Industrial Internet of Things (IIoT) Status in Jordan: Application and Challenges

Dr. Ala' Khalifeh, Eng. Mustafa Abu-Ghazaleh

***Abstract*—This paper examines the current status and future potential of Industrial Internet of Things (IIoT) technology within Jordan. While global adoption of IIoT is rapidly increasing, Jordanian industries, particularly manufacturing, have been slow to integrate these technologies into their production cycles. The paper identifies key challenges hindering wider adoption, including a lack of awareness regarding the benefits of IIoT, limited digital infrastructure, and economic constraints. Despite these challenges, some Jordanian companies, particularly in regulated sectors like pharmaceuticals and cosmetics, utilize IIoT for data collection to meet compliance standards. This paper explores existing and potential applications of IIoT in Jordan, analyzes the challenges, and proposes strategies to promote wider adoption and maximize its potential benefits for the Jordanian economy.**

I. Introduction

The Industrial Internet of Things (IIoT) is revolutionizing industries across the globe by connecting machines, systems, and people, enabling real-time data collection, analysis, and automation. This interconnectedness offers significant potential benefits, including increased efficiency, improved productivity, reduced costs, and enhanced product quality. While many countries are experiencing rapid IIoT adoption, Jordan's progress in this area has been relatively slow. This paper aims to provide a comprehensive overview of the current status of IIoT in Jordan, examining its applications, challenges, and potential for future growth. A key focus will be on understanding the reasons behind the slow adoption and exploring strategies to overcome these barriers.

II. IIoT Applications in Jordan

A. Current Applications

While the challenges to widespread IIoT adoption in Jordan are significant, there are encouraging signs of progress and pockets of successful implementation. The Jordan Industry 4.0 Digitalization Innovation Center (INJO4.0) is playing a key role in fostering this growth by actively supporting businesses in their IIoT journeys.

One of the ways INJO4.0 is doing this is by providing financial grants to help companies upgrade their production lines and integrate IIoT technologies. These grants are instrumental in overcoming the financial barriers that often hinder adoption, particularly for smaller businesses with limited resources.

A concrete example of this support is the case of a Jordanian pharmaceutical factory that leveraged INJO4.0's grant to implement an IIoT system for monitoring energy consumption. By installing power monitoring units throughout the facility, the factory can now collect real-time data on energy usage across different processes and equipment. This data is then fed into IIoT programs and visualized on dashboards, providing valuable insights into energy consumption patterns and areas for potential optimization. This not only helps the factory reduce its environmental footprint but also leads to significant cost savings through improved energy efficiency.

Beyond energy monitoring, other Jordanian factories are also embracing IIoT, albeit on a smaller scale. Some are utilizing sensors to gather data on environmental conditions such as temperature and humidity. This is particularly crucial in industries like pharmaceuticals and food processing, where maintaining strict environmental controls is essential for ensuring product quality and compliance with regulations. By continuously monitoring these parameters, businesses can proactively identify and address any deviations that could compromise product integrity.

These examples, while still limited in number, demonstrate the growing awareness and adoption of IIoT in Jordan. They also highlight the crucial role that organizations like INJO4.0 play in supporting businesses, overcoming barriers, and fostering a thriving IIoT ecosystem in the country.

However, a recent self-assessment survey conducted by INJO4.0 of 48 companies between February 2021 and June 2021, revealed that the average readiness index for Industry 4.0, including IIoT, among Jordanian manufacturing SMEs is still quite low (1.56 out of 5). This suggests that while there are pockets of progress, the overall adoption of IIoT is still in its early stages. The survey also highlighted that many companies lack the basic digital infrastructure and automation systems needed for IIoT implementation. This underscores the need for continued efforts to raise awareness, provide support, and address the challenges hindering wider IIoT adoption in Jordan. The survey included companies from a

Princess Sumaya University for Technology, King Hussein School of Computing Sciences, Master's Degree in Enterprise Systems Engineering, Internet of Things course.

