

Report

Mobile and Emerging Technologies: Implications for Enterprises and Consumers

nomtek



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Introduction

Emerging mobile technologies present significant opportunities for businesses seeking competitive differentiation and improved efficiency. Innovations in edge-based artificial intelligence, augmented reality, virtual reality, and robust 5G networks enable organizations to enhance productivity and customer experiences. However, these advancements also introduce risks related to privacy, security, and regulatory compliance.

This report examines critical mobile technology trends, exploring practical applications and their impacts across industries. Topics include the Internet of Things (IoT), wearables, generative AI interfaces, spatial computing, mobile commerce, migration technologies, and sustainable development practices. Each area is evaluated for its potential to drive efficiency, reduce costs, and enrich user interactions.

Organizations that successfully adopt these technologies can achieve stronger customer relationships and operational effectiveness. Yet, careful management of cybersecurity, sustainability, and rapidly changing consumer expectations is essential for sustainable success.

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Mobile and Emerging Technologies: Implications for Enterprises and Consumers

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1.1 Internet of Things (IoT) and Wearables: Building a Connected World

We're seeing an increasing availability of wearable and IoT devices. Smartwatches, smart headphones, smart rings, and smart glasses are all gaining popularity. For example, the global smart rings market was valued at approximately \$348.56 million in 2024 and is projected to grow at a compound annual growth rate (CAGR) of 21.1% from 2025 to 2030.¹ Shipments of smart glasses are projected to increase from 5.9 million in 2024 to 114.1 million by 2030, indicating a steady rise in adoption.² Many of these devices still lack their own interfaces and rely on mobile apps to connect and unlock their full potential. In the realm of home goods, we are observing a trend toward creating interoperable products, such as connecting smart fridges and heaters to create a more integrated home ecosystem.

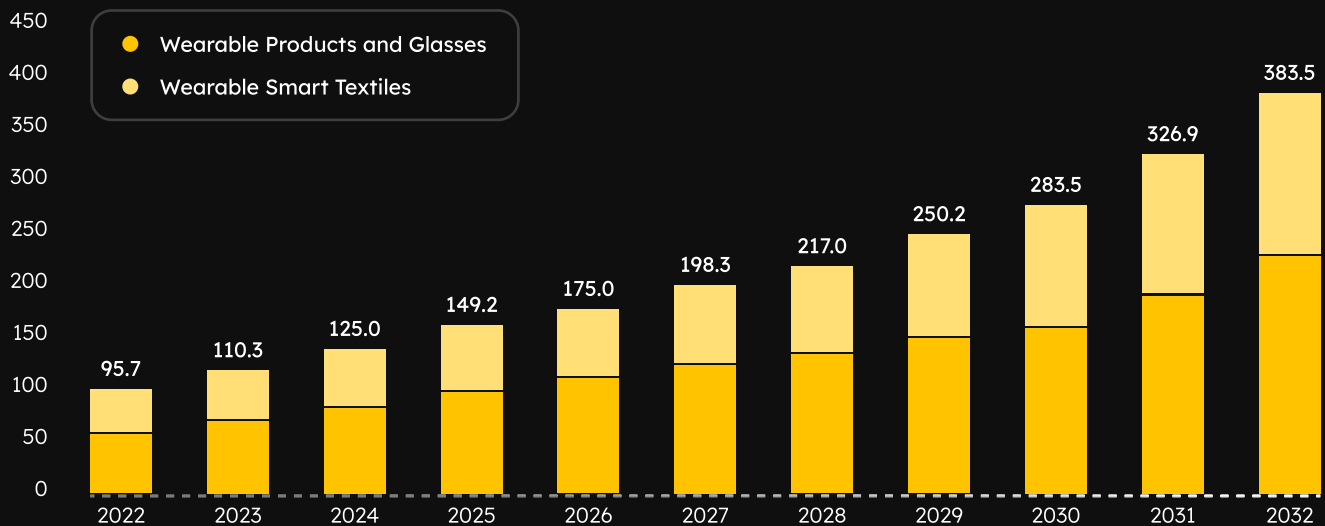
Every smart device will need a gateway for syncing and setup, with the most popular option currently being mobile devices. The demand for mobile apps in the IoT space will continue to grow as these devices become more widespread, creating significant opportunities for mobile app development.

¹ <https://www.grandviewresearch.com/industry-analysis/smart-rings-market-report>

² <https://www.abiresearch.com/news-resources/chart-data/smart-glasses-shipments-by-connectivity>

Global Smart Wearable Market

Size, by type, 2022-2032 (USD Billion)



Source: <https://scoop.market.us/smart-wearables-statistics>

The market will grow
at the CAGR of: **15.3%**

The forecasted market size
for 2032 in USD: **\$383.5B**

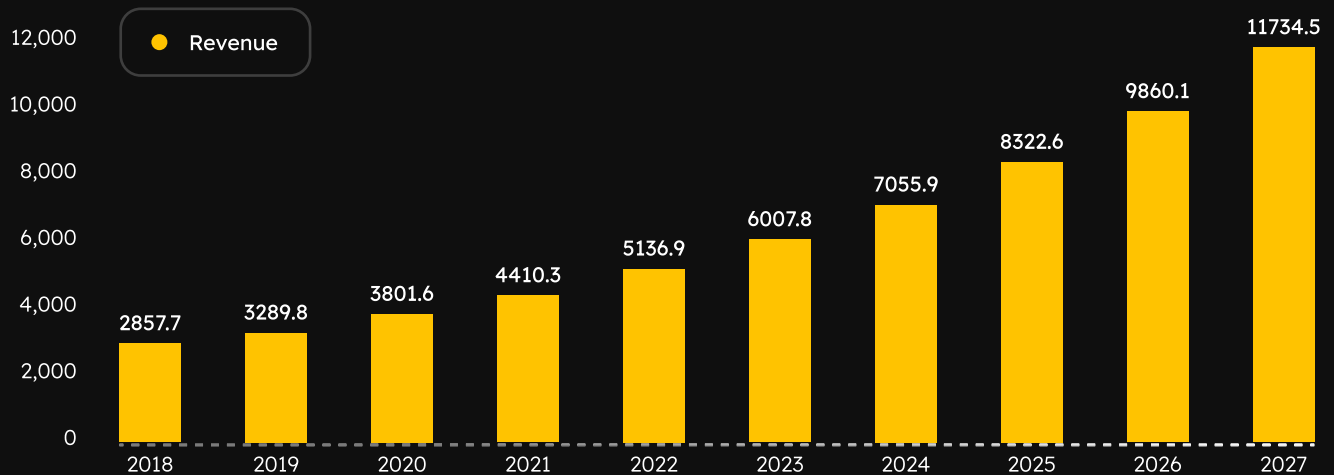
Smart rings serve as efficient tools for contactless transactions and the monitoring of daily health metrics, such as heart rate monitoring, sleep tracking, and calorie counting.³

Smart glasses are still in the beginning stage, with lots of potential for development and enterprises. They display notifications, instructions, or analytics directly in the user's field of view. Smart glasses overlay digital content onto the real world, enabling hands-free navigation and interaction via voice commands or physical gestures.

³ <https://www.gminsights.com/industry-analysis/smart-rings-market>

Global Smart Glass Market Revenue

Market Revenue in USD million



Source: <https://scoop.market.us/smart-wearables-statistics>

1.2 Edge AI: Artificial Intelligence (AI) on Device

Edge AI enables complex data processing directly on devices like smartphones, wearables, and IoT gadgets, without needing to send it to the cloud. The benefits are faster results, tighter privacy, and reduced reliance on cloud services.

The growing demand from the Android and Apple ecosystems, along with manufacturers seeking to run Small Language Models (SLMs) directly on devices, reflects a clear trend towards more localized AI processing. This trend is expected to become mainstream in the next 2-3 years, driven by the increasing power of mobile devices and the benefits of processing data on-device.

Emerging models like Llama 3.2 (1B) and Gemini Nano are designed for on-device use. These models are compact yet powerful enough to deliver sophisticated AI functionalities without relying on cloud-based infrastructure. This shift towards smaller, more efficient language models is expected to play a crucial role in the next generation of smart devices.



Photo Source: Vuzix Blade 2

Why on-device AI matters

Traditionally, AI tools relied heavily on cloud computing for tasks like language translation, virtual assistants, and image recognition. But this setup has its downsides: data transmission delays, privacy concerns, and dependency on stable internet connections.

In the next 2-3 years, businesses that embrace edge AI and on-device technologies will be better positioned to lead in industries like retail, healthcare, manufacturing, finance, and consumer tech.

With on-device AI computing happening locally, we get:

- **Speed boost** — On-device AI processes data instantly without needing to send information back and forth to the cloud. For instance, AI-powered keyboards like Microsoft SwiftKey predict your next word in milliseconds, offering a smooth typing experience.
- **Privacy first** — Sensitive data, like health metrics or personal chats, remains on the device, reducing risks of breaches. Apple, for example, emphasizes its “privacy-first” approach with on-device Siri voice processing.

- **Offline functionality** — On-device AI ensures tools like real-time translation apps and smart assistants remain functional, even without internet access - a boon for travelers and remote workers.
- **Reduced cloud costs** — Businesses won't need to rely as heavily on expensive cloud infrastructure to process data. Since Edge AI processes data locally on devices, companies can save on server costs, bandwidth, and storage.
- **Lower latency costs** — Real-time data processing on devices means faster responses (like in smart sensors or customer service apps), reducing inefficiencies.
- **Faster time to market** — Edge AI models like Llama 3.2 are smaller and easier to customize, meaning businesses can integrate AI faster into their existing products and bring new innovations to market quicker. Companies won't need a massive AI infrastructure to compete: they can use off-the-shelf models and adapt them locally.

Current edge AI uses

- **Autonomous vehicles** — Edge AI powers real-time decision-making in autonomous vehicles, including object detection, collision avoidance, and navigation.
- **Smart cameras and surveillance** — Security cameras to detect motion, recognize faces, and analyze behaviors in real time, without needing to send data to the cloud.
- **Smartphones** — Voice assistants such as Siri, improved facial recognition, speech recognition, camera enhancements (like object detection).
- **Smart home devices** — Edge AI powers smart speakers, thermostats, and other devices to analyze voice commands, predict behavior, and adjust settings automatically.

1.3 AI Assisted Interfaces and Optimization

Since its introduction in the 1950s, generative AI shifted from being used experimentally to becoming integral to real-time media interactions and content personalization. It enables mobile apps to deliver highly personalized experiences by analyzing user behavior and preferences that drive deeper brand engagement and loyalty.

Spotify uses generative AI to improve user experiences through personalized playlists, recommendation algorithms, Spotify Wrapped, and AI-generated DJ voice features. Their "AI DJ" feature combines generative AI with machine learning to create a more dynamic, interactive music experience.⁴

Meta's Advantage+ uses AI to optimize ad campaigns, improving targeting and making real-time adjustments, potentially increasing return on ad spend by up to 32%.⁵

Amazon uses AI to generate personalized recommendations, product descriptions, enhanced listings, and voice interactions via Alexa.⁶

Eleven Labs uses AI to clone any person's voice with just a 30 minute sample, for uses such as reading audiobooks, creating meditations, or video games, shortening a human's time and reducing workload.⁷ 62% of Fortune 500 companies now have at least one employee using ElevenLabs.⁸

AI-driven tools let casual users and businesses integrate elements like text-to-speech, auto-generated subtitles, or perform edits into their workflows without professional assistance, which improves accessibility and reduces workload.

Features like voice assistants, auto-translation, and text-to-speech expand app usability to diverse audiences, including people with disabilities or language barriers. 60% of consumers prefer AI-powered assistants for interactions, and 67% are ready to use AI for tasks like order tracking and personalized recommendations.⁹

⁴ <https://newsroom.spotify.com/2024-12-04/the-art-and-science-behind-spotify-wrapped/>

⁵ <https://nomadicadvertising.com/metad-advantage-plus-how-does-it-work>

⁶ <https://www.aboutamazon.com/news/innovation-at-amazon/how-amazon-uses-generative-ai>

⁷ <https://elevenlabs.io/voice-cloning>

⁸ <https://www.stateof.ai/>

⁹ https://www.zendesk.com/newsroom/articles/2025-cx-trends-report/?utm_source=chatgpt.com

Key applications of generative AI in mobile apps

- **Real-time personalization** — AI tools analyze user behavior and deliver hyper-targeted experiences, driving deeper engagement and loyalty.
- **Voice AI and chatbots** — Seamless, human-like interactions improve accessibility and customer satisfaction.
- **Content creation** — AI simplifies tasks for users, enabling text-to-speech, auto-subtitles, and other advanced features without professional expertise.

Why it matters for businesses

1. Enhanced user engagement

By customizing experiences to each user, apps keep users engaged and returning for more. Personalization increases loyalty and word-of-mouth referrals.

2. Easier cost-effectiveness

Generative AI automates tasks like content creation, customer service, and data analysis, reducing reliance on human labor and cutting operational costs.

3. More competitive advantage

Early adopters of generative AI set themselves apart by offering smarter, faster, and more dynamic apps that adapt to user needs in real time.

4. Better accessibility

AI-powered features like voice assistants, auto-translation, and text-to-speech make apps usable for a broader audience, including those with disabilities or language barriers.

Future trends in mobile AI

1. **Predictive features** — Apps will predict what users want before they ask, offering highly proactive assistance.

2. **Voice as the new interface** — Voice-first apps will emerge, where most interactions are conducted through natural language rather than touch.
3. **AI-Powered creativity** — Generative AI will enable users to create their own content directly within apps, whether it's art, music, or personalized experiences.
4. **Smaller, faster AI models** — Edge AI will allow apps to run powerful AI tools locally on devices, improving speed, privacy, and offline functionality.

