Revisiting the IIoT Platform Graveyard: Key Learnings from Failed IIoT Platform Initiatives

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Short Paper

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Abstract

The Industrial Internet of Things (IIoT) has led to a competitive race among digital and incumbent players to establish IIoT platforms. However, despite the undisputed potential of the IIoT, a first wave of IIoT platforms failed around 2018, with GE's Predix being the most prominent one. Nevertheless, building upon valuable lessons learned, the IIoT platform market continued to grow significantly. We now experience a second wave of IIoT platform failures, with companies like Siemens, Google, and SAP divesting or restructuring significant parts of their IIoT platform. Acknowledging this, we revisited the IIoT platform graveyard to challenge and extend existing lessons learned. Hence, we interviewed major IIoT platforms and customers that were impacted by IIoT platform failures. We identified six key learnings that we integrated into a preliminary model for IIoT platform growth, highlighting evolutionary steps for successful platform growth. These findings provide practitioners strategic orientation for establishing IIoT platforms long-term.

Keywords: Industrial Internet of Things, IIoT, Platforms, Lessons Learned, Growth Path

Introduction

Platforms within the Industrial Internet of Things (IIoT) continue to attract significant attention from both research and practice (Boyes et al. 2018; Ives et al. 2016; Schreieck et al. 2017). Over more than two decades, research has investigated the fundamental business impact of IIoT, spurring real-world implementation (Fleisch 2010; Porter and Heppelmann 2014; Wortmann and Flüchter 2015). A major milestone for the IIoT was the introduction of General Electric's Predix platform in 2016. Predix aimed to integrate cutting-edge analytics with engineering solutions (Jacobides 2022). However, what was meant to generate billions turned out to be entirely the opposite and GE Predix became the first prominent example of a failed IIoT platform. Consequently, GE Predix garnered the interest of scholars investigating the root causes and tensions leading to IIoT platform failure, and ultimately deriving valuable lessons learned (Boyes et al. 2018; Jacobides 2022; Mancha et al. 2019; Van Alstyne et al. 2016b).

However, despite this prominent failure, advancements in data analytics, cloud computing, and the success of platform companies like Amazon, Apple, and Airbnb triggered a second wave of IIoT platform initiatives. Building upon the collected lessons learned, the IIoT platform market, again, continued to grow significantly (Lueth 2019). Industry incumbents and digital players intensified their investments to

establish own IIoT platforms (e.g., Siemens MindSphere, MS Azure IoT, AWS IoT, IBM Watson IoT) (Pauli et al. 2021). With many other firms also engaging in building their own IIoT platforms, this led to a highly fragmented landscape of IIoT platforms addressing a magnitude of different domains such as smart buildings, automation, and agriculture (Koenen and Falck 2020; Lueth 2019). However, most recently, the tables have turned once again. Various industry incumbents, startups, and even digital players publicly announced divesting or restructuring significant parts of their IIoT platform initiatives (Bremmer 2022; Miller 2022). This inverted dynamic, piling up to a second wave of failures, prompts us to revisit the IIoT platform graveyard to question, reassess, and build upon previous lessons learned.

An IIoT platform resembles a software infrastructure (platform) that enables the integration of physical devices (things) providing services to access, store, and manage device data while simultaneously empowering external entities (e.g., third party developers) to create complementary products or services (e.g., predictive maintenance) (Gawer and Cusumano 2014; Marheine 2020; Püschel et al. 2016). IIoT platforms have two fundamental characteristics that are vital to reflect upon. First, IIoT platforms are an integral part of complex system landscapes and gather, process, and share data from IIoT devices such as sensors, machines, or assembly lines (Porter and Heppelmann 2014). As a consequence, IIoT platform architectures are significantly more complex than better-known platforms, such as marketplaces (Guth et al. 2018; Schreieck et al. 2017). Second, this inherent complexity of IIoT platforms forces the deliberate alignment between a vast number of different players (e.g., platform partners, complementors, and customers). In essence, IIoT platforms must be designed and nurtured within a highly complex and rapidly developing ecosystem (Adner 2017; Hagiu and Wright 2015; Marheine 2020).

