

Activity 8.1 Research the impact of emerging technologies on application system design and present justified findings

Access course FAQ chatbot (<https://lms.griffith.edu.au/courses/24045/pages/welcome-to-the-course-chatbot>)

Module 8 - Research and apply emerging technologies

The image shows a video player interface. On the left, there is a portrait of a woman with long dark hair, wearing an orange blouse and black pants, standing with her hands clasped. To her right, the text "Abby's introduction to:" is displayed above the large title "Activity 8.1". On the far right, the Griffith University logo is visible, featuring a red stylized flower icon and the text "Griffith UNIVERSITY Queensland, Australia". At the bottom left of the video player, a progress bar indicates "0:00 / 1:26".

What is this activity?

In Activity 8.1, you will conduct research on the impact of emerging technologies on application system design and present findings. This activity is designed to help you develop a comprehensive understanding of the latest technological advancements and their potential to revolutionise the field of application system design. By critically analysing a range of emerging technologies and their

implications, you will gain valuable insights into how these technologies can be leveraged to enhance the performance, functionality, and user experience of application systems.

Why is this activity important?

By engaging in this activity, you will develop the skills and knowledge needed to identify, evaluate, and apply cutting-edge technologies that can significantly improve the quality and impact of your application system design projects. Some key benefits of this activity include:

Developing a comprehensive understanding of emerging technologies - Through researching a range of emerging technologies, such as AI, blockchain, IoT, augmented and virtual reality, and quantum computing, you will gain a deep understanding of their fundamental concepts, capabilities, and limitations. This knowledge will enable you to make informed decisions about which technologies to leverage in your application system design projects and how to optimise their implementation.

Enhancing your critical thinking and analysis skills - Researching and analysing the impact of emerging technologies on application system design requires strong critical thinking and analysis skills. By engaging in this activity, you will develop your ability to critically evaluate the potential benefits, challenges, and trade-offs of different technologies, and to justify your findings with evidence and examples from credible sources.

Staying ahead of the curve in a rapidly evolving field - By conducting regular research on emerging technologies, you will stay up-to-date with the latest trends and developments, ensuring that your skills and knowledge remain relevant and valuable in a competitive industry.

Identifying opportunities for innovation and differentiation - By being among the first to understand and apply cutting-edge technologies, you can create application systems that offer novel capabilities, improved performance, and enhanced user experiences, setting your projects apart from competitors.



Case study

- ▶ SupplySure - Supply Chain Management System



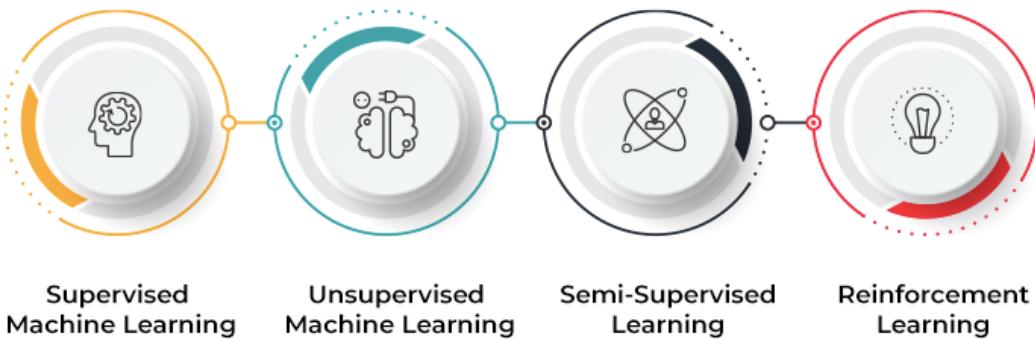
Supporting content for this activity

You should then work through the content elements below. These will reinforce the principles and elements from the lab exercise and will provide you with the knowledge and tools that you need to successfully complete this activity.

▼ Supporting content A - Artificial intelligence and machine learning

Overview of artificial intelligence (AI) and machine learning (ML) concepts and techniques

Artificial Intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think like humans and mimic their actions. The term encompasses a **wide range of technologies**, including machine learning, natural language processing, robotics, and computer vision. AI systems are designed to perform tasks that typically require human intelligence, such as understanding language, recognising patterns, and making decisions. The development of AI involves **creating algorithms and models** that enable machines to learn from data, reason about information, and improve their performance over time.



Machine Learning ([Image source ↗ \(https://www.spiceworks.com/tech/artificial-intelligence/articles/what-is-ml/\)](https://www.spiceworks.com/tech/artificial-intelligence/articles/what-is-ml/))

Machine Learning (ML) is a subset of AI that focuses on the development of algorithms that can learn from and make predictions or decisions based on data. Instead of being explicitly programmed to perform a task, ML systems are trained using large amounts of data and algorithms that give them the ability to learn how to perform the task. There are various types of machine learning, including supervised learning, unsupervised learning, and reinforcement learning. **Supervised learning** involves training a model on labeled data, **unsupervised learning** deals with unlabeled data and aims to find patterns, while **reinforcement learning** is about taking suitable actions to maximise rewards in a particular situation. Machine learning is widely used in applications such as recommendation systems, speech recognition, and autonomous vehicles.

Key capabilities and limitations of AI and ML technologies

AI and ML technologies have demonstrated remarkable capabilities across various domains. One of the key strengths of AI is its **ability to process and analyse vast amounts of data far beyond**



human capacity, enabling it to identify patterns and insights that would be impossible for humans to discern. This data processing capability is particularly evident in machine learning, where algorithms can be trained on large datasets to improve their performance on specific tasks, such as image recognition, speech-to-text conversion, and predictive analytics. Furthermore, AI's ability to perform tasks with **high precision and consistency**, without the limitations of human fatigue or error, makes it invaluable for applications in manufacturing, healthcare, and finance.

Despite these capabilities, AI and ML technologies are not without limitations. One significant constraint is the **reliance on quality data for training**. AI systems can only be as good as the data they are trained on, and biased or incomplete datasets can lead to flawed or discriminatory outcomes. Additionally, the "**black box**" nature of some ML models, where it is difficult to understand how they arrive at their decisions, can be problematic, especially in critical applications where transparency and accountability are essential. This lack of explainability can hinder trust and adoption of AI systems in sensitive areas like healthcare and criminal justice.

Another limitation is the **vulnerability of AI systems** to adversarial attacks and manipulation. Since AI models often rely on pattern recognition, they can be fooled by carefully crafted inputs designed to exploit their weaknesses. For instance, deep learning models have been shown to misclassify objects when presented with images that have been subtly altered. This raises concerns about the **security and reliability** of AI systems, particularly in areas such as cybersecurity and autonomous vehicles, where safety and security are paramount. Moreover, the **constant evolution of technology** means that AI and ML systems require frequent updates and maintenance to adapt to new threats and challenges, which can be resource-intensive.

Potential applications of AI and ML in application system design

AI and ML are revolutionising application system design by introducing intelligent automation, which can significantly enhance the efficiency and effectiveness of software applications. **Intelligent automation** involves the use of AI algorithms to automate complex tasks that typically require human intelligence. For example, in customer service applications, chatbots powered by AI can handle a wide range of inquiries, freeing up human agents to deal with more complex issues. In the context of business process management, AI can automate workflows, making decisions based on predefined rules and learned patterns, thus reducing the need for manual intervention and minimising errors.

Predictive analytics is another powerful application of AI and ML in system design. By analysing historical data and identifying trends, predictive models can forecast future events or behaviours, providing valuable insights for decision-making. In finance, for instance, predictive analytics can be used to assess credit risk, detect fraud, or optimise investment strategies. In healthcare, it can predict patient outcomes, enabling proactive treatment adjustments. Integrating predictive analytics

into application systems can lead to more intelligent and adaptive software that anticipates user needs and system demands, thereby improving overall performance and user satisfaction.



Personalisation ([Image source ↗ \(https://www.techopedia.com/ai-powered-personalization-how-machine-learning-is-transforming-customer-experience\)](https://www.techopedia.com/ai-powered-personalization-how-machine-learning-is-transforming-customer-experience))

Personalisation is a key area where AI and ML are making a significant impact on application system design. By learning from user interactions and preferences, machine learning algorithms can tailor the application experience to individual users, enhancing engagement and utility. This is evident in content recommendation systems used by streaming services and e-commerce platforms, where AI algorithms suggest movies, shows, or products based on a user's viewing or purchasing history. Personalisation extends beyond content recommendations; it can also include adaptive user interfaces, personalised notifications, and customised features that respond to the unique needs and behaviours of each user, creating a more intuitive and satisfying user experience.

Real-world examples and case studies of AI-powered application systems

Real-world examples and case studies of AI-powered application systems showcase the transformative impact of AI and ML across various industries. Here are a few notable examples:



Healthcare: IBM Watson for Oncology

IBM Watson for Oncology is an AI system that assists oncologists in making treatment recommendations for cancer patients. By analysing vast amounts of medical literature and patient data, Watson can provide evidence-based treatment options. Memorial Sloan Kettering Cancer Center collaborated with IBM to train Watson on their treatment protocols. The system has been

used to help doctors in rural areas access the latest cancer treatment information, thereby improving patient care outcomes.



Retail: Amazon's Recommendation Engine

Amazon's e-commerce platform utilises a sophisticated AI-powered recommendation system that personalises the shopping experience for each customer. The system analyses users' browsing and purchasing history to suggest products they might be interested in. This not only enhances the customer experience but also drives additional sales for Amazon. The recommendation engine is a prime example of how AI can be used to increase customer engagement and loyalty.



Transportation: Tesla's Autopilot

Tesla's Autopilot is an AI-driven semi-autonomous driving system that allows electric vehicles to navigate roads with minimal human intervention. The system uses a combination of machine learning algorithms, radar, and cameras to control the car's speed, steering, and braking. Over time, as the system collects more data, it learns to improve its decision-making, making the driving experience safer and more efficient.



Finance: PayPal's Fraud Detection

PayPal employs AI to detect and prevent fraudulent transactions. The system uses machine learning algorithms to analyse transaction patterns and identify anomalies that may indicate fraud. By learning from historical data, the AI system can adapt to new types of fraud, reducing false positives and minimising the impact on legitimate users. This application of AI helps protect both PayPal and its customers from financial loss.



Manufacturing: GE's Predictive Maintenance

General Electric (GE) uses AI for predictive maintenance in its manufacturing operations. By analysing data from sensors on equipment, GE's AI system can predict when a machine is likely to fail or require maintenance. This proactive approach reduces downtime, extends the life of equipment, and saves costs by preventing unexpected failures.