1.4 Augmented Reality (AR), Virtual Reality (VR), and Spatial Computing

Understanding AR, VR, and spatial computing

- **Augmented reality** overlays digital content, such as video, images, and interactive elements, onto the real world using smartphones or AR glasses. It's widely used in gaming, education, retail, and training.
- **Virtual reality** creates fully immersive, computer-generated environments that users experience through headsets like the Meta Quest 3 and Apple Vision Pro.
- **Spatial computing** integrates AR, VR, mixed reality (MR), and AI to enable real-time interaction between the digital and physical worlds. The market is expected to grow from \$110 billion in 2023 to \$1.7 trillion by 2033, driven by innovations in extended reality (XR) and AI-powered experiences.¹⁰

The future of AR, VR, and spatial computing in business

The augmented and virtual reality market was valued at \$16.77 billion in 2023 and is projected to reach \$237.0 billion by 2032, growing at a CAGR of 34.24% from 2024 to 2032.¹¹ This rapid expansion is fueled by advancements in AI, 5G connectivity, and cross-platform integration, making AR/VR more accessible and cost-effective for businesses and consumers.

Mobile and XR integration: New opportunities for business

Smartphones are increasingly evolving into processing hubs for AR/VR wearables, optimizing battery life and enhancing XR applications. This synergy improves performance and expands AR/VR accessibility beyond dedicated headsets, allowing businesses to integrate immersive experiences into everyday mobile devices.

AR/VR applications across industries

- **Gaming and entertainment** — AR/VR is revolutionizing gaming by delivering hyper-immersive experiences. Devices like the Meta Quest 3 and Apple Vision Pro set new benchmarks in graphics, AI-driven gameplay, and interactive storytelling.¹²
- **In workplace training**, AR-based training is transforming corporate learning and job simulations, letting employees practice real-world scenarios in virtual environments.¹³

¹¹ https://www.globenewswire.com/news-release/2024/11/07/2976752/0/en/Augmented-and-Virtual-Reality-Market-Set-to-Reach-USD-237-0-Billion-by-2032-Driven-by-Growing-Demand-for-Immersive-Experiences-Across-Industries-Research-by-S-S-Insider.html?utm_source=chatgpt.com

¹² <https://newzoo.com/resources/blog/gaming-industry-trends-roundup-october-11>

¹³ <https://www.mercer.com/assets/global/en/shared-assets/local/attachments/pdf-2024-global-talent-trends-report-en.pdf>

- **In retail**, AI-powered AR/VR solutions are redefining online shopping and reducing return rates through:
 - Virtual try-on experiences — Retailers like **Zara** and **Sephora** use AR to let customers preview clothing, accessories, and cosmetics in real-time before purchasing.
 - Immersive shopping environments — Brands create **virtual storefronts**, allowing shoppers to explore digital versions of their stores from home.
 - Snapchat's AR filters enable brands to showcase virtual try-ons for fashion, beauty, and accessories. Similarly, Meta's Horizon Worlds and Apple Vision Pro offer new platforms where advertisers can place interactive, spatially-aware ads inside virtual worlds, creating personalized shopping experiences.

Platforms like Roblox and Unity are bridging the gap between virtual and physical commerce, letting brands sell tangible goods directly within metaverse-like environments. Notable collaborations include:

- **Roblox-Shopify partnership** — This integration allows brands to create virtual storefronts inside Roblox, where users can browse and purchase real-world products.
- **Walmart-Roblox-Unity initiatives** — Walmart has launched virtual shopping experiences on Roblox, letting users explore digital replicas of physical stores and order real-world products without leaving the platform.

This trend reflects a shift toward blended commerce, where digital and physical retail merge, catering to consumers who spend more time in virtual spaces.

- **In healthcare**, spatial computing enables real-time 3D medical visualizations, improving diagnostics and patient care. A recent study found that medical students trained in VR surgery completed procedures **20% faster** and performed **38% more steps correctly** than those using traditional methods.¹⁴



- **In real estate**, AR/VR-powered virtual property tours are transforming real estate by allowing buyers to explore homes remotely. Platforms like Zillow integrate VR to provide 360-degree property walkthroughs.

Industry collaborations and developments

- **Samsung, Google, and Qualcomm's XR Partnership** — Samsung, Google, and tech giants Samsung, Google, and Qualcomm have announced Project Moohan, an initiative under Android XR, to develop next-gen AR glasses with a built-in voice-enabled AI assistant (Gemini), similar to Siri and Alexa.^{15 16}

Meta's advancements in AR/VR

- **Meta's Reality Labs division** has exceeded its sales and user adoption targets, driven by the strong demand for Quest VR headsets and the popularity of Horizon Worlds.¹⁷

¹⁵ <https://www.theverge.com/2024/9/25/24253712/meta-rayban-ai-features-reminders-translation-transparent-style>

¹⁶ <https://blog.google/products/android/android-xr/>

¹⁷ <https://www.businessinsider.com/meta-reality-labs-beats-nearly-all-sales-user-targets-2025-1?IR=T>

Emerging trends in AR/VR

- **Preference for smaller size glasses** — There is almost a consensus in the industry that smaller AR glasses are an ideal headworn device that can wirelessly connect to a smartphone. This approach improves battery life by shifting heavy processing to the smartphone and allows developers to easily port their apps to AR glasses, unlocking numerous possibilities. The success of Ray-Ban Stories (an estimated 981,818 units sold during Q4 2024) also indicates that even glasses without a display can capture consumer interest, suggesting growing demand for wearable technology in the near future.¹⁸
- **AI-driven personalization** — AI enhances real-time customization, making AR/VR applications more intuitive and user-friendly.¹⁹
- **5G-powered XR experiences** — Faster, low-latency 5G networks enable seamless cloud-based AR/VR experiences without needing high-end local hardware.²⁰
- **AR/VR in hybrid workspaces** — Companies are integrating virtual offices and meeting spaces using platforms like Microsoft Mesh and Meta Horizon Workrooms.²¹

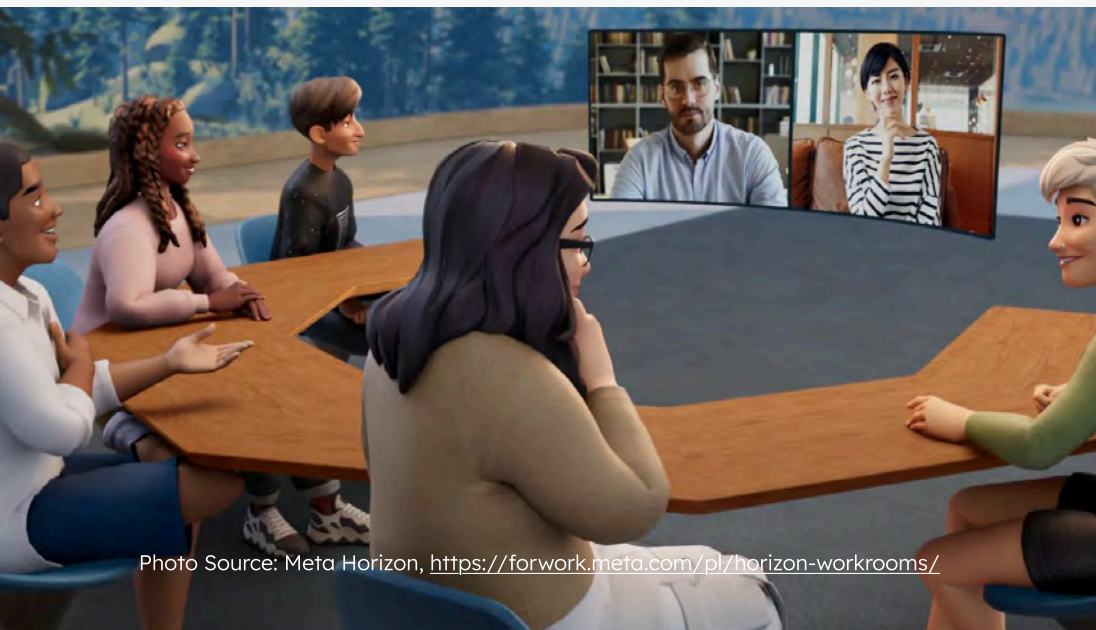


Photo Source: Meta Horizon, <https://forwork.meta.com/pl/horizon-workrooms/>

¹⁸ <https://www.theverge.com/2024/9/25/24253712/meta-rayban-ai-features-reminders-translation-transparent-style>

¹⁹ <https://innowise.com/blog/ar-vr-trends/>

²⁰ <https://www.businessinsider.com/meta-reality-labs-beats-nearly-all-sales-user-targets-2025-1?IR=T>

²¹ <https://www.businessinsider.com/meta-reality-labs-beats-nearly-all-sales-user-targets-2025-1?IR=T>

1.5 Network Infrastructure & Data: The 5G Revolution and Beyond

The evolution of network infrastructure: From 4G to 5G

The transition from 4G to 5G represents a paradigm shift in network capabilities, transforming mobile experiences, creating new business models, and driving demand for advanced devices. The global 5G infrastructure market size is projected to grow from \$34.22 billion in 2024 to \$590.18 billion by 2032, at a CAGR of 42.7%.²²

Impact of 4G on streaming services

The deployment of 4G networks significantly improved mobile connectivity, paving the way for high-quality streaming services. Companies like Netflix, Spotify, and YouTube leveraged faster speeds to provide smooth video and music streaming, transforming smartphones into powerful entertainment hubs. **The global video streaming market is expected to surpass \$416 billion by 2030** due to this shift.²³

Rise of mobile-first businesses

The capabilities of 4G connectivity fostered the rise of mobile-first businesses. Platforms like Uber, Snapchat, and TikTok were able to scale rapidly due to faster and more reliable connections.²⁴ Without 4G's high-speed data transmission, these startups might not have achieved widespread adoption.

²² <https://www.fortunebusinessinsights.com/industry-reports/5g-infrastructure-market-100869>

²³ <https://www.grandviewresearch.com/press-release/global-video-streaming-market>

²⁴ <https://www.ctia.org/news/report-the-4g-decade-quantifying-the-benefits?>

Driving demand for better devices

4G's ability to support rich media experiences increased demand for devices with larger screens, better graphics, and more storage. The release of the iPhone 6 Plus in 2014 was a direct response to the growing need for high-quality mobile streaming experiences.

5G as a game-changer for data transmission and mobile innovation

5G promises speeds up to 100 times faster than 4G, with ultra-low latency and the ability to connect more devices simultaneously. This transformation unlocked opportunities in gaming, augmented reality, virtual reality, and autonomous systems.²⁵

Enabling smart cities and autonomous vehicles

The low-latency and high-bandwidth capabilities of 5G are critical for autonomous vehicle deployment and smart city infrastructure. T-Mobile and Miller Electric's partnership is already leveraging 5G to support real-time communication in autonomous vehicles in Jacksonville, Florida.²⁶ In 2020, Mayo Clinic used electric AVs to transport COVID-19 tests.²⁷

Revolutionizing edge computing and IoT

5G networks will facilitate edge computing (local devices), reducing reliance on centralized data centers and enabling faster real-time processing for IoT devices.²⁸ By 2026, **over 75% of enterprise data will be processed at the edge** rather than traditional data centers.²⁹

²⁵ <https://www.fortunebusinessinsights.com/industry-reports/5g-infrastructure-market-100869>

²⁶ <https://tecknexus.com/5gusecase/miller-electric-t-mobile-boost-autonomous-vehicles-with-5g-network/2/>

²⁷ <https://health.wusf.usf.edu/hnf-stories/2020-04-02/jta-mayo-clinic-use-autonomous-shuttles-to-transport-covid-19-tests-in-jacksonville>

²⁸ <https://www.fortunebusinessinsights.com/industry-reports/5g-infrastructure-market-100869>

²⁹ <https://www.gartner.com/smarterwithgartner/what-edge-computing-means-for-infrastructure-and-operations-leaders>

Powering the Next Wave of AI & Cloud Computing

5G networks will enhance AI applications and cloud computing, unlocking real-time analytics and AI-driven automation in industries such as healthcare, finance, and manufacturing. The combination of 5G + AI is expected to contribute an estimated \$1.5 trillion to the global economy by 2030.³⁰

Challenges and considerations

Despite its promise, the widespread adoption of 5G faces several challenges:

- 1. Infrastructure costs** — The rollout of 5G networks requires significant investment, with global expenditures expected to exceed **\$1.1 trillion by 2025**.³¹
- 2. Energy consumption** — 5G networks consume significantly more power than 4G, necessitating advances in energy-efficient hardware and green computing strategies.
- 3. Security risks** — The increased complexity of 5G networks raises concerns around cybersecurity, data privacy, and potential vulnerabilities in IoT devices.

Preparing for the 5G era

5G can significantly improve mobile applications and enterprise connectivity. Businesses that invest in 5G-ready infrastructure, AI integration, and edge computing can potentially gain a competitive edge. While challenges remain, the potential for new revenue streams and operational efficiencies make 5G a critical investment for forward-thinking organizations.

³⁰ <https://www.mckinsey.com/~media/mckinsey/industries/technology%20media%20and%20telecommunications/telecommunications/our%20insights/>

connected%20world%20an%20evolution%20in%20connectivity%20beyond%20the%205g%20revolution/mgi_connected-world_discussion-paper_february-2020.pdf

³¹ <https://data.gsmainelligence.com/research/research-2020/2025-capex-outlook-2020-update-the-1-trillion-investment>



Photo Source: Mayo Clinic transports Covid-19 tests via an autonomous vehicle in Jacksonville, Florida.

1.6 Emerging Use Cases and Challenges in AI-Enabled Mobile Applications

Artificial intelligence is injecting innovation into mobile applications by improving personalization and security. But as businesses eagerly try to leverage AI for competitive advantage, they face opportunities and challenges in deployment. This report highlights three critical emerging use cases and their impact on the IT landscape.