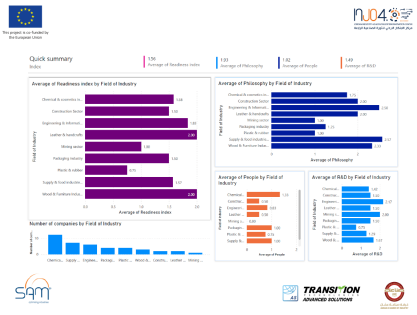

Figure 1. Industry 4.0 Readiness and Key Performance Indicators (KPIs) in Jordanian Manufacturing SMEs

variety of sectors, including:

- Food and beverage
- Chemical and cosmetics
- Pharmaceutical
- Plastic and rubber
- Engineering and electrical
- Wood
- Construction
- Leather
- Mining

Figure 1 provides a snapshot of the current state of Industry 4.0 readiness among Jordanian manufacturing SMEs, based on a self-assessment survey conducted by INJO4.0. It highlights the average readiness index across all participating companies, as well as a breakdown by sector. Additionally, it shows the average scores for key performance indicators (KPIs) related to philosophy, people, and R&D, providing further insights into the areas where companies are excelling and where they need more support.

B. Potential Applications

Despite the nascent stage of IIoT adoption in Jordan, the potential applications across various sectors are vast and promising. Leveraging these technologies could significantly contribute to economic growth, resource optimization, and improved quality of life.

1. Manufacturing

The manufacturing sector, a cornerstone of Jordan's economy, stands to gain significantly from IIoT implementation. Key applications include:

- **Predictive Maintenance:** Integrating sensors into machinery to monitor performance parameters (vibration, temperature, etc.) enables predictive maintenance, minimizing costly downtime and optimizing production schedules [8]. This approach shifts maintenance from a reactive to a proactive strategy, enhancing efficiency and reducing operational costs.
- **Quality Control:** Real-time data collection and analysis through IIoT sensors embedded in production lines can facilitate continuous quality control. By identifying deviations from quality standards early on, manufacturers can take corrective action promptly, ensuring consistent product quality and minimizing waste (Tao et al., 2018).
- **Supply Chain Optimization:** IIoT-enabled tracking of goods and materials throughout the supply chain provides real-time visibility into inventory levels, location, and movement. This enhanced visibility can optimize logistics, reduce delays, and improve overall supply chain efficiency (Zhong et al., 2017).

2. Water Resource Management

Given Jordan's water scarcity challenges, IIoT applications in water resource management are particularly crucial. Potential applications include:

- **Smart Irrigation:** Deploying IIoT sensors in agriculture allows for precise monitoring of soil moisture, weather conditions, and crop health. This data enables optimized irrigation schedules, ensuring that crops receive the right amount of water at the right time, conserving this precious resource and maximizing yields (Ruiz-Garcia et al., 2011).
- **Leak Detection:** Integrating IIoT sensors into water distribution networks enables real-time monitoring of pipeline integrity. This facilitates rapid leak detection, minimizing water loss and preventing damage to infrastructure (Mounce et al., 2017).
- **Water Quality Monitoring:** IIoT-enabled sensors can continuously monitor water quality parameters (pH, turbidity, etc.) at various points in the water system. This ensures the provision of safe drinking water and facilitates efficient wastewater treatment, safeguarding public health and environmental sustainability (Gikas & Fouskitakis, 2018).

3. Energy Management

Optimizing energy consumption is critical for both economic and environmental sustainability. IIoT offers various applications in this domain:

- **Smart Grids:** Integrating IIoT sensors and smart meters into the power grid enables real-time monitoring of energy demand and supply. This facilitates optimized energy distribution, improved grid stability, and seamless integration of renewable energy sources, promoting a more efficient and sustainable energy system (Yan et al., 2013).
- **Building Automation:** IIoT-powered building automation systems utilize sensors and controls to optimize energy consumption for heating, cooling, and lighting. This can lead to significant

reductions in energy costs and carbon emissions, contributing to a greener built environment (Kim & Kim, 2012).

- **Industrial Energy Efficiency:** Implementing IIoT solutions in factories allows for granular monitoring of energy consumption across different processes and equipment. By identifying areas of inefficiency and optimizing energy usage, businesses can achieve substantial cost savings and reduce their environmental impact (Wang et al., 2011).

4. Healthcare

IIoT has the potential to revolutionize healthcare delivery, particularly in improving access and patient outcomes:

- **Remote Patient Monitoring:** Wearable sensors and IIoT devices enable remote monitoring of patients' vital signs (heart rate, blood pressure, etc.), providing continuous health data. This is particularly beneficial for patients in remote areas or with chronic conditions, allowing for timely interventions and improved healthcare access (Lee & Lee, 2015).
- **Smart Hospitals:** Integrating IIoT solutions in hospitals can optimize resource allocation, streamline workflows, and enhance patient care. For example, tracking medical equipment and supplies in real-time can improve efficiency and prevent shortages (Al-Ali et al., 2017).
- **Pharmaceutical Supply Chain:** IIoT-enabled tracking of pharmaceuticals throughout the supply chain can ensure product integrity, prevent counterfeiting, and maintain optimal storage conditions. This is critical for patient safety and the efficacy of medications (Ding et al., 2018).

