Internet of Things Platforms and Connected Devices

Lab 58 Technology Research Brief

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Over the past 20 years, Internet of Things (IoT) technology has evolved from a fledgling platform to a massive series of systems increasingly disrupting how humanity lives, communicates, grows, and builds.[1] IoT has quickly become an increasingly integrated facet of modern life, serving as the technological guiding hand of smart cities, smart homes, and industry 4.0—the transition in manufacturing, product development, and logistics toward digital connectivity and data driven efficiency optimization. Its impacts have already revolutionized modernity and will only continue to do so as it becomes further entrenched in numerous aspects of infrastructure growth. But what is IoT and how does it function?

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Figure 1. Smart City IoT Platform Integration.

This figure displays the interconnected devices and sensors on an IoT network for a smart city grid. The figure shows interconnected transportation networks, waste management, energy efficient buildings, digital and telecommunication networks, and electric utility infrastructure.

KEY TAKEAWAYS

1. **IoT has expansive use cases for industry, urban development and infrastructure, personal use, and medical use.**
2. **Continued refinement of sensors, edge computing, and cloud services, and increased demand for IoT services are creating massive sector growth.**
3. **IoT presents significant data and security challenges, though many of these can be eliminated using cloud data storage and end-to-end encryption.**

[1] CompTIA. (2022). The history of the Internet of Things. *CompTIA*.

IoT and Its Applications

Simply put, IoT is a platform or group of technologies in which "things" not traditionally considered computers are connected to each other via the internet.[2] Once connected, these "things" exchange and process data and directives in real time. The "things" that comprise an IoT platform can be any range of everyday objects or sensors, making its flexibility and use cases nearly inexhaustible. Essentially, via an IoT platform, any range of devices can be attached to each other, enabling the data inputs of one device's sensors or commands to guide the actions of other devices (and vice versa) without human intervention. IoT platforms have the potential to greatly heighten the efficiency of all services and sectors for which they are deployed. Their implementation has already exploded, and as of 2020, 7 billion devices were already connected to IoT platforms, with this number poised to grow to 22 billion before 2025.[3]

Why has IoT taken off?

Although the potential of IoT platforms has long been lauded, their widespread implementation has only recently begun, due to multiple technological advancements. For example, digital sensors have become far more widely produced and standardized, allowing for lower product fabrication and installation costs and paving the way for the large-scale deployment necessary for IoT system infrastructure.[4] Beyond this, IoT gathers a great deal of data—data that must be stored—advances in cloud[5] and edge computing[6] have allowed that data to be stored far more efficiently and cheaper than ever before. In addition, IoT has benefited from macro-trends, such as demands for greater automation in a range of industries, the greater digital and internet connectivity of the world today, and advancements in artificial intelligence technology, especially "conversational" tools such as Alexa and Siri. Lab 58 has extensively researched recent advancements in edge computing and IoT. If you are interested in reading more, click here.

IoT Platform Use Cases

IoT platforms' potential use cases are expansive, but a few stand out as particularly significant. First among these use cases is its potential for integration into industry and logistics, heavily expanding the use of data in factory settings and shipping. In manufacturing settings, IoT connected sensors can control and alter rates of production, issue maintenance and safety alerts, identify product quality issues, and track supply inventory.[7] In shipping and logistics, IoT sensors can offer insights, such as real-time data on inventory, vehicle location and tracking, temperature control, and damage monitoring.[8] Additionally, IoT platforms can update delivery routes in real time in response to obstacles like accidents or construction, detect theft and security issues, and monitor equipment.[9]

IoT wearable technologies, such as smart watches and health sensors, represent another budding industry.[10] Devices monitoring heart rates, breathing, body temperature, physical exertion, and sleeping patterns can be connected to cloud infrastructure to offer individuals and their physicians' insights on personal health. These updates are delivered through direct updates to personal cellphones, updating electronic health records and charts, or creating aggregated data sets tracking trends in groups. IoT wearables hold a range of uses from allowing physicians to monitor their patients' vital trends in real time to assisting professional sports teams in maximizing on-field performance.

IoT technology is also redefining city and regional planning through the creation of smart cities. Municipalities are deploying sensors across their infrastructure systems to monitor and guide energy grids, water infrastructure, crime patterns, waste systems, traffic patterns, and public transportation.[11] These sensors allow governments and utility companies to maximize sustainability and efficiency, while also allowing individual customers with greater data to track and alter their own utility consumption. Ultimately, these use cases represent just a small portion of the available avenues for integrating IoT platform technology into society, with IoT also producing smart homes, transforming agriculture, and modernizing healthcare management.