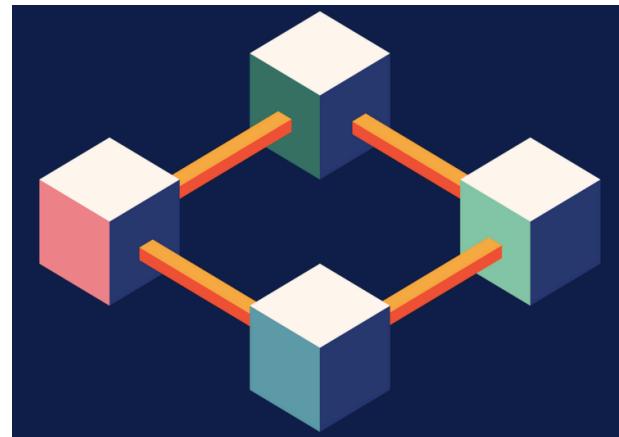
Customer Service: H&R Block's Tax Software

H&R Block, a tax services provider, has integrated AI into its tax preparation software to provide personalised tax advice. The AI system asks users questions about their financial situation and uses the answers to guide them through the tax filing process, offering personalised deductions and credits suggestions. This not only simplifies the tax filing process for users but also helps them maximise their returns.

These examples illustrate the diverse applications of AI in enhancing the functionality, efficiency, and user experience of application systems across different sectors. As AI technology continues to evolve, we can expect even more innovative and sophisticated AI-powered systems to emerge in the future.

▼ Supporting content B - Blockchain and distributed ledger technologies

Overview of blockchain and distributed ledger technology (DLT) concepts and principles



Blockchain ([Image source ↗\(https://www.chainalysis.com/blog/what-are-blockchains/\)](https://www.chainalysis.com/blog/what-are-blockchains/))

Blockchain and **Distributed Ledger Technology (DLT)** are revolutionary concepts that have emerged to provide a decentralised and secure method for recording transactions and managing data across various applications. At its core, a **blockchain** is a digital ledger of transactions that is duplicated and distributed across the entire network of computer systems on the blockchain. Each block in the chain contains a number of transactions, and every time a new transaction occurs on the blockchain, a record of that transaction is added to every participant's ledger. This creates a permanent, unalterable record that is publicly verifiable and resistant to data tampering. The **consensus mechanism**, which can vary (e.g., Proof of Work, Proof of Stake), ensures that all participants agree on the validity of transactions, thereby maintaining the integrity of the ledger.

Distributed Ledger Technology extends the concept of blockchain by providing a broader framework for recording transactions and tracking assets in a distributed and decentralised manner. Unlike traditional centralised systems, where a single entity has control over the entire database, **DLT** allows multiple entities to have access to the ledger, with each entity independently recording and verifying transactions. This not only enhances transparency and trust among participants but also reduces the risk of fraud and error. DLT can be implemented in various forms, including **public**, **private**, and **consortium blockchains**, each tailored to different use cases and requirements, ranging from financial services to supply chain management and beyond.

Key characteristics and benefits of blockchain and DLTs



Blockchain and DLTs offer a suite of key characteristics that set them apart from traditional centralised systems. One of the most significant features is **decentralisation**. Unlike centralised databases that rely on a single point of control, blockchain and DLTs distribute data across multiple nodes in a network. This decentralisation ensures that no single entity has complete control over the entire system, reducing the risk of censorship, fraud, and data manipulation. It also enhances resilience, as the system can continue to operate even if some nodes fail, thanks to the distributed nature of the ledger.

Immutability is another critical characteristic of blockchain and DLTs. Once a transaction is recorded on the blockchain, it is extremely difficult to alter. This is due to the cryptographic hash functions and consensus mechanisms that underpin the technology. Each block in the chain contains a cryptographic hash of the previous block, creating a chain of data that is secure and tamper-evident. This immutability ensures that the history of transactions is permanent and unalterable, providing a high level of data integrity and security. It is particularly valuable in scenarios where an unalterable record is required, such as in financial transactions, legal documents, and supply chain tracking.

Transparency is a core benefit of blockchain and DLTs, as all participants in the network can view the entire transaction history. This openness builds trust among users, as everyone can verify the authenticity of transactions and the state of the ledger. However, it's important to note that transparency does not necessarily mean that all data is public. In private or permissioned blockchains, access to view or add transactions can be restricted to certain participants, balancing the need for openness with privacy and confidentiality requirements. This **selective transparency** ensures that blockchain and DLTs can be adapted to various use cases, from public voting systems to private business networks.

Potential applications of blockchain and DLTs in application system design

Blockchain and DLTs have the potential to revolutionise application system design by introducing **secure data sharing mechanisms** that enhance privacy, integrity, and trust. Traditional data sharing methods often rely on centralised servers, which can be vulnerable to hacking and data breaches. Blockchain's **decentralised nature** and **cryptographic security** provide a robust framework for sharing sensitive information without the risk of a single point of failure. For instance, in healthcare, blockchain can facilitate the secure sharing of patient records among authorised parties, ensuring that patient data is protected and only accessible to those with the necessary permissions. This not only improves the efficiency of healthcare delivery but also empowers patients with greater control over their personal health information.



Smart contracts ([Image source ↗\(https://blockgeeks.com/guides/smart-contracts/\)](https://blockgeeks.com/guides/smart-contracts/))

Smart contracts are another transformative application of blockchain and DLTs in application system design. **Smart contracts** are self-executing contracts with the terms of the agreement directly written into code. They automate contract execution and enforcement, reducing the need for intermediaries and minimising the potential for disputes. In application design, smart contracts can be integrated into various systems to automate processes such as payments, legal agreements, and supply chain management. For example, in the real estate industry, smart contracts can automate the process of property sales, ensuring that all conditions are met before transferring ownership and releasing payment, thereby streamlining transactions and reducing the likelihood of fraud.

Digital identity management is a critical area where blockchain and DLTs can offer significant improvements in application system design. With the increasing importance of digital identities in our daily lives, there is a growing need for secure and reliable identity verification systems. Blockchain provides a platform for creating decentralised digital identity systems that give individuals control over their personal information. Users can share only the necessary details required for a transaction, reducing the risk of identity theft and unauthorised data usage. For instance, in the context of online services, users could provide a digital certificate from a blockchain-based identity system to verify their age or credentials without revealing unnecessary personal details. This approach enhances user privacy and security while simplifying identity verification processes for service providers.

Real-world examples and case studies of blockchain-based application systems

Real-world examples and case studies of blockchain-based application systems showcase the diverse applications of this technology across various industries. Here are a few notable examples:



Supply Chain Management: Walmart China has implemented a blockchain system to track the provenance of pork. By using blockchain, Walmart can trace the journey of a pork product from the farm to the store shelves in just a few seconds, compared to the previous days or even weeks it took with traditional paper-based systems. This has significantly enhanced food safety and quality control.



Financial Services: Ripple is a blockchain-based system that enables banks to conduct real-time cross-border payments. By using Ripple's protocol, financial institutions can settle international transactions in a matter of seconds, with end-to-end transparency and reduced costs compared to traditional SWIFT transfers.



Healthcare: The Medicalchain platform uses blockchain to securely store and share electronic health records. Patients have control over their data and can grant access to healthcare providers when

needed. This ensures privacy and security while facilitating better healthcare delivery through easy access to medical histories.



Voting Systems: Voatz is a mobile app that utilises blockchain technology to create a secure digital voting system. It has been piloted in several U.S. states for absentee voting by military personnel and overseas citizens. The blockchain ensures the integrity of the votes and provides a transparent and auditable voting process.



Real Estate: Propy is a blockchain-based platform that allows for the tokenisation of real estate assets, enabling fractional ownership and streamlining property transactions. It uses smart contracts to automate the process of property sales, making it more efficient and reducing the costs associated with traditional real estate deals.



L O 3 E N E R G Y

Energy Sector: LO3 Energy has developed a blockchain platform called Exergy that enables local energy markets where producers and consumers of renewable energy can trade directly with each other. This peer-to-peer energy trading system promotes the use of renewable energy and gives consumers more control over their energy consumption.

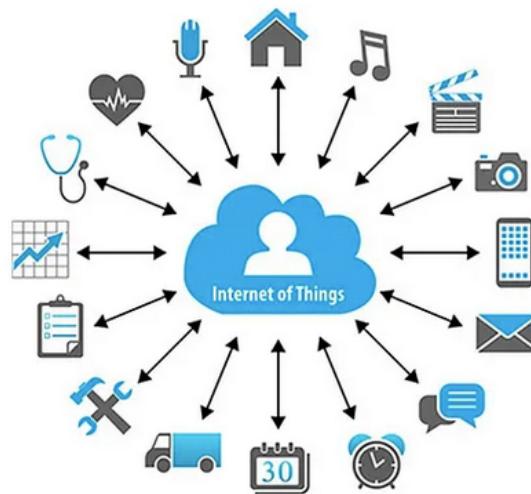


Music Industry: Mycelia is a blockchain-based platform that aims to revolutionise the music industry by giving artists more control over their work and fair compensation for their streams. It uses smart contracts to manage rights and royalties, providing transparency and reducing the need for intermediaries.

These case studies demonstrate the practical applications of blockchain technology in creating more efficient, secure, and transparent systems across different sectors. They highlight the potential for blockchain to disrupt traditional business models and pave the way for innovative solutions to complex problems.

▼ Supporting content C - Internet of Things (IoT) and edge computing

Overview of IoT and edge computing concepts and architectures

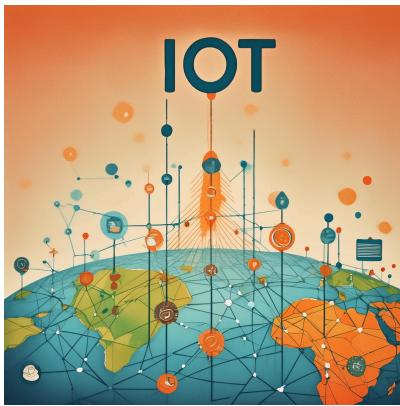


Internet of Things ([Image source ↗\(https://medium.com/@bmuha1/what-is-the-iot-introduction-to-the-internet-of-things-57335391cd5f\)](https://medium.com/@bmuha1/what-is-the-iot-introduction-to-the-internet-of-things-57335391cd5f))

The **Internet of Things (IoT)** refers to the network of physical objects embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. These "things" can range from everyday household items like thermostats and lights to industrial machines, wearable healthcare devices, and even entire cities in the context of smart city initiatives. IoT enables **advanced connectivity**, allowing devices to communicate and operate with minimal human intervention, thereby creating opportunities for automation, improved efficiency, and the generation of large volumes of data that can be analysed for various applications.

Edge computing, on the other hand, is a distributed computing paradigm that brings computation and data storage closer to the location where it is needed, meaning closer to the data sources. This is particularly relevant in the context of IoT, as it allows for real-time processing and analysis of data at the edge of the network, near the IoT devices themselves. This reduces latency, bandwidth use, and the need to send vast amounts of data to centralised data centers for processing. Edge computing architectures can vary, but they often involve **edge servers** or **micro data centers** that are geographically distributed and can perform tasks such as data filtering, analytics, and control, thereby enabling more responsive and autonomous IoT applications.

Key capabilities and benefits of IoT and edge computing technologies



IoT and edge computing technologies offer a suite of key capabilities that significantly enhance the performance and efficiency of application system design. One of the primary capabilities is **real-time data processing**. IoT devices generate vast amounts of data, and by leveraging edge computing, this data can be processed and analysed at the edge of the network, close to where it is generated. This enables immediate insights and actions, which are crucial for time-sensitive applications such as autonomous vehicles, industrial automation, and healthcare monitoring systems. Real-time processing ensures that decisions are made promptly, leading to more agile and responsive systems.