5. Transportation and Logistics

Efficient transportation and logistics are vital for economic growth. IIoT offers solutions to optimize these sectors:

- **Fleet Management:** IIoT sensors in vehicles can track location, performance, and driver behavior, providing valuable data for fleet optimization. This can improve efficiency, reduce fuel consumption, and enhance safety (Frias-Martinez et al., 2012).
- **Traffic Management:** Implementing IIoT sensors and intelligent traffic systems can optimize traffic flow, reduce congestion, and improve road safety by providing real-time traffic data and enabling adaptive traffic control (Zhang et al., 2017).
- **Supply Chain Visibility:** Real-time tracking of goods in transit using IIoT sensors provides end-to-end visibility into the supply chain. This can improve delivery times, optimize logistics, and enhance customer satisfaction (Wu et al., 2016).

III. Challenges to IIoT Adoption in Jordan

A. Awareness and Mindset

The Jordan Industry 4.0 Digitalization Innovation Center (INJO4.0) highlights a critical obstacle to IIoT adoption in Jordan: a widespread lack of awareness and understanding regarding the transformative potential of this technology. Many businesses remain unconvinced of the tangible benefits and added value that IIoT can bring to their operations. This lack of awareness extends beyond simply acknowledging the existence of IIoT; it encompasses a deeper understanding of how data collection and analysis can drive significant improvements across various aspects of their businesses.

For example, many companies are unaware that IIoT can:

- **Optimize production processes:** By monitoring equipment performance in real-time, businesses can identify bottlenecks, predict maintenance needs, and optimize production schedules to improve efficiency and reduce downtime. This translates to increased output and reduced costs.
- **Enhance product quality:** Real-time data analysis can help identify deviations from quality standards early on, allowing for prompt corrective action and minimizing defects. This leads to improved product quality, reduced waste, and increased customer satisfaction.
- **Facilitate better decision-making:** By providing access to real-time data and insights, IIoT empowers businesses to make informed decisions based on accurate and up-to-date information. This can lead to improved strategic planning, more effective resource allocation, and increased agility in responding to market changes.
- **Create new revenue streams:** IIoT can enable businesses to develop new products and services based on data-driven insights. For example, a manufacturer could offer predictive maintenance services to its customers based on real-time data collected from their equipment.
- **Improve workplace safety:** IIoT can be used to monitor environmental conditions and equipment performance, helping to identify and mitigate potential safety hazards. This can lead to a safer working environment for employees and reduced risk of accidents.

By failing to grasp these potential benefits, many Jordanian businesses are missing out on opportunities to enhance their competitiveness, optimize their operations, and unlock new avenues for growth. Addressing this lack of awareness is crucial for driving wider IIoT adoption and realizing its full potential in Jordan.

B. Infrastructure and Economic Factors

A significant hurdle in the path of IIoT adoption in Jordan lies in the insufficient development of the necessary technological infrastructure. To understand this challenge fully, it's important to grasp the context of Industry 4.0, the current paradigm of industrial automation and data exchange, and its predecessor, Industry 3.0.

Industry 3.0, which emerged in the latter half of the 20th century, is characterized by the adoption of computers and automation technologies to enhance manufacturing processes. While this represented a significant leap forward, it often involved isolated systems and limited data sharing.

Industry 4.0, on the other hand, builds upon this foundation by integrating those systems and leveraging advancements in technologies like the Internet of Things (IoT), cloud computing, and artificial intelligence. This creates a fully interconnected "smart factory" where machines, systems, and people communicate and collaborate in real-time, enabling data-driven decision-making, increased efficiency, and greater flexibility.

The transition to Industry 4.0, and the implementation of IIoT within it, requires a robust digital infrastructure that many Jordanian factories currently lack. Many businesses are still operating with Industry 3.0 practices and haven't implemented foundational technologies like Enterprise Resource Planning (ERP) systems, which are essential for collecting, storing, and managing the vast amounts of data generated by IIoT devices.

Furthermore, the implementation of IIoT necessitates considerable investment in:

- **Hardware:** This includes sensors, actuators, network devices, and other hardware components that form the backbone of the IIoT network.
- **Software:** Specialized software platforms are needed to collect, store, analyze, and visualize the data generated by IIoT devices.
- **Data storage and processing:** IIoT generates massive amounts of data that require adequate storage and processing capabilities, often necessitating cloud computing solutions.
- **Cybersecurity:** Protecting sensitive data and ensuring the integrity of IIoT systems requires robust cybersecurity measures.

