations but still lacks the mobility to reach its full potential. Integration with 5G's high speed networks will overcome this barrier and provide the network needed to provide viable VR solutions in a ubiquitous environment(see Section 3.2). Integrating VR with the blockchain has created opportunities to develop novel applications and test mechanisms to integrate blockchain into businesses (see Section 3.1). Blockchain technologies can support 5G NR's operation and, thus, provide the infrastructure to disrupt business and society (see Section 3.2).

Figure 3. 5G, VR, and Blockchain Technological Integration to Disrupt Business and Society

3.1 Virtual Reality & Blockchain

Practitioners and researchers, such as Glaser (2017), have often considered blockchain an innovative technology that requires use cases. Recently, a novel area of blockchain development focused on VR applications has grown rapidly. While these projects mostly remain under development, they have already raised a considerable amount of funds and attracted remarkable user numbers (Wood, 2018). For example, Decentraland, a VR platform comparable to Second Life with a limited number of lots that currently sell between US$15k and US$200k USD, manages property rights through a blockchain ledger. Miners process transactions for pixels rather than cryptocurrencies that they can terraform to create new land for sale. In Decentraland, users connect using VR devices to not only participate in the network but also become fully immersed in the virtual environment. Decentraland represents the first virtual world that connects VR to blockchain technology using Ethereum. This project has currently raised US$75 million in market capitalization and attracted approximately 18,000 users. Other projects include online augmented and virtual reality market places such as VibeHub ($34m, 3,800 users) and Cappasity ($10m, 6,700 users) who offer online events or 3D content in exchange for crypto tokens. Moreover, by managing content through the blockchain, Cappasity prevents copyright infringements through illegal redistribution since one can uniquely identify all objects. Similarly, Matryx ($10m, 2,400 users) provides a platform to post a 3D design or simulation problem with a bounty. Users can provide a solution to problems to earn the bounty. If users decide to collaborate in the process, the will receive the bounty according to their individual contributions, which the blockchain stores (Wood, 2018). These examples just illustrate some ways in which blockchain technologies support virtual reality.

Admittedly, these use cases in entertainment and e-commerce do not necessarily indicate entirely novel use cases that would not have been possible without blockchain technologies. Rather, we can deduce that VR offers a sandbox environment to test blockchain solutions' real-world implications. Thereby, we can practically explore difficulties in and solutions of blockchain applications with regards to identification systems, payment channels, trust interface points, intellectual rights management, and industry standards. Looking at blockchain-based VR applications will help move research beyond its current conceptual and descriptive state by providing prescriptive findings and best practices (Zhao, Fan, & Yan, 2016). Regarding identity systems, most current online transactions (e.g., PayPal, Amazon Pay, Google Wallet) require users to disclose some personal information, which certain parties can misuse with severe consequences (e.g., see the Equifax hack). VR platforms such as Decentraland will help explore the viability of decentralized identity checks or transactions with encrypted digital identities (Pinto, 2018). Virtual reality market places such as VibeHub also enable feasibility assessments of blockchain-based payment channels in a trust-free economy and to determine the extent to which this concept holds up. Virtual asset exchanges for crypto tokens create a purely blockchain-based economic environment. Here, we can experience the practicability of blockchain technologies in an Internet of value that manages digital transactions and identifies potential weaknesses. Other marketplaces such as Cappasity offer the opportunity to test how one can integrate blockchain technologies into established legacy systems. Users can transfer the purchased or rented objects to their websites, which will also show blockchain's capability of managing intellectual rights and recognizing potential flaws. Lastly, VR platforms will help developers to determine industry standards. Industry standards that evaluate liability issues and intellectual property rights will be necessary in an economy that offers global blockchain-based transfer and storage of digital assets. The intersection of VR and blockchain offers a sandbox environment to explore these issues.

Overall, while blockchain technologies may offer considerable advantages (i.e., immutability, transparency, and cost and time savings), they also present some currently unresolved challenges (i.e., privacy, scalability, integration, and regulation). Most research currently covers conceptual and descriptive topics (Risius & Spohrer, 2017; Zhao et al., 2016). The introduction of VR on blockchain can provide blockchain-based communities that serve as use cases for exploring the feasibility of blockchain-based economies in real-world settings (i.e., identity systems, payment channels, interface points of trust, and intellectual rights management) and provide the foundation to adapt digital rights legislation.

