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Interplay of User Behavior, Communication, and Computing in Immersive Reality 6G Applications

Olga Chukhno, Olga Galinina, Sergey Andreev, Antonella Molinaro, and Antonio Iera

***Abstract*—Emerging extended reality (XR) services and applications that submerge users into a virtual universe pave the way toward ubiquitous contextualized experiences. Immersive interactions on-the-go not only bring new use cases but also distract users from the real world and modify their behavior and motion, which may, in turn, affect the operation of communication networks. This article explores the effects of XR user motion from the communication and computing perspectives. To this end, we offer a review of mobility patterns in XR and a detailed simulation study regarding the impact of interaction-dependent gait patterns on delay and resource utilization. The results confirm the uniqueness of XR applications in terms of user behavior patterns, which calls for novel application-centric algorithms, protocols, and mechanisms to facilitate high-performance connectivity under demanding XR requirements.**

I. INTRODUCTION

Mobile XR offers unique "anywhere, anytime" interactive experiences, such as real-time collaboration, training, and gaming, supported by the flexibility to move around a virtual space through physical movement. Unlike traditional interfaces, such as mobile phones or tablets, XR submerges the users into a virtual world, distracting them from the surrounding environment [1]. While the XR users are able to freely navigate around the area (e.g., a room or a pedestrian way) and circumvent obstacles, such mobility might be affected by the patterns of use [2] and unique immersive interactions [3].

The use of a head-mounted display (HMD) naturally leads to significant gait changes, such as shorter stride length, greater stance time, and higher speed variability, compared to conventional user behavior [3], [4]. Due to the specific features of XR content presentation and navigation, motion patterns of HMD owners may considerably differ from what the use of mobile phones entails [5]. For example, in the case of conventional mobile phone applications, the walking patterns of users involved in text message writing and voice audio recording are noticeably different. Typing a message on a small phone screen demands a lot of focus and significantly restricts the freedom of movement, whereas voicemails can be received and sent with much less constraint. This substantial difference in motion patterns might not characterize XR interactions, due to the improvements in user perception.

The provided examples demonstrate that the uniqueness of XR does not only derive from the stringent application requirements, such as high peak data rate and low latency for a fully immersive experience with the sense of reality, but also brings along unique interaction models and motion patterns, which, in turn, may affect network performance. XR applications are expected to be flexible and dynamic, which requires a real-time response that depends on both communication and computing capabilities. In addition, as the motion of an XR user heavily relies on service provisioning, the output of such a system is circled back to interaction and movement dependency, thus, creating a *feedback loop*. Consequently, the convergence of communication, computing, and use/motion patterns (see Fig. 1) becomes the next step toward the development of advanced XR services.

To bridge the existing research gap by exploring communication networks from the perspective of user interaction patterns, this article reveals the essential features of XR user behavior and motion and highlights the entailed challenges in communication and computing. First, we offer a review of user behavior patterns, which confirms use case dependent changes in gait parameters, i.e., direction, velocity, stride length, step width, and stance time. Further, we provide the sources for evidence of the user motion impact on the network operation. Finally, we present a case study on mobile XR that characterizes system performance with respect to user motion, communication, and computing. We quantify the resultant interplay via system-level simulations and compare XR with traditional mobile broadband services to characterize the usage pattern impact on communication system performance.

II. USE CASE-MOTION-NETWORK LOOP

A. Application-Dependent Mobility

Multi-sensory immersive experience is one of the key factors that affect user behavior. Recent literature has been rich in reporting experiments with walking in virtual reality (VR). Ever since the pioneering work in [2], strengthened by the recent research in [4], *variations in gait parameters, which reflect instability in motion*, have been thoroughly investigated. In a virtual environment, *subjects move with greater step widths, shorter step lengths, and more significant variability in velocity*. These deviations have also been quantified for immersive VR against walking in a physical environment: the average walking speed decreases by 46 %, cadence and stride length lower by 14 % and 33 %, correspondingly. At the same time, step width and stance time increase by 18 % and 7 % [3].

