International Journal of Smart Business and Technology
Vol. 12, No. 2 (2024), pp. 13-20
http://dx.doi.org/10.21742/ijsbt.2024.12.2.02

Impact of IoT on Capacity Efficiency and Customer Satisfaction

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Abstract

The Internet of Things (IoT) has emerged as a pivotal force in driving the evolution of smart business practices. By leveraging IoT sensors, organizations can seamlessly collect critical data related to workplace activities, offering real-time insights into operational dynamics. Tracking key elements such as active personnel, customer behavior, and entry points to the workplace enables managers to optimize workflow efficiency and make informed decisions instantly. This transformative capability empowers businesses to maintain agility and enhance productivity. With its increasing prevalence, IoT has become a cornerstone of industrial strategies, transcending traditional approaches to business management. IoT-driven solutions allow for granular monitoring and analysis of processes, enabling businesses to address inefficiencies, forecast trends, and improve overall performance. Integrating IoT technology is reshaping how businesses operate in today's competitive landscape, from automating routine tasks to generating actionable intelligence. This article explores the intersection of IoT engineering and business management, presenting a framework for applying IoT strategies across diverse industries. Unlike traditional approaches that depend heavily on the specific nature of the business, IoT solutions offer a universal methodology adaptable to various sectors. The discussion highlights the practical implementation of IoT in areas such as supply chain management, customer engagement, resource allocation, and operational oversight. Through case studies and strategic insights, this study demonstrates how IoT can drive innovation and create value for businesses of all sizes and types, underscoring its potential as a transformative tool for sustainable growth and competitiveness.

Keywords: *IoT, IoT solution for businesses, Capacity efficiency, customer satisfaction*

1. Introduction

The most important thing, especially for service-oriented businesses, is controlling the entrance area. Maintaining a consistent flow of customers during peak hours ensures better service and customer satisfaction [1]. The key solution is to provide a comprehensive monitoring system across the whole business area and analyze job distribution.

Such a system can provide a real-time queuing system analyzer, which can help detect and prevent bottlenecks in a system. With the help of positioning systems provided by IoT systems and real-time data collection, time labels can offer valuable data [2]. Data mining

Article history:
Received (September 18, 2024), Review Result (October 20, 2024), Accepted (December 1, 2024)

techniques can create visualizations for analyzing and optimizing peak load management [3]. Providing such an environment can directly impact the decision-making process and productivity.

Integration of all observations is possible, as illustrated in the following graph. As shown in Figure 1, we assume that the business has three work areas (Area01, Area02, and Area03), and each area has several spots. Spots are working places for any services the business provides. We assume that services or products in each area are different. Depending on the work area and nature of the company, the output can be a different graph and chart.

Figure 1. Possible work area

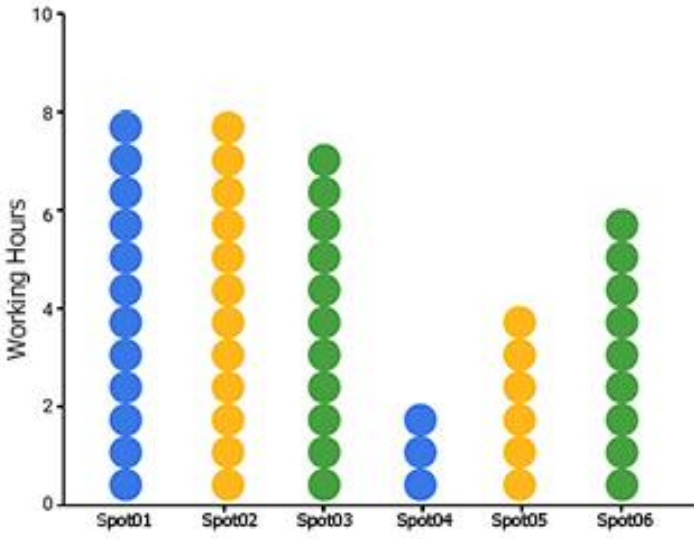

Figure 2. Possible visualized graph for rush hours

A centralized cloud-based system can collect real-time data from IoT positioning systems, enabling managers to monitor workload and identify idle times. Instantly, the manager can observe overload or idle time in a service area. It can be easy to solve such a problem by