3.2 Expanding the Capabilities with 5G NR

In regard to expanding 5G NR to millimeter wave (mmWave) frequency bands standardization, 3GPP agreed to divide the Rel 15 specification into two phases: non-standalone (NSA) and standalone (SA). The NSA specification, which 3GPP approved in December, 2017, utilize the existing LTE backbone combined with 5GNR radios to boost capacity for end users (Cartenberg, 2018). However, initial deployments will not likely meet the International Telecommunication Union's exact specifications. Early

trial runs used a competing specification that some operators have picked up, but operators around the world have not adopted it as a standard. Despite not meeting specifications, scheduled 5G implementations remain on schedule with companies releasing the first 5G-compatible smartphones in 2019. Technologies such as VR and blockchain require the speeds and bandwidth that 5G offers. Figure 4 outlines the timeline for 5G deployment across three phases that comprise 5G architecture implementation and projected use cases utilizing 5G networks (Kornelis, 2019; McGarry, 2019). Experts predicts the first 5G technology applications to revolve around VR and the Internet of things (IoT) due to decreased technology costs and continued improvements in mobility (McGarry, 2019).

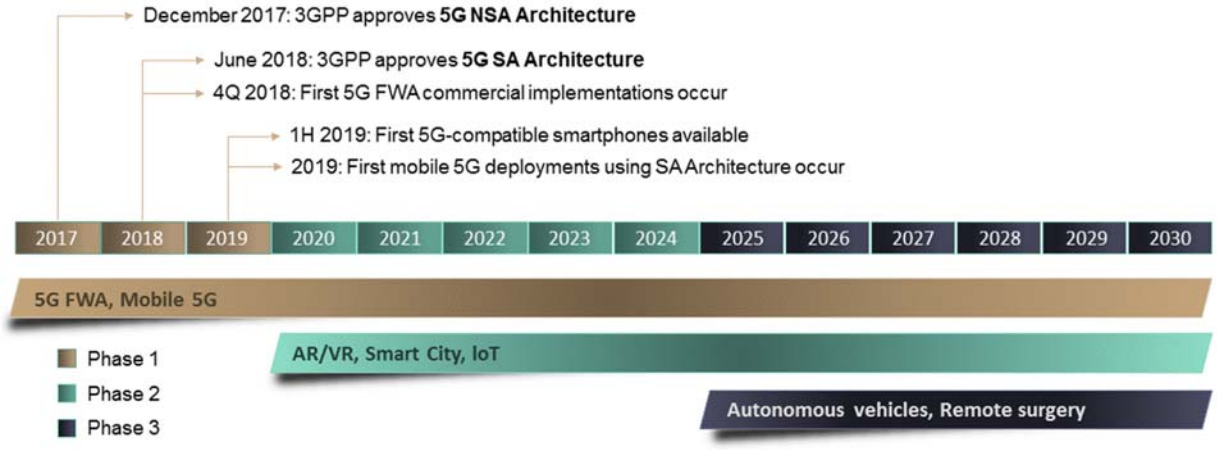

Figure 4. 5G Timeline and Use Cases (Kornelis, 2019; McGarry, 2019)

VR and blockchain can gain several advantages with 5G technology's release. For instance, VR worlds such as Decentraland can create immersive VR environments accessible through mobile devices. Using two-layer protocols on a high speed 5G network could help blockchain overcome some scalability issues that currently limit its capabilities. Being able to conduct instant transactions via blockchain using a mobile device could benefit many industries ranging from supply chains to e-commerce and auctions. Users can easily validate items' authenticity when they purchase them through blockchain tokenization. Marketing companies can expand the "reach" and "range" (Housel and Skopec, 2001) of their customers by using VR applications via mobile devices. Users no longer need to visit a store or use a personal computer with wired systems to access virtual environments.

VR and blockchain technology can also enhance entertainment. By having their own mobile device with VR capabilities and headphones, individual family members can go to the movies together and each watch the movie they want rather than compromising on a movie that everybody agrees with. Theaters would just need to provide comfortable lounges, refreshments, and use blockchain to verify purchases and record transactions. Blockchain and mobile devices would also benefit data analytics. Currently, organizations can analyze big data based on interactions with their customers. Many data analytics tools require high-speed processors that can handles massive amounts of data. With blockchain, data analytics can span beyond a single company and provide information about purchases across several industries and activities. The blockchain would contain transactions that link purchases for dinner, entertainment, and activities and could expand market-basket analysis beyond similar items that customers purchased together to related activities that they may enjoy. High-speed 5G networks would provide the speed and capabilities that organizations would need to perform analytics in the field, which would give mobility to their marketing teams and managers.