Gait instability and variability are but one example of phenomena caused by submerging into immersive XR. Another one is dissimilar adaptation in physical and virtual environments and the related changes in circumvention – the

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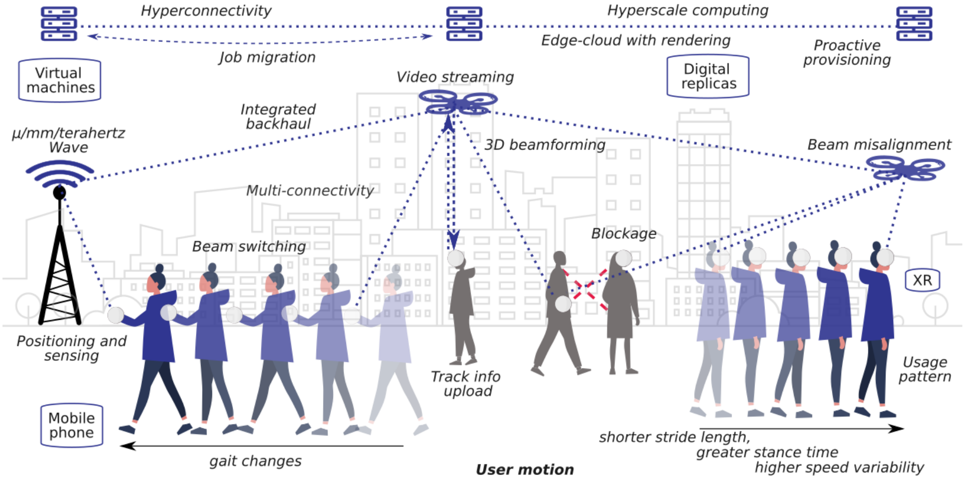

Fig. 1: Convergence of motion, communication, computing, and usage patterns.

process of avoiding obstacles and barriers by steering the body in another direction. *Avoiding collisions and searching for adequate clearance for all parts of a human body require more careful trajectory and speed adjustment and, thus, result in a more "conservative" circumvention strategy when using immersive applications* [2], [4]. Experiments on locomotor behavior in a virtual environment have identified slight but tangible differences in paths, larger maximum deviation, greater obstacle clearance, and lower movement speeds as compared to walking through obstacles in a physical world.

Circumvention strategies in physical and virtual environments have also been studied in scenarios where other pedestrians become obstacles. In this case, *circumvention patterns become role-dependent by dividing the opposing users into passing and bypassing. Lower walking speeds and increased distances from the interferer have been detected among the subjects who dive into immersive experience* [4]. However, as the number of repeating experiments in the same environment increases, this gap diminishes, but users still prefer more "conservative" circumvention strategies for avoiding both stationary (objects) and moving (other pedestrians) obstacles. The collision avoidance patterns in physical and virtual environments are nearly identical.

Another set of experiments has been centered around multitasking that is defined in neuropsychology as performing several tasks simultaneously, as well as around a comparison of multi-task and single-task performance. *Speaking, texting, calculating, among others, affect the overall walking performance by changing speed, cadence, and gait pattern* [6]. The gait, in turn, impacts the multi-tasking efficiency. Paced motion worsens the user performance in dual-task activities and makes walking more challenging, especially when the displayed content deteriorates the visibility of ambient objects required for active dynamic locomotion [7].

A vast volume of work has concentrated on comparative analysis regarding the impact of the use of mobile phones and XR wearables (such as HMDs) on the gait variability. The results are consistent across various research groups and have established that *head-up tasks (i.e., those involving HMDs) degrade walking performance to a lesser extent than head-down activities (i.e., those with mobile phones)* [5]. In the case of mobile phone use, walking speed decreases significantly for dual-task versus single-task activity. For head-up walking, the difference between single- and dual-task operations is marginal, which confirms XR stability and robustness to multi-tasking.