guiding customers and adjusting queues. By this, addressing bottlenecks at both the input and output stages will be refined [4]. In terms of the importance of an IoT positioning system, queue management is one of the significant challenges for service-oriented businesses. Queue management is a significant challenge for service providers, as it directly affects Customer Relationship Management (CRM) results, whether at the input or output queues. IoT solutions offer an effective approach to service capacity efficiency. Traditional methods, such as increasing budgets or building more facilities, are often temporary and unsustainable. The solution used must be elastic and can be refined and redefined depending on the time. IoT solutions, on the other hand, can enhance business sustainability by providing a dynamic analyzing system. IoT solutions maximize utilization, minimize waste of available resources, and optimize available capacity [1]. Decision-makers can use this data to review processes and make timely adjustments.

2. Capacity efficiency

Effective capacity management is essential for any business, whether it provides products or services. Because it is directly related to customer satisfaction and business profitability, senior managers must prioritize capacity management as a critical component of their business strategy. Capacity is defined as the total productive capability of all the utilized productive resources [5]. But, in simpler terms, capacity is the number of employees and their equipment based on the working space needed to deliver service and how to manage these variables to increase efficiency. Capacity can be categorized based on resources involved [1]. Differentiate capacity in two different categories. One is the permanent capacity, which contains all resources available for all the time, and the other is contingent capacity, which is resources temporarily added. The challenge is based on provided service entities; in the case of service as a product, the service entity's fluctuation could not be assumed as a fixed item. Consequently, capacity management solutions are inadequate and cannot be fixed permanently. In the best-case scenario, an optimal solution must be based on real-time analysis and decision-making, which could be provided by real-time visualization. Therefore, IoT-based solutions are well-suited and accurate for business capacity management in such cases. We can define business efficiency as how a business can effectively produce a product or service, considering factors like employees' electricity costs [6]. Capacity efficiency directly affects overall business revenue. Any business underestimating the importance of efficiency can hinder its growth and directly reduce customer satisfaction, consequently decreasing revenue [7].

In most cases, especially in businesses that provide services by considering only one service line, Capacity Efficiency (CE) directly comes from the Working Area (WA), Number of Employees (Em), and Standard Service Time (ST) by considering the Proper Waste Time (PWT). It can be formulated as

$$CE = (WA / Em) * ST + PWT \quad (1)$$

For series of work lines, it can be formulated as:

$$CE = \sum_{i=1}^{n} \left({}^{WAi}/_{Emi} \right) * STi + PWTi \quad (2)$$

Hence, Overloading or underutilizing jobs in the service provider line or idle line directly affects capacity efficiency and, accordingly, benefits. The capacity of a firm service is defined as the highest quantity of output possible in a given period with a predefined level of staffing, facilities, and equipment [8].

3. Efficiency characteristic

Efficiency means accomplishing tasks with a minimum amount of resources. However, saving resources and budgets should not compromise business effectiveness. There are differences between efficiency and productivity. Productivity is the output a business can achieve in a given time. However, efficiency shows how well you use the resources to complete a job

.

Two types of efficiency lead us to capacity efficiency. One is process efficiency, and the second is execution efficiency [9]. Process efficiency is designing roles and workflow that minimize time and resource waste. The key to achieving positive results is how it applies. The implementation and execution significantly influence customer satisfaction and business revenue. Ultimately, they are essential for business growth and transforming a small business into a recognizable brand.

4. Capacity constraints

Defining the condition of capacity constraints is critical for effective capacity planning. Capacity constraints can be categorized into different states [10]. The first state is 'Hard Capacity Constraints,' where all capacities are fixed and cannot be increased. The second stage is 'Soft Capacity Constraints,' in which flexibility can increase or decrease available resources. The third state is 'No capacity Constraints,' with no limitations. Required resources are immediately available

; dynamic capacity management will overcome the constraints. Management based on a dynamic real-time controlling system can guide the workforce and movement of tools to distribute them dynamically over different working areas, reducing wasting resources and increasing capacity efficiency. Hence, IoT technology is well-suited for developing such a system. IoT technology can collect real-time information from the working area and store it to provide analysis and reporting, enabling senior managers to make informed decisions [11].