3.3 Industry Initiatives

The New Orleans-based company Juncture Strategies exemplifies a company that creates new and innovative solutions with the help of technological advances in virtual reality. Juncture Strategies focuses on the customer experience and how VR can provide new experiences for customers related to events, real estate, products, and technology. One of its clients, Max Home, sought new ways to engage attendees and demonstrate new products. Through virtual reality, the company learnt to provide users with immersive experiences for various products and services at home shows. Further, in collaboration with local Fox8 news in New Orleans, Juncture Strategies innovatively covered the Mardi Gras with 360

video to provide viewers with an engaging experience if they could not attend the event live. The company also partnered with Tulane's School of Social Work to assist students who could not travel for recruiting visits. Through virtual experiences, the two organizations captured the campus experience at Tulane for potential students to assist in the recruitment process.

While Juncture Strategies has begun using technology to engage and enhance the customer experience, the company recognizes the potential blockchain and 5G to further increase opportunities in this area. VR has mobility limitations due to the bandwidth it requires. With increased network speeds from 5G, users can ubiquitously access VR through mobile devices. With the emergence of blockchain technology and its integration in the VR industry, decentralized platforms with immutable ledgers will provide access and security to empower users to engage and interact through peer-to-peer networks. While companies such as Decentraland work on providing VR worlds via blockchain, Juncture Strategies and other VR companies have the opportunity to use these networks to enhance the customer experience and provide ubiquitous access to various products or services.

4 Societal Disruption and Compliance Issues

Virtual reality, blockchain, and 5G all represent revolutionary technologies that may disrupt all industries and dramatically change the world. While many tout VR as a novelty, it also provides the tools and capabilities to help healthcare workers treat several disorders such as social anxiety and addiction. Blockchain provides a public platform that empowers users through peer-to-peer transactions, but it can also expand the reach and range of many companies that provide a secure and reliable network. 5G will only fuel this growth by ensuring that large-scale applications have the necessary connectivity and bandwidth. In this section, we discuss how virtual reality, blockchain, and 5G may disrupt industry and society in more detail.

4.1 Digital and Economic Disruption

When technology becomes pervasive, it creates entry barriers that disrupt new entrants in the market and eliminates competitors that do not adapt. We expect VR, blockchain, and 5G to have this type of impact on various industries such as social networks, financial institutions, supply chain management, gaming, health, and more. Based on the use cases that we describe above, one can see how VR could impact the social networking industry, particularly when 5G networks are available. With users continually creating and using digital content such as images and videos, VR will add additional capabilities for users to become fully immersed in the digital content they create. VR and 5G have the capabilities to reshape digital interactions and, thus, completely change the landscape of social networking environments. Blockchain and 5G technology will also likely drastically disrupt supply chain management. For instance, several companies have begun exploring whether they can use blockchain to capture transactions along the supply chain. With blockchain's immutable ledgers and auditing capabilities, one will be able to track every individual product from the original source to the customer. Automobile organizations will be able to target specific automobiles when they initiate recalls, which will save time and money. Grocery and food organizations will be able to identify specific farms that products come from. They will be able to identify what specific farms bad products come from rather than discarding all products to prevent an outbreak. By integrating the supply chain using blockchain with 5G technology, organizations gain the capability to monitor these networks in real time. In these examples, organizations that do not conform to the new technologies will be at a technological disadvantage, which could affect their ability to compete in the market. Gaming companies have already begun looking into adding VR experiences to their games (e.g., Fortnite) for their users. VR gaming is becoming more than just a technology but rather a social phenomenon that is causing the entire gaming industry to react and meet users' needs. The tourism and travel industry will also likely see disruption as VR provides users with real-life experiences without having to actually physically travel. While VR will not replace the real-life experiences one obtains from traveling, it does serve as a tool that allows individuals to explore what they will experience when traveling. Several travel agencies have already begun adding VR components to their websites, and, as the technology improves, the experiences they can provide will become more enticing, which will create a try-before-you-buy scenario and cause companies that do not integrate VR to fall behind. Logistics companies such as FedEx and UPS have also reportedly begun working on blockchain solutions to improve delivery times and customer service, save costs from lost packages, and reduce inefficient delivery schedules. 5G will further disrupt society through smart cities and the Internet of things (IoT) as the latter expands to become Internet of everything (IoE). Further, autonomous vehicles that use 5G networks will impact any industry

that relies on transportation (i.e., logics, shipping, taxi, travel, etc.). Standard phone and texting services will become obsolete as voice over IP (VoIP) becomes more prevalent with higher-quality communications due to increased speed and bandwidth. 5G will create real-time ubiquitous communication and connectivity from a global perspective, which will allow people to remotely access services that range from entertainment to healthcare.