Previous research (Adner 2021; Jacobides 2022) has derived actionable learnings from IIoT platform failures (e.g., engaging in deliberate partnerships instead of developing in-house solutions) (Jacobides 2022; Marheine and Petrik 2021). Adner (2021) further extends this body of research and emphasizes the importance of establishing a minimal viable ecosystem to create evidence of value creation early stage. However, existing research has most often taken a very specific theoretical lens and focused on the difference between platform and product (Marheine and Petrik 2021; Van Alstyne et al. 2016a) or platform and ecosystem (Adner 2017; Fuller et al. 2019; Jacobides 2022). In contrast, our findings indicate that successful IIoT platforms start as products rather than platforms and that IIoT platform owners face diverse challenges until they eventually can mature their IIoT platform. At the core, we see a vital necessity to overcome the rather dichotomic conceptualizations in existing literature and integrate the perspectives of product, ecosystem, and platform, recognizing their intertwined and highly fluid relationship. Thus, we set out to investigate:

> *(RQ)* What are key learnings from failed IIoT platform initiatives, and what can we specifically learn about the growth path of IIoT platform initiatives?

We conducted a multiple case study to answer this RQ. Based on 13 semi-structured interviews, we derived six key learnings of failed IIoT platform initiatives. Furthermore, we conceptualize the growth path of IIoT platforms over time, thereby integrating three fundamental perspectives: product, ecosystem, and (innovation) platform. Based on these insights, we present a preliminary model of IIoT platform growth. In our future research, we intend to conduct additional interviews to enhance and validate our findings, thereby enriching the depth and breadth of insights obtained.

Background: IIoT, platforms and ecosystems

The Internet of Things (IoT) describes interconnected and digitized physical devices (things) which are interoperable through information and communication technologies (ICT) (Atzori et al. 2010; Marheine et al. 2021; Porter and Heppelmann 2014). The Industrial Internet of Things (IIoT) is an IoT subdomain that is focused on industrial use cases and applications (Porter and Heppelmann 2014; Porter and Heppelmann 2015). The IIoT relies on an IIoT software stack that consist of multiple core layers (Fleisch 2010; Porter and Heppelmann 2014). The information systems domain developed consensus that edge and cloud depict the two most fundamental pillars of the IIoT software stack (Porter and Heppelmann 2015; Wortmann and Flüchter 2015). Edge and cloud both incorporate functionality to control and manage IIoT devices (system software) as well as functionality to process and analyze data from IIoT devices (application software) (Chang et al. 2022; Goetz et al. 2023). While on the edge, system and application software are often still tightly coupled (due to the limited computational resources and the real-time processing requirements of

the edge devices), the cloud is characterized by a clear separation of system and application software. Consequently, the IIoT software stack is most often conceptualized on the basis of three layers, namely edge, cloud (system) and (cloud) application layer (Boyes et al. 2018; Pauli et al. 2021).

Platforms facilitate exchanges between two or more market sides (e.g., buyers and sellers), creating two or multi-sided markets that enable network effects (Cusumano et al. 2019; Eisenmann et al. 2006; Van Alstyne et al. 2016a). Aligned with previous research, we refer to IIoT platforms as software infrastructures integrating industrial IoT devices (e.g., sensors, machines, and assembly lines) and providing services to access, store, and manage device data (Marheine 2020; Pauli et al. 2020). IIoT platforms further empower external entities (i.e., third party developers) to provide complementary products or services, thus attributing a multi-sided market (Gawer and Cusumano 2014; Hodapp et al. 2019; Püschel et al. 2016). IIoT platforms incorporate a significantly more complex technological architecture than better-known platforms like marketplaces (e.g., Airbnb) due to their nature of integrating a diverse set of technologies and systems that are most often deployed company-wide (Guth et al. 2018; Schreieck et al. 2017).

Existing IS and management research examines how platforms develop over time (Hendricks and Matthyssens 2023; Jacobides 2022; Marheine and Petrik 2021; Schreieck et al. 2022). Practitioner-oriented seminal work investigates the lifecycle phases of platforms such as establishment and maturity (Marheine and Petrik 2021), new rules of strategy (Van Alstyne et al. 2016a), or B2B platform ecosystem networking mechanisms (Hendricks and Matthyssens 2023; Sjödin et al. 2022). Thereby, the ecosystem lens is applied to investigate the dynamics around the platform lifecycle (Adner 2021; Jacobides 2022; Jacobides et al. 2018; Marheine and Petrik 2021). We want to build upon existing research and ultimately leverage the ecosystem lens to understand the growth path of IIoT platforms, thereby relying on Adner (2017) who understands ecosystems as "*the alignment structure of the multilateral set of partners that need to interact"* to create value (Adner 2017, p. 40).