Micro-moments in mobile apps

Definition

Micro-moments refer to AI-enabled real-time, personalized interactions that boost user engagement and loyalty. These moments occur when users turn to their mobile devices for quick solutions, whether for learning, shopping, or entertainment.

Case study: Learning platforms

Educational platforms leverage AI-driven micro-moments to deliver tailored content based on individual user behavior and progress. For instance, Duolingo and Khan Academy utilize AI to recommend exercises and lessons suited to a learner's proficiency, increasing retention rates and engagement.

Business impact

- **Enhanced user engagement** — Real-time personalization increases app retention and satisfaction.
- **Data-driven insights** — AI analyzes user behavior to optimize app design and functionality.
- **Competitive advantage** — Companies utilizing micro-moments improve customer loyalty and brand trust.

Sustainability and energy efficiency

Green AI and energy optimization

As AI adoption grows, concerns about energy consumption rise. Developers now focus on creating energy-efficient AI models that minimize carbon footprints while maintaining performance.

Green cloud computing strategies

Major cloud providers, including Google Cloud, AWS, and Microsoft Azure, are implementing sustainability measures such as:

- **Carbon-aware load balancing** — AI shifts workloads to data centers powered by renewable energy.

- **Optimized model training** — Reducing redundant computations lowers energy use while maintaining AI effectiveness.
- **Edge AI implementation** — Processing data locally reduces reliance on cloud servers, saving energy.

We cool our servers without using mechanical chillers, we light our buildings with motion-controlled LED lighting, and we don't start equipment until it's absolutely necessary to do so. So we had to look for other ways to reduce our energy impact,

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says Alain Deprez, facility manager for Google's Saint-Ghislain site.

Business impact

- **Cost reduction** — Lower energy consumption leads to reduced operational expenses.
- **Sustainability compliance** — Helps organizations meet ESG (environmental, social, and governance) standards.
- **Reputation boost** — Companies that adopt green AI gain a competitive edge in sustainability-conscious markets.

Security and privacy

Edge computing for data security

Edge computing processes data locally rather than sending it to centralized cloud servers, reducing vulnerabilities and improving response times. This approach tightens security by minimizing exposure to external threats and ensuring compliance with GDPR and CCPA regulations.

Biometric authentication

The rise and evolution of convincing deepfake technology poses a severe threat to traditional authentication systems that rely on visual or auditory cues for verification.³² AI-powered facial recognition, fingerprint scanning, and voice authentication improve security while enhancing user convenience.

Case study: Banking sector

Financial institutions such as JPMorgan Chase and HSBC implement AI-driven biometric authentication to prevent fraud.³³ AI continuously learns user behaviors, detecting anomalies and mitigating security risks in real-time.

³² <https://securityandtechnology.org/wp-content/uploads/2024/10/The-Implications-of-Artificial-Intelligence-in-Cybersecurity.pdf>

³³ <https://www.jpmorgan.com/insights/payments/payments-optimization/ai-payments-efficiency-fraud-reduction>

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Global Trends Impacting Mobile

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2.1 Migration and Migration Tech: Navigating the Intersection of Human Mobility and Technological Innovation

Driven by economic shifts, political instability, and climate change, global migration has increased over the past five decades.³⁴ Concurrently, mobile technology is transforming how migrants navigate financial services, job markets, and their destinations. For businesses in the mobile sector, this presents a lucrative opportunity to develop solutions that cater to the needs of millions of displaced individuals and cross-border workers.

The business potential of migration technology

The intersection of migration and mobile technology is a fast-growing market. Companies that develop digital solutions for migrants, refugees, and cross-border workers can tap into an expanding customer base while also addressing global challenges.

Key areas of opportunity include:

- **Mobile banking and remittances** — Migrants send billions of dollars in remittances each year. Mobile financial solutions, such as digital wallets and blockchain-based transfers, can reduce transaction costs and increase accessibility. Companies like Wise and Revolut are already capitalizing on this demand.³⁵

³⁴ <https://worldmigrationreport.iom.int/msite/wmr-2024-interactive/>

³⁵ <https://migrationnetwork.un.org/statements/promoting-digital-remittances-and-financial-inclusion-achieve-sdgs>

- **Job matching platforms** — Many migrants struggle to find employment that matches their skills. AI-powered job marketplaces, integrated with government databases and corporate HR systems, can help businesses connect with a qualified global workforce.³⁶
- **Legal and immigration services** — Apps that leverage AI and automation can simplify visa applications, work permits, and legal documentation to streamline bureaucratic processes for both migrants and employers.³⁷

Mobile-first solutions for a growing user base

Migrants are heavy mobile users. In emerging markets, over 80% of internet access comes from mobile devices, making mobile-first apps the default approach for businesses targeting this demographic.

Key trends include:

- **Affordable smartphones** — Affordable smartphones are democratizing access to mobile technology, with nearly half of all handsets sold in regions like Southeast Asia and Africa costing under \$100.³⁸ This trend dramatically expands the potential user base for mobile apps, making localized and lightweight applications crucial for success.³⁹
- **Language and translation tech** — AI-driven real-time translation tools (e.g., Google's Interpreter Mode and DeepL) are breaking language barriers, making it easier for migrants to work, communicate, and access services.⁴⁰
- **Cross-border gig economy** — Platforms like Upwork and Fiverr already enable global freelance work, but dedicated mobile-first gig apps for migrants could tap into an untapped labor pool.⁴¹

³⁶ <https://www.upwardlyglobal.org/ai-for-impact-report/>

³⁷ <https://www.jobbatical.com/>

³⁸ <https://www.trustonic.com/opinion/overcoming-the-crisis-of-smartphone-affordability-in-africa/>

³⁹ <https://developingtelecoms.com/telecom-technology/telecom-devices-platforms/17361-how-do-we-improve-smartphone-affordability-in-africa.html>

⁴⁰ https://www.upwardlyglobal.org/news/press-releases/upwardly-global-receives-schmidt-futures-support-to-break-down-barriers-for-low-income-immigrants-and-refugees-with-ai-powered-tool/?utm_source=chatgpt.com

⁴¹ <https://www.trendhunter.com/trends/migrant-labor-platform>

- **Location and navigation services** — Apps that provide real-time location-based services for job opportunities, housing, and local assistance can improve migrant integration and engagement.⁴²

Migration data: A new potential goldmine for business intelligence

Migrants generate vast amounts of data that can be leveraged for business insights. Companies that analyze migration patterns can:

- **Optimize service delivery** — Predict migration flows and adjust supply chains, financial services, and job marketplaces accordingly.
- **Enhance advertising and personalization** — Use AI-driven analytics to tailor content, ads, and services based on migrant preferences and behaviors.
- **Develop scalable technology solutions** — Governments and NGOs are actively seeking private-sector tech partners for digital identity verification, border management, and aid distribution, creating B2G (business-to-government) revenue streams.

The future of migration technology: AI, blockchain, and Web3

Emerging technologies are set to redefine migration tech:

- **AI-powered digital assistants** — AI chatbots can guide migrants through visa applications, job searches, and housing options.⁴³
- **Blockchain for identity verification** — Decentralized digital IDs can streamline border control and help migrants prove their credentials without physical documents.

⁴² <https://globalcompactrefugees.org/good-practices/geomatch-connecting-people-places-using-artificial-intelligence>

⁴³ <https://www.upwardlyglobal.org/news/press-releases/upwardly-global-receives-schmidt-futures-support-to-break-down-barriers-for-low-income-immigrants-and-refugees-with-ai-powered-tool>

- **Web3 and decentralized work platforms** — As remote work expands, blockchain-based smart contracts can facilitate secure cross-border employment without intermediaries.⁴⁴

2.2 The Silver Tsunami: Mobile Tech for Aging Populations

The "silver tsunami" refers to the rapid increase in aging populations worldwide, primarily driven by the baby boomer generation entering their senior years. This demographic shift presents unique challenges and opportunities, particularly in the realm of mobile technology. As older adults continue to integrate into the digital world, businesses and developers must prioritize accessibility, security, and usability to accommodate this growing market.

The aging population and its impact on technology

According to KANTAR's Marketing Trends 2025 report, sustainably active consumers will increase from **22% to 29% by 2030**, reflecting a shift in market demands.⁴⁵ The aging population impacts various aspects of society, including technology adoption, migration patterns, employment needs, and social interactions. Longer life expectancy means that many seniors will require ongoing workforce participation, necessitating re-skilling and technological adaptation.

Key challenges faced by aging users

- **Loss of functionality** — Physical and cognitive decline can make traditional digital interfaces difficult to use.

⁴⁴ <https://neontri.com/blog/digital-id-wallets/>

⁴⁵ <https://www.kantar.com/>

- **Social isolation** — Many seniors identify as socially isolated, increasing the need for digital communication tools.
- **Lack of tech proficiency** — Many older adults struggle to keep up with technological advancements, creating a knowledge gap.
- **Cybersecurity risks** — Seniors are more vulnerable to scams and online security threats due to limited digital literacy.

Solutions for improving mobile accessibility

1. Building trust in technology for older adults

Older users tend to be cautious with digital tools, and building trust is essential. Companies must provide:

- **Clear instructions and thoughtful design** — Seniors benefit from interfaces with simple language, large fonts, and minimal steps for navigation.
- **Error prevention and confirmation steps** — Features such as undo options, confirmation prompts, and tutorial pop-ups help prevent mistakes.
- **Reducing cognitive load** — Simple interfaces with fewer distractions improve usability for older users.⁴⁶
- **Intergenerational solutions** — Ensuring digital products cater to younger and older generations fosters inclusivity without alienation.

2. Mobile training and support

- Technology skills training programs adjusted to older users.
- Providing tech equipment, such as simplified smartphones and tablets.
- Supporting the adoption of voice assistants for easier navigation.⁴⁷

⁴⁶ <https://www.nngroup.com/articles/usability-for-senior-citizens/>

⁴⁷ <https://www.investopedia.com/silver-tsunami-8418065>

3. UI/UX for senior-friendly devices

- **Larger fonts and buttons** — Improve readability and usability.
- **Simplified navigation** — Reduces cognitive load and frustration.
- **High-contrast themes** — Enhance visibility.
- **Screen readers and text resizing** — Provides better accessibility for visually impaired users.
- **Alternative navigation methods** — Eye-tracking and gesture-based controls increase accessibility.
- **Voice interaction** — Integration of natural language processing for hands-free control. Many older users prefer voice assistants due to ease of use. Mobile apps may integrate more voice commands and natural language processing.

The GrandPad tablet is designed specifically for seniors, featuring a simple interface, voice-command capabilities, and pre-installed security measures.⁴⁸

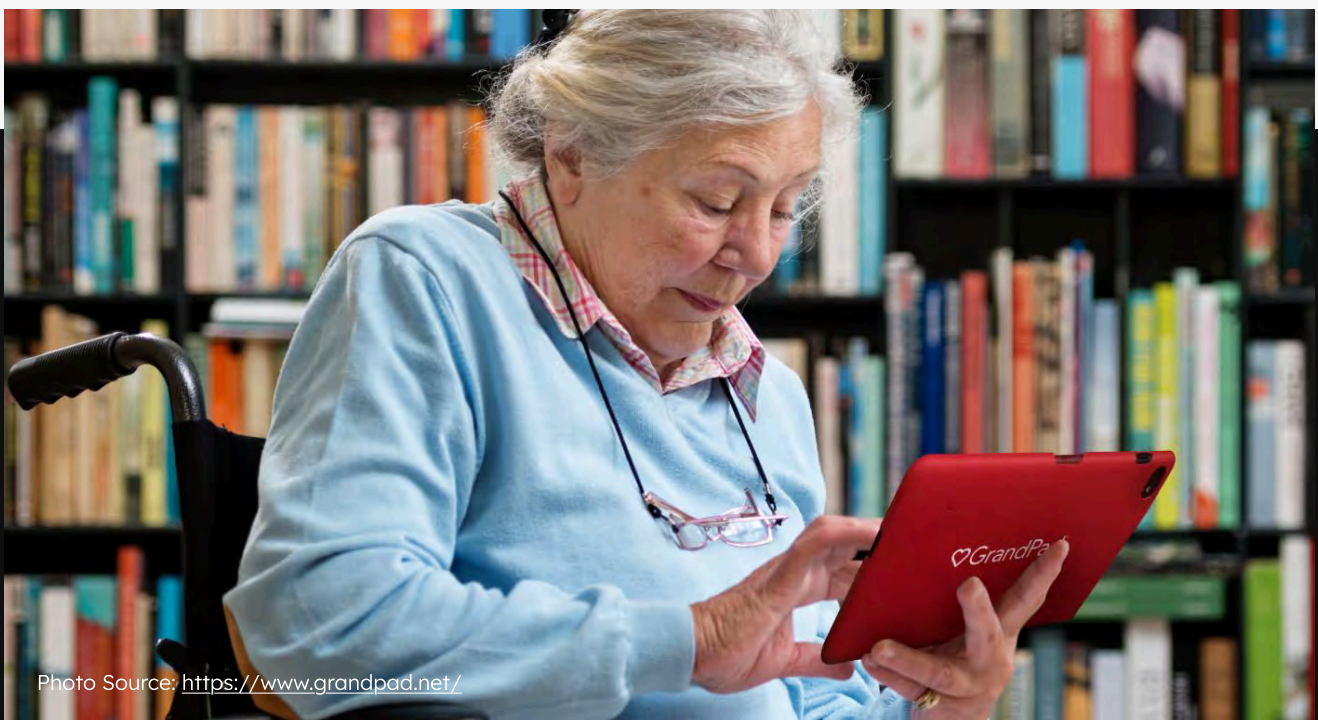


Photo Source: <https://www.grandpad.net/>

4. Cybersecurity and data protection

- User-friendly security measures, including biometric login and simple password management.
- Clear privacy policies and easy-to-understand security notifications.
- Cybersecurity training programs to educate seniors on avoiding scams and fraud.⁴⁹