Another key factor that determines user motion is equipment diversity. More specifically, the gait pattern is sensitive to both hardware and software [4]. This fact has been identified through experiments with XR wearables of different manufacturers, generations, and models. The results have revealed *an interplay between the user motion and the equipment type, which affects such walking parameters as speed (minimum, maximum, and average) and trajectory*. The diversity in user behavior patterns is driven by various levels of equipment usability (defined by temperature, texture, tightness, weight, size, and shape) as well as by perceived comfort in a virtual environment (depends on image resolution, colors, time perception, degree of realism).

In summary, user motion to a large extent depends on the application type. Engagement in XR applications leads to walking with greater widths and shorter lengths of steps as well as to more significant variability in pedestrian velocity as compared to conventional mobile phone use. Variations in gait parameters stem from the physical constraints of user equipment, the discrepancy between virtual and real worlds, and the unique immersive experience. Furthermore, dual- and multi-task activities impair the motion of users involved in XR less severely than in the case of mobile phone use, which underpins the uniqueness of immersive applications. These unconventional behavioral patterns of XR viewers may have a significant impact on communication operations.

B. Mobility-Dependent Communication

Connectivity on the move introduces new challenges, especially in data-intensive systems such as immersive XR, which operate with a massive amount of data. In this regard, we overview the enabling management and optimization techniques for mobility support and discuss them from the perspective of XR applications in the emerging 6G era. Today, many network operators already utilize microwave (μWave) radio systems operating in the 4.1–7.125 GHz band for basic coverage, which is expected to carry most of the traditional cellular traffic. However, unlike the extremely high frequency (EHF) bands, such as millimeter-wave (mmWave) and terahertz, μWave systems are unable to meet the demand for multi-gigabit-per-second throughput and low-latency communication. To support high data rate services, network operators are expected to rely on both lower and higher frequencies (mmWave or terahertz) [8].

Integration of μWave and mmWave combines extreme data transfer rates with the reliability of legacy μWave channels. Specifically, μWave band can be utilized for lighter XR traffic, i.e., location information, whereas higher frequency bands are then dedicated to heavier video streaming. However, for highly mobile users, resource allocation and cell association functions in multi-radio access technology (multi-RAT) scenarios are especially challenging due to more frequent traffic rerouting [9]. In addition, high-frequency channels are prone to severe fluctuations; they demand resource allocation within shorter time intervals as compared to lower frequency bands, and involve more complex beam management and medium access control (MAC) protocols.

Multi-cell connectivity allows devices to achieve reliable data transmission by maintaining several signal paths from/to different base stations (BSs). The BSs and users continuously monitor the potential wireless links via dynamic beam tracking and beam refinement, which results in significant overhead in the case of the EHF band. The network may benefit from accurate positioning and sensing information, which, however, is obtained using the same radio resources and might also noticeably increase the overhead.

In addition, the specific position of a mobile XR device on the user body requires further studies that assess motion and rotation patterns. For example, the relative motion of different body parts, e.g., head or hands, can cause occasional signal drops due to beam misalignment and/or blockage of mmWave links. The level at which the user carries the device also impacts link blockage, especially in scenarios with high user density. Since the XR wearable is attached to the user's head, it is expected to be less blockage-prone and, therefore, less affected by channel quality deterioration as compared to smartphones elevated at the chest level. This effect may lead to the need for new service provisioning models mindful of the diversity of use cases and corresponding behavior patterns.

In summary, traditional communication techniques might be insufficient for immersive XR applications, thus demanding, inter alia, the development of novel tailor-made mechanisms that efficiently adapt to diverse and dynamic conditions.