Another significant benefit of IoT and edge computing is the **reduction of latency**. Traditional cloud computing models require data to be transmitted to centralised data centers for processing, which can introduce delays due to the distance the data must travel. Edge computing minimises this latency by processing data locally or at the edge of the network. This is particularly advantageous for applications that require instantaneous responses, such as augmented reality and virtual reality experiences, remote surgery, and high-frequency trading systems. The reduced latency not only improves user experience but also enhances the reliability and safety of IoT-driven applications.

Furthermore, IoT and edge computing contribute to **improved scalability** of application systems. As IoT devices proliferate, the ability to scale computing resources to manage the increasing volume of data becomes critical. Edge computing allows for **distributed scaling**, where additional edge nodes can be added to handle more devices and data processing tasks. This distributed architecture is more scalable than relying solely on centralised cloud infrastructure, which may face bottlenecks as the number of connected devices and the volume of data grow exponentially. Moreover, edge computing can offload some of the processing tasks from the central cloud, ensuring that the overall system remains efficient and responsive even as it scales to accommodate more IoT devices and applications.

Potential applications of IoT and edge computing in application system design



Smart homes ([Image source ↗](https://www.techopedia.com/how-to/how-to-build-a-smart-home) (<https://www.techopedia.com/how-to/how-to-build-a-smart-home>))

The integration of IoT and edge computing technologies opens up a myriad of potential applications in application system design, particularly in smart home automation. **Smart homes** are equipped with a variety of IoT devices, such as smart thermostats, lighting systems, security cameras, and appliances, all of which generate and exchange data. Edge computing enables these devices to **process data locally**, providing immediate responses to environmental changes or user commands. For instance, a smart thermostat can adjust the temperature in real-time based on the occupancy of a room or the ambient conditions, without the need to send data to a remote server. This not only improves the responsiveness of the system but also enhances privacy and reduces bandwidth usage.

In industrial settings, IoT and edge computing can revolutionise **monitoring and control processes**. Machines and equipment can be fitted with sensors that collect data on performance, wear-and-tear, and operating conditions. Edge computing devices can **analyse this data in real-time** to detect anomalies or predict maintenance needs, leading to proactive maintenance strategies that minimise downtime and extend the lifespan of equipment. Furthermore, edge computing can enable **real-time optimisation** of production processes, adjusting parameters such as speed, temperature, or pressure to maximise efficiency and output quality. This level of automation and control can significantly enhance industrial productivity and safety.

Autonomous vehicles represent another frontier where IoT and edge computing can have a transformative impact. **Autonomous vehicles** are equipped with numerous sensors and cameras that collect data about their surroundings, road conditions, and traffic. Edge computing allows this **data to be processed onboard the vehicle**, enabling it to make split-second decisions and navigate safely. The **low latency** provided by edge computing is critical for autonomous vehicles, as any delay in processing sensor data could lead to accidents. Moreover, edge computing can help in managing the vast amounts of data generated by these vehicles, allowing for **continuous learning and improvement** of the vehicle's AI systems without overwhelming centralised data centers. As autonomous vehicle technology advances, the combination of IoT and edge computing will be essential in ensuring their safety, efficiency, and reliability.

Real-world examples and case studies of IoT and edge computing-powered application systems

Real-world examples and case studies of IoT and edge computing-powered application systems showcase the transformative impact of these technologies across various industries.



Smart Agriculture: Precision Farming

A notable example is the use of IoT and edge computing in precision farming. Companies like CropX deploy IoT sensors in fields to collect data on soil moisture, temperature, and nutrients. Edge devices process this data in real-time to provide farmers with actionable insights for optimal irrigation and fertilisation. This not only increases crop yields but also conserves water and reduces chemical usage, making agriculture more sustainable.



Healthcare: Remote Patient Monitoring

In healthcare, IoT devices such as wearable health monitors and implantable sensors collect patient data, which is processed at the edge to provide real-time health status updates. For instance, the company Medtronic offers a range of connected medical devices, including insulin pumps and cardiac devices, that use edge computing to analyse patient data and adjust treatment without the need for constant cloud connectivity. This enables continuous patient care and reduces the risk of critical health events.



Manufacturing: Predictive Maintenance

General Electric (GE) has implemented IoT and edge computing in its Predix platform, which is used in various industries including manufacturing. Predix uses sensors on industrial equipment to collect data that is processed at the edge for predictive maintenance. This allows for the detection of equipment anomalies before they lead to failures, reducing downtime and maintenance costs. For example, in a case study, GE's technology helped a mining company predict and prevent potential failures, leading to a 15% reduction in maintenance costs.



Retail: Inventory Management

In retail, IoT and edge computing are used for real-time inventory management. Companies like Amazon deploy IoT sensors on shelves to track inventory levels, which are processed at the edge to automatically reorder products when stock is low. This minimises stockouts and overstock situations, optimising inventory and enhancing the customer shopping experience.



Transportation: Traffic Management

IoT sensors installed on roads and in vehicles collect data on traffic flow, which is processed at the edge to optimise traffic signals and reduce congestion. For example, the city of San Diego implemented such a system and reported a 25% reduction in travel times and a 10% reduction in traffic delays.

These examples illustrate the diverse applications of IoT and edge computing, demonstrating how these technologies are enhancing efficiency, safety, and sustainability in various sectors. As the technology continues to evolve, we can expect even more innovative use cases to emerge, further transforming the landscape of application system design.

▼ Supporting content D - Augmented reality (AR) and virtual reality (VR)

Overview of AR and VR concepts and technologies



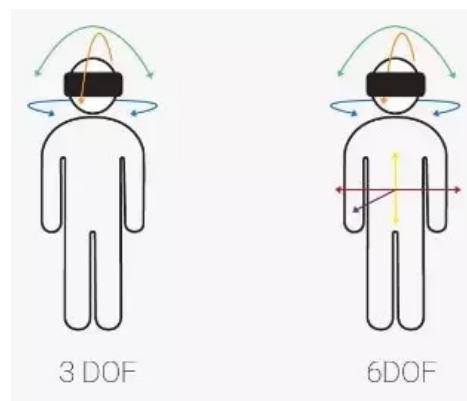
Augmented reality ([Image source ↗\(https://www.ptc.com/en/blogs/ar/what-is-augmented-reality/\)](https://www.ptc.com/en/blogs/ar/what-is-augmented-reality/))

Augmented Reality (AR) and **Virtual Reality (VR)** are two transformative technologies that are reshaping the way we interact with digital content and the world around us. **Augmented reality** superimposes digital information onto the physical world, enhancing users' perception and interaction with their environment. This is achieved through various devices such as smartphones, tablets, and specialised glasses that use sensors, cameras, and processing power to recognise the user's surroundings and project contextually relevant information. AR applications range from gaming and entertainment to industrial uses like maintenance and design, providing users with real-time data and interactive experiences that blend the digital and physical realms.

Virtual Reality, on the other hand, immerses users in a completely simulated environment, isolating them from the physical world. VR headsets and sensors track the user's movements and translate them into the virtual space, creating a sense of presence and allowing for interactions with objects and entities that exist only in the digital domain. VR technology is widely used in gaming, simulation training, and virtual tours, offering experiences that are not bound by physical constraints. Both AR and VR are advancing rapidly, with improvements in display technology, sensors, and data processing, making these experiences more realistic, accessible, and integrated into various aspects of daily life and professional work.

Key characteristics and capabilities of AR and VR systems

AR and VR systems are distinguished by their ability to create immersive experiences that blur the lines between the physical and digital worlds. AR systems achieve this by **overlaying digital information onto the user's perception of the real world**, enhancing it with contextual data, graphics, and interactive elements. This is made possible through **advanced spatial tracking technologies** that use sensors and cameras to understand the user's environment and position within it. As a result, AR applications can deliver location-based information, instructions, or data visualisations that are precisely aligned with the user's view of the real world, creating a seamless integration of digital content into the physical space.



Spatial tracking ([Image source ↗\(https://4experience.co/vr-tracking-meet-degrees-of-freedom/\)](https://4experience.co/vr-tracking-meet-degrees-of-freedom/))

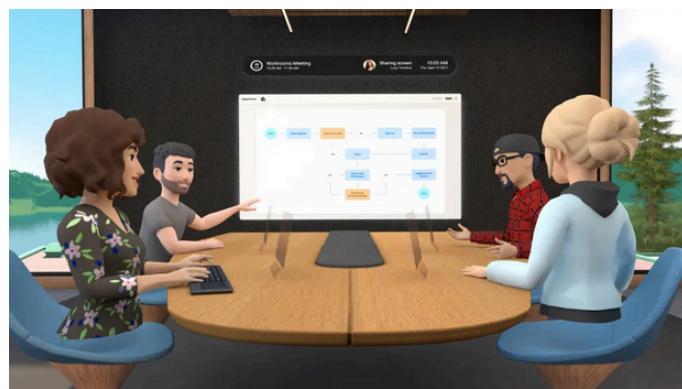
VR systems, on the other hand, immerse users in a **completely artificial environment**, disconnecting them from the physical world and placing them in a virtual one. This is achieved through the use of VR headsets that cover the user's eyes and display screens that provide a 360-degree view of the virtual space. VR systems also employ **spatial tracking** to monitor the user's movements, allowing for a high degree of interaction within the virtual environment. Users can navigate through virtual spaces, manipulate objects, and interact with virtual entities as if they were in a real environment. The sense of presence and immersion in VR is further enhanced by haptic feedback devices and motion-tracking controllers that translate physical gestures into virtual actions, making the experience more intuitive and engaging.

Both AR and VR systems are capable of gesture recognition, which is a key characteristic that enables natural and intuitive interaction with digital content. **Gesture recognition** technology allows users to control and interact with virtual objects using hand movements and gestures, mimicking real-world actions. This is particularly important for VR, where physical controllers or hand-tracking systems interpret the user's movements to manipulate objects in the virtual space. In AR, gesture recognition can be used to navigate through information layers, select options, or control applications without the need for traditional input devices, making the interaction more seamless and user-friendly. As these technologies continue to evolve, the capabilities for gesture recognition and spatial tracking are becoming more sophisticated, leading to more immersive and interactive experiences in both AR and VR systems.

Potential applications of AR and VR in application system design

AR and VR have the potential to revolutionise application system design across various domains, including gaming, education, and remote collaboration. In **gaming**, AR and VR technologies offer immersive experiences that go beyond traditional screens, allowing players to interact with virtual environments in real-world spaces or to be fully immersed in a digital world. AR games like "Pokémon GO" have demonstrated the appeal of integrating digital gameplay with the physical environment, while VR has enabled fully immersive experiences that provide a sense of presence within virtual game worlds. As application system designers incorporate these technologies, they can create more engaging and interactive gaming experiences that leverage the unique capabilities of AR and VR.