[2] Oracle. (2022). Internet of Things. *Oracle*.
[3] Oracle, 2022
[4] Oracle, 2022
[5] Oracle, 2022
[6] IBM. (n.d.). What is edge computing? *IBM*.
[7] Digiteum Team. (2019, May 21). The Internet of Things in manufacturing: How IoT is changing manufacturing. *Digiteum*.
[8] DHL. (2023). Physical internet. *DHL*.
[9] Digiteum Team. (2021, December 29). How to use IoT (Internet of Things) in logistics industry: Successful use cases. *Digiteum*.
[10] ScienceSoft. (2022). Wearable medical devices. *ScienceSoft*.
[11] National Geographic Society. (2022, May 29). Smart cities. *National Geographic*. https://education.nationalgeographic.org/resource/smart-cities

Figure 2. IoT in Shipping and Logistice.

Source: gorodenkoff/iStock/Getty Images Plus via Getty Images

This figure displays a warehouse manager checking on a warehouse IoT platform including sensors for temperature, warehouse efficiency, and inventory.

Risks and Limitations of IoT

Despite IoT platforms holding deep potential, they also hold some important limitations and risks that must be addressed prior to their widespread adoption. Chiefly, IoT implementation demands robust data storage and management. Running IoT platforms requires extremely large data storage capabilities as all sensors and devices produce and transfer data. This has been alleviated to some extent by the introduction of cloud storage and edge computing, rather than using centralized data storage, but governments and organizations must invest heavily in accessing and developing cloud storage systems that meet the demands imposed by IoT.[12] Edge computing analyzes and processes data collected by sensors so only the most important or relevant data are extracted, uploaded to data storage networks, and sent to central data-processing locations.[13] Essentially, edge computing acts as a strainer for data at its collection sources on the edge of networks, disregarding irrelevant data that might slow or overwhelm IoT data storage networks. Cloud services allow for data storage on remote servers on the internet rather than utilizing physical data storage hardware at a centralized server farm.[14]

IoT platforms also face serious security and data privacy vulnerabilities. Many IoT platforms contain weak security infrastructure, allowing easy access to hackers.[15] This issue is especially pressing given the extent to which IoT platforms will be implemented across social structures, supply chains, and production. Targeted attacks on critical infrastructure services connected to IoT could very easily wreak havoc on economic systems and social organization. Beyond this, many IoT platforms, especially those that are private, gather personal data. IoT platform developers and managers must be cognizant of collecting only relevant data that are not personally identifiable and properly encrypting personal data at rest and in transit if they must be collected.

With IoT platforms being produced and managed disparately, there are also concerns over interoperability and the potential to merge and integrate IoT systems with one another.[16] However, many of these concerns can be avoided through the use of cloud and edge infrastructure rather than on-premises software and hardware. In addition, some IoT technologies, especially wearables, still hold significant user access costs, curbing their user bases. However, as with other sensors, the cost of wearables continues to decrease, and they should become more financially accessible over time.

[12] Gaur, A., Scotney, B., Parr, G., & McClean, S. (2015). Smart city architecture and its applications based on IoT. *Procedia Computer Science. 52.* 1089-1094.

[13] Microsoft. (2023). What is edge computing? *Microsoft.*

[14] Microsoft. 2023

[15] Banafa, A. (2017, March 21). 3 major challenges IoT is facing. *OpenMind BBVA.*

[16] Pratt, M. K. (2021, April 19). IoT interoperability standards complicate IoT adoption. *TechTarget.*

Potential of IoT and IoT Market Space

As discussed throughout this brief, IoT technology will hold significant sway in shaping communication, logistics, and human organization now and into the future. IoT platform deployments are already changing city management, crop irrigation, and home management. It is arguably the new frontier of data-driven analytics and management, and as such, its market is rapidly expanding. The global market is forecasted to grow from $478 billion in 2022 to $2.465 trillion by 2029.[17] Estimates even place IoT use's global value between $5.5 trillion to $12.6 trillion by 2030.[18] With its use revolutionizing commerce and governmental services, along with increasing policy interest, harnessing and utilizing IoT platform technology will be of paramount importance for any organization seeking to stay ahead in an increasingly connected world.

Work With Lab 58

Thanks for your interest in our work! We want to help you explore opportunities to work with IoT Platforms.

Please email us at Lab58@rti.org. We will set up a 30-minute, one-on-one chat to discuss opportunities and answer any questions. We are interested in partnering with you to find a solution that meets your needs.

For more information, contact Lab58@rti.org.

[17] Fortune Business Insights. (2022). Internet of Things (IoT) Market. *Fortune Business Insights.*

[18] Chui, M., Collins, M., & Patel, M. (2021, November 9). IoT value set to accelerate through 2030: Where and how to capture it. *McKinsey & Company.*