5. How can IoT help capacity efficiency?

One of the primary benefits of using IoT solutions is controlling resource waste, which will be profitable for the business. IoT-based monitoring systems can achieve this by real-time tracking service line performance [12]. By storing employee active time data or employees' positions in working space collected by IoT devices, their behavior and active time can be plotted and analyzed over the workday. Job congestion on one side of our service line, queue entry or exit, will directly affect efficiency. Such a situation can be detected using IoT devices to collect environmental data. The nature of the business also can affect the service line. Services are always not handled on a First-In-First-Out (FIFO) basis. It may serve based on the job type and time cost. Decision makers and managers need to visually observe the behavior of their customers and employees during peak times to regulate the existing roles.

However, all the observation and control systems should not be isolated from the work environment [13]. Providing all connected environments based on the positioning system requires various devices such as RFID, Bluetooth, and Wi-Fi. Despite all hardware and sensor

design achievements [14], designing and implementing a platform for workspace geometry independent positioning systems can be challenging and difficult, based on the nature of the business.

6. Challenges

Overcoming challenges, particularly security, is the most critical for developers [15]. Outdoor connectivity and sensor communication are among the major issues that must be solved. Designing IoT ecosystem communications based on devices' communication capabilities is complex because there are no fixed and permanent standards for designing an IoT ecosystem [16]. Ensuring consistency between sensors, sources, and targets is another challenge. Developing analytical and visualization cloud-based applications that satisfy business demands is also challenging to design. Managers and decision-makers usually focus on real-time reporting that can help them to manage their employees on time. One of the major challenges that needs to be taken care of is the power source for IoT devices. Based on the nature of these devices, providing a long-time low-power system is vital. Power source for running long-term activities from positioning components, including with or without processing unit impact IoT system design. Another challenge is collecting clean, reliable, and real-time data for visualization reports. Real-time communication, storage, cleansing, and data provision takes time. However, in such a design, developers must consider any obstacle preventing the system from collecting critical data.

Last, a significant challenge in designing IoT solutions and platforms is the diversity of workspaces. It is different from building and workspace to another. Designing solutions independent from workspace geometry for developing positioning systems is challenging.

7. Detecting the bottleneck

Resolving firms' bottlenecks directly affects productivity and overall costs [17]. Every service provider, from the first customer to the last contact point, can be divided into different layers based on capacity constraints. Capacity constraints can cause bottlenecks at any layer. As shown in Figure 2, businesses can be divided into different layers to understand the situation better. Bottlenecks can arise from the infrastructure layer, workforce layer, or even customer congestion at a specific time.