5. Integration of health and wellness features

- **Telehealth services** — Mobile platforms connecting seniors to doctors and therapists.
 - Teladoc Health offers comprehensive virtual care services tailored for seniors, including primary care, mental health support, and chronic condition management.⁵⁰
 - Total Life specializes in mental health services for seniors, providing therapy and counseling through an easy-to-use telehealth platform.⁵¹
- **Wearable technology** — Devices with larger screens, enhanced audio, and integrated medical sensors.
 - MobileHelp Smart is a smartwatch that combines health monitoring with emergency assistance. It tracks activity levels, heart rate, and includes a one-touch emergency button connecting users to emergency operators.⁵²
 - Apple Watch is equipped with features beneficial for seniors, such as health tracking, automatic fall detection, and easy communication options like texting and calling.⁵³

⁴⁹ <https://www.cisa.gov/resources-tools/resources/cisa-cybersecurity-awareness-program-older-american-resources>

⁵⁰ <https://www.teladochealth.com/individuals/seniors>

⁵¹ <https://totallife.com/top-5-telehealth-companies-the-future-of-senior-mental-health-services>

⁵² <https://www.seniorlifestyle.com/resources/blog/wearable-technology-for-seniors>

⁵³ <https://www.safewise.com/blog/top-safety-wearable-products-for-seniors>

- **Smart home connectivity** — Voice-controlled devices for lighting, security, and communication with family members.
 - Amazon Echo with Alexa are voice-controlled devices that allow seniors to manage lighting, security systems, and communicate with family members through simple voice commands.
 - JubileeTV is a system that connects to the TV, enabling video calls, sharing of family photos and videos, setting medication reminders, and tracking activity, thereby facilitating remote support from family members.⁵⁴
- **Fall detection and emergency response systems** — Ensuring safety for aging users.⁵⁵
 - CPR Guardian is a personal alarm smartwatch designed specifically for seniors, featuring an SOS emergency medical alert button to summon help when needed.⁵⁶
 - Mobile Help provides wearable devices with built-in fall detection and emergency response features, ensuring that seniors receive immediate assistance in case of falls or other emergencies.⁵⁷

⁵⁴ <https://www.wired.com/review/jubileetv>

⁵⁵ <https://www.who.int/teams/social-determinants-of-health/demographic-change-and-healthy-ageing/age-friendly-environments>

⁵⁶ <https://www.makeuseof.com/wearable-devices-seniors-improve-health-safety/>

⁵⁷ <https://www.seniorlifestyle.com/resources/blog/wearable-technology-for-seniors>

2.3 Sustainable and Energy-Efficient Design and Development

Sustainable software development is a pivotal lever for reducing environmental impact and helping curb the negative effects of climate change and resource scarcity. Businesses aiming to align with global sustainability goals will need to think of energy-efficient design, cloud computing, and green software practices.

1. Energy-efficient coding

Optimizing code to reduce energy consumption is a fundamental practice:

- **Algorithm optimization** — Efficient algorithms lower CPU usage and memory demands, cutting energy consumption. For example, sorting algorithms like QuickSort outperform Bubble Sort in large datasets, reducing processing time and power usage.⁵⁸
- **Efficient programming languages** — Languages like C and Rust are more energy-efficient compared to Python or Java due to their lower runtime overhead.⁵⁹ But they are not exactly interchangeable. Performance-critical parts (like algorithms, encryption, data processing) could be written in C or Rust, while high-level features (like UIs, APIs, business logic) could be built with Java, Kotlin, or Python for faster development.
- **Example:**
 - **Instagram** — Core features are written in Python, but performance-heavy components (like image processing) are written in C.
 - **Firefox browser** — Written in C++ originally, now with critical components rewritten in Rust for security and performance.

⁵⁸ https://www.researchgate.net/publication/325327435_Analysis_of_Energy_Consumption_of_Sorting_Algorithms_on_Smartphones

⁵⁹ <https://arxiv.org/html/2410.05460v1>

2. Sustainable cloud computing

Cloud infrastructure significantly influences energy efficiency:

- **Dynamic resource allocation** — Tools like Kubernetes optimize resource usage through containerization, reducing idle server time.⁶⁰
- **Serverless architectures** — Platforms like AWS Lambda execute code on-demand, eliminating the need for continuously running servers, leading to substantial energy savings.⁶¹

3. Green software development practices

Embedding sustainability throughout the software lifecycle ensures long-term impact:

- **Lifecycle assessment** — Analyzing environmental footprints from development to deployment helps identify areas for improvement.⁶²
- **Minimizing e-waste** — Optimizing software for older hardware extends device lifespans, reducing electronic waste. For example Google Chrome OS Flex is designed to breathe new life into old PCs and Macs, reducing e-waste in educational and corporate sectors.

4. Data management for efficiency

Efficient data practices can dramatically cut energy use:

- **Minimizing data exchange** — Implements caching and compression techniques to reduce network load.^{63 64}

⁶⁰ <https://medium.com/@dskydragon/using-kubernetes-resource-requests-and-limits-a9d44401127e>

⁶¹ <https://aws.amazon.com/lambda/>

⁶² <https://greensoftware.foundation/>

⁶³ <https://www.cachefly.com/news/understanding-and-utilizing-caching-for-improved-web-performance/>

⁶⁴ <https://www.cachefly.com/news/strategies-for-achieving-high-throughput-in-challenging-environments>

- **Data lifecycle management** — Aggregates and compresses data to lower storage and processing demands.⁶⁵

5. Green hosting and infrastructure

Choosing sustainable hosting solutions reduces energy consumption:

- **Green hosting providers** — Companies like GreenGeeks use renewable energy to power their data centers, cutting carbon emissions significantly. GreenGeeks offset 300% of the energy they use through renewable energy investments.⁶⁶
- **Localized (edge) data centers** — Reducing data transmission distances lowers energy usage and improves efficiency. These centers have compact design, leverage renewable energy sources, and use innovative cooling strategies.⁶⁷

2.4 Artificial Intelligence and Automation: Navigating the Energy and Sustainability Landscape

The rapid adoption of AI technologies has brought on notable environmental challenges, particularly regarding energy consumption and sustainability.

High energy consumption

AI technologies, especially advanced models like generative AI, demand substantial computational power. A typical interaction with an AI model like ChatGPT consumes **about 10 kilojoules of energy**: approximately ten times more than a standard Google search.⁶⁸ This disparity underscores the intensive energy requirements of AI-driven processes compared to traditional software solutions.

⁶⁵ <https://www.datadynamicsinc.com/blog-transitioning-from-dark-data-to-green-growth-two-essential-pillars-for-data-sustainability-in-the-digital-age>

⁶⁶ <https://www.greengeeks.com/>

⁶⁷ <https://netzero-events.com/what-is-the-role-of-edge-data-centers-in-energy-efficiency/>

⁶⁸ <https://www.heise.de/en/news/ChatGPT-s-power-consumption-ten-times-more-than-Google-s-9852327.html>

Generative AI models, such as those used for creating text, images, or code, can require **up to 33 times more energy** to complete tasks than conventional software.⁶⁹ As these models become more complex and widely adopted, their energy consumption is projected to rise sharply, potentially accounting for a significant portion of global electricity usage.

Carbon emissions impact

The energy-intensive nature of AI operations translates directly into higher greenhouse gas emissions. Training the BLOOM AI model emits **10 times more greenhouse gases** than a French person in a year.⁷⁰ This statistic highlights the environmental cost associated with developing and deploying large-scale AI systems.

Tech giants have also observed increases in their carbon footprints due to AI-related activities. For example, Google reported a **48% increase in greenhouse gas emissions** over five years, attributing much of this rise to the energy demands of its AI data centers.⁷¹ However, most of the centres in Europe and the Americas get the majority of their energy from carbon-free sources (Google's $\frac{2}{3}$ energy sources are carbon-free), while data centres in the Middle East, Asia and Australia use far less carbon-free energy.⁷²

Strain on natural resources

Beyond electricity, AI's growing energy consumption places additional stress on water resources. Data centers, which power AI technologies, require substantial water for cooling systems to maintain optimal operating temperatures. This dual demand for electricity and water poses significant challenges, especially in regions already grappling with climate-related resource scarcity.

The increasing energy — and water — use of AI has prompted a series of warnings, especially as the sector is forecast to keep growing rapidly.⁷³

⁶⁹ <https://www.weforum.org/stories/2024/07/generative-ai-energy-emissions/>

⁷⁰ <https://www.polytechnique-insights.com/en/columns/energy/generative-ai-energy-consumption-soars/>

⁷¹ <https://www.bbc.com/news/articles/c51yvz51k2xo>

⁷² <https://www.bbc.com/news/articles/c51yvz51k2xo>

⁷³ <https://www.bbc.com/news/technology-67053139>

Local infrastructures face increased pressure due to these demands, potentially exacerbating vulnerabilities in power grids and water supplies.⁷⁴

Opportunities for sustainable AI development

While AI contributes to sustainability challenges, it also offers pathways to mitigate environmental impacts through smart resource management:

- 1. Energy-efficient algorithms** — Research into optimizing AI algorithms can lead to models that require less computational power without sacrificing performance.
- 2. Green data centers** — Innovations in data center design, such as the use of renewable energy sources and advanced cooling technologies, can reduce the carbon footprint of AI operations.
- 3. AI for energy optimization** — AI can be leveraged to optimize energy use in various industries, from smart grids that balance supply and demand to predictive maintenance systems that enhance operational efficiency.

2.5 AI: Potential for Sustainability

AI as a tool for efficiency

Artificial intelligence holds transformative potential in advancing global sustainability goals. Effective AI applications could mitigate between **5% to 10% of global greenhouse gas emissions by 2030**.⁷⁵ This reduction is possible through AI-driven optimization across various sectors, e.g., energy, manufacturing, and logistics.

For example, AI algorithms optimize supply chain routes, significantly reducing fuel consumption. In agriculture, AI-powered predictive analytics improve crop yields with fewer resources, while smart grids powered by AI enhance energy distribution, minimizing waste.

⁷⁴ <https://planetdetroit.org/2024/10/ai-energy-carbon-emissions/>

⁷⁵ <https://blog.google/outreach-initiatives/sustainability/report-ai-sustainability-google-cop28/>

Advancements in hardware

One of the critical drivers for sustainable AI deployment is the evolution of energy-efficient hardware. Innovations in specialized chips, such as Google's Tensor Processing Units (TPUs) and NVIDIA's A100 GPUs, claim to deliver up to 30 times better performance while consuming 25 times less energy than traditional processors.⁷⁶

These advancements not only support high-performance AI computations but also reduce the carbon footprint of data centers, which are notorious for their significant energy demands.

Measuring and monitoring energy efficiency

Energy efficiency in AI is not solely about hardware: continuous monitoring and optimization of software performance play a pivotal role.

- **Energy measurement tools** — Tools like Microsoft's Green Software Foundation enable developers to assess the energy consumption of applications, identifying inefficiencies for targeted improvements.⁷⁷
- **Continuous monitoring** — Real-time monitoring solutions track energy metrics, providing actionable insights. This data-driven approach helps organizations make informed decisions about resource allocation, improving sustainability outcomes.

For instance, predictive control powered by AI achieved a remarkable 20% reduction in heating energy without compromising comfort. Additionally, smart home energy management algorithms demonstrated a notable **22.63% decrease in electricity costs and a 22.77% reduction in the peak-to-average ratio**.⁷⁸

⁷⁶ <https://www.avenga.com/magazine/explore-green-software-development>

⁷⁷ <https://www.softwareimprovementgroup.com/green-software-development/>

⁷⁸ https://www.researchgate.net/publication/378875742_Advancing_Sustainable_Energy_Management_A_Comprehensive_Review_of_Artificial_Intelligence_Techniques_in_Building

2.6 M-Commerce: Trends in Mobile Commerce

Mobile commerce has emerged as a transformative force in the digital economy, reshaping how consumers shop and businesses operate. With the rapid proliferation of smartphones and advancements in mobile technology, M-Commerce is experiencing unprecedented growth. Today, **73% of US consumers shop online with their mobile phones.**

What triggers a mobile purchase?

The most common trigger for mobile shopping is remembering a product that is needed or wanted (23.79%), followed by seeing an ad on social media (18.28%). The key takeaway here is that brands need to focus on activities like targeted ads and reminders to capture the attention of potential customers.

Market growth and projections

In 2024, shoppers spent over **\$546 billion on mobile devices**, highlighting the significant role mobile commerce plays in consumer behavior.⁷⁹ Experts predict that mobile e-commerce sales will soar to **\$710 billion in 2025**, driven by increased smartphone penetration and improved mobile shopping experiences.

Omnichannel integration

The global omnichannel retail commerce systems market is projected to grow from **\$6.57 billion in 2023 to \$11.24 billion by 2028.**⁸⁰ This growth underscores the importance of easy integration across multiple platforms, with mobile devices at the forefront.

⁷⁹ <https://www.statista.com/statistics/249855/mobile-retail-commerce-revenue-in-the-united-states/>

⁸⁰ <https://clutch.co/resources/mobile-commerce-trends>

Shift to mobile-specialized apps

As per PEW Research, **almost 60% of American buyers** have looked at a product's details using an app on their phone.⁸¹ Retailers are increasingly shifting towards mobile-specialized apps to improve user engagement and retention. Data indicates that the average order value (AOV) via a mobile app is \$102, compared to \$92 from a mobile website.⁸² This suggests that apps offer a more personalized and efficient shopping experience, encouraging higher spending.

Mobile landing page design

Online stores with a high mobile abandonment rate may be missing out on plenty of potential customers due to their page design. 65.52% of respondents consider the design of a mobile landing page extremely or very important in their decision to stay or leave an online store while shopping.