The integration of these technologies provides capabilities that can significantly disrupt economic markets and financial industries. With blockchain initial coin offerings (ICO), startups have begun to raise money and create new investment options outside traditional markets that involve stocks and exchanges. Cryptocurrencies such as bitcoin have yet to see widespread adoption as an actual currency, but they have much promise. With global usage, no exchange rate fees, and lower transaction fees, many banks have begun to realize the threat that cryptocurrencies pose to their markets and to evaluate options to either join the crypto market or find other ways to compete. Companies such as Facebook and Amazon have explored payment methods using their own cryptocurrencies that could significantly reduce costs and replace credit cards or other traditional forms of payment. 5G also provides the foundation for organizations and users around the world to make mobile payments using cryptocurrencies, which will further disrupt the economy. As such, governments have begun to create regulations, financial institutes have begun to new innovations in financial technology, and major corporations have begun to evaluate cryptocurrency options. Blockchain has already disrupted various industries and markets without even seeing full-scale adoption.

4.2 Societal Effects

While one can measure societal affects at the macro level, VR, blockchain, and 5G also have significant micro-level impacts. Healthcare practitioners have used VR to treat individuals with a wide array of conditions such as autism spectrum disorder (Thai & Nathan-Roberts, 2018), anxiety disorders (Maples-Keller, Bunnell, Kim, & Rothbaum, 2017), rehabilitation (Howard, 2017), and substance additions (Bordnick et al., 2008). In 2014, an estimated 22.5 million Americans self-reported needing treatment for substance abuse, and 9.8 million suffered from serious mental illness (Substance Abuse and Mental Health Services Administration, 2018). With 1 in 59 children having autism spectrum disorder (CDC, 2018) and over 9.9 percent of Americans suffering from substance abuse or mental health, the potential for VR as a treatment could have significant societal effects. Researchers in the social sciences have studied whether one can use VR to help treat various disorders for decades, but the recent advances in technology have converted the theoretical findings from behavioral science into reality with real-life implementations beginning to take place. Several treatment centers have implemented VR into their rehabilitation programs to treat various disorders using real-life simulations.

With VR, healthcare practitioners can treat and condition patients in real-life situations where they most likely need the skills to avert relapse and recall their training. For example, in traditional alcoholism treatments, individuals attended a clinical environment with others in which they refrained from drinking and discussed their experiences. In doing so, they could attend a safe environment to discuss their addiction without the temptation to relapse. They receive the training recommended to fight the addiction once they leave the clinic. However, many people face challenges when put in an environment where alcohol is readily available. Leaving the controlled environment where they learned their training and being exposed to environments where others are consuming alcohol increases the chance of relapse. Through VR, a person can progress through clinical training in a virtual environment that simulates real-life situations where a relapse would occur. Through this type of training, they can learn the skills necessary to fight the addiction in a representative environment that can help them easily recall the skills they learned once they leave the clinic. Such training could also benefit children with autism spectrum disorder by introducing them to a virtual classroom or playground and teaching them the social skills they need in a safe setting. As a result, the children could more easily repeat the lessons and recall the skills learned in actual settings with other children.

The challenges in implementing VR environments to help treat these various disorders involve cost and expertise (e.g., programmers). Various clinics around the world have experimented with VR treatment but lack the connectivity and collaboration required to continually advance this area. Here, blockchain and 5G provide additional benefits. A public or consortium blockchain can connect all the people required to develop and implement VR from programmers to end users. Each clinic would not need to create every VR environment to treat each patient as all involved clinics on the blockchain can develop and share resources among them. A treatment center in California could easily adopt a virtual environment

developed at another center around the world to treat a specialized condition or addiction with ease. Clinics and sponsors could perform audits to ensure that patients complete the required modules necessary for treating their problem. 5G could expand these results to a ubiquitous environment where patients can retrieve treatment from anywhere without the need to physically attend a clinic with a doctor. Blockchain can ensure patient privacy and ubiquitous access, which would mean one could contact a therapist as easily as one can get an Uber.

4.3 Regulation and Compliance Issues

Despite the benefits, integrating VR, blockchain, and 5G raises concerns about regulatory adoption requirements. Currently, different countries regulate blockchain economies differently. Thus, for example, China completely bans ICOs, South Korea strictly regulates the crypto-investments from foreigners, and the US has implemented broader financial regulation for cryptocurrencies. At the same time, different states vary in what they allow one to use blockchain for, such as keeping real estate records. Researchers have shown these uncertain and constantly evolving regulatory systems to inhibit blockchain adoption and investments (Guadamuz & Marsden, 2015; Kiviat, 2015). These different issues provide the basis for blockchain skeptics' concerns.