In **education**, AR and VR offer innovative tools for learning that can make abstract concepts tangible and complex information more accessible. AR can overlay educational content onto real-world objects, enabling students to visualise and interact with three-dimensional models of historical sites, biological systems, or molecular structures. VR, with its ability to create fully immersive environments, can transport students to different times and places, offering virtual field trips to historical events, distant planets, or microscopic worlds. Application system designers in education are exploring these technologies to develop interactive learning platforms that cater to different learning styles and provide hands-on experiences that are otherwise impossible in a traditional classroom setting.



Remote collaboration ([Image source ↗\(https://about.fb.com/news/2021/08/introducing-horizon-workrooms-remote-collaboration-reimagined/\)](https://about.fb.com/news/2021/08/introducing-horizon-workrooms-remote-collaboration-reimagined/))

Remote collaboration is another area where AR and VR are poised to make a significant impact. These technologies can bridge the gap between physical distance and collaborative work, allowing teams to interact with each other and with digital content in shared virtual spaces. VR can create collaborative environments where team members from around the world can meet, discuss, and work on projects as if they were in the same room. AR, meanwhile, can enhance video conferencing and remote support by providing spatial context and enabling users to annotate and manipulate shared digital objects in real-time. Application system designers are developing collaborative tools that leverage AR and VR to enhance communication, facilitate project visualisation, and streamline workflows for teams working remotely. As these technologies mature, they will continue to shape the future of remote work and collaboration, offering new ways to connect, share, and create.

Real-world examples and case studies of AR and VR-based application systems

Real-world examples and case studies of AR and VR-based application systems showcase the diverse applications of these technologies across industries. Here are a few notable examples:



Gaming: "Pokémon GO"

"Pokémon GO" is an AR-based mobile game developed by Niantic. It became a global phenomenon in 2016, demonstrating the potential of AR to engage users by blending digital creatures with the real world. Players use their smartphone cameras to see and catch PokéMon in their actual surroundings, encouraging physical activity and exploration.



Education: "Labster"

Labster offers VR lab simulations for students in science education. These simulations allow students to perform experiments in a virtual laboratory, providing an immersive learning experience that is both educational and cost-effective. Labster's VR simulations cover various subjects, including biology, chemistry, and biotechnology.



Retail: "IKEA Place"

IKEA Place was an AR application that allowed users to visualise IKEA furniture in their own homes through their smartphone cameras. Users could scale, rotate, and place 3D models of furniture in their space to help with decision-making before purchasing. This app demonstrated the potential of AR in enhancing the shopping experience.



Real Estate: "Matterport"

Matterport uses VR and AR to create virtual tours of properties. Real estate agents and property managers can use these tours to give potential buyers or renters a realistic preview of a space. This technology is particularly useful for remote viewings and for properties that are difficult to access.



Healthcare: "Osso VR"

Osso VR provides a VR-based surgical training platform that allows medical professionals to practice procedures in a risk-free virtual environment. This application of VR in medical training helps to improve surgical skills and patient outcomes by offering realistic simulations that can be repeated and refined.



Manufacturing: "Boeing"

Boeing has implemented AR and VR in its manufacturing processes. For example, engineers use VR to visualise and manipulate 3D models of aircraft parts, while AR is used on the factory floor to provide workers with hands-free access to maintenance manuals and instructions overlaid on the equipment they are servicing.



Automotive: "Volvo"

Volvo has used AR in its design process to allow engineers and designers to visualise and interact with vehicle prototypes in real-world environments. This technology helps in making design decisions and understanding the impact of design changes before physical prototypes are built.



Remote Collaboration: "Spatial"

Spatial is a VR platform that enables remote teams to collaborate in a shared virtual space. It allows users to interact with each other and with digital content as if they were in the same room, facilitating meetings, workshops, and collaborative work sessions.

These examples illustrate the practical applications of AR and VR in enhancing user experiences, training, retail, real estate, healthcare, manufacturing, automotive design, and remote collaboration. As the technology continues to evolve, we can expect to see even more innovative uses of AR and VR in application system design.

▼ Supporting content E - Quantum computing and quantum-resistant cryptography

Overview of quantum computing and quantum-resistant cryptography concepts and principles



Quantum computers ([Image source](https://scienceexchange.caltech.edu/topics/quantum-science-explained/quantum-computing-computers)) ↗ (<https://scienceexchange.caltech.edu/topics/quantum-science-explained/quantum-computing-computers>)

Quantum computing represents a paradigm shift in computational capabilities, leveraging the principles of quantum mechanics to process information. Unlike classical computers that use bits as the basic unit of information, which can be either a 0 or a 1, **quantum computers** utilise **quantum bits** or **qubits**. Qubits can exist in multiple states simultaneously, a phenomenon known as **superposition**, and can be **entangled**, meaning the state of one qubit can depend on the state of another, no matter the distance between them. These quantum properties enable quantum computers to perform certain types of calculations much more efficiently than classical computers, particularly in areas such as cryptography, optimisation, and simulation of quantum systems.

Quantum-resistant cryptography, also known as **post-quantum cryptography**, is a field of study concerned with the development of cryptographic systems that are secure against both quantum and classical computers. The impetus behind this field is the realisation that many of the cryptographic algorithms currently in use, such as RSA and ECC, rely on mathematical problems that are difficult for classical computers to solve but could potentially be **solved quickly by quantum computers**, especially those that implement Shor's algorithm. Quantum-resistant cryptography aims to create new algorithms that can withstand attacks from quantum adversaries, ensuring the security of digital communications in a future where quantum computing becomes a reality. This includes exploring various **mathematical constructs** such as lattice-based cryptography, code-based cryptography, multivariate cryptography, hash-based signatures, and others, each with its own set of security guarantees and practical considerations.

Key capabilities and limitations of quantum computing technologies, and their potential impact on traditional cryptographic systems

Quantum computing technologies possess key capabilities that differentiate them from traditional computing systems. One of the most significant is their potential to **perform calculations at speeds unattainable by classical computers** for specific types of problems. This is due to the ability of



qubits to exist in multiple states simultaneously, allowing quantum computers to process a vast amount of possibilities at once. This capability is particularly relevant for optimisation problems, database searches, and complex simulations. Furthermore, quantum computing excels in **parallel processing**, meaning it can execute numerous operations simultaneously, which is a significant advantage over classical computers that typically process operations in a sequential manner. However, these capabilities come with **limitations**. Quantum computers are currently expensive to build, require extremely low temperatures to operate, and are prone to errors due to quantum decoherence and noise. These factors make quantum computing a **niche technology**, at least in the near term, with its applications primarily focused on research and specialized industries.

The potential impact of quantum computing on traditional cryptographic systems is profound and has been a subject of significant concern and research. Many of the cryptographic algorithms currently in use, such as RSA and ECC, rely on the computational difficulty of certain mathematical problems, such as factoring large prime numbers or solving discrete logarithms. Quantum computers, particularly those that implement Shor's algorithm, have the theoretical capability to solve these problems efficiently, thereby rendering these cryptographic systems vulnerable. This means that data encrypted with current standards could be **decrypted by a sufficiently powerful quantum computer**, potentially compromising secure communications, financial transactions, and digital identities. The race to develop quantum-resistant cryptography is therefore critical to ensure the security of digital infrastructure in a future where quantum computing becomes more prevalent.

Potential applications of quantum computing and quantum-resistant cryptography in application system design



Quantum computing has the potential to revolutionise application system design across various domains. In secure communication, for instance, quantum computing could both pose a threat and offer a solution. On one hand, as mentioned earlier, it **could break many of the cryptographic systems** currently in use. On the other hand, quantum-resistant cryptography, such as **quantum key distribution (QKD)**, leverages the principles of quantum mechanics to enable secure communication that is theoretically **immune to eavesdropping**. QKD uses the phenomenon of quantum entanglement and the no-cloning theorem to ensure that any attempt to intercept the communication would be detected, thereby providing a secure channel for transmitting sensitive information. This could be integrated into application system design to ensure robust security in the quantum era.

In complex optimisation, quantum computing's ability to process vast amounts of possibilities simultaneously could lead to breakthroughs in **solving optimisation problems** that are currently intractable for classical computers. This has implications for supply chain management, logistics, financial modeling, and more. **Quantum algorithms**, such as the **Quantum Approximate Optimisation Algorithm (QAOA)**, could be applied to design applications that optimise routes, schedules, and resource allocations with unprecedented efficiency. As quantum computing technology matures, application system designers will need to consider how to integrate these quantum optimisation capabilities to enhance their systems' performance and decision-making processes.

Machine learning is another area where quantum computing could have a transformative impact. **Quantum machine learning algorithms** have the potential to analyse and process large datasets much faster than their classical counterparts. This could lead to more accurate and efficient predictive models, pattern recognition, and anomaly detection. Quantum-enhanced machine learning could be integrated into application systems to improve data analysis, enabling better decision-making and insights. For example, in finance, quantum machine learning could be used for fraud detection and risk assessment. In healthcare, it could lead to more effective diagnosis and treatment plans by analysing complex genetic and medical data. As quantum computing and quantum-resistant cryptography advance, application system designers will need to stay abreast of these developments to incorporate quantum-enhanced features that can provide competitive advantages in terms of security, optimisation, and data analysis.

Real-world examples and case studies of quantum computing and quantum-resistant cryptography in application systems

Quantum computing is still in the early stages of development, and practical real-world applications are limited but growing. However, there are several notable examples and case studies where quantum computing and quantum-resistant cryptography are being explored or implemented in application systems:



Quantum Key Distribution (QKD) for Secure Communication:

Example: The city of Moscow has been using QKD to secure its banking system communications since 2010. QKD networks have also been deployed in other parts of the world, such as the

"Quantum Experimental Satellite" (QUESS) launched by China, which enables secure quantum communication between satellite and ground stations.

Case Study: The European project called "Quantum Communications Infrastructure" (EuroQCI) aims to build a secure communication network across Europe using QKD. This initiative is a clear example of how quantum-resistant cryptography is being considered for application in large-scale communication systems.



Quantum Computing in Drug Discovery:

Example: Pharmaceutical companies like Biogen and 1QBit are collaborating with quantum computing firms to apply quantum algorithms to drug discovery processes. These collaborations aim to simulate molecular interactions more efficiently than classical computers, potentially leading to the discovery of new drugs.

Case Study: The use of quantum computing by Biogen and 1QBit is a case study in how quantum algorithms can be applied to complex optimisation problems in life sciences, showcasing the potential for quantum computing to accelerate research and development in the pharmaceutical industry.



Quantum Computing in Finance:

Example: Goldman Sachs and other financial institutions are exploring quantum computing for optimising portfolio management and risk analysis. Quantum algorithms could process vast amounts of financial data to find optimal investment strategies.

Case Study: JPMorgan Chase's collaboration with IBM to explore quantum computing in financial services is a notable case study. They are investigating how quantum computing could be used for pricing derivatives and other complex financial instruments, which could significantly impact the design of financial application systems.



NATIONAL INSTITUTE OF
STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

Quantum Computing in Cybersecurity:

Example: The National Institute of Standards and Technology (NIST) is in the process of evaluating and standardising post-quantum cryptographic algorithms. This initiative is crucial for preparing cybersecurity measures against future quantum attacks.

Case Study: Google's experiment with post-quantum cryptography in 2016, where they ran a small trial of a post-quantum key exchange algorithm on Google Cloud, is a case study in the practical testing of quantum-resistant cryptography in real-world applications.