These costs can be prohibitive, especially for small and medium-sized enterprises (SMEs) that may lack the financial resources and technical expertise to undertake such a significant digital transformation.

In essence, the lack of adequate infrastructure, coupled with the financial burden of implementation, presents a formidable challenge to IIoT adoption in Jordan. Addressing these issues through strategic investments, government support, and industry collaboration will be crucial for paving the way for a successful IIoT revolution in the country.

IV. Strategies for Promoting IIoT Adoption

A. Government Initiatives

The Jordanian government, recognizing the transformative potential of IIoT, is taking proactive steps to promote its adoption across various industries. The Jordan Industry 4.0 Digitalization Innovation Center (INJO4.0) is at the forefront of these efforts, serving as a key driver and facilitator of IIoT implementation in the country.

INJO4.0's role extends beyond merely providing financial support. The center is actively involved in guiding businesses through the process of IIoT adoption, starting with a comprehensive assessment of their readiness. This assessment, known as the SIRI assessment (Smart Industry Readiness Index), is a crucial first step in determining a company's current level of digital maturity and its capacity to effectively implement IIoT solutions.

The SIRI assessment evaluates various aspects of a business's operations, including:

- **Technology:** This dimension assesses the current state of technology infrastructure, including the presence of automation systems, data collection capabilities, and connectivity.
- **Processes:** This evaluates the efficiency and optimization of existing processes, identifying areas where IIoT can bring improvements.
- **Organization:** This dimension focuses on the organizational structure, culture, and leadership's commitment to digital transformation.
- **People:** This assesses the skills and competencies of the workforce and their readiness to embrace and utilize IIoT technologies.

By conducting this thorough assessment, INJO4.0 can provide tailored guidance and support to businesses, helping them identify their strengths and weaknesses, prioritize areas for improvement, and develop a roadmap for successful IIoT adoption.

Furthermore, INJO4.0 is committed to establishing itself as the leading authority and central hub for IIoT knowledge and expertise in Jordan. The center aims to be the go-to resource for businesses seeking information, guidance, and best practices on IIoT implementation. This central role will foster collaboration, knowledge sharing, and the development of a robust IIoT ecosystem in the country.

Through these initiatives, the Jordanian government is demonstrating its commitment to driving digital transformation and positioning the country as a leader in the adoption and application of Industry 4.0 technologies.

B. Industry Collaboration

The successful adoption and implementation of IIoT in Jordan necessitates a collaborative approach, bringing together key stakeholders from industry, academia, and research institutions. This collaborative ecosystem can foster knowledge sharing, technology transfer, and the development of a skilled workforce capable of driving IIoT innovation.

- **Joint Research and Development:** Collaboration between industry and academia can facilitate joint research and development projects focused on addressing specific challenges and opportunities related to IIoT implementation in Jordan. This can lead to the development of innovative solutions tailored to the needs of local industries.
- **Knowledge Transfer:** Universities and research institutions can play a crucial role in disseminating knowledge and expertise on IIoT technologies to industry professionals. This can be achieved through workshops, seminars, training programs, and collaborative research projects.
- **Testbeds and Pilot Projects:** Industry-academia partnerships can create testbeds and pilot projects to experiment with and validate IIoT solutions in real-world settings. This provides valuable insights and accelerates the adoption of proven technologies.

- **Sharing Best Practices:** Collaboration among businesses, particularly those with experience in IIoT implementation, can facilitate the sharing of best practices, lessons learned, and successful strategies. This can help accelerate adoption and avoid common pitfalls.
- **Industry Clusters:** Creating industry clusters focused on IIoT can foster collaboration, innovation, and knowledge sharing among businesses operating in the same sector or value chain.
- **Joint Ventures:** Collaborative joint ventures between businesses can pool resources and expertise to develop and deploy IIoT solutions, reducing risks and accelerating time to market.

C. Workforce Development

A critical factor for successful IIoT adoption is the availability of a skilled workforce capable of designing, implementing, and maintaining these technologies. Addressing the skills gap requires a multifaceted approach:

- **Curriculum Development:** Integrating IIoT-related topics into university curricula, particularly in engineering, computer science, and information technology programs, can equip future graduates with the necessary skills and knowledge.
- **Specialized Training Programs:** Developing specialized training programs and certifications focused on IIoT can provide professionals with the skills needed to design, implement, and manage IIoT systems.
- **Vocational Training:** Offering vocational training programs on IIoT can provide technicians and operators with the skills needed to work with and maintain IIoT-enabled equipment.