Privacy issues represent another concern, and recent updates to the European General Data Protection Regulation (GDPR) introduced new compliance issues that organizations must address with these emerging technologies. With digital technology spanning across borders, the GDPR focuses on personal data in digital contexts (Krystlik, 2017). In the United States, each state has begun to or already added its own legislature that addresses privacy issues related to digital technology. For instance, organizations must comply with the California Consumer Privacy Act (CCPA), which came into effect on 1 January, 2020. Seven additional states have pending comprehensive privacy legislation (Dorsey & Whitney LLP, 2019). With VR, blockchain, and 5G reaching global scales, we face monumental challenges to address privacy compliance laws at various levels (e.g., state, country, and global).

5 Research Opportunities and Conclusion

In this section, we outline some ways in which future research can accommodate and explore VR, blockchain, and 5G.

5.1 Research Opportunities

Researchers have many opportunities to evaluate VR, blockchain, and 5G as both standalone and integrated technologies. Based on the panel discussion that took place, panelists offered various research recommendations to help researchers and practitioners grow and develop these technologies and integrate them. In Table 1, we summarize these recommendations. Subsequently, we describe specific opportunities to help fuel and grow this exciting area.

Table 1. Research Opportunities

Enabling technology		
Virtual reality (VR) Eye-tracking usability studies Psychological effects Usability studies	**Blockchain (BC)** Scalability solutions Cryptocurrency volatility Feasibility studies	**5G wireless telecom (5G)** Big data growth and implications Capabilities and opportunities Societal effects
Synergy effects		
VR and BC Digitized economies Intellectual rights management Virtual identities	**BC and 5G** Layer 2 protocol BC system Design science research Extended privacy and security	**5G and VR/AR** New visualizations Travel and tourism Virtual experiences
VR and BC and 5G Ubiquitous digital environments Universal mental health care Digital laws and regulations		

Since the panel primarily focused on evaluating how these technologies interact and their disruptive power, we only briefly discuss research recommendations as standalone technologies and focus more on

opportunities that reside in digital integration. With VR technologies growing in popularity and use, we recommend that researchers use new data-collection methods such as eye-tracking software to evaluate how users interact in virtual environments. Since VR may produce psychological effects from long-term use, behavioral studies could evaluate potential pitfalls due to long-term exposure and immersion in virtual environments. Usability studies for VR could focus on the technology itself or as integrated with any number of other technologies. While numerous use cases highlight blockchain technology's potential, we still need to resolve scalability and volatility issues that prevent the technology from reaching its full potential. Researchers should conduct feasibility studies to evaluate if blockchain suits companies' needs and if it represents a viable solution from a resource, technical, and economic perspective. While 5G technology provides a network that supports a multitude of other technologies, researchers should evaluate the capabilities and opportunities that these high-speed networks provide, what implications data's growth may have, and how it may affect society as a whole.

We have already seen immersive communities due to the integration between VR and blockchain, such as Decentraland. The integration of blockchain and VR provides new opportunities for research in digitized economies as virtual environments contain products and payment methods. In the VR environment, intellectual property rights could become a bigger issue as parties produce and sell digital products across the blockchain. While blockchain provides an immutable ledger for validating authenticity, pirated digitals goods or other inappropriate digital content could still spread across the blockchain. Extended research should evaluate user behaviors in these environments and ways in which the platform can properly manage intellectual property to protect content creators. Virtual identity also warrants significant research. While participants on a blockchain use a pseudonym, methods that can identify them do exist. This point holds true for virtual environments as well. How users interact through immersive environments where they are anonymous could have significant implications on their behaviors and interactions with others. Furthermore, with user pseudonyms linked to blockchain accounts, one could possibly identify participants. The potential benefits and pitfalls of blockchain environments provide many opportunities for behavioral studies such as adoption and use, social interactions, social capital, and numerous psychological studies.