C. Communication-Dependent Computing

XR may require intensive computing (i.e., 3D rendering and processing user motion or camera feed) at edge nodes, which are inherently resource-constrained. From this perspective, we further discuss today's computing techniques in the context of applications that trigger specific motion patterns. Further, many XR services frequently request rich content, such as background scenes, which demands large volumes of storage space and, thus, challenges the traditional edge cache management. This might, in turn, hinder data replication, which requires additional resource processing and storage costs for continuous synchronization across the digital replicas that enable real-time interaction and reliable communication between the digital space and the physical systems.

Furthermore, seamless support of low-latency connectivity (i.e., 5 ms) with high data rates poses challenges across both communication and computing domains, especially in the presence of high user mobility. User motion causes handovers on the communication plane. As a result, virtualized representations of users and their data migrate from one edge node to another by following the user trajectory. Therefore, proactive provisioning is essential for efficient resource management under low latency requirements. Compared to reactive strategies or data replication, advanced proactive solutions offer multiple advantages that include accurate synchronization with the back-end storage and immediate access to an on-demand state, which help maintain the required application performance.

Pre-loading of computational tasks or data onto the target edge server is but one component of efficient proactiveness that strongly depends on user mobility and requires accurate motion predictions. In this context, significant inaccuracy may lead to the content re-generation and, consequently, to increased delay, which cannot be tolerated by XR applications. Another essential component that benefits from predicting the user location and motion is the association of XR users and edge servers. Due to high susceptibility of the EHF band signal to blockage, effective data rates and robustness to mobility can be enhanced through the use of multi-connectivity. Here, accurate prediction of user orientation and motion patterns in the immersive environment is essential to associate users with appropriate BSs and edge servers proactively.

Moreover, frequent radio handovers and migrations of computation jobs/outcomes when moving out of the coverage of an edge server challenges load balancing. Using relevant information on the capacity and current loading of nodes, the network optimizes migration strategies. For example, computations can be performed on the previously serving edge node so that the results are forwarded to the moving user via a new proximate server. Such computations may also migrate to a neighboring server immediately or, alternatively, be transferred to another – more powerful – server in the network.

In summary, user motion and type of application, along with a massive amount of generated data, require more flexibility in the network architectures, new application-specific configuration options that allow dynamic adaptation, and better uniformity of cross-application performance.

III. SYSTEM-LEVEL ASSESSMENT

Our above review of trends confirms that XR applications offer unique usage patterns that affect user motion and, hence, communication and computing functionalities. Despite the accelerating efforts on 6G systems, the research community

TABLE I: Scenario and main parameters

Deployment	
Area of interest	**Area:** Street Canyon **Size:** 50 m x 200 m
Pedestrians	**Number:** 20 (low density) – 60 (high density) **Mobility:** Social force model [10] **Speed:** 3 km/h (baseline) **Height:** Normal distribution ($\mu=1.65$, $\sigma=0.08$ m)
Behavior models	Mobile phone / XR wearable usage **1.** Single-task mode **2.** Dual-task mode
User devices	
Devices	**Category:** Mobile phone / HMD **Number:** Number of users
Traffic	**Uplink motion information data rate:** 150 kbps **Downlink frame size:** 0.425 Gb (150 : 1 rate)
Weak-interaction	**Quality of experience:** 8K with 30 fps **Period between requests:** 33 ms **Typical RTT requirement:** 30 ms
Strong-interaction	**Quality of experience:** 8K with 90 fps **Period between requests:** 11 ms **Typical RTT requirement:** 10 ms
Edge segment	
Edge severs	**Deployment:** Servers are co-located with BSs
Edge processing	**Frame rendering time:** 16.9 ms **Degradation factor due to I/O interference between virtual machines (VMs):** $d = 0.02$ **Number of VMs on one edge server:** 50
Radio segment	
mmWave radio	**Frequency:** 28 GHz **Bandwidth:** 400 MHz **Signal degradation under human blockage:** 15 dB **Resource block size:** 1.44 MHz
μWave radio	**Frequency:** 3.5 GHz **Bandwidth:** 100 MHz **Signal degradation under human blockage:** 4 dB **Resource block size:** 0.72 MHz
Propagation	**Model:** 3GPP Urban Microcell (UMi) Street Canyon **Effect of buildings:** Line-of-sight, Non-line-of-sight **Effect of blockages:** Blocked, non-Blocked
Base stations	**Deployment:** Strauss process ($c=0.9$, $\delta=200$ m) **Transmit power:** 33 dBm **Height:** 10 m **Degree of multi-connectivity:** 2, 4, 6, 8, 10 **Handover delay:** $[2-10]$ ms
User devices	**Transmit power:** 10 dBm **Mobile phone / HMD height:** Normal distribution ($\mu=1.50$ / 1.65, $\sigma=0.08$ m)