The most appreciated features on a mobile landing page are high-quality images and videos (63.10%), easy navigation (67.93%), and clear and concise information (61.03%).

One-click ordering

The simplicity of one-click purchasing is revolutionizing mobile e-commerce by removing the long checkout procedure that is often necessary when making items online. Entering personal information such as names, addresses (billing and shipping), credit card numbers, and more on mobile websites may be a pain due to the smaller displays.⁸³

⁸¹ <https://www.pewresearch.org/short-reads/2022/11/21/for-shopping-phones-are-common-and-influencers-have-become-a-factor-especially-for-young-adults/>

⁸² <https://instant.so/blog/us-online-shopping-trends-report-2024>

⁸³ <https://clutch.co/resources/mobile-commerce-trends>

Social commerce

Social platforms directly impact the brands and purchase market for businesses. Social media has become and will continue to be one of the influencer markets for users to buy their items. Brands may now include shoppable product tags in postings on social media platforms like Instagram and Facebook. Users may purchase products straight from these articles inside the app, skipping the usual steps to an e-commerce website. The success of this streamlined purchasing process was shown by the brands' **20% increase in revenue and 1,416% increase in visits** after the implementation of shoppable content.⁸⁴ The majority of respondents (53.10%) expect to be redirected to the product page when they click on a product ad.

The rise of voice search and conversational AI

Voice search features and conversational AI are redefining accessibility and convenience in m-commerce. **Voice commands now account for 20% of mobile searches**, simplifying the shopping process and enhancing user engagement. Real-life examples include the integration of voice assistants like Amazon's Alexa and Google Assistant in e-commerce platforms, which allow users to search for products, track orders, and make purchases hands-free.

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3.

Companion and Super Apps

3. Companion and Super Apps

3.1 Companion Apps

The rise of companion apps

Businesses are seeking ways to strengthen their relationship with users while improving engagement and retention. One of the most effective strategies has been the development of companion apps, which serve as extensions of primary products or services. These applications add functionalities that improve user experience, integrating with hardware or digital platforms.

Many hardware companies are diversifying their business models by investing in companion apps. These applications act as a bridge between users and services, fostering brand loyalty and improving overall satisfaction. With the rise of AI and IoT, companies are focusing on apps that create an ecosystem between hardware and software.

One of the biggest adopters of this strategy is Samsung, which has developed an array of companion apps to enhance user experience across its ecosystem of devices.

Samsung as an example of companion app excellence

Samsung has consistently pushed the boundaries of innovation in the companion app space, leveraging cutting-edge technology to enrich its hardware offerings. Some notable examples include:

- **Samsung SmartThings** — A central hub for controlling smart home devices, creating an intuitive user experience across different connected gadgets.⁸⁵
- **Samsung Health** — A comprehensive fitness and wellness companion that integrates with Samsung wearables and smartphones to provide personalized health insights.⁸⁶
- **Galaxy Wearable** — An app that improves user interaction with Samsung smartwatches, offering customization and seamless device integration.⁸⁷

The three pillars of companion apps

The effectiveness of companion apps is determined by their ability to provide a great user experience, improve engagement, and deliver personalized interactions. The three most critical aspects of companion apps are:

1. Convenient connection between hardware and software

Companion apps must integrate effortlessly with hardware to provide a frictionless experience. For example, Apple's WatchOS app syncs seamlessly with iPhones, ensuring a unified interface between the watch and smartphone, making it easier to manage notifications, fitness tracking, and calls.

2. Enhanced user experience and engagement

A successful companion app should improve usability rather than complicate it. For instance, Tesla's mobile app allows users to control vehicle functions remotely, check battery status, and even summon their car from a parking space, providing a convenient and interactive user experience.

⁸⁵ <https://www.samsung.com/us/smartthings/>

⁸⁶ <https://www.samsung.com/us/apps/samsung-health/>

⁸⁷ <https://www.samsung.com/us/support/owners/app/galaxy-wearable-watch>

3. Personalized experiences

Companion apps leverage AI and machine learning to deliver personalized content. For example, Google Home suggests automations based on a user's routines, while Peloton's app tailors workout recommendations based on user preferences and performance data.⁸⁸

The future of companion apps

The companion app market is set to expand as businesses recognize the value of integrated digital ecosystems. Companies will continue refining AI-driven personalization, expanding IoT integration, and improving real-time engagement for a superior user experience.

As technology advances, companion apps will become an indispensable part of user interaction with hardware and digital platforms, reinforcing brand loyalty and delivering unparalleled convenience in an increasingly connected world.

3.2 The Rise of Super Apps

Super apps are redefining the digital landscape, consolidating multiple services into a single, seamless experience. Unlike traditional applications that offer a single function, super apps integrate diverse services — payments, messaging, shopping, and even workforce management — within a unified platform. This model not only improves user convenience but also fosters deeper customer loyalty by minimizing the need to switch between multiple applications.

Asian super apps like WeChat and Grab are one-stop shops for users to do everything from ordering food and shopping for clothes to making payments and chatting with friends.

In Europe, Revolut is the only neobank that's close to this kind of product, offering everything from crypto and equity investment to airport lounge passes. With 30m users globally, Revolut also has far more customers than any other European neobank.⁸⁹

Revolut: a case study in European fintech innovation

Revolut exemplifies the super app model in digital banking. Originally launched as a foreign exchange service, Revolut has evolved into a one-stop financial hub, offering features like stock trading, cryptocurrency investments, insurance, and instant peer-to-peer transfers.

- **Revolut chat** — The app's in-built messaging feature allows users to communicate while making transactions, revolutionizing peer-to-peer payments by improving social interaction.⁹⁰
- **Expanding beyond banking** — Revolut's venture into travel bookings and rewards programs demonstrates how fintech super apps can extend into lifestyle services.⁹¹

The future of super apps

With mobile commerce sales expected to reach \$710 billion by 2025, super apps are positioned to dominate the next phase of digital transformation.⁹² Key trends shaping this evolution include:

- **AI-powered personalization** — Voice assistants, conversational AI, and predictive analytics will drive tailored user experiences.
- **Omnichannel integration** — Businesses will increasingly merge in-store and mobile experiences within super apps, improving accessibility and engagement.
- **Regulatory challenges** — As super apps grow in influence, governments worldwide are scrutinizing their data privacy and market dominance.

⁸⁹ <https://sifted.eu/articles/europe-superapp-revolut-klarna>

⁹⁰ https://www.revolut.com/news/revolut_launches_revolut_chat_an_instant_messaging_feature_in_step_forward_to_super_app/

⁹¹ <https://sifted.eu/articles/revolut-super-app-travel-experience-bookings-news>

⁹² <https://www.yaguara.co/online-shopping-statistics>

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4.

Design and User Interfaces

4. Design and User Interfaces

The Shift towards Next Generation Interfaces

Mobile app interfaces are evolving driven by advancements in AI, AR/VR, and changing user behavior. Traditional tactile interfaces are giving way to more intuitive and immersive experiences, facilitated by voice commands, gestures, and personalization. Over the next five to ten years, these changes will redefine how users interact with mobile applications, with significant implications for user engagement and accessibility.

4.1 The rise of less-tactile interfaces — voice and gesture controls

The development of more accurate accelerometers and infrared cameras has resulted in the accelerated use of gesture recognition systems. Touchless gesture recognition includes the use of various techniques such as motion sensor fusion, camera-based gesture, proximity touchscreen, short-range wireless, eye-tracking, and voice recognition. Companies are doubling down on high-growth sectors like automotive, consumer electronics, and healthcare, where intuitive, hands-free controls improve safety and user experience.

For instance, Tesla's Autopilot integrates gesture recognition for in-car controls, while Apple's Vision Pro is redefining spatial computing with hand and eye-tracking.^{93 94} Healthcare applications, such as touch-free robotic surgery by companies like Intuitive Surgical, highlight the transformative potential of gesture-based interactions.⁹⁵

⁹³ <https://www.notateslaapp.com/news/2030/tesla-full-self-driving-to-recognize-hand-gestures-in-upcoming-update-according-to-employee>

⁹⁴ <https://www.apple.com/apple-vision-pro/>

⁹⁵ <https://www.intuitive.com/>

The market is estimated to grow, owing to advancements in technology such as AI/ML, IoT, big data, natural user interface (NUI), and increasing rate of adoption of gesture recognition technology in end-user segments.

Gesture-based controls, while innovative, face adoption challenges due to technological constraints and user habits. Mid-air hand gestures, eye-tracking, and facial recognition technologies are being explored but require further development before widespread implementation. As of now, BMW has revoked gesture control in their cars since people don't use them enough to justify their existence in the next-gen infotainment system. Users believe it's simpler and quicker to press the buttons on the steering wheel or touch the screen to increase volume or change songs. As the accuracy of gesture recognition technology improves, we may continue to see this input method rise over the next decade. **By 2031, gesture control will have a market value of over \$51 billion globally.**⁹⁶

Samsung's One UI integrates voice and gesture controls for accessibility, allowing users to interact with their devices without touching the screen.⁹⁷

Voice user interfaces (VUIs) and gesture controls are at the forefront of the next-generation mobile experience. Technologies such as Amazon Alexa, Google Assistant, and Apple's Siri have demonstrated the feasibility of voice-driven interactions. With AI advancements, VUIs are becoming more context-aware and responsive, enabling hands-free navigation (e.g., Google Assistant for app commands), improved accessibility (voice-controlled apps for visually impaired users), and natural language processing (NLP) enhancements for intuitive interactions.

4.2 Adoption of augmented reality and virtual reality

Augmented reality and virtual reality are introducing immersive, spatial, and gesture-driven interactions into user interfaces. Instead of static screens, interfaces now extend into three-dimensional spaces, allowing users to interact with digital elements naturally.

⁹⁶ <https://inkbotdesign.com/mobile-interface-design-trends/>

⁹⁷ <https://www.samsung.com/us/apps/one-ui/>

Retail and e-commerce leverage AR for virtual try-ons and product visualization, as seen in IKEA Place and Sephora Virtual Artist, improving usability by integrating real-world context. In education, platforms like Google Expeditions create interactive learning environments, while gaming experiences demonstrate how mobile AR interfaces engage users through intuitive overlays.

Leading tech companies such as Apple, Meta, and Google are embedding AR/VR into their ecosystems. Apple's Vision Pro introduces spatial UI, where app windows float in mixed reality, redefining interface design. Meta's VR platforms focus on social and workplace interactions, while Google's ARCore enhances mobile UI by integrating digital objects into the physical world.⁹⁸

As AR/VR adoption grows, UI design shifts toward gesture recognition, voice commands, and adaptive interfaces, prioritizing seamless interactions between physical and digital environments.

4.3 The Challenges with the Integration of AI

AI-driven features, including chatbots, will facilitate real-time, conversational interactions, improving user engagement and satisfaction. These intelligent systems can provide personalized assistance, streamline tasks, and predict user needs, making app interactions more efficient. The emergence of sophisticated AI models and their speed of adoption might also push user interfaces into directions that are difficult to predict - not all of them with beneficial outcomes.

AI adoption can lead to negative results, such as:

Increased development complexity

Increasingly complex AI systems face challenges in scalability, often requiring massive computational and energy resources to maintain performance.

Ethical and (gender and racial) bias issues

Biases inherent in the data used to train AI often permeate the model's outputs, which can lead to discriminatory outcomes such as racial or gender prejudice. Amazon built an AI-based tool to "out recruit" other tech firms in the tech brains arms race.⁹⁹ The company trained their models to look for top talent in the resumes, but used tainted data collected over a 10-year period in which the vast majority of candidates were men. The AI model gave higher priority to male resumes. After many attempts to make the program gender-neutral, Amazon gave up and disbanded the tool and the team.

When it comes to other ethical issues and danger, AI chatbots can be leveraged to engage in antisocial or illegal activities, such as learning how to create explosives, commit theft, or cheat in various scenarios, or spread misinformation, and promote offensive messages.¹⁰⁰

Deepfakes and content amplification

AI enables highly realistic, fabricated content (images, videos, and audio) designed to spread false narratives.

Misinformation campaigns and echo chambers

Automated bots can rapidly spread false information (echo chambers), creating a false perception of credibility or consensus.¹⁰¹ Personalization algorithms reinforce existing biases by presenting content aligned with users' beliefs, making distinguishing between true and false information harder, and lead to polarization.

⁹⁹ <https://www.reuters.com/article/us-amazon-com-jobs-automation-insight-idUSKCN1MK08G>

¹⁰⁰ <https://www.cutter.com/article/shining-light-ai%E2%80%99s-dark-side>

¹⁰¹ https://www.researchgate.net/publication/354459868_Filter_Bubbles_Echo_Chambers_and_Fake_News_How_Social_Media_Conditions_Individuals_to_Be_Less_Critical_of_Political_Misinformation

User over-dependency and loss of human control

AI is flawed, struggles with moral decision-making and often depends on human oversight for critical functions.¹⁰² Human oversight in AI systems faces several significant challenges, stemming from the complexity, scale, and partial or full autonomy of modern AI technologies.¹⁰³ Many AI models, especially deep learning systems, operate as "black boxes," making their decision-making processes opaque and difficult for humans to interpret. Also, AI systems process vast amounts of data and perform tasks at speeds beyond human cognitive capability, which renders continuous human supervision infeasible. This complicates oversight, particularly in high-risk applications where understanding the rationale behind AI decisions is critical and may harm humans.¹⁰⁴ A tendency to over-rely on automation for oversight where humans uncritically accept AI outputs, too is a problem. This problem is further compounded by a shortage of professionals with the interdisciplinary knowledge necessary to oversee complex AI systems effectively.¹⁰⁵

Autonomous driving fatalities

An Uber self-driving experiment was called off after the self-driving car killed a pedestrian in Tempe, Arizona.¹⁰⁶ The victim was fatally struck by the Uber test vehicle while pushing a bicycle across a four-lane road away from a crosswalk. The National Transportation Safety Board determined the AI failed to classify the jaywalking pedestrian as such, as the object was not near a crosswalk as expected under normal circumstances.¹⁰⁷ This means the training and AI models were not properly implemented.