5G and blockchain integration provides numerous other research opportunities, particularly in the design science arena. IS researchers should explore, for example, the feasibility of a layer 2 protocol blockchain system based on a 5G infrastructure to address scalability concerns. Subsequently, research should assess the effects of layer 2 solutions related to security, scalability, and decentralized features. With increased speeds from 5G, the types of applications that one can develop and implement will grow exponentially. Design science research has unlimited possibilities to research and develop new applications that use these integrated infrastructure technologies. The migration to 5G wireless telecommunications also provides new opportunities for its integration with VR. Relying on the bandwidth from 5G, VR can provide new approaches to data visualization. Analytics research could benefit from using design science approaches to create new visualizations that immerse users in data and interact with the visualizations through a virtual environment that they could access via mobile devices. This type of immersion could extend to various industries as increased bandwidth makes virtual environments more accessible. For example, the travel and tourism industry could provide customers sample tours where they can try a vacation package before they buy it. Further, individuals could experience living in a house before they buy it, people entertainment before purchasing tickets, or the thrills of a theme park before attending it. As a result, a two-stage adoption process could emerge wherein individuals consider adopting products, services, or technology and then participate in a VR user experience, which would influence their ultimate adoption decision.

When integrated together, 5G, blockchain, and VR could produce even more capabilities. For example, one could extend digitized economies created through VR and blockchain can to a global scale. Users would have the opportunity to participate in the digital environment any time through their mobile device(s). Research should evaluate the implications of a continuously connected subversive digital environment and the implications it would have on individuals and societies. Habitual use and technology addiction could require particular attention since users could potentially become so ingrained in the technology that they spend more time immersed in the technology than they do in the real world. While immersion could have potential pitfalls, it also has many potential benefits. The ability to provide metal healthcare on a global scale could have significant societal impacts. Given that much research on using VR to treat mental and psychological disorders already exists, researchers could extend it to include blockchain for knowledge sharing and 5G for ubiquitous access. Individuals in rural areas who suffer from autism spectrum disorders, addictions, or any number of other psychological effects could gain access to

treatments they would otherwise not have the opportunity to access. Research should continue to evaluate the effects of VR treatments and how blockchain and 5G could propel them further. The final implications the panelists discussed concern privacy and security, such as digital laws, regulations, and compliance issues. The technologies individually and together present various concerns. As organizations collect more data due to increased integration, the more privacy and security become a concern. Existing privacy and security research should evaluate the new types of data that the technologies generate alone and together to identify vulnerabilities, concerns, and resolutions to address these issues. Since these technologies have the potential to see use on a global scale, digital laws and regulations across borders poses an issue that businesses will face. IS research has a significant opportunity to address these issues and inform business as these technologies continue to grow and organizations pursue new endeavors.

5.2 Closing Remarks

In this paper, we report on a panel discussion at the 2018 AMCIS on the technological advances in VR, blockchain, and 5G technology and their impacts on business and society. This timely and informative panel discussion offers first-hand practices and insightful perspectives. We strongly believe that research on VR, blockchain, and 5G NR technology represents an imminent and challenging task. However, through continued engagement and knowledge dissemination such as these panels, we hope that we can form new ideas to help guide innovative and new research in the future.

Acknowledgments

We gratefully acknowledge the panel audience for their helpful comments and valuable discussion at AMCIS 2018 Blockchain/VR/5G panel session. We also acknowledge Dr. Patrick Bordnick of Tulane University and David Holtman of Juncture Strategies who served as panelists.

References

Avital, M., Beck, R., King, J., Rossi, M., & Teigland, R. (2016). Jumping on the blockchain bandwagon: Lessons of the past and outlook to the future. In *Proceedings of the 37th International Conference on Information Systems.*

Beck, R., Stenum Czepluch, J., Lollike, N., & Malone, S. (2016). Blockchain—the gateway to trust-free cryptographic transactions. In *Proceedings of the 24th European Conference on Information Systems.*

Bidgoli, H. (2017). *MIS* (7th ed.). Boston, MA: Cengage.

Bordnick, P., Traylor, A., Copp, H., Graap, K., Carter, B., Ferrer, M., & Walton, A. (2008). Assessing reactivity to virtual reality alcohol based cues. *Addictive Behaviors*, *33*(6), 743-756.

Cartenberg, C. (2018). The 5G standard is finally finished with new standalone specification. *The Verge*. Retrieved from https://www.theverge.com/2018/6/15/17467734/5g-nr-standard-3gpp-standalone-finished

CDC. (2018). Autism spectrum disorder (ASD). *Centers for Disease Control and Prevention*. Retrieved from https://www.cdc.gov/ncbddd/autism/data.html

Christidis, K., & Devetsikiotis, M. (2016). Blockchains and smart contracts for the Internet of things. *IEEE Access*, *4*, 2292-2303.

Craig, A. B., Sherman, W. R., & Will, J. D. (2009). *Developing virtual reality applications: Foundations of effective design*. London, UK: Morgan Kaufmann.