continues to rely on the existing pedestrian mobility models, regardless of the patterns of use. To assess their impact, we further evaluate communication and computing performance of mobile XR in terms of (i) total delay, which is represented by a sum of communication and computing components, and (ii) resource utilization measured as a ratio between the utilized resource blocks and the available ones. We note that the communication delay, i.e., the round-trip time (RTT), is defined as a sum of the uplink and the downlink transmission times, while the edge processing latency is associated with the time required to render and migrate video frames. Below, we summarize the considered scenario of interest, the simulation settings, and the selected simulation results. The key system parameters are listed in Table I.

A. Evaluation Scenario

We consider a user terminal with 4K resolution and a content provider that renders 8K video [11], while focusing on two types of services, termed *weak interaction* and *strong interaction*. Weak-interaction applications cover various video services, including 360° video and live broadcasts. In such scenarios, users have limited or no interaction with the environment, i.e., they do not initiate physical interactions but may select their own viewing point and position. Hence, the freedom is naturally limited as the users do not turn their heads frequently when the information is rendered in front of them. Weak-interaction services tolerate the end-to-end/motion-to-photon latency of around 30 ms and require the content quality of 30 fps [11].

In strong-interaction immersive scenarios such as virtual gaming arcades or XR social media, users interact with the virtual space around them and respond in real time. The resolution is significantly improved, which further increases the desired bandwidth, while the end-to-end latency requirement approaches 10 ms. To provide a truly immersive experience, such services demand higher frame rates (90 fps) as compared to the weak-interaction scenarios [11].

B. Simulation Outline

In the considered setup, user devices communicate with multiple BSs, each co-located with an edge computing server via a dual mmWave/μWave radio interface. We assume the 3GPP channel model in an urban micro (UMi) environment [12] for both the mmWave band at 28 GHz and the μWave band at 3.5 GHz. The BSs are deployed across the tracking area according to the Strauss process with the inhibition coefficient of 0.9 and the inhibition distance of 200 m [13]. Devices can transition to the BS providing the best signal-to-interference-plus-noise (SINR) ratio with the handover delay of $2-10$ ms [14].

We consider the system in which the users first transmit the tracking data, e.g., user position, to the selected BS in the uplink channel and then to a back-end server used for accurate synchronization and immediate access to an on-demand state. The edge node renders the video frames, which are sent through the serving BS back to the user. In XR, different uplink and downlink communication bands might be utilized for more efficient data transfer [9].

The end-to-end delay (without encoding/decoding) comprises uplink transmission over μWave links, processing, migration, and downlink mmWave transmission delays. The processing delay is estimated based on the measurements of Huawei 5G network XR test with edge/cloud services [15], whereas the communication delays depend on the channel conditions. We also assume the implementation of virtual machines for parallel computing of multiple tasks on the same edge server with the degradation factor of 0.02 (the degradation factor defines a computation-service rate reduction when multiplexed with other virtual machines).

The period between two consecutive requests is 33 ms and 11 ms for weak- and strong-interaction scenarios, respectively [11]. The uncompressed video frame size that has to be downloaded is 63.7 Gb (i.e., 8K resolution, 8-bit color depth). We utilize 150 : 1 compression rate that reduces the bandwidth and bitrate requirements, thereby decreasing the interaction latency. The uplink channel supports data rates of 150 kbps for transmitting the motion information [9].