¹⁰² https://www.cutter.com/article/shining-light-ai%E2%80%99s-dark-side?utm_source=chatgpt.com

¹⁰³ <https://www.sciencedirect.com/science/article/pii/S1871678424005636#bib6>

¹⁰⁴ <https://www.sciencedirect.com/science/article/pii/S1871678424005636>

¹⁰⁵ <https://www.sciencedirect.com/science/article/pii/S1871678424005636>

¹⁰⁶ <https://www.bbc.com/news/technology-54175359>

¹⁰⁷ <https://www.nbcnews.com/tech/tech-news/self-driving-uber-car-hit-killed-woman-did-not-recognize-n1079281>

Privacy and security risks

AI systems are vulnerable to sophisticated cyberattacks, including those engineered by other AI systems. Additionally, users may expose sensitive personal or business information by sharing it with chatbots like ChatGPT. Hackers could potentially store, analyze, or misuse this data, raising significant security, ethical, and privacy concerns.¹⁰⁸

Mitigating strategies

- Transparent messaging
- Bias audits
- Minimizing data collection
- Offering manual overrides and customization options
- Continuous monitoring and updating of AI models
- Establishing legal and moral guidelines

4.4 Security and Biometric Authentication — Addressing Privacy Concerns

As mobile interfaces become more advanced, security measures must evolve accordingly. Biometrics such as fingerprint scanning and facial recognition provide better security while simplifying access.

Key trends

Multi-modal authentication utilizes multiple biometric identifiers to verify a user's identity. These identifiers can be physiological (fingerprint, iris), behavioral (voice, gait), or a pin. By combining these modalities, the system creates a more unique and spoof-resistant profile compared to single-factor authentication methods. Traditional biometric authentication occurs during the initial login.¹⁰⁹ However, the future trend is continuous authentication. Systems will monitor users throughout their sessions, analyzing behavioral cues (typing speed, mouse movements, etc.) to ensure ongoing security.¹¹⁰

AI-assisted fraud detection

AI identifies deviations from normal behavioral patterns, such as unusual login times or locations, flagging potential breaches. This way, systems can prevent unauthorized access and detect fraud attempts in sensitive environments like banking or healthcare.

Privacy-focused UI elements

In 2023 Apple introduced App Tracking Transparency that requires app developers to request explicit permission from users before tracking their activity across other apps and websites.¹¹¹ Samsung's Knox Security integrates biometric authentication with AI-driven threat detection to prevent unauthorized access.¹¹²

¹⁰⁹ <https://fastercapital.com/keyword/biometric-authentication.html>

¹¹⁰ <https://fastercapital.com/keyword/behavioral-cues.html>

¹¹¹ <https://appsamurai.com/blog/app-tracking-transparency/>

¹¹² <https://news.samsung.com/ph/samsung-one-ui-7-enhances-security-and-privacy-in-the-age-of-ai-giving-users-greater-transparency-and-choice>

4.5 Cross-Platform Compatibility: Unifying User Experience

With an increasing number of interconnected devices, cross-platform app development is crucial for maintaining consistency across smartphones, tablets, wearables, and smart home devices.

Users are increasingly going to turn to apps that play nice with the other apps,

”

said our VP of Business Development Woody Zantzinger.¹¹³

Strategies for seamless cross-platform UI

Progressive web apps (PWAs)

PWAs are web apps available to users from any browser. Examples of such web apps range from Google Sheets to online stores.¹¹⁴ Modern PWAs offer a consistent experience across devices, including iPad web apps, smartphones, and PCs. Examples of progressive apps are Uber, Tinder, Pinterest, Spotify, Google Maps.¹¹⁵

Universal design systems

The two main options for developers are React Native, made by Meta and based on JavaScript, and Flutter, made by Google and using the newer Dart language.¹¹⁶ The primary appeal of both React Native and Flutter is largely the same.

¹¹³ <https://www.willowtreeapps.com/insights/mobile-app-development-trends-2025>

¹¹⁴ <https://www.transcenda.com/insights/mobile-development-trends>

¹¹⁵ <https://onilab.com/blog/20-progressive-web-apps-examples>

¹¹⁶ <https://www.nomtek.com/blog/flutter-vs-react-native>

Developers can work on a single code base in one unified team, preventing silos, disconnect, and extra spending. Because apps require long-term upkeep after they go live, the budgetary and functional advantages of cross-platform development keep paying off over time.

Cloud-synced interfaces

These interfaces enable cross-device user experiences by storing data, settings, and interactions in the cloud. Instead of relying on local storage, applications sync across smartphones, tablets, desktops, and even wearables, ensuring continuity and accessibility. Users can start a task on one device and resume on another without interruption, for example using Google Drive. Cloud-based interfaces enable multi-user interactions in real time, as seen in Google Docs, Figma, and Notion. Apps like Spotify and Netflix adjust recommendations across devices by syncing user behavior.

4.6 User Well-Being — Designing Interfaces for Digital Health

Concerns about screen addiction and doom scrolling have prompted UI designers to implement strategies promoting healthier digital habits.

Design frictions are intentional pauses to prevent excessive usage. Study found that short design frictions introduced by one sec effectively reduce how often users attempt to open target apps and lead to more intentional app-openings over time.¹¹⁷

Video interrupters — TikTok launched daily screen time limits in February 2020, enlisting top creators who encouraged users to keep tabs on their viewing habits.¹¹⁸ Videos reminded users to take a break from their phones and "do something IRL." TikTok also introduced a Screen Time Management setting, which lets users choose a time cap that can be locked behind a four-digit passcode.

¹¹⁷ https://www.researchgate.net/publication/377774169_A_Longitudinal_In-the-Wild_Investigation_of_Design_Frictions_to_Prevent_Smartphone_Overuse

¹¹⁸ <https://newsroom.tiktok.com/en-us/helping-users-manage-their-screen-time>

Well-being metrics like screen time monitoring and usage nudges are now built into most smartphones.¹¹⁹ However, fighting technology with technology may pose a conflict of interest, since phone manufacturers or app designers may be financially motivated to maximize rather than reduce engagement.¹²⁰ Google's Digital Wellbeing features include app timers and grayscale mode to reduce screen fatigue. iPhones also have screen time reports, including time spent using certain kinds of apps, how often the iPhone and other devices were picked up, which apps send the most notifications, and more.¹²¹

4.7 Emphasis on Minimalist and Adaptive Design

Minimalist design principles prioritize simplicity, reducing cognitive load and improving navigation. Adaptive interfaces leverage AI to modify layouts and content dynamically based on user behavior, device type, and environmental conditions.¹²² This results in cleaner, more intuitive UI (Google's Material You), AI-driven personalization (Netflix and Spotify recommendations), adaptive themes for accessibility (Apple's dark mode and color contrast settings).

Minimalist design contributors

White spaces, also known as negative space, play a crucial role in minimalistic UI design. These empty areas within the interface guide users' attention to essential elements, improve readability, and contribute to the overall aesthetics of the application. Research indicates that proper utilization of white space can increase comprehension by up to 20%.¹²³

¹¹⁹ <https://pmc.ncbi.nlm.nih.gov/articles/PMC9112639/#CR88>

¹²⁰ <https://pmc.ncbi.nlm.nih.gov/articles/PMC9112639/#CR71>

¹²¹ <https://support.apple.com/guide/iphone/get-started-with-screen-time-iphbfa595995/ios#:~:text=View%20your%20Screen%20Time%20summary,Go%20to%20Settings%20%E2%3E%20Screen%20Time.>

¹²² <https://arxiv.org/pdf/2404.11370>

¹²³ <https://www.okoone.com/spark/product-design-research/how-creating-a-minimalist-ui-design-can-help-mobile-app-performance/>

Cohesive color scheme that aligns with the brand's identity and resonates with the target audience.

Clear and legible typography improves app readability and accessibility for users. Studies have shown that typography influences user perception of a brand, with 38% of consumers stating they would stop engaging with a website if the content or layout is unattractive.¹²⁴

Simple, intuitive navigation is paramount in minimalistic UI design, so that users can easily find and access the content they need. Complex navigation structures can lead to frustration and abandonment, with 94% of users citing ease of navigation as the most important website feature.¹²⁵

Implementing minimalistic UI design doesn't come without challenges. While simplifying the UI design is essential, there's a risk of oversimplification that may result in the omission of critical functionalities. Developers must strike a balance between simplicity and functionality and meeting user's needs without sacrificing essential features. Along with this, minimalistic UI designs run the risk of appearing dull or boring if not executed effectively. To prevent user boredom, developers must incorporate engaging micro-animations, subtle visual cues, and thoughtful interactions that improve the user experience without adding unnecessary complexity.

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<https://www.okoone.com/spark/product-design-research/how-creating-a-minimalist-ui-design-can-help-mobile-app-performance/>

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<https://www.okoone.com/spark/product-design-research/how-creating-a-minimalist-ui-design-can-help-mobile-app-performance/>

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5.

AI in Mobile Development

5. AI in Mobile Development

AI — Transforming Mobile Development

AI is transforming mobile development with automated coding, AI-driven testing, and performance optimization, making apps faster and highly adaptive to user needs.

5.1 Automated App Development and Testing

Developers save time thanks to AI

AI is significantly accelerating mobile development through automation tools that assist developers. Tools like GitHub Copilot and OpenAI Codex cut development time by up to 55% by suggesting reusable and maintainable code.¹²⁶ They reduce time spent on pull requests and reviews, allowing developers to focus on high-priority tasks. Higher quality code from the start minimizes rollbacks and extra testing.¹²⁷

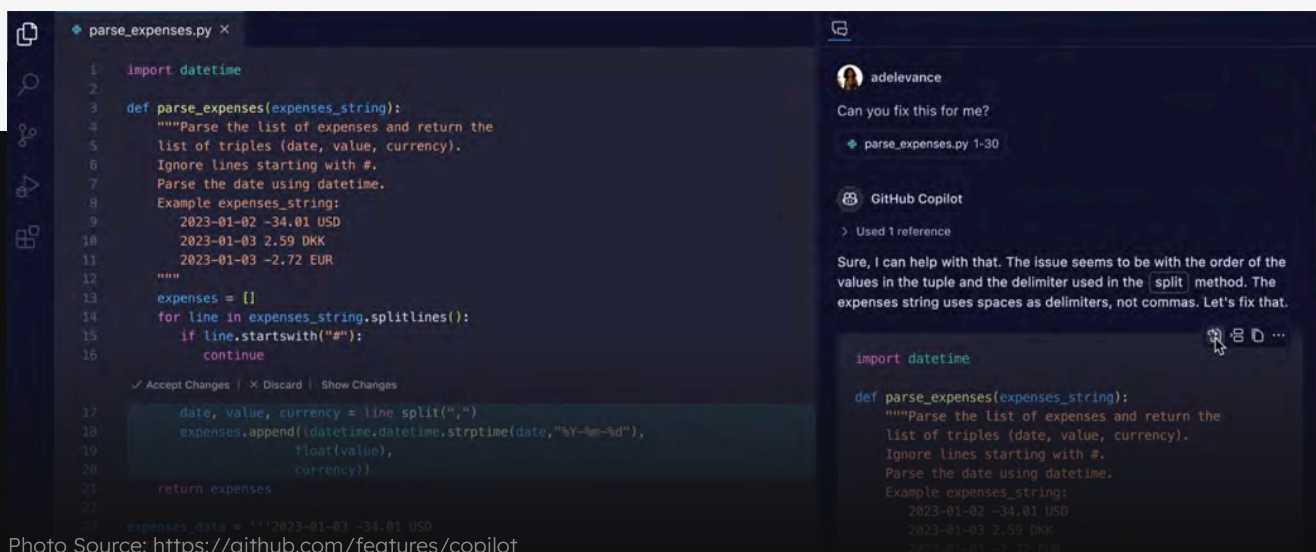


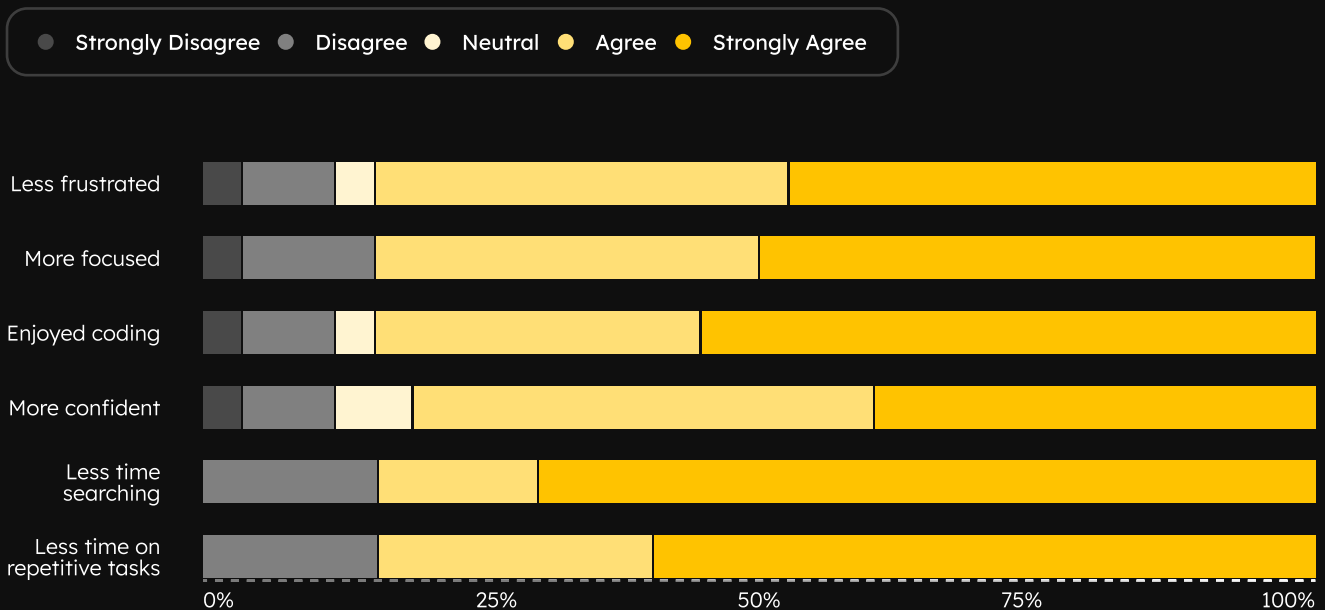
Photo Source: <https://github.com/features/copilot>

¹²⁶ <https://github.blog/news-insights/research/research-quantifying-github-copilots-impact-on-code-quality/>

¹²⁷ <https://github.blog/news-insights/research/research-quantifying-github-copilots-impact-on-code-quality/>

Participant Rating:

Authoring and reviewing code with GitHub Copilot Chat



Source: <https://github.blog/news-insights/research/research-quantifying-github-copilots-impact-on-code-quality/>

Automated testing — AI-driven platforms like Test.ai and AppliTools analyze UI and functionality in real-time, catching bugs instantly, significantly faster than manual testing. This means fewer crashes and smoother updates.¹²⁸ Plus, automation frees up developers to focus on innovation instead of debugging.