Quantum Computing in Machine Learning:

Example: NASA and Google have been working with the quantum computer company D-Wave to apply quantum annealing to machine learning problems. They have used D-Wave's systems for applications such as image recognition and AI.

Case Study: The collaboration between Volkswagen and D-Wave to optimise traffic flows in cities using quantum computing is a case study in how quantum technologies can be applied to complex optimisation problems in urban planning and transportation.

It's important to note that while these examples and case studies demonstrate the potential of quantum computing and quantum-resistant cryptography, **quantum technology is still in its infancy**. Many of these applications are in the research and development phase, and it may take years before they become mainstream in application system design. Nonetheless, these early efforts are paving the way for the future integration of quantum technologies into various sectors.

▼ Supporting content F - Implications for system architecture and infrastructure

Analysis of how emerging technologies may impact the design and implementation of application system architectures and infrastructures



Emerging technologies are continuously shaping the landscape of application system design and implementation, with profound implications for both architecture and infrastructure. Technologies such as AI, ML, IoT, blockchain, and edge computing are at the forefront of these changes. **AI and ML** are influencing system architectures by enabling more intelligent decision-making processes and adaptive behaviours, requiring architectures that can support complex algorithms and large-scale data processing. **IoT** is driving the need for architectures that can handle vast numbers of connected devices and the associated data streams, often in real-time. **Blockchain technology** introduces the need for decentralised architectures that ensure security, transparency, and immutability. Lastly, **edge computing** is pushing compute resources closer to the data sources, necessitating a distributed infrastructure that can support low-latency, high-bandwidth operations.

The infrastructure supporting these architectures must evolve to accommodate the demands of emerging technologies. This includes **robust data storage solutions** that can handle the volume, velocity, and variety of data generated by IoT devices and processed by AI/ML algorithms. Network infrastructures must be **scalable and secure** to support the distributed nature of edge computing and blockchain. Additionally, the rise of **containerisation and microservices** architectures allows for more flexible and resilient systems that can adapt to the dynamic requirements of emerging technologies. **Cloud computing platforms** are also pivotal in providing the scalable and on-demand resources necessary for these modern applications. As a result, system designers and infrastructure engineers must stay abreast of these technological advancements to create systems that are not only functional but also future-proof.

Consideration of the scalability, flexibility, and resilience requirements for application systems incorporating emerging technologies



As application systems increasingly incorporate emerging technologies, the considerations of scalability, flexibility, and resilience become paramount. **Scalability** is crucial because emerging technologies often handle large volumes of data and users, which can grow exponentially over time. For instance, AI and ML systems require scalable architectures to process and analyse big data effectively, while IoT applications must support a potentially vast number of connected devices. Cloud computing platforms offer a scalable infrastructure that can dynamically adjust resources to meet demand, ensuring that systems can grow without compromising performance.

Flexibility is another key requirement, as emerging technologies evolve rapidly and application systems must adapt to these changes. Microservices architectures provide the necessary flexibility

by breaking down applications into smaller, independent services that can be updated or replaced without affecting the entire system. This modular approach allows for easier integration of new technologies and facilitates continuous deployment and innovation. Containerisation technologies, such as Docker and Kubernetes, further enhance flexibility by encapsulating applications and their dependencies, making them portable and consistent across different environments.

Resilience is essential for application systems that incorporate emerging technologies, as these systems often underpin critical operations and must remain operational in the face of failures or attacks. Resilient architectures incorporate redundancy, failover mechanisms, and disaster recovery plans to ensure high availability. The use of distributed systems and edge computing can also enhance resilience by spreading the computational load and reducing the impact of any single point of failure. Additionally, security must be integrated into the design from the outset, with considerations for encryption, access controls, and monitoring to protect against threats that may exploit vulnerabilities in emerging technologies. By designing for scalability, flexibility, and resilience, application systems can effectively harness the power of emerging technologies while ensuring reliability and longevity.

Exploration of the potential for emerging technologies to enable new architectural patterns and infrastructure models



Emerging technologies are not only being integrated into existing application systems but are also driving the development of new architectural patterns and infrastructure models. **Microservices**, for example, have gained popularity as a result of the need for systems to be more agile and responsive to change. This architectural style allows for complex applications to be composed of small, independent, and loosely coupled services. Each microservice can be developed, deployed, and scaled independently, which aligns well with the rapid iteration and deployment cycles enabled by DevOps practices.

Emerging technologies, such as containerisation and orchestration tools like Kubernetes, provide the necessary infrastructure to support microservices, making it easier to manage and scale these distributed systems.

Serverless computing is another paradigm that has been enabled and popularised by emerging technologies. This model allows developers to run code without provisioning or managing servers, with services like AWS Lambda, Azure Functions, and Google Cloud Functions abstracting away the infrastructure. Serverless architectures can automatically scale with demand, making them particularly well-suited for applications with unpredictable workloads. They also promote a finer-grained scaling approach, where resources are allocated based on the actual execution time of functions, potentially leading to cost savings. Emerging technologies in serverless computing continue to expand the scope of what can be built with this model, including state management, stream processing, and machine learning inference.

The **edge-cloud continuum** is an emerging infrastructure model that bridges the gap between edge computing and traditional cloud services. This model is driven by the need to process data closer to where it is generated, reducing latency and bandwidth requirements. Technologies such as 5G and advanced edge devices enable this by providing the necessary connectivity and computational power at the network's edge. The edge-cloud continuum allows for a distributed architecture where data can be analysed and acted upon locally, with only relevant information being sent to centralised cloud services for further processing or storage. This model is particularly beneficial for applications in areas like autonomous vehicles, smart cities, and industrial IoT, where real-time decision-making is critical. As these technologies mature, we can expect to see more sophisticated edge-cloud architectures that blend the benefits of centralised cloud resources with the responsiveness of edge computing.

Real-world examples and case studies of application system architectures and infrastructures designed to leverage emerging technologies

Real-world examples and case studies of application system architectures and infrastructures designed to leverage emerging technologies abound across various industries. Here are a few notable examples:



Netflix's Microservices Architecture:

Netflix transitioned from a monolithic architecture to a microservices-based system to improve scalability, flexibility, and resilience. By breaking down their application into hundreds of microservices, Netflix can deploy thousands of code changes per day without impacting the entire system. They use cloud infrastructure provided by AWS and their own open-source tools like Eureka for service discovery, Zuul for edge service proxy, and Spinnaker for continuous delivery.



Uber's Real-Time Market Platform:

Uber's platform is a prime example of leveraging emerging technologies for scalability and real-time processing. It uses a microservices architecture to handle millions of rides per day, with each service responsible for different aspects of the ride-sharing experience, such as dispatching, routing, and

payment processing. Uber also employs machine learning for dynamic pricing and leverages containerisation with Docker and orchestration with Kubernetes to manage its fleet of services.



Amazon Go's Just Walk Out Technology:

Amazon Go is a chain of convenience stores that use computer vision, sensor fusion, and deep learning to offer a checkout-free shopping experience. The store's infrastructure is designed to process massive amounts of data from cameras and sensors in real-time, using a combination of edge computing for immediate response and cloud computing for more complex processing and storage.



Tesla's Autopilot and Over-the-Air Updates:

Tesla's electric vehicles are equipped with sensors and onboard computers that enable Autopilot, their semi-autonomous driving system. The architecture behind Autopilot leverages machine learning algorithms to interpret sensor data and make driving decisions. Additionally, Tesla's vehicles support over-the-air updates, allowing the company to roll out software updates and improve vehicle functionality continuously.



H&R Block's Use of AI for Tax Services:

H&R Block, a tax preparation company, has implemented AI and machine learning to provide more personalised tax advice to its clients. Their system, called Tax DNA, analyses client data to identify unique tax situations and provide tailored recommendations. The infrastructure supporting this service is designed to handle the sensitive nature of tax data with robust security measures and scalable cloud services.



Farmers Insurance's AI-Driven Claims Processing:

Farmers Insurance has adopted AI to streamline its claims processing. Using machine learning algorithms, the company can now predict the cost of claims more accurately and automate many aspects of the claims handling process, reducing the time required to settle claims. The underlying architecture is built on a combination of legacy systems and modern cloud-based services to support the integration of AI technologies.

These examples illustrate how organisations across different sectors are redesigning their application system architectures and infrastructures to harness the power of emerging technologies. By doing so, they are able to achieve greater agility, efficiency, and innovation in their operations.

▼ Supporting content G - Implications for performance and scalability

Analysis of how emerging technologies may impact the performance and scalability of application systems



Emerging technologies are continuously shaping the landscape of application system design, particularly in terms of performance and scalability. One of the most significant impacts comes from advancements in **cloud computing**, which offers scalable resources that can be dynamically allocated to meet the demands of growing user bases or fluctuating workloads. With cloud services, application systems can leverage auto-scaling features to add or remove computing resources in real-time, ensuring that performance remains consistent even under varying loads. This elasticity is a game-changer for scalability, as it allows applications to handle peak usage times without the need for substantial upfront investments in hardware.

Another emerging technology with profound implications is the rise of **edge computing**, which processes data closer to the data source rather than relying on centralised data centers. This decentralised approach reduces latency and improves response times, which is particularly beneficial for applications that require real-time processing, such as those in IoT or autonomous vehicles. By bringing computational power closer to the edge, these applications can achieve better performance

and scalability, as they are less constrained by the limitations of centralised processing and bandwidth.

Moreover, advancements in AI and ML are also influencing application system design. **AI-driven algorithms** can optimise application performance by predicting usage patterns and automatically adjusting system configurations to meet anticipated demands. For instance, **machine learning models** can analyse historical data to forecast traffic spikes, allowing the system to preemptively scale resources accordingly. This proactive approach not only enhances performance but also contributes to better resource utilisation and cost efficiency. Additionally, AI can be used to improve the scalability of applications by automating complex tasks such as data analysis and decision-making processes, which can otherwise become bottlenecks as the volume of data increases.

Consideration of the potential for emerging technologies to enable faster processing, reduced latency, and improved resource utilisation



The advent of emerging technologies has opened new avenues for enhancing the processing speed, reducing latency, and optimising resource utilisation in application systems. One such technology is **quantum computing**, which, although still in its nascent stage, promises to revolutionise processing capabilities by performing complex calculations at speeds unattainable by classical computers. This could lead to significant advancements in areas such as cryptography, drug discovery, and financial modeling, where processing speed is critical. By leveraging quantum computing, application

systems could potentially process vast amounts of data in fractions of the time it currently takes, thereby enabling real-time decision-making and analysis.

Another technology that is making strides in improving processing speeds and reducing latency is the development of **advanced semiconductor materials and architectures**. For instance, the transition from silicon to materials like **gallium nitride (GaN)** and **silicon carbide (SiC)** is leading to the creation of faster and more efficient transistors and integrated circuits. These new materials can operate at higher frequencies and withstand higher temperatures, allowing for the design of systems that can process data more quickly and with less energy consumption. Furthermore, innovative architectures such as **3D chip stacking** and **advanced packaging techniques** are enabling increased bandwidth and reduced signal latency, further enhancing the performance of application systems.