C. Pedestrian Dynamics

To mimic real-life user behavior in different application scenarios, we undertake a detailed pedestrian flow simulation. Our modeling is based on the social force-based model of human behavior [10]. It captures realistic crowd dynamics represented in such applications as collective XR, virtual games, etc. We conduct simulation experiments under different user density conditions (i.e., $20 - 60$ devices in the area).

We experiment with pedestrian movement by taking into account the variability in speed, stance time, step length, head direction, and the presence of obstacles, which all characterize human behavior in XR and mobile phone applications. As a baseline model, we consider the motion of a pedestrian with the speed of 3 km/h and imitate the user movement in single- and dual-task modes [5].

In our *single-task* setup, XR user motion changes in speed (-46%), step length (-33%), stance time ($+7\%$), distance from an interferer or obstacle ($+3\%$) as compared to the baseline [3], [4]. For the users with mobile phones, the difference in speed, step length, stance time, and distance from an interferer is -25%, -20%, 0%, $+2\%$, respectively. In the *dual-task* mode, XR yields the difference of -70% in speed, -65% in step length, $+20\%$ in stance time, $+7\%$ in the distance from an interferer, compared to the baseline model. For mobile phone services, the corresponding variations in these parameters are given by -80%, -69%, $+27\%$, and $+5\%$. We also model the variability in the user equipment mobility (located on the head or in a hand) by decreasing the range and the frequency of motion for dual-task activities with respect to the single-task mode [6].

D. Performance Results

The type of application, and XR in particular, is associated with a certain user reaction in terms of gait patterns. In fact, interaction pattern has a noticeable impact on the user mobility that, in turn, affects – on the communication plane – multi-connectivity and handover operation and – on the computing plane – job migration. This subsection evaluates the convergence of usage, motion, communication, and computing patterns by quantifying the differences between XR and conventional mobile broadband applications in terms of the end-to-end delay (as shown in Fig. 2 and Fig. 3) and resource utilization (Fig. 4) subject to user density, service quality, and BS deployment settings.

We begin our evaluation with a study on the end-to-end latency for four mobility models associated with the mobile phone and XR usage under single- and dual-task conditions. Ti this aim, Fig. 2 reports the latency for weak-interaction (30 fps) and strong-interaction (90 fps) services under low (20 users) and high (60 users) density. The system-level performance results for XR and mobile phone applications differ substantially in both single- and dual-task setups. The observed gap is due to the distinct motion patterns that affect the connectivity as well as due to different channel conditions, which vary according to, for example, equipment elevation. This gap becomes more tangible with the improved service quality: in the case of strong-interaction services, which trigger heavier system loads, and for higher user density, due to both load and blockage.

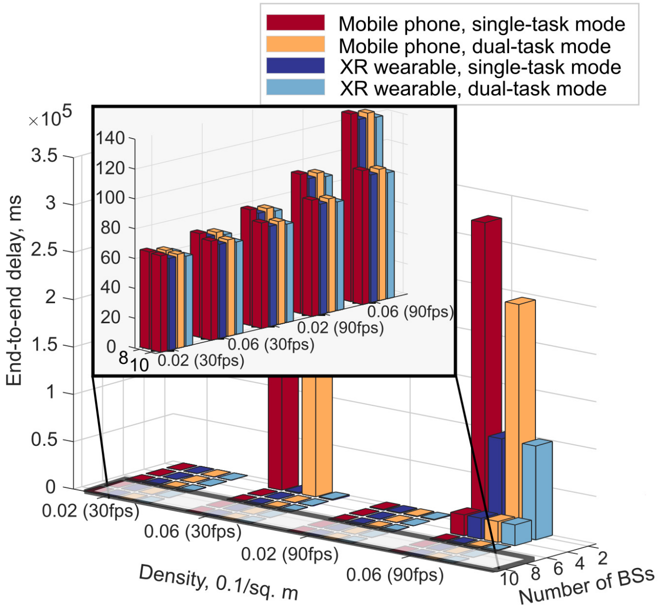

Fig. 2: End-to-end delay assessment.