Easy updates, fewer headaches — CircleCI and GitHub Actions are AI-powered continuous integration and deployment (CI/CD) tools that decrease the launching of new app updates. By predicting deployment failures before they happen, AI helps developers catch issues early, preventing buggy releases and downtime.¹²⁹

¹²⁸ <https://medium.com/@GetInRhythm/enhancing-test-automation-with-visual-ai-using-applitoools-25eb5273c118>

¹²⁹ <https://www.bdcglobal.com/blog/ai-revolutionizing-devops-automating-ci-cd-pipelines/#:~:text=How%20does%20AI%20improve%20CI,deployment%20faster%20and%20more%20reliable.>

5.2 AI — Increasing Mobile Performance

App performance optimization

AI can make apps faster and smarter. Here's how:

Predictive caching — Thanks to AI predicting a viewer's next move, Netflix is preloading content before a tap or click.

Battery and resource optimization — AI-powered features like Google's Adaptive Battery learn the usage patterns and cut down unnecessary background processes, so the phone battery lasts longer.¹³⁰

Performance monitoring and crash detection — AI tools like Instabug and Firebase Performance Monitoring analyze crashes and detect slowdowns, helping developers fix issues.

Adaptive performance scaling — AI adjusts CPU and GPU usage for high-performance tasks like gaming and video editing. Samsung's AI-based Game Booster optimizes frame rates, while Apple's Neural Engine enhances efficiency in resource-intensive apps.¹³¹

AI-driven apps adjust network usage based on connectivity conditions. Facebook's AI-powered network adaptation optimizes video quality on slow connections, while Google Duo's AI-enhanced calls maintain quality even on weak signals.¹³²

AI automates app maintenance by detecting unused features, optimizing databases, and reducing storage bloat. Android's AI-powered storage management suggests clearing unused files, while Google Photos' AI-driven cleanup helps free up space.¹³³

¹³⁰ <https://support.google.com/pixelphone/answer/7015477?hl=en>

¹³¹ <https://resources.compugen.com/en-ca/blog/how-apples-npu-technology-offers-an-edge-for-ai-workloads-in-education-and-enterprise>

¹³² <https://voicebot.ai/2020/04/23/google-is-using-ai-to-fill-in-gaps-in-duo-calls/>

¹³³ <https://www.news18.com/tech/google-photos-is-now-using-ai-to-clean-up-your-gallery-and-arrange-them-in-order-heres-how-8757793.html>

5.3 AI-Driven Personalization and Ultrapersonalization

Ultrapersonalized experience that drives engagement

Hyper-personalization is becoming the standard in mobile applications, leveraging AI to analyze vast amounts of user behavior, preferences, and environmental data in real time. By leveraging machine learning (ML) models, natural language processing (NLP), and predictive analytics, AI enables mobile apps to deliver highly curated and responsive experiences that evolve with the user.

Content recommendation systems drive engagement by predicting what users want before they even search. Netflix uses deep learning to analyze viewing history and personalize thumbnails.¹³⁴ Spotify's Discover Weekly applies collaborative filtering to suggest music based on listening habits. TikTok's For You Page (FYP) curates video feeds using reinforcement learning, factoring in watch time, interactions, and user behavior patterns.¹³⁵

UI dynamic customization — platforms like Android's Material You and Apple's iOS Adaptive UI use AI to modify UI elements dynamically. Material You adjusts app themes based on user wallpaper and preferences, while iOS Smart Widgets rearrange based on usage patterns.¹³⁶ AI also improves accessibility, such as iOS Voice Control, which adapts the interface for hands-free navigation.¹³⁷

Context-aware applications — AI enables apps to react to real-world conditions, adapting content and functionality based on time, location, and activity. Google Assistant Routines automate tasks like adjusting smart home settings when a user arrives home.¹³⁸ Starbucks' AI-powered Deep Brew customizes app promotions and order suggestions based on the user's location, weather, and previous orders.¹³⁹

¹³⁴ <https://netflixtechblog.com/>

¹³⁵ <https://www.nytimes.com/2021/06/22/technology/tiktok-algorithm.html>

¹³⁶ <https://source.android.com/docs/core/display/material>

¹³⁷ <https://developer.apple.com/accessibility/>

¹³⁸ <https://support.google.com/googlenest/answer/7029585?hl=en&co=GENIE.Platform%3DAndroid>

¹³⁹ <https://aiexpert.network/case-study-starbucks-revolutionizes-the-coffee-experience-with-ai/>

5.4 AI in Client-Facing Solutions: Chatbots and Virtual Assistants

AI-powered mobile chatbots and virtual assistants are increasing customer engagement, automating support, and improving user experience. Advances in natural language processing, machine learning, and speech recognition let AI understand context, respond conversationally, and provide hands-free interactions.

NLP and AI chatbots

AI-driven chatbots leverage NLP to interpret and respond to user queries in real time, significantly improving customer service efficiency. ChatGPT and Google Bard provide detailed, human-like interactions for customer support, content recommendations, and task automation.¹⁴⁰ NLP-powered voice assistants such as Siri and Google Assistant handle commands, answer questions, and integrate with mobile apps for smart home control. In banking and fintech sectors, chatbots like Erica (Bank of America), who handles hundreds of millions of inquiries a year from BofA's customers, provide financial insights, alert users about transactions, and automate bill payments.¹⁴¹ Roughly four out of every ten Americans interacted with a bank chatbot last year, a figure they expect will grow.¹⁴²

5.5 AI for Accessibility and Security

AI is refining mobile app accessibility and security, resulting in a more inclusive and safer digital experience for users.

In accessibility, AI-powered speech-to-text and text-to-speech technologies, such as Google Live Transcribe, provide real-time transcription services, making communication easier for individuals with hearing impairments.

¹⁴⁰ <https://openai.com/chatgpt/>

¹⁴¹ <https://www.pbs.org/newshour/economy/customer-service-chatbots-used-by-banks-raises-concerns-for-consumer-watchdog>

¹⁴² <https://www.pbs.org/newshour/economy/customer-service-chatbots-used-by-banks-raises-concerns-for-consumer-watchdog>

Dynamic UI adjustments, including adaptive font sizing and contrast optimization (for example in Apple’s VoiceOver and Android’s TalkBack) improve readability and usability. AI-driven gesture recognition enables touchless navigation, offering independence for users with mobility impairments.

For security, AI can mitigate risks and safeguard mobile applications. Fraud detection systems, like PayPal’s AI-driven security layers, analyze behavioral patterns to identify suspicious activity and prevent financial fraud.¹⁴³ Biometric authentication, including AI-powered facial recognition and fingerprint scanning technologies, such as Face ID, adds an extra layer of security. AI-powered tools like Zimperium proactively identify malware and vulnerabilities.¹⁴⁴

5.6 The Future of AI in Mobile App Personalization

Blurring the line between digital and real life

With emotion-aware AI, neural interfaces, and adaptive biometrics, AI will continue blurring the lines between digital and real-world experiences. Future AI-driven personalization will include real-time mood-based recommendations, voice emotion detection for customer service, and predictive lifestyle adjustments based on passive behavioral tracking.

Emotion AI

Companies like Affectiva have pioneered Emotion AI, developing machine learning-based software that detects human emotions by analyzing non-verbal cues such as facial expressions, gestures, and body language.¹⁴⁵

¹⁴³ <https://www.restack.io/p/paypal-ai-answer-fraud-detection-cat-ai>

¹⁴⁴ <https://www.zimperium.com/>

¹⁴⁵ <https://www.affectiva.com/emotion-ai>

AI in customer service

In customer service, AI systems are being designed to detect emotions in voice, allowing for more empathetic and effective interactions. These systems analyze acoustic elements of speech, such as intonation, volume, and speech rate, to interpret emotional states.¹⁴⁶

67% of consumers already prefer AI-powered personal assistants for simplifying daily tasks.¹⁴⁷ Companies integrating personalized AI assistants into their apps can differentiate themselves in a competitive market while increasing user engagement and retention.

A more intuitive AI future

AI-driven personalization is advancing to include real-time mood-based recommendations and predictive lifestyle adjustments based on passive behavioral tracking. For example, AI-powered sentiment analysis algorithms can discern emotions expressed in social media posts, letting researchers and mental health organizations monitor shifts in public sentiment and provide timely interventions.¹⁴⁸

These developments suggest a future where AI not only responds to user commands but also adapts to their emotional and behavioral contexts, creating more personalized and intuitive experiences.

¹⁴⁶ <https://www.nice.com/info/the-power-of-emotion-detection-in-voice-ai-enhancing-human-computer-interaction>

¹⁴⁷ <https://cxtrends.zendesk.com/>

¹⁴⁸ <https://pmc.ncbi.nlm.nih.gov/articles/PMC10982476>

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6.

Security and Privacy

6. Security and Privacy

Security and privacy are paramount concerns for AI implementations. As AI systems increasingly integrate into various sectors, robust safeguards for data and operations are essential.

6.1 AI Regulatory Frameworks in the European Union (EU)

The EU has implemented several directives to improve cybersecurity and data protection.

General Data Protection Regulation (GDPR): Enforced since May 2018, GDPR sets stringent standards for personal data protection, mandating that organizations obtain explicit consent for data processing and ensure data subjects' rights are upheld.¹⁴⁹ It's the toughest privacy and security law in the world. Though it was drafted and passed by the European Union (EU), it imposes obligations onto organizations anywhere, so long as they target or collect data related to people in the EU. The GDPR will levy harsh fines against those who violate its privacy and security standards, with penalties reaching into the tens of millions of euros.

Network and Information Security Directive 2 (NIS2): Effective from October 17, 2024, NIS2 establishes minimum cybersecurity requirements for essential and important entities across sectors such as energy, transport, finance, health, and digital infrastructure. The directive mandates that each Member State adopt a national cybersecurity strategy, which includes policies for supply chain security, vulnerability management, and cybersecurity education and awareness. Organizations must implement risk management measures and report incidents promptly.¹⁵⁰

¹⁴⁹ <https://gdpr.eu/what-is-gdpr/>

¹⁵⁰ <https://nis2directive.eu/who-are-affected-by-nis2>

Digital Operational Resilience Act (DORA): Applicable from January 17, 2025, DORA focuses on the financial sector, requiring firms to maintain robust operational resilience against ICT-related incidents, including comprehensive testing and third-party risk management.¹⁵¹

AI Act — Regulation (EU) 2024/1689 laying down harmonized rules on artificial intelligence. This regulation proposed in 2021, when implemented, will mandate AI systems to be analysed and classified according to the risk they pose to users.¹⁵² The different risk levels will mean more or less regulation. High-risk AI applications must meet specific cybersecurity requirements to mitigate potential vulnerabilities. When implemented, it will be the world's first comprehensive AI law.

According to the AI Act, unacceptable risk AI systems are systems considered a threat to people and will be banned.¹⁵³ They include:

- Cognitive behavioral manipulation of people or specific vulnerable groups: for example voice-activated toys that encourage dangerous behaviour in children
- Social scoring: classifying people based on behaviour, socio-economic status or personal characteristics
- Biometric identification and categorisation of people
- Real-time and remote biometric identification systems, such as facial recognition

6.2 AI Legal Initiatives in the United States

Executive Order on AI. On January 23, 2025, President Donald J. Trump signed an executive order titled "Removing Barriers to American Leadership in Artificial Intelligence." This directive aims to cement the United States' global dominance in AI by eliminating existing policies perceived as obstacles to innovation.

¹⁵¹ https://www.eiopa.europa.eu/digital-operational-resilience-act-dora_en

¹⁵² <https://www.europarl.europa.eu/topics/en/article/20230601STO93804/eu-ai-act-first-regulation-on-artificial-intelligence>

¹⁵³ <https://www.europarl.europa.eu/topics/en/article/20230601STO93804/eu-ai-act-first-regulation-on-artificial-intelligence>

Notably, it revokes Executive Order 14110, issued on October 30, 2023, by former President Joe Biden, which focused on the safe, secure, and trustworthy development of AI. The new order mandates the development of an action plan within 180 days to promote AI systems free from “ideological bias and engineered social agendas”¹⁵⁴ In conjunction with this order, President Trump announced a \$500 billion AI infrastructure project named “Stargate,” in partnership with companies like OpenAI, Oracle, and SoftBank.¹⁵⁵ The new order emphasizes economic competitiveness and national security, potentially at the expense of ethical considerations in AI deployment.¹⁵⁶

California Consumer Privacy Act (CCPA). As a state-specific law in the United States, the CCPA provides California residents with rights similar to GDPR, including data access, deletion, and opt-out of data selling.¹⁵⁷ It mandates transparency in data collection and sharing practices and applies to businesses that meet certain criteria, such as revenue thresholds or data processing volumes.