In terms of reduced latency, the proliferation of **5G networks** is set to have a transformative effect. With its promise of significantly faster data transfer rates and reduced latency compared to 4G LTE, 5G technology is poised to enable a new generation of applications that require **real-time responsiveness**, such as augmented reality, virtual reality, and telemedicine. This reduced latency is not only beneficial for end-users but also for the backend systems that need to process and respond

to data in near-real-time, thereby improving the overall performance and user experience of application systems.

Lastly, the potential for improved resource utilisation is greatly enhanced by technologies such as **AI** and **machine learning**, which can optimise the allocation and management of computational resources. By analysing usage patterns and predicting demand, AI algorithms can dynamically adjust the allocation of resources to ensure that systems operate efficiently, minimising waste and downtime. This intelligent management of resources can lead to significant cost savings and improved performance, as application systems can scale up or down in response to actual usage, rather than being provisioned for peak loads that may only occur occasionally.

Exploration of the scalability challenges and opportunities associated with application systems incorporating emerging technologies



The integration of emerging technologies like distributed data management and parallel processing into application systems presents a unique set of scalability challenges and opportunities. **Distributed data management**, which involves storing and processing data across multiple locations or nodes, offers the opportunity to **scale out horizontally**, meaning that more nodes can be added to a system to increase its capacity and processing power. This approach can lead to improved performance and reliability, as the workload is spread across various nodes, reducing the risk of a single point of failure. However, it also introduces challenges such as data consistency, synchronisation, and the complexity of managing a distributed system. Ensuring that data remains accurate and up-to-date across all nodes requires sophisticated algorithms and protocols, which can be difficult to implement and maintain.

Parallel processing, on the other hand, involves breaking down a task into smaller parts that can be executed simultaneously on multiple processors or cores. This can significantly speed up computation for applications that are able to take advantage of parallelism. However, designing applications to effectively use parallel processing can be complex, as it requires careful consideration of how tasks can be divided and coordinated without introducing bottlenecks or inefficiencies. Additionally, parallel processing may not be suitable for all types of workloads, and some tasks may inherently be more sequential in nature, limiting the scalability benefits that can be achieved through parallelisation.

Despite these challenges, the opportunities for **scalability** offered by distributed data management and parallel processing are substantial. As the volume of data and the complexity of computational tasks continue to grow, these technologies enable application systems to scale in ways that were previously impossible. By leveraging distributed systems and harnessing the power of parallel processing, developers can create applications that are not only more scalable but also more responsive and capable of handling the demands of modern, data-intensive environments. Moreover,

the ongoing advancements in these technologies, along with the development of **new programming models and tools**, are making it easier to implement scalable solutions, further democratising the benefits of these emerging technologies for application system design.

Real-world examples and case studies of application systems that have achieved enhanced performance and scalability through the use of emerging technologies

Several real-world examples and case studies demonstrate how emerging technologies have been instrumental in achieving enhanced performance and scalability in application systems. Here are a few notable instances:



Netflix and the Cloud: Netflix is a prime example of a company that has leveraged cloud computing to scale its streaming service to millions of users worldwide. By migrating its infrastructure to the cloud, specifically using Amazon Web Services (AWS), Netflix can dynamically scale its resources to meet the demands of its user base, which can fluctuate significantly depending on the time of day or when popular content is released. The cloud's elasticity allows Netflix to allocate more resources during peak times and scale back when demand decreases, ensuring both performance and cost-efficiency.



Uber and Microservices: Uber's platform, which connects riders with drivers, has evolved from a monolithic architecture to one based on microservices. This transition has allowed Uber to scale each service independently, which is particularly useful given the varying demands in different regions and times. For example, during peak hours, services related to ride matching and payment processing can be scaled up, while other services remain at a normal level. This approach has enabled Uber to maintain high performance and reliability even as its user base and service offerings have grown exponentially.



Airbnb and Data Processing: Airbnb handles vast amounts of data, from user profiles and property listings to search queries and booking information. To manage this data effectively, Airbnb has adopted a data infrastructure that includes technologies like Apache Hadoop and Apache Spark for distributed data processing. These technologies allow Airbnb to analyse data across its global marketplace, enabling the company to make data-driven decisions, personalise user experiences, and detect fraudulent activity, all of which contribute to scalability and performance.



Spotify and CDNs: Spotify, the music streaming service, uses content delivery networks (CDNs) to ensure that users around the world can stream music with minimal latency. By caching content at various locations around the globe, Spotify can reduce the distance data needs to travel, thereby decreasing latency and improving performance. This is particularly important for a service like Spotify, where real-time streaming and a seamless user experience are critical.



LinkedIn and Kafka: LinkedIn developed and open-sourced Apache Kafka, a distributed streaming platform, to handle its messaging and real-time data processing needs. Kafka's ability to handle millions of events per second has enabled LinkedIn to scale its real-time data pipelines, which are essential for features like news feeds, notifications, and real-time analytics. By using Kafka, LinkedIn has been able to maintain high performance and scalability as its user base and data volume have grown.

These examples illustrate how companies across various industries have embraced emerging technologies to enhance the performance and scalability of their application systems, allowing them

to meet the demands of their users and stay competitive in a rapidly evolving technological landscape.

▼ Supporting content H - Implications for security and privacy

Analysis of how emerging technologies may impact the security and privacy of application systems and their users



Emerging technologies, such as AI, ML, blockchain, and IoT, are reshaping the landscape of application system design with profound implications for security and privacy. **AI and machine learning algorithms** can enhance security by identifying patterns and anomalies indicative of cyber threats more effectively than traditional methods. However, they also introduce new vulnerabilities; for instance, machine learning models can be deceived by adversarial attacks, where malicious inputs are designed to trick the system into making incorrect decisions. Furthermore, the increased use of data for training these models raises concerns about privacy, as sensitive information may be inadvertently exposed or misused.

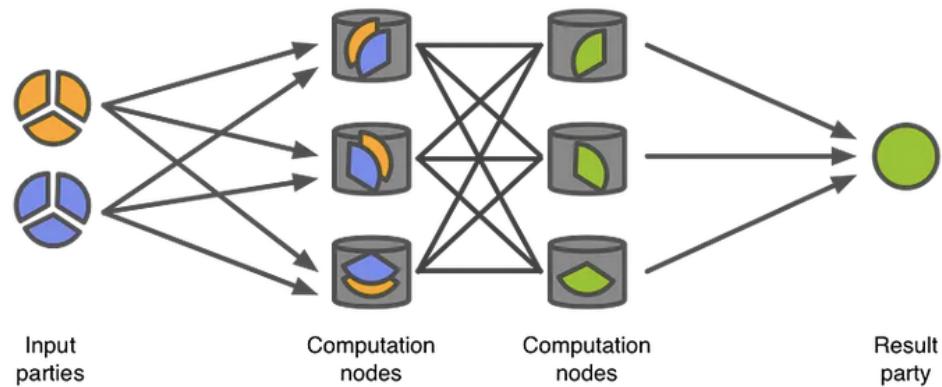
Blockchain technology, known for its role in cryptocurrencies, offers a decentralised and tamper-resistant approach to data management that can significantly bolster security in application systems. Its **immutable ledger** can protect against data breaches and unauthorised alterations. However, the privacy aspect of blockchain is more nuanced; while it ensures transaction integrity, the transparency of public blockchains can compromise user privacy unless additional measures like zero-knowledge proofs are implemented. The **IoT**, with its vast network of interconnected devices, expands the attack surface for cyber threats, making it crucial to secure a multitude of endpoints. As these devices often lack robust security measures, they can become entry points for larger-scale attacks, underscoring the need for integrated security solutions that can adapt to the evolving IoT ecosystem.

Consideration of the potential for emerging technologies to introduce new security risks and vulnerabilities, as well as opportunities for enhanced security controls and privacy preservation

Emerging technologies, while offering innovative solutions and capabilities, often introduce new security risks and vulnerabilities that were not previously considered. For instance, the rapid adoption of **cloud computing** has led to a **distributed data architecture** that, while scalable and flexible, requires a rethinking of traditional security perimeters. Data breaches and unauthorised access can occur if proper security protocols are not in place, highlighting the need for robust identity and access management systems. Similarly, the proliferation of **IoT devices** has **expanded the attack surface**

for cybercriminals, as these devices are frequently less secure and can serve as backdoors into more critical systems. This necessitates a shift towards a defense-in-depth strategy, where multiple layers of security are employed to mitigate risks.

On the flip side, emerging technologies also present opportunities for enhanced security controls and privacy preservation. **AI and machine learning**, for example, can be leveraged to develop predictive analytics that identify potential security threats before they materialise. By analysing patterns and behaviours, these technologies can enhance the effectiveness of intrusion detection systems and improve incident response times. Furthermore, **blockchain technology** offers a secure and transparent way to manage transactions and data sharing, with its immutable ledger providing a strong foundation for trust in digital interactions. This can be particularly beneficial in securing supply chains and ensuring the integrity of shared data across different stakeholders.



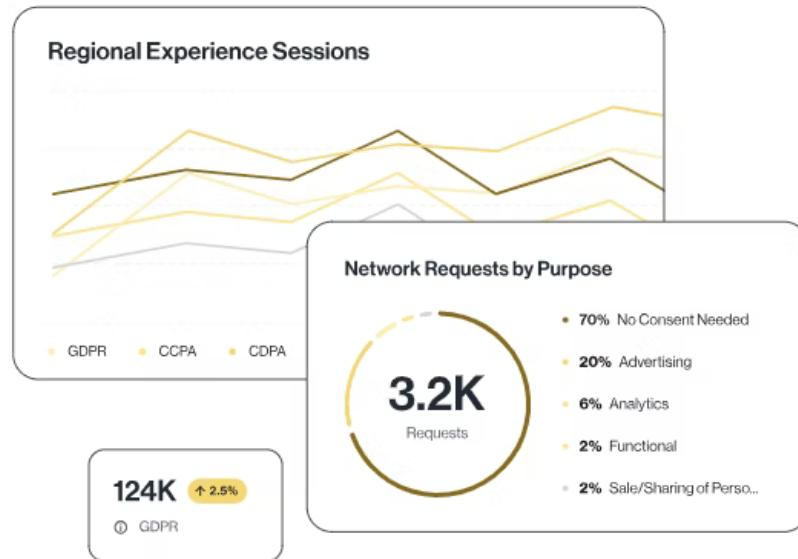
Secure multi-party computation ([Image source ↗\(https://medium.com/keleno/secure-multiparty-computing-bd44ee70e1a6\)](https://medium.com/keleno/secure-multiparty-computing-bd44ee70e1a6))

Privacy preservation is another area where emerging technologies can make a significant impact. Technologies such as **homomorphic encryption** and **secure multi-party computation** enable computations on encrypted data, allowing for data analysis without compromising privacy. This is particularly relevant in healthcare and finance, where sensitive information must be protected. Additionally, the concept of **privacy by design** is gaining traction, encouraging the integration of privacy considerations from the early stages of technology development. This proactive approach ensures that privacy is not an afterthought but a fundamental component of emerging technologies, fostering user trust and compliance with increasingly stringent data protection regulations.