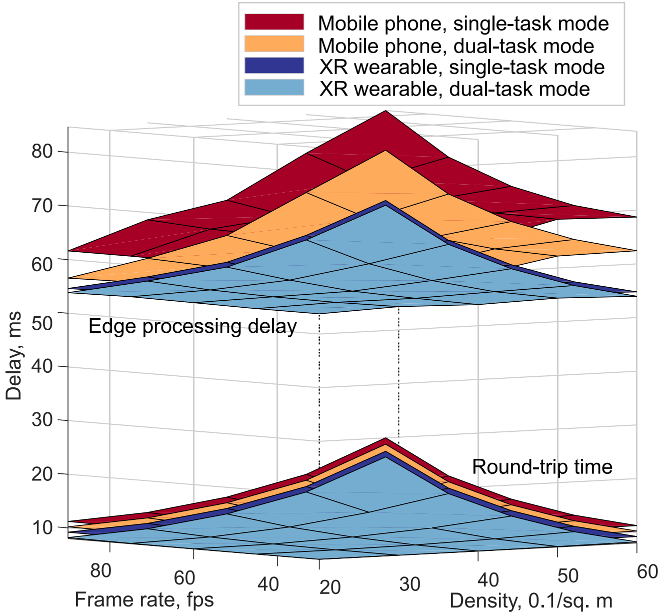

Fig. 3: RTT and edge processing delay assessment, 10 BSs.

Further, in Fig. 2, we observe the impact of the multi-connectivity degree (the number of the available BSs) on the system latency. The difference between XR and phone applications for higher degrees of multi-connectivity is noticeably smaller than for the multi-connectivity degrees of 2 to 4. The explanation behind these results stems from the fact that regardless of the application type, multi-connectivity offers a better processing environment since the number of the available BSs, servers, and virtual machines increases. In particular, significant discrepancies between XR and mobile phone use cases occur in systems with the multi-connectivity degree of 2; if 10 BSs are deployed in the area, these gaps shrink to 11 % and 9 % for single- and dual-task modes, respectively.

To better understand the impact of user motion on communication and computing patterns, we separately evaluate communication- and computing-related delay. The difference between the mobile phone and XR models in Fig. 3 preserves the same trend as that in Fig. 2. Specifically, in the case of higher user density and strong-interaction mode, RTT deviations between the mobile phone and the XR setup reach 2 ms and 3 ms for single- and dual-task modes, respectively. However, for lower density, mobile phone- and XR-induced communication delays display similar trends. On the contrary, the deviations in edge processing delay among the mobile phone and XR models are visible for all density and service quality conditions and reach up to 10 ms (single-task) and 17 ms (dual-task). This behavior is explained by different body blockage patterns, which lead to more frequent beam switching events with growing user densification for mobile phones. Here, body blockage affects the frequency of handovers and job migrations.

As per our additional results, we investigate the multi-connectivity effects on communication and computing performance. In terms of latency, the BS density affects communication and computing functionalities differently. Since the users have more alternative BSs to choose from, the average SINR grows, and the transmission delay decreases, approaching similar values regardless of the application type. However, handovers lead to more frequent job migrations and cause extra delay; hence, the total edge processing delay grows with an increase in the degree of multi-connectivity. To complement the above, we have conducted additional simulation experiments to assess the impact of motion parameters on the resulting performance. The main factors affecting the system-level results are the distance from interferers, XR/phone elevation, head direction and hand position, and changes of the device location caused by the head or arm motion.