6.3 Authentication Methods and Data Security

Authentication methods

To strengthen security and privacy, new authentication methods are being adopted:

Passkeys — As a passwordless authentication method, passkeys allow users to sign in to apps and websites by leveraging the device’s locking mechanism, whether based on biometrics (e.g., Face ID, Touch ID, or fingerprint), PIN code, or another method, reducing reliance on traditional passwords and enhancing security.¹⁵⁸

¹⁵⁴ <https://www.whitehouse.gov/presidential-actions/2025/01/removing-barriers-to-american-leadership-in-artificial-intelligence/>

¹⁵⁵ <https://www.businessinsider.com/trump-wants-us-create-ai-action-plan-180-days-2025-1?IR=T>

¹⁵⁶ <https://apnews.com/article/trump-ai-artificial-intelligence-executive-order-eef1e5b9bec861eaf9b36217d547929c>

¹⁵⁷ <https://www.wearediagram.com/blog/first-party-data-privacy-compliant-strategies>

¹⁵⁸ <https://developers.google.com/identity/passkeys>

Insights on data security and consumer trust

Understanding the nuances of customer data collection is pivotal for crafting privacy-compliant strategies that not only respect consumer preferences but also fuel business growth.

First-party data

First-party data is information a company collects directly from its customers or users through its own channels, such as websites, mobile apps, social media pages, and loyalty programs. Unlike third-party data, which comes from external sources, first-party data is more accurate, privacy-compliant, and valuable for personalized marketing, customer insights, and business growth.

The business significance of first-party data

1. Higher accuracy and reliability

Since first-party data is collected directly from users, it's more accurate, relevant, and reliable than third-party data, thus better for decision-making.

2. Privacy compliance and competitive advantage

With growing data privacy regulations (e.g., GDPR, CCPA) and the decline of third-party cookies, businesses that prioritize first-party data gain a competitive edge by staying compliant while maintaining effective targeting strategies.

3. Personalized marketing and customer retention

First-party data enables hyper-personalized marketing, improving customer retention and loyalty through custom recommendations, dynamic content, and personalized offers.

4. Predictive analytics and business insights

By analyzing first-party data, businesses can forecast customer behavior, optimize pricing strategies, and refine product development based on real user interactions.

5. Fraud detection and risk management

Patterns from first-party data help detect fraudulent activities, mitigate risks, and strengthen security in transactions and account activities.

Customer trust concerns

Consumer trust concerns — A significant portion of consumers express distrust toward social media payment systems, underscoring the need for transparent privacy practices and robust security measures to build and maintain user trust. **56% of respondents do not trust sharing personal details virtually** because they do not trust privacy with AI.¹⁵⁹

Rise in mobile fraud — As of 2025, mobile fraud continues to escalate, with financial losses projected to reach \$45 billion this year.¹⁶⁰ AI-enabled scams, including deepfakes and AI-based phishing, have become more prevalent, posing new challenges to financial institutions and consumers.¹⁶¹ AI-powered systems analyze vast datasets to identify anomalies and predict fraudulent activities with remarkable accuracy. Studies indicate that these systems achieve **accuracy rates exceeding 90%**, significantly outperforming traditional methods.¹⁶² In response to these evolving threats, major corporations are investing heavily in AI-driven cybersecurity solutions. For instance, Mastercard's acquisition of Recorded Future for \$2.65 billion aims to enhance fraud detection capabilities through AI, doubling the identification rate of compromised credit cards.¹⁶³

¹⁵⁹ <https://nielseniq.com/global/en/insights/report/2024/mid-year-consumer-outlook-guide-to-2025/>

¹⁶⁰ <https://kaleidointelligence.com/mobile-security-losses-2025/>

¹⁶¹ <https://pointpredictive.com/emerging-threats-of-ai-enabled-fraud>

¹⁶² https://www.bombaysoftwares.com/blog/ai-in-fraud-detection?utm_source=chatgpt.com

¹⁶³ <https://www.marketwatch.com/story/mastercard-paying-2-65-billion-for-cyber-security-company-that-uses-ai-58fc625d>

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7.

Business and Monetization Models

7. Business and Monetization Models

New approach to monetization

Businesses are continually exploring innovative monetization strategies. Emerging models such as **flexible subscriptions, pay-per-use (PPU) frameworks, and dynamic pricing** are at the forefront of this transformation.

Flexible subscriptions

Flexible subscription models let users customize their service experiences according to individual preferences, offering refinement in areas like delivery frequency, product selection, and service tiers. This approach not only increases user satisfaction but also fosters customer loyalty. It works for several reasons: it simplifies reordering for regular customers. It keeps customers engaged by adjusting subscriptions to their needs. It encourages upgrades with exclusive benefits.

Build-a-Box options — Companies like Perlego, a digital library service, let users select specific content for their subscriptions, providing access to a vast range of textbooks and academic resources.¹⁶⁴

Flexible delivery — Services offer varied delivery schedules (weekly, bi-weekly, or monthly) catering to user needs and convenience.

Pause or skip features — Subscribers can pause or skip services as needed, offering control over their subscriptions.

Tiered plans — Introducing multiple subscription tiers with benefits like ad-free experiences, exclusive content, or bundled services has become a prevalent strategy. For instance, streaming platforms are adopting hybrid models that combine ad-supported and premium tiers to cater to diverse consumer preferences.¹⁶⁵

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<https://www.thetimes.co.uk/article/subscription-works-for-music-and-films-it-works-for-study-too-enterprise-network-6mg2k5nfj>

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<https://www.pymnts.com/subscription-commerce/2025/beyond-flat-fees-the-rise-of-hybrid-subscription-models>

Pay-per-use (PPU)

The PPU model charges customers based on actual usage, offering a cost-effective alternative to traditional subscription services. PPU is increasingly popular across various industries, including utilities, software, and shared services. It's cost efficient. Users pay solely for the services they utilize, which can be more economical for those with variable usage patterns. It encourages responsible consumption by linking costs directly to usage. Allows businesses to attract a broader customer base by lowering the barrier to entry, potentially increasing overall revenue.

In this model it is difficult to predict income for businesses due to the ad-hoc nature of customer usage. It also requires sophisticated tracking and billing systems (investment in technology) to manage usage accurately and ensure transparent customer invoicing.

Dynamic pricing

Dynamic pricing involves adjusting prices in real-time based on factors such as demand fluctuations, market conditions, and consumer behavior. This strategy is prevalent in industries like travel, entertainment, and retail.

The integration of artificial intelligence allows for more precise pricing adjustments by analyzing vast datasets to predict market trends and consumer responses.¹⁶⁶ Businesses can offer personalized pricing based on individual user data. Coordinating pricing across various platforms, for example on Airbnb and Booking.com, ensures consistency and maximizes reach.

While dynamic pricing can optimize profits and resource utilization, it necessitates careful management to maintain customer trust and prevent perceptions of unfairness.

Buy now, pay later (BNPL)

Embedded finance features like BNPL and payment plans, are being integrated into apps to open new revenue streams. In 2022, 21.2% of consumers with a credit report financed at least one purchase with a BNPL loan — most of these borrowers had a low credit score.¹⁶⁷ Popular BNPL apps include Klarna, Afterpay, Affirm, Sezzle. Companies can boost customer loyalty and profitability by incorporating embedded financial services into their apps.

Freemium

Freemium models offer a basic version of a product or service for free, with the option to pay for additional features. The goal is to attract a big number of users to the service and convert them into paying customers. Though many of these users may not be explicitly purchasing upgrades or items, the company can collect their user information and data, show them ads to make revenue, and boost their own business numbers to continue to improve the application.¹⁶⁸

It works well for internet-based businesses with small customer acquisition costs, but high lifetime value.¹⁶⁹ Combined with in-app purchases, freemium models continue to dominate mobile monetization strategies, but there's increasing pressure to innovate due to rising acquisition costs. Analyzing user spending behavior is key to optimizing monetization strategies.

Mobile app industry implications

The adoption of these monetization strategies is reshaping the mobile app ecosystem. Notably, regulatory changes like the EU's Digital Markets Act are opening app ecosystems, enabling alternative marketplaces and payment methods.

¹⁶⁷ <https://www.consumerfinance.gov/about-us/newsroom/cfpb-research-reveals-heavy-buy-now-pay-later-use-among-borrowers-with-high-credit-balances-and-multiple-pay-in-four-loans/>

¹⁶⁸ <https://www.investopedia.com/terms/f/freemium.asp#:~:text=Freemium%20is%20a%20business%20model,term%20was%20coined%20in%202006.>

¹⁶⁹ <https://www.investopedia.com/terms/a/acquisition-cost.asp>

Companies such as Epic Games and Microsoft are planning expansions into mobile gaming, leveraging these new opportunities.¹⁷⁰

This shift reduces reliance on dominant platforms like Apple and Google, creating opportunities for businesses to diversify revenue streams and reach broader audiences. Companies can adapt by exploring partnerships with alternative app stores.¹⁷¹

Additionally, the rise of ad-supported and hybrid app models reflects a shift towards more flexible consumer behaviors, especially in markets experiencing subscription fatigue.

¹⁷⁰ <https://www.reuters.com/technology/epic-games-kicks-off-plan-add-third-party-games-own-mobile-store-2025-01-23/>

¹⁷¹ <https://landing.kantarmedia.com/mtp25#about>

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8.

The Future of App Development

8. The Future of App Development

Developers have for some time been moving away from native applications toward more versatile and efficient alternatives. This transition is driven by advancements in cross-platform frameworks, Progressive Web Apps (PWAs), and no-code/low-code development platforms, which now offer comparable performance and user experiences without the redundancy of developing separate codebases for iOS and Android.

The decline of native mobile development

Historically, native app development was the gold standard for delivering optimal performance and seamless user experiences on mobile devices. However, maintaining distinct codebases for multiple platforms has become increasingly resource-intensive. With alternative technologies matching native apps in features and performance, the incentive to invest in native development has diminished. For most applications, initiating development with a native-only approach is no longer justifiable.

No-code and low-code development platforms

The demand for rapid application development has led to the proliferation of no-code and low-code platforms. They lower the barrier to entry, enabling the creation of functional applications quickly. Built atop cross-platform frameworks, they offer rich component libraries and increasingly integrate AI to expedite development processes. In case, some very specific native features are necessary, falling back to the native layer is possible in both frameworks with little overhead.

Embracing cross-platform solutions

Cross-platform frameworks like Flutter, React Native, and Kotlin Multiplatform have matured, enabling developers to create applications that are virtually indistinguishable from native ones.

1. **React Native** — Adopted by industry leaders such as Shopify and Coinbase, React Native facilitates efficient development across platforms. Shopify recently completed a significant migration of its mobile app to React Native, consolidating over a decade's worth of development into a unified codebase.¹⁷² Similarly, Coinbase successfully transitioned its onboarding flows to React Native, enhancing team velocity and maintaining high-quality standards.¹⁷³
2. **Flutter** — Google's UI toolkit, Flutter, has seen substantial growth, with over 1 million monthly active developers worldwide. It powers nearly 30% of all new iOS apps, offering a vast component library and tooling support.¹⁷⁴
3. **Kotlin Multiplatform** — While less mature than its counterparts, thanks to its closer integration with Android, Kotlin allows for smooth gradual integration into existing solutions. Using Kotlin with Compose Multiplatform mirrors Kotlin with Jetpack Compose on Android and Swift with SwiftUI on iOS, allowing developers to adapt quickly.¹⁷⁵

The rise of Progressive Web Apps (PWAs)

Progressive Web Apps (PWAs) provide app-like experiences directly through web browsers while maintaining cross-device compatibility. They support features like offline access, push notifications, and home screen installation without requiring an app store download. Modern PWAs offer a consistent experience across devices, including iPad web apps, smartphones, and PCs. Examples of progressive apps are Spotify web player, Starbucks PWA, Aliexpress.¹⁷⁶ While they may be less performant than on-device apps, the gap continues to narrow as web technologies advance.¹⁷⁷

¹⁷² <http://x.com/mustafa01ali/status/1853619638141071573>

¹⁷³ <https://www.coinbase.com/blog/onboarding-thousands-of-users-with-react-native>

¹⁷⁴ https://medium.com/%40Kevin_Finnerty_Gabagool/flutter-development-in-2025-2442ab0f6d36

¹⁷⁵ <https://kotlinlang.org/docs/multiplatform.html>

¹⁷⁶ <https://onilab.com/blog/20-progressive-web-apps-examples>

¹⁷⁷ <https://whatpwacando.today>

Conclusion

The strategic adoption of emerging mobile technologies can position businesses for increased competitiveness and growth. IoT, wearables, AI-driven interfaces, and mobile-centric business models offer tangible benefits, including improved productivity and deeper customer engagement. However, realizing these advantages requires careful planning around security, privacy, and sustainability considerations.

Companies investing thoughtfully in innovations such as on-device AI and advanced network infrastructure will be better equipped to navigate evolving market demands. Addressing risks associated with regulatory compliance, privacy, and sustainable practices will also be crucial.

By proactively tackling these challenges, businesses can effectively leverage mobile technologies, strengthening resilience and driving long-term growth in a digital-first environment.

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Turning insights into action

Mobile technology evolves fast — but with the right strategy and execution, it becomes a powerful enabler of business growth.

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