Exploration of the legal and ethical implications of application systems incorporating emerging technologies

The integration of emerging technologies into application systems brings with it a host of legal and ethical considerations, particularly concerning data protection regulations and user consent mechanisms. As technologies like AI, machine learning, and IoT devices become more prevalent, they generate and process vast amounts of data, raising concerns about privacy and data security. Regulations such as the **General Data Protection Regulation (GDPR)** in the European Union set a

high standard for data protection, requiring organisations to implement appropriate technical and organisational measures to ensure a level of security appropriate to the risk. This includes protecting personal data against unauthorised access, accidental or unlawful destruction, and loss or alteration. Compliance with these regulations necessitates a thorough understanding of the technologies in use and the implementation of robust security measures.



User consent management ([Image source ↗\(https://transcend.io/blog/consent-management-strategy\)](https://transcend.io/blog/consent-management-strategy))

User consent mechanisms are another critical aspect of the legal and ethical landscape. With the growing awareness of privacy rights, users are demanding more control over their data. Emerging technologies must incorporate transparent and user-friendly consent mechanisms that allow individuals to understand how their data will be used and to give or withdraw consent accordingly. This is not only a **legal requirement** in many jurisdictions but also an **ethical imperative** to respect individual autonomy and privacy. The challenge lies in balancing the benefits of data utilisation for innovation and service improvement with the rights of individuals to have their personal information protected. organisations must navigate these complexities carefully, ensuring that their application systems incorporating emerging technologies are designed with privacy and ethical considerations at their core.

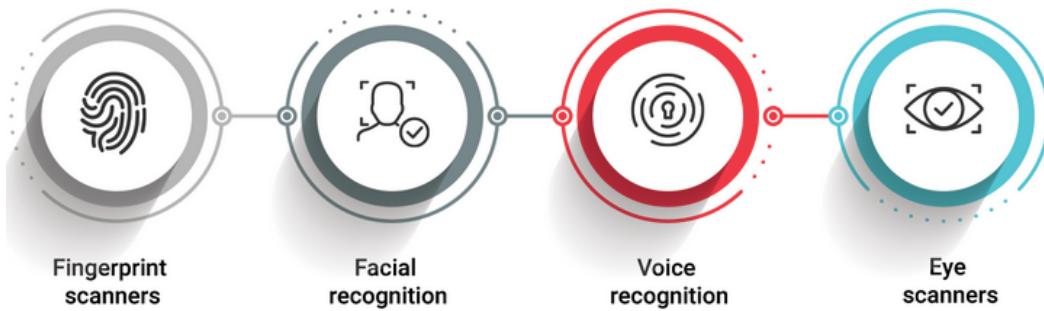
Real-world examples and case studies of application systems that have addressed security and privacy challenges through the use of emerging technologies

One real-world example of an application system addressing security and privacy challenges through emerging technologies is the implementation of **blockchain** in supply chain management. **Walmart**, for instance, has utilised blockchain to trace the journey of food products from their origin to store shelves. This ensures transparency and accountability, making it easier to identify and isolate contaminated products in the event of an outbreak. By using blockchain, Walmart has enhanced

security by reducing the risk of fraud and error in its supply chain, while also preserving the privacy of sensitive business data through the use of smart contracts and permissioned ledgers.

Another example is the use of **AI and machine learning** in cybersecurity. Companies like **Darktrace** have developed AI-driven cybersecurity systems that learn the 'norm' within an organisation's network and can quickly identify and respond to anomalies that may indicate a cyber attack. These systems are particularly effective against sophisticated threats like zero-day exploits and insider threats, as they can adapt to new patterns of behaviour without human intervention. This not only enhances security but also preserves privacy by minimising the exposure of data during a breach.

In the healthcare sector, the use of **homomorphic encryption** is an emerging technology that addresses security and privacy challenges. Homomorphic encryption allows data to be analysed without ever being decrypted, which means that sensitive patient information can remain secure even during analysis. Companies like **Cryptomedical** are working on solutions that use homomorphic encryption to enable medical research and personalised medicine without compromising patient privacy.



Biometric authentication ([Image source ↗\(https://www.spiceworks.com/it-security/identity-access-management/articles/what-is-biometric-authentication-definition-benefits-tools/\)](https://www.spiceworks.com/it-security/identity-access-management/articles/what-is-biometric-authentication-definition-benefits-tools/))

A case study of an application system that has successfully addressed security and privacy challenges is the implementation of **biometric authentication** in mobile banking apps. Banks like **Chase** and **Wells Fargo** have integrated fingerprint and facial recognition technologies to provide an additional layer of security for user authentication. This not only enhances security by making it more difficult for unauthorised users to access accounts but also improves the user experience by offering a more convenient login process. These biometric systems are designed with privacy in mind, ensuring that biometric data is stored securely and not shared without user consent.

These examples demonstrate how emerging technologies can be harnessed to create application systems that are not only more secure and privacy-preserving but also more efficient and user-friendly. As these technologies continue to evolve, it is likely that we will see even more innovative solutions to the perennial challenges of security and privacy in application system design.

▼ Supporting content I - Implications for user experience and interaction design

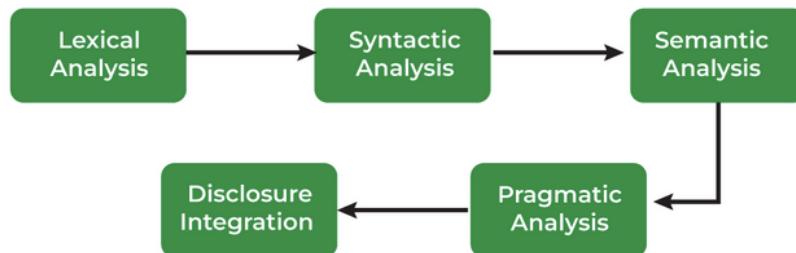
Analysis of how emerging technologies may impact the design and development of user experiences and interaction paradigms in application systems



Emerging technologies are reshaping the landscape of user experiences and interaction paradigms in application systems in profound ways. Technologies such as AI, ML, AR, VR, and IoT are not only changing what users expect from applications but also how developers design and implement these systems. For instance, **AI** and **machine learning** are enabling applications to offer personalised experiences by learning from user behaviour and preferences, leading to more intuitive and adaptive interfaces. **AR** and **VR** are transforming interaction design by creating immersive environments that allow users to engage with digital content in more natural and embodied ways. Meanwhile, **IoT** is expanding the scope of application systems to include a vast array of interconnected devices, each with its own set of interactions and user experiences to consider.

The implications of these emerging technologies for user experience and interaction design are **multifaceted**. Designers must now grapple with creating interfaces that are not only user-friendly but also capable of leveraging the advanced capabilities of these technologies. This often means **rethinking traditional design patterns and workflows** to accommodate new modes of interaction, such as gesture-based controls, voice commands, or even brain-computer interfaces. Additionally, the data-driven nature of many emerging technologies requires designers to address **privacy concerns** and ensure that user experiences are not only **engaging** but also **trustworthy**. As these technologies continue to evolve, the challenge for application system designers will be to harness their potential to create meaningful, inclusive, and ethical user experiences that enhance rather than detract from the human condition.

Consideration of the potential for emerging technologies to enable more natural, intuitive, and engaging user interfaces and interactions



Natural language processing ([Image source ↗\(https://www.geeksforgeeks.org/natural-language-processing-nlp-tutorial/\)](https://www.geeksforgeeks.org/natural-language-processing-nlp-tutorial/))

Emerging technologies are paving the way for user interfaces and interactions that are more natural, intuitive, and engaging than ever before. **Conversational agents**, or chatbots, are a prime example of this shift. By leveraging **natural language processing (NLP)** and machine learning, these agents can understand and respond to user queries in a conversational manner, mimicking human interaction. This not only makes the user experience more intuitive but also opens up new possibilities for accessibility, as users can interact with applications through voice or text without the need for complex navigation or form filling. The result is a more seamless and user-friendly experience that can significantly lower the barrier to entry for users of all skill levels.

Gesture-based controls represent another leap forward in natural user interfaces. With advancements in sensor technology and computer vision, devices can now interpret a user's movements and gestures to control applications. This technology is particularly transformative in fields like **gaming**, where it allows for immersive and physically interactive experiences, and in **accessibility**, where it can provide alternative methods of input for users with limited mobility. Gesture-based controls also have practical applications in everyday interfaces, making tasks such as scrolling, zooming, and selecting items more intuitive and reducing the learning curve for new users.

Immersive environments, created by AR and VR technologies, offer perhaps the most radical departure from traditional user interfaces. By enveloping users in a digital world, these technologies enable interactions that are as close to real-life experiences as possible. This has profound implications for training and education, where immersive simulations can provide hands-on learning experiences, and for entertainment, where users can explore virtual worlds or step into the shoes of a character in a story. Moreover, the ability to manipulate and interact with digital objects in a 3D space opens up new design challenges and opportunities, pushing the boundaries of what user interfaces can be and how users can engage with digital content in a truly immersive and engaging way.

Exploration of the challenges and opportunities associated with designing user experiences for application systems incorporating emerging technologies



Accessibility ([Image source ↗\(https://www.boia.org/blog/what-the-future-of-virtual-reality-means-for-accessibility_\)](https://www.boia.org/blog/what-the-future-of-virtual-reality-means-for-accessibility_))

Designing user experiences for application systems that incorporate emerging technologies presents a unique set of challenges and opportunities, particularly in the realms of accessibility, cultural diversity, and user trust. **Accessibility** is paramount, as the introduction of new technologies like voice interfaces, AR, and VR must be accompanied by considerations for users with disabilities. This includes ensuring that voice recognition systems are adept at understanding various speech patterns, that AR/VR environments are navigable for users with visual or auditory impairments, and that gesture-based controls can be used by individuals with limited mobility. By addressing these challenges, emerging technologies can actually enhance accessibility, providing alternative and often more intuitive ways for users with disabilities to interact with digital content.

Cultural diversity is another critical aspect that must be considered when designing user experiences with emerging technologies. The **global nature of technology** use means that applications must be sensitive to and inclusive of different languages, customs, and interaction norms. For instance, conversational agents must be programmed to understand and use a variety of languages and dialects, while also being aware of cultural nuances that can affect communication styles and expectations. AR and VR experiences should be designed to be culturally relevant and respectful, avoiding stereotypes and ensuring that content is engaging and appropriate for a diverse user base. By embracing cultural diversity in design, emerging technologies can foster a more inclusive digital world that resonates with users from various backgrounds.

User trust is a significant opportunity and challenge in the context of emerging technologies. As users interact with intelligent interfaces and share data with applications, concerns about privacy, security, and the ethical use of data come to the forefront. Designers must navigate these concerns by building transparency into the user experience, clearly communicating how data is used and providing users with control over their information. Additionally, establishing trust involves creating **reliable and consistent experiences** with AI and other technologies, ensuring that they perform as expected and do not inadvertently introduce biases or errors that could erode user confidence. By prioritising user trust and addressing these challenges head-on, emerging technologies can be integrated into application systems in a way that is not only innovative but also responsible and user-centric.