Cruz-Neira, C., Sandin, D. J., & DeFanti, T. A. (1993). Surround-screen projection-based virtual reality: The design and implementation of the cave. In *Proceedings of the 20th Annual Conference on Computer Graphics and Interactive Techniques*.

Dorsey & Whitney LLP. (2019). As CCPA effective data draws nearer, hearings highlight potentially increased liability risks. *JDSupra*. Retrieved from https://www.jdsupra.com/legalnews/as-ccpa-effective-date-draws-nearer-99678/

French, A., & Shim, J. P. (2016). The digital revolution: Internet of things, 5G, and beyond. *Communications of the Association for Information Systems*, *38*, 840-850.

Glaser, F. (2017). Pervasive decentralisation of digital infrastructures: A framework for blockchain enabled system and use case analysis. In *Proceedings of the 50th Hawaii International Conference on System Sciences,*

GSMA. (2018). *The 5G era in the US.* Retrieved from https://www.gsma.com/publicpolicy/resources/the-5g-era-in-the-us

Guadamuz, A., & Marsden, C. (2015). Blockchains and Bitcoin: Regulatory responses to cryptocurrencies. *First Monday*, *20*(12), 1-47.

Housel, T., & Skopec, E. (2001). *Global telecommunications revolution.* New York, NY: Mcgraw-Hill.

Howard, M. (2017). A meta-analysis and systematic literature review of virtual reality rehabilitation programs. *Computers in Human Behavior*, *70*, 317-327.

Intel. (2018). *Demystifying the virtual reality landscape*. Retrieved from https://www.intel.com/content/www/us/en/tech-tips-and-tricks/virtual-reality-vs-augmented-reality.html

Kane, G. C., Palmer, D., Phillips, A. N., & Kiron, D. (2014). Finding the value in social business. *MIT Sloan Management Review*, *55*(3), 81-89.

Kiviat, T. (2015). Beyond Bitcoin: Issues in regulating blockchain transactions. *Duke Law Journal*, *65*(3), 569-608.

Kornelis, C. (2019). What to expect from 5G phones—and when. *The Wall Street Journal.* Retrieved from https://www.wsj.com/articles/what-to-expect-from-5g-phonesand-when-11551208337;

Krystlik, J. (2017). With GDPR, preparation is everything. *Computer Fraud & Security*, *2017*(6), 5-8.

Maples-Keller, J., Bunnell, B., Kim, S,-J., & Rothbaum, B. (2017). The use of virtual reality technology in the treatment of anxiety and other psychiatric disorders. *Harvard Review of Psychiatry*, *25*(3), 103-113.

McGarry, C. (2019). The truth about 5G: What's coming (and what's not) in 2019. *Tom's Guide*. Retrieved from https://www.tomsguide.com/us/5g-release-date,review-5063.html

Meiklejohn, S., Pomarole, M., Jordan, G., Levchenko, K., McCoy, D., Voelker, G. M., & Savage, S. (2013). A fistful of bitcoins: Characterizing payments among men with no names. In *Proceedings of the Conference on Internet Measurement.*

Merel, T. (2018). *Digi-capital: 2017 saw $3 billion invested in AR/VR, half in Q4 alone*. *Venture Beat.* Retrieved from https://venturebeat.com/2018/01/08/digi-capital-2017-saw-3-billion-invested-in-ar-vr-half-in-q4-alone/

Mills, S., & Noyes, J. (1999). Virtual reality: An overview of user-related design. *Interacting With Computers*, *11*(4), 375-386.

Morris, C. (2018). *Why Walmart and other F500 companies are using virtual reality to train the next generation of American workers*. *CNBC*. Retrieved from https://www.cnbc.com/2018/10/29/why-f500-companies-use-virtual-reality-to-train-workers-of-the-future.html

Piekarski, W., & Thomas, B. (2002). ARQuake: The outdoor augmented reality gaming system. *Communications of the ACM*, *45*(1), 36-38

Pinto, R. (2018). How blockchain can solve identity management problems. *Forbes*. Retrieved from https://www.forbes.com/sites/forbestechcouncil/2018/07/27/how-blockchain-can-solve-identity-management-problems/#2080ad5813f5

Raskin, M. (2016). The law of smart contracts. *Georgetown Law Technology Review*, *304*(1), 1-37.

Risius, M., & Spohrer, K. (2017). A blockchain research framework: What we (don't) know, where we go from here, and how we will get there. *Business & Information Systems Engineering*, *59*(6), 385-409.