- **Internship Programs:** Industry-led internship programs can provide students and recent graduates with hands-on experience in IIoT-related fields, preparing them for the workforce.
- **Mentorship Programs:** Pairing experienced professionals with those new to IIoT can facilitate knowledge transfer and accelerate skills development.
- **Continuing Education:** Providing opportunities for continuing education and professional development can help existing workers upskill and adapt to the changing demands of the IIoT era.

By fostering collaboration between industry, academia, and research institutions, and investing in workforce development, Jordan can create a thriving IIoT ecosystem that drives innovation, economic growth, and societal advancement.

V. Discussion and Conclusion

This paper has provided a deep dive into the Industrial Internet of Things (IIoT) landscape in Jordan, revealing a sector ripe with potential yet facing unique challenges that necessitate a tailored approach. While global trends indicate rapid IIoT adoption, Jordan's progress is hindered by a complex interplay of factors.

Limited awareness among Jordanian businesses, particularly SMEs, is not merely about unfamiliarity with IIoT, but a lack of understanding of its transformative potential. This is compounded by the absence of robust digital infrastructure, with many businesses still reliant on legacy systems ill-equipped for the data-driven demands of Industry 4.0. This creates a "chicken and egg" scenario where the lack of awareness discourages investment in infrastructure, and the lack of infrastructure limits the ability to demonstrate the benefits of IIoT, further hindering adoption.

Financial constraints, particularly for SMEs, present a significant barrier to entry. The perceived high cost of IIoT implementation, coupled with uncertainty about return on investment, discourages businesses from taking the leap. This is exacerbated by the skills gap in the workforce, where a shortage of qualified professionals capable of designing, implementing, and managing IIoT systems hinders effective adoption.

However, amidst these challenges, there are sparks of innovation. Organizations like INJO4.0 are playing a crucial role by providing financial support, conducting readiness assessments (like the SIRI assessment), and facilitating knowledge sharing. Early adopters in sectors like pharmaceuticals and energy management are demonstrating the tangible benefits of IIoT, paving the way for wider adoption.

Looking ahead, Jordan has the opportunity to not only catch up with global IIoT trends but to become a regional leader in this transformative technology. To achieve this, a concerted and collaborative effort is required. The government must develop targeted policies that incentivize IIoT adoption, invest in robust digital infrastructure, and promote cybersecurity awareness. Fostering a collaborative ecosystem through industry-academia partnerships, industry clusters, and joint ventures can accelerate innovation and knowledge sharing. Investing in targeted workforce development programs focused on key IIoT skills, such as data analytics, cybersecurity, and industrial automation, is crucial for long-term success.

Industry leaders must embrace digital transformation as a strategic imperative, actively exploring and adopting IIoT solutions to optimize operations, enhance competitiveness, and create new business models. Investing in continuous skills development for employees and actively participating in knowledge-sharing initiatives can further accelerate progress. Academia and research institutions can contribute by aligning curricula with industry needs, conducting research and development focused on Jordan-specific IIoT challenges, and facilitating knowledge transfer through active engagement with industry.

By addressing these challenges and fostering a collaborative ecosystem, Jordan can not only unlock the full potential of IIoT but also position itself at the forefront of the Fourth Industrial Revolution. This will not only drive economic growth and enhance productivity but also create a more sustainable and resilient industrial sector, well-equipped to compete in the global market.

VI. Summary

This paper has provided a concise overview of the Industrial IoT landscape in Jordan, highlighting the significant potential of this transformative technology while acknowledging the current limitations in its adoption. The key challenges include limited awareness among businesses, inadequate digital infrastructure, financial constraints, and a skills gap in the workforce. Despite these hurdles, organizations like INJO4.0 and early adopters in sectors like pharmaceuticals and energy are demonstrating the tangible benefits of IIoT and paving the way for wider adoption. By fostering a collaborative ecosystem that includes targeted government initiatives, active industry participation, and strategic workforce development, Jordan can unlock the full potential of IIoT. This will not only enhance productivity and efficiency but also foster innovation and competitiveness, positioning Jordan as a leader in the region's digital transformation and ensuring a more sustainable and prosperous future.

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[18] Innovate Jordan. Jordan Industry 4.0 Digitalization Innovation Centre (InJo4.0). (2021). ANNEX I- 1 - Self Assessment tool development summary report.