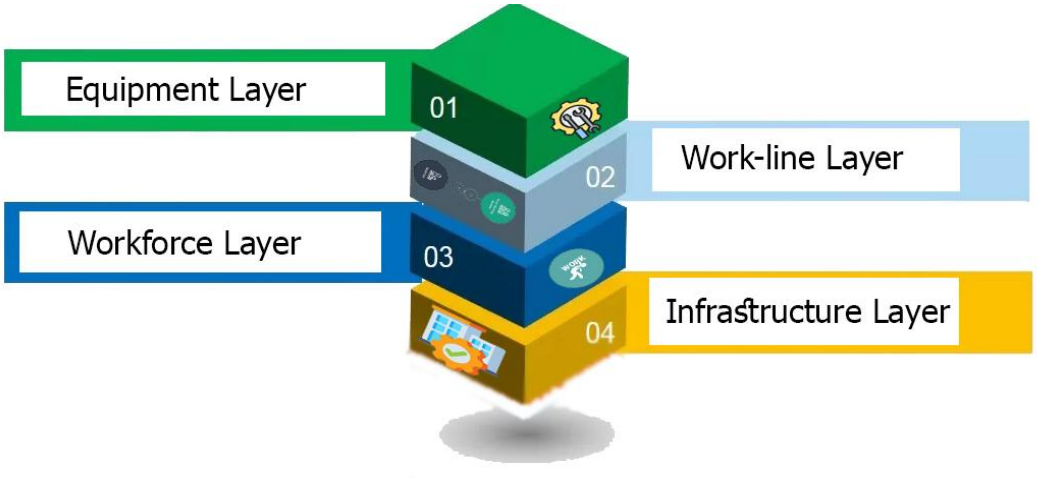

Figure 3. Work layers

Reducing the number of assignments that refer to one service line in the same time slot and distributing assignments between multiple service lines or time slots will help to prevent bottlenecks. There is a difference between occasional and frequent bottlenecks [18]. Two different strategies must be used for each case. Sometimes, bottlenecks happen rarely, so they can be ignored. Sometimes, bottlenecks can occur in certain circumstances and are caused by any factor outside the firm.

But in most cases, a bottleneck is a continuous problem. In this case, any manager at any level should be its first concern to detect and solve the bottleneck problem. Also, bottlenecks can be caused by the unorganized sequencing of processes. It is usually caused by inconsiderate and untrained staff, which creates problems for the business. In any case, the bottleneck is a critical issue for successful companies and must be detected and resolved in any circumstances. It directly affects customer satisfaction and company revenue.

8. Data Collection

Collecting relevant and accurate data is essential for capacity efficiency decision-making. The raw data must be prepared for further analysis, which requires pure and clean data. Different devices and methodologies may be used in development based on the designed scheme. In IoT-based platforms, two different data types are present. Type one is real-time data provided by sensors and devices connected to the data source system. The data source provides the current state of the environment. Type two is archival data. Archival data is used for visualization and comparable situations. As mentioned before, IoT devices generate data based on the sensors that observe the objects in the work area [19]. This data can track object movement from entry to service completion, and the object will be ready to exit. These raw data are sent to the gateways, and through the gateways, raw data will be sent to data stores. The software retrieves data and plots the current situation for a specific object the system needs. The type of data, labeled or unlabeled, depends on what kind of charts or reports that business needs. Hence, data structure varies based on the business's nature and the organization's services.

9. Data analysis

Data analysis is a critical component of capacity management and efficiency. By analyzing real-time data or stored data, businesses can visualize resource usage in the provided service or product [20]. Comparing current and expected resource consumption helps managers observe the effectiveness of their resources, whether their workforce or equipment. Another method for analyzing capacity status is comparing current capacity scenarios with retrieved data from archive capacity scenarios. By comparing these two or more scenarios and visualizing the situation, businesses can identify differences between different capacity situations that lead them to determine which scenario outcome can be effective with the current workforce and equipment in an active workspace. IoT solutions can provide these data types by retrieving data from sensors that transmit real-time data through gateways.

10. Conclusion

This research defines capacity efficiency and explores how IoT solutions can empower businesses to identify and resolve challenges by utilizing real-time and historical data. As outlined in this study, IoT sensors and devices serve as indispensable tools for monitoring specific working environments, capturing critical events, and generating actionable insights.

These insights enable businesses to enhance decision-making processes, optimize operations, and improve efficiency. Moreover, this paper highlights the broader implications of IoT solutions beyond their immediate operational benefits. It serves as a stepping stone for future research endeavors, particularly in conducting detailed case studies of service-oriented businesses. Such studies could illustrate how IoT applications can cater to the unique demands of diverse industries. Furthermore, the study encourages exploring the design and implementation of IoT solutions tailored to specific business models, emphasizing their role in boosting customer satisfaction, operational productivity, and profitability.

By addressing these future research directions, scholars and practitioners can unlock more sophisticated uses of IoT, from predictive analytics to intelligent automation, all of which contribute to a more dynamic and responsive business environment. This paper underscores the transformative potential of IoT in shaping modern business practices, providing a roadmap for organizations seeking to leverage data-driven technologies. Integrating IoT into business strategies offers unparalleled opportunities to achieve sustainable growth, innovation, and a competitive edge in an increasingly digital economy.