Ron, D., & Shamir, A. (2013). Quantitative analysis of the full Bitcoin transaction graph. In *Proceedings of the International Conference on Financial Cryptography and Data Security.*

Substance Abuse and Mental Health Services Administration. (2018). *Prevention of substance abuse and mental illness*. Retrieved from https://www.samhsa.gov/prevention

Scribani, J. (2019). What is extended reality (XR)? *Visual Capitalist*. Retrieved from https://www.visualcapitalist.com/extended-reality-xr/

Seymour, N., Gallagher, A., Roman, S., O'Brien, M., Bansal, V., Andersen, D., & Satava, R. (2002). Virtual reality training improves operating room performance. *Annals of Surgery*, *236*(4), 458-464.

Shim, J. P., Avital, M., Dennis, A., Sheng, O., Rossi, M., Sorensen, C., & French, A. (2017). Internet of things: Opportunities and challenges to business, society, and IS research. In *Proceedings of the 38th International Conference on Information Systems.*

Shim, J. P., Sharda, R., French, A., Syler, R., & Patten, K. (2020). The Internet of things: Multi-faceted research perspectives. *Communications of the Association for Information Systems*, *46*, 511-536.

Smee, J. (2018). 5G NR theory and practice. In *Proceedings of the Wireless Telecommunication Symposium.*

Thai, E., & Nathan-Roberts, D. (2018). Social skill focuses of virtual reality systems for individuals diagnosed with autism spectrum disorder: A systematic review. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *62*(1), 1469-1473.

The Economist. (2018). *Blockchain technology may offer a way to re-decentralise the Internet*. Retrieved from https://www.economist.com/special-report/2018/06/30/blockchain-technology-may-offer-a-way-to-re-decentralise-the-internet

Wood, J. (2018). Blockchain and AR/VR—a match made in virtual heaven? *Medium*. Retrieved from https://medium.com/trivial-co/blockchain-and-ar-vr-a-match-made-in-virtual-heaven-26e54782be56

Xu, X., Weber, I., Staples, M., Zhu, L., Bosch, J., Bass, L., Pautasso, C., & Rimba, P. (2017). A taxonomy of blockchain-based systems for architecture design. In *Proceedings of the IEEE International Conference on Software Architecture.*

Zhang, Y., & Wen, J. (2015). An IoT electric business model based on the protocol of Bitcoin. In *Proceedings of the 18th International Conference on Intelligence in Next Generation Networks.*

Zhao, J. L., Fan, S., & Yan, J. (2016). Overview of business innovations and research opportunities in blockchain and introduction to the special issue. *Financial Innovation*, *2*(28), 1-7.

About the Authors

Aaron M. French is an Assistant Professor of Management Information Systems in the College of Business at the University of New Mexico. He received his PhD in Business Information Systems at Mississippi State University. Dr. French is active in software development and the evaluation emerging technologies. His research has been published in the *Journal of Information Technology*, *Information & Management*, *Decision Support Systems*, *Behaviour & Information Technology*, *Journal of Computer Information Systems*, *Communications of the Association for Information Systems*, and *Pacific Asian Journal of the Association of Information Systems*. His research interests include social networking, cross-cultural studies and emerging technologies.

Marten Risius is a Senior Lecturer in Business Information Systems at the University of Queensland. His research interests are in the areas of social media management with a focus on social media analytics and blockchain technology. His articles have been published in several conference proceedings and journals such as *Journal of Strategic Information Systems*, *Journal of Information Technology*, *Information & Management*, *MISQ Executive*, *Business & Information Systems Engineering*, the *International Conference of Information Systems*, the *European Conference on Information Systems*, the *Hawaii International Conference on System Sciences*, the *Americas Conference on Information Systems*, and the *Pacific Asian Conference on Information Systems*.

J.P. Shim is CIS faculty and Executive Director of Korean-American Business Center at Georgia State University. He is adjunct professor (dual appointment) at Georgia Tech School of Public Policy. He is Professor Emeritus and was professor, Notable Scholar, John Grisham faculty at Mississippi State University. He has published books and 100 refereed articles, including *Communications of the ACM*, *Journal of AIS*, *Journal of Strategic Information Systems, IEEE IT Professional*, *Journal of Information Technology*, *European Journal of Information Systems*, *Decision Support Systems*, *Omega*, *CAIS, I&M*, *Computers & Operations Research*, *Human Relations*, *Journal of the Operational Research Society*, *AoM Proceedings*, *ICIS Proceedings*. He was AMCIS Program Co-chair, Wireless Telecommunication Symposium Program Chair. He received grants from National Science Foundation, US SBA, US DoED, Microsoft, Mississippi Institutions of Higher Learning, Japan Foundation.