Real-world examples and case studies of application systems that have leveraged emerging technologies to create innovative and effective user experiences

Several real-world examples and case studies demonstrate how emerging technologies have been leveraged to create innovative and effective user experiences in application systems. Here are a few notable instances:





Google Assistant and Amazon Alexa: These virtual assistants have revolutionised user interaction with devices through voice commands. They use AI and machine learning to understand natural language and execute tasks, from setting reminders and playing music to controlling smart home devices. The user experience is hands-free and conversational, making it particularly useful for users with visual impairments or those who are multitasking.



Nike+ Run Club AR: Nike integrated AR technology into its Nike+ Run Club app to create an immersive running experience. Users can see motivational messages and running stats overlaid onto their surroundings through their smartphone cameras. This innovative use of AR enhances the user experience by providing an engaging and interactive way to track fitness goals.



Zappos' AR Try-On Feature: The online shoe retailer Zappos implemented an AR feature that allows customers to virtually try on shoes using their phone's camera. This technology, powered by augmented reality, helps users visualise how the shoes would look on their feet, reducing the uncertainty often associated with online shopping and improving the overall shopping experience.



Volvo's Use of AI for personalised In-Car Experiences: Volvo has been exploring the use of AI to create personalised in-car experiences. The company's vehicles can learn from the driver's

behaviour and preferences to adjust settings like seat position, music, and temperature automatically. This creates a seamless and intuitive user experience that enhances comfort and convenience.



Netflix's Recommendation Engine: Netflix employs sophisticated AI algorithms to analyse user behaviour and provide personalised content recommendations. This not only enhances the viewing experience by helping users discover content they are likely to enjoy but also increases user engagement and retention for the platform.



Magic Leap's Spatial Computing: Magic Leap's mixed reality headset offers a new way to interact with digital content in a physical space. The device projects holograms into the user's field of view, creating an immersive experience that blends the digital and real worlds. This technology has potential applications in gaming, education, and professional training, offering innovative user experiences that were previously impossible.



Apple's Face ID: Apple's introduction of Face ID on the iPhone X was a significant step forward in user authentication technology. Using facial recognition powered by neural networks, Face ID provides a seamless and secure way for users to unlock their devices and make payments. This technology has set a new standard for user experience in mobile security.

These examples illustrate how emerging technologies such as AI, AR, VR, and machine learning are being integrated into application systems to create user experiences that are more natural, intuitive,

and engaging. As these technologies continue to evolve, we can expect to see even more innovative applications that push the boundaries of what is possible in user interaction design.

▼ Supporting content J - Implications for development processes and methodologies

Analysis of how emerging technologies may impact the processes and methodologies used in application system development



Emerging technologies are reshaping the landscape of application system development, influencing both the processes and methodologies that developers and organisations employ. Technologies such as AI, ML, IoT, and blockchain are not only changing what applications can do but also how they are designed and developed. For instance, **AI** and **ML** are enabling more intelligent and adaptive applications, which require development teams to incorporate data science and algorithm design into their processes. This often necessitates a multidisciplinary approach, bringing together software engineers, data scientists, and domain experts. Furthermore, the integration of **IoT devices** into applications demands a focus on real-time data processing and secure communication protocols, leading to adjustments in development methodologies to accommodate these requirements.

The impact of emerging technologies on development processes and methodologies is also evident in the shift towards more agile and iterative approaches. As technologies evolve rapidly, traditional waterfall models may struggle to adapt, prompting a move towards **agile frameworks** that can accommodate frequent changes and updates. **DevOps practices** are also being enhanced with automation tools and **continuous integration/continuous deployment (CI/CD)** pipelines, which are becoming increasingly sophisticated with the advent of AI-driven testing and deployment strategies. Additionally, the rise of low-code/no-code platforms is democratising application development, allowing non-technical stakeholders to participate more actively in the design and creation of applications, further transforming development processes and methodologies.

Consideration of the potential for emerging technologies to enable more agile, collaborative, and automated development practices

Emerging technologies are playing a pivotal role in transforming traditional development practices into more agile, collaborative, and automated processes. **Continuous integration (CI)** and **continuous deployment (CD)** are two practices that have been significantly enhanced by these advancements. **CI** allows developers to merge code changes into a central repository frequently, while automated tests are run to ensure the changes do not break the existing functionality. **CD** automates the deployment process, ensuring that new features and bug fixes are rapidly delivered to

customers. Technologies such as containerisation (e.g., Docker) and orchestration tools (e.g., Kubernetes) have made CI/CD more accessible and efficient, enabling teams to adopt agile methodologies more effectively.

Low-code platforms represent another significant shift in development practices, reducing the traditional barriers to application development by allowing users to create applications with minimal coding. **Low-code platforms** provide visual interfaces and pre-built components that enable rapid development and prototyping. This not only accelerates the development process but also democratises development, allowing individuals without extensive programming knowledge to contribute to the creation of applications. As these platforms continue to evolve with emerging technologies, they are becoming increasingly sophisticated, capable of handling more complex applications and further streamlining the development process.

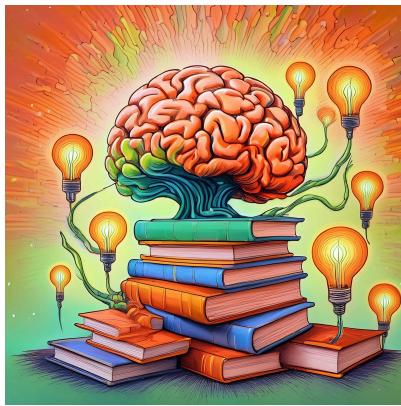
```
let subjectAverage;
query(
    "SELECT * FROM marks WHERE subject_ID=" + subject
)
function (datasetsWithSubject) {
    if (datasetsWithSubject.length > 0) {
        subjectAverage = 0;
        datasetsWithSubjectLength = datasetsWithSubject.length;
        datasetsWithSubject.forEach((dataset) =>
            subjectAverage += parseFloat(dataset['mark']));
        subjectAverage =
    } else {
        subjectAverage / datasetsWithSubjectLength;
    }
}
```

AI-assisted programming ([Image source ↗ \(https://medium.com/keleno/ai-assisted-coding-top-5-coding-assistants-8cc4558cb1d9\)](https://medium.com/keleno/ai-assisted-coding-top-5-coding-assistants-8cc4558cb1d9))

AI-assisted programming is an emerging technology that has the potential to revolutionise development practices by automating various aspects of the coding process. AI can assist in code completion, bug fixing, and even in generating code snippets based on natural language descriptions. This can significantly increase the productivity of developers and reduce the time required for application development. Moreover, AI can analyse vast amounts of code and identify patterns, helping to optimise performance and security. As AI continues to advance, it is likely to become an integral part of the development process, enabling more agile and efficient practices by augmenting the capabilities of human developers.

Exploration of the skills and competencies required for application system developers to effectively leverage emerging technologies, and the implications for education and professional development

As emerging technologies continue to shape the landscape of application system development, the **skills and competencies** required for developers to effectively leverage these advancements are evolving. Developers must now possess not only traditional programming skills but also a broader set



of competencies that include an understanding of AI, ML, data analytics, cybersecurity, and IoT, among others. This expansion of required knowledge reflects the increasing complexity and interconnectedness of modern applications.

The implications for education and professional development are profound. **Educational institutions** must update their curricula to include these emerging technologies, ensuring that students are proficient in the latest tools and methodologies. This means incorporating hands-on experience with AI frameworks, cloud computing platforms, and IoT devices into the learning process. Additionally, there is a growing need for **interdisciplinary learning**, as developers must often collaborate with experts in fields such as data science, design thinking, and user experience to create effective applications.

For professional development, the onus is on both individuals and organisations to foster a **culture of continuous learning**. Developers need to stay abreast of the latest technological trends and be willing to engage in lifelong learning to remain competitive. Organisations, in turn, must invest in training and development programs that help their workforce adapt to new technologies. This can include workshops, conferences, and certifications in emerging technologies. Moreover, the rise of online learning platforms and communities has made it easier for developers to access resources and learn at their own pace, further emphasising the importance of **self-directed learning** in the development of necessary skills and competencies.

Real-world examples and case studies of application system development teams and organisations that have adapted their processes and methodologies to incorporate emerging technologies

Several application system development teams and organisations have successfully adapted their processes and methodologies to incorporate emerging technologies. Here are a few real-world examples and case studies:



Spotify's Use of AI for Music Recommendations:

Spotify has revolutionised the music streaming industry by using AI to personalise user experiences. The company's development teams have integrated machine learning algorithms into their applications to analyse user behaviour and provide personalised music recommendations. This has not only changed the way users interact with music but also transformed Spotify's development processes to include data science and AI expertise.



Automation Anywhere's AI-Driven Robotic Process Automation (RPA):

Automation Anywhere is a leader in RPA, which uses software robots to automate repetitive tasks. The company has incorporated AI and machine learning into its RPA platform, enabling robots to learn from each transaction and improve over time. This has required a shift in development methodologies to include AI training and continuous learning cycles, demonstrating how emerging technologies can drive changes in development processes.



Netflix's Cloud-Native Architecture:

Netflix was an early adopter of cloud-native architecture, migrating its infrastructure to Amazon Web Services (AWS) and developing its own cloud-native tools like Chaos Monkey. This move allowed Netflix to scale its services globally and handle peak loads efficiently. The company's development teams had to adapt to a culture of automation, microservices, and continuous delivery, showcasing how cloud technologies can influence development methodologies.



Airbnb's Adoption of Machine Learning for Search Ranking:

Airbnb has implemented machine learning to improve its search ranking algorithm, providing users with more personalised and relevant search results. The development team had to integrate complex data processing and machine learning models into their application, which necessitated a shift towards more data-driven development practices.



Ford's Use of IoT and AI in Vehicle Development:

Ford Motor Company has embraced emerging technologies like IoT and AI to enhance vehicle

performance and safety. By integrating sensors and AI algorithms into their vehicles, Ford's development teams are now working on connected cars that can learn from driving habits and provide real-time feedback. This has led to the adoption of new development processes that include cybersecurity, data analytics, and cross-functional collaboration.



Capital One's Cloud Transformation with AWS:

Capital One, a major bank, underwent a significant transformation by moving its operations to the cloud with AWS. This shift allowed the company to innovate faster and deploy new financial services more quickly. The development teams at Capital One had to adapt to cloud-native development practices, including serverless computing and containerization, to leverage the benefits of the cloud.

These examples illustrate how leading companies across various industries have adapted their development processes and methodologies to incorporate emerging technologies. By doing so, they have been able to innovate, improve user experiences, and gain a competitive edge in their respective markets.



This activity is complete when you have

- Engaged with the AI tutor in the SupplySure case study and participated in class discussion to share your experiences and learn from others.
- Documented your analysis and recommendations for the SupplySure case study in a short report (1-2 pages, or a copy of the chat transcript), which will form part of your portfolio (<https://lms.griffith.edu.au/courses/24045/pages/building-a-portfolio-for-assignment-2>)..
- Explored potential emerging technologies to enhance your application system design report (<https://lms.griffith.edu.au/courses/24045/assignments/93487>)..