Further, the impact of the application type on the radio resource utilization for the downlink transmission is illustrated in Fig. 4. To this end, we consider the mmWave carrier frequency of 28 GHz and corresponding NR numerology $\mu = 3$ with the physical resource block size of 1.44 MHz. Since downlink transmission delays dominate RTT in such applications as XR, the trend in resource deviations repeats the RTT delay variations, which also intensify with higher BS densification. As the users have access to more alternative BSs, the distances from the BSs to the users decrease. In this case, the SINR rises, thus, improving the resource utilization ratio. However, the downlink delivery of the processed video frames significantly contributes to the system load, serving as another bottleneck (second to computing resources) in XR systems.

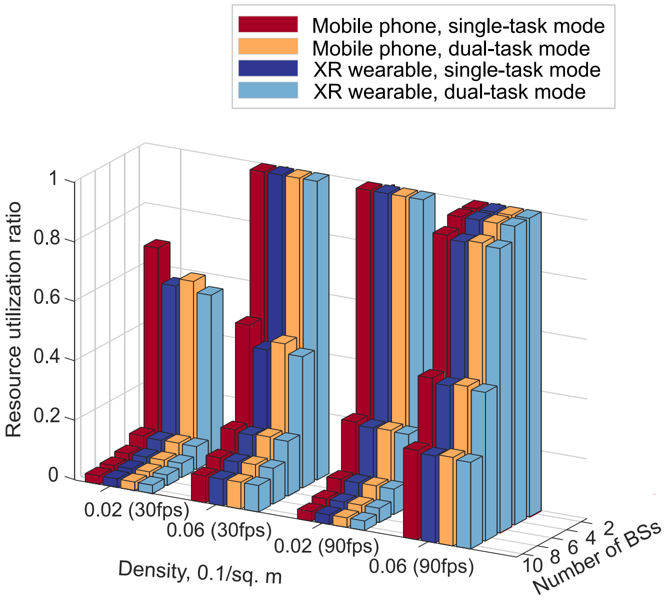

Fig. 4: Resource utilization assessment.

As one may notice, the communication resources of 2 BSs are utilized at full capacity for strong-interaction services at any considred user density. For 30 fps and the multi-connectivity of degree 2, the difference between XR and mobile phone use cases is 21% and 7% in single- and dual-task modes, respectively; for 90 fps and the 10 BS setup, it is less noticeable but still remains at the level of 1% and 0.7%. The observations in Fig. 4 related to the need for higher degrees of multi-connectivity are confirmed in Fig. 2. We may conclude that for future wireless networks, which are expected to support high-quality XR services under high user density, BS densification is required to meet the demand on the quality of user experience and ensure low-latency connectivity.

In summary, this study confirmed that the application usage patterns affect user behavior models and communication and computing performance. As per our axtended results, these conclusions also maintain for different mobility models, such as the Lévy walk process. Mobile XR is therefore unique not only in terms of the system requirements but also in interaction, motion, computing, and communication patterns.

IV. KEY OUTCOMES AND CONCLUSIONS

With a shift toward immersive interactive and contextualized experiences, one can identify new use cases, which not only require low-latency and high-bandwidth communication but also impact user motion and, therefore, system performance. This interplay also operates in reverse. The interaction and user gait patterns may vary depending on the service provisioning quality. As a result, there is a feedback loop, which comprises usage, motion, communication, and computing patterns. However, this important effect had not yet received due attention of the research community.

To bridge the indicated gap, in this article, we reviewed XR-driven motion patterns, collected the respective sources of evidence, and conducted a detailed simulation study on the impact of the use of XR on communication and computing performance. Our system-level evaluations confirmed that the utilization of untethered XR has a distinct effect on motion models and the overall service provisioning. As a potential research direction, we envision collecting real-world mobility pattern datasets and applying more advanced methods of data analysis to refine the outlined dependencies and identify other factors that affect the system performance.

This article intends to serve as an impulse to reconsider the standard mobility patterns and service models currently utilized by the research community and move toward novel algorithms, architectures, and service provisioning methods, which accurately capture user motion based on the patterns of use.

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