References

[1] H. J. Wu, “Analysis of Quality management for better capacity utilization,” **(2024)**

[2] F. Ciccozzi and R. Spalazzese, “Mde4iot: supporting the internet of things with model-driven engineering,” in International Symposium on Intelligent and Distributed Computing. Cham: Springer International Publishing, **(2016)**

[3] D. Fawzy, S. M. Moussa, and N. L. Badr, "The Internet of things and architectures of big data analytics: Challenges of intersection at different domains," IEEE Access, vol.10, pp.4969–4992, **(2022)**

[4] S. Roy, Bottleneck Management through Strategic Sequencing in Smart Manufacturing Systems. MS thesis, West Virginia University, **(2022)**

[5] O. Alp and T. Tan, “Tactical capacity management under capacity flexibility,” IIE Transactions, vol.40, no.3, pp.221–237, **(2008)**

[6] K. Czarnecki and S. Helsen, “Classification of model transformation approaches,” in Proceedings of the 2nd OOPSLA Workshop on Generative Techniques in the Context of the Model Driven Architecture, vol.45, no.3, **(2003)**

[7] M. Saadat, M. Heydari, and Z. Dongsheng, “Developing sustainable hospital capacity management protocols using clinical prognostic analysis: A novel stochastic model for Covid-19,” **(2024)**

[8] B. Adenso-Díaz, P. González-Torre, and V. Garcia, “A capacity management model in service industries,” International Journal of Service Industry Management, vol.13, no.3, pp.286–302, **(2002)**

[9] S. A. Odei, L. Ardito, and I. Soukal, “The impact of capacity utilization on product innovation in emerging economies: The moderating effects of firm ownerships,” Technological Forecasting and Social Change, vol.208, p.123664, **(2024)**

[10] A. Narayanan, A. W. Mackelprang, and M. K. Malhotra, “System performance implications of capacity and flexibility constraints on bullwhip effect in supply chains,” Decision Sciences, vol.53, no.5, pp.783–801, **(2022)**

[11] A. Sinha et al., "Impact of Internet of things (IoT) in disaster management: A task-technology fit perspective,” Annals of Operations Research, vol.283, pp.759–794, **(2019)**

[12] L. Zhao et al., "Design of an industrial IoT-based monitoring system for power substations,” IEEE Transactions on Industry Applications, vol.55, no.6, pp.5666–5674, **(2019)**

[13] T. Abass, et al., “Advancing food safety through IoT: real-time monitoring and control systems,” International Medical Science Research Journal, vol.4, no.3, pp.276–283, **(2024)**

[14] S. Hadzovic, S. Mrdovic, and M. Radonjic, “Identification of IoT actors,” Sensors, vol.21, no.6, p.2093, **(2021)**

[15] J. M. Kizza, "Internet of Things (IoT): growth, challenges, and security,” in Guide to Computer Network Security. Cham: Springer International Publishing, pp.557–573, **(2024)**

[16] H. Park and S. Park, “Emerging trends and challenges in IoT networks,” Electronics, vol.13, no.3, p.513, **(2024)**

[17] F. Witlox et al., "Changing tracks: identifying and tackling bottlenecks in European rail passenger transport," European Transport Research Review, vol.14, no.1, p.7, **(2022)**

[18] S. M. Javadi, S. J. Sadjadi, and A. Makui, “Identification and fixing bottlenecks of a food manufacturing system using a simulation approach,” Scientific Reports, vol.13, no.1, p.11786, **(2023)**

[19] S. Arora, et al., “Seed: secure and energy efficient data-collection method for IoT network,” Multimedia Tools and Applications, vol.82, no.2, pp.3139–3153, **(2023)**

[20] R. Krishnamurthi et al., "An overview of IoT sensor data processing, fusion, and analysis techniques,” Sensors, vol.20, no.21, p.6076, **(2020)**

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