Research approach

We employ a multiple case study approach (Eisenhardt 1989; Martin and Eisenhardt 2010; Yin 2018) investigating the growth path of IIoT platforms to capture current real-world IIoT platform dynamics. This research approach, consequently, provides an opportune setting to dissect the vivid impetus of IIoT platforms' establishment and maturing from a practitioner-oriented point of view.

Through purposeful sampling, we targeted globally operating IIoT platforms, specifically those conducting business on at least two continents serving a diverse set of customers across various industries (Patton 2014). We considered companies attributing to these selection criteria to have matured significant parts of their business, thus exceeding eventual start-up tensions (Täuscher and Kietzmann 2017). We further narrowed on companies that eventually faced the most severe consequences for their mistakes made when establishing and maturing their business (i.e., failed their business) offering a comprehensive range of insights in line with our research objective (Christensen and Bower 1996; Nelson 2007; Patton 2014). We labeled a company as 'failed their business' if it had publicly announced its divestiture of the IIoT platform and consequently ended or is currently in the process of terminating its services. Sources for information on the IIoT platform's failure included the company's press releases and reputable newspapers. Furthermore, we chose cases where we established good contact with stakeholders of the companies. These contacts allowed us to gather comprehensive but most importantly authentic insights into the challenges each IIoT platform faced when maturing regardless of its eventual business success (Sjödin et al. 2022).

Our data collection ranges from June 2022 to May 2023. The resulting data set comprises 13 semi-structured interviews with C-Level executives and (senior) managers with an average length of 66 minutes. In total, we investigated nine different IIoT platform initiatives (i.e., C1 - C9). In some instances (i.e., C2, C6, C7), we conducted two rounds of interviews with changing representatives at different management levels to obtain a more diversified perspective on the lessons learned. Furthermore, we contrasted failed IIoT platform initiatives with currently successfully operating ones (i.e., C6, C7, C8, C9) to spur our critical reflection on the insights gained (Nelson 2007; Täuscher and Kietzmann 2017). In one case (C2), we further received access to an IIoT platform's parting customer with whom we conducted another interview. We provide an overview of our interviews and cases in Table 1 below. Moreover, we enhanced our initial dataset by incorporating publicly available secondary data from sources like the IIoT platforms' website, external communications, and seminal practitioner-oriented research. While we did not record the interviews

verbatim due to authenticity reasons, key takeaways and themes were noted and discussed between at least two researchers immediately after each interview for accurate representation in our subsequent analysis. We structured the interviews twofold. First, looking back to refurbish mistakes made when establishing and maturing the IIoT platform, investigating underlying root causes, and second, projecting ahead, deriving lessons learned from mistakes made. We embarked these additional efforts to enrich our preliminary dataset and include a holistic yet diversified perspective on IIoT platforms and their maturing.

	Interview ID	Position	Interview length	Case
Failed	I01	C-Level	50 min	C1: Software
	I02	Senior manager	45 min	C2: Software
	I03	Manager	45 min	
	I04	Senior manager	120 min	C3: Mechanical engineering
	I05	Manager	60 min	C4: Mechanical engineering
	I06	C-Level	30 min	C5: Software
	I07	Manager	60 min	Customer of C2 in smart buildings
Successful	I08	C-Level	60 min	C6: Healthcare
	I09	Manager	60 min	
	I10	Senior manager	90 min	C7: Automation
	I11	Manager	60 min	
	I12	Senior manager	75 min	C8: Smart buildings
	I13	C-Level	90 min	C9: Chemicals

Table 1: Overview interviewed experts

We analyzed our data sample reexamining each interview documentation highlighting key learnings across cases (Blaikie 1991; Eisenhardt 1989). We processed these learnings as first-order categories and continuously reflected them against the insights embedded in our secondary data (Eisenhardt 1989). This reflection most importantly unveiled novel aspects inherent in the current dynamics of the IIoT market previously unrecognized. Each researcher prepared this reflection individually, before discussing and subsequently conceptualizing the synthesized key learnings together to prevent bias and drawing premature conclusions (Charmaz 2006). A first draft of our insights was presented during an in-depth workshop with key decision makers from C1 (i.e., C-Level executive, multiple senior managers, and a member of the company's supervisory board). Integrating this practitioner feedback, we subsequently adjusted and refined our preliminary model for IIoT platform growth (cf. Figure 1).

Key learnings from failed IIoT platform initiatives

Drawing from the findings of our data, we aggregated six key learnings. We further conceptualized these learnings into a preliminary model depicting the growth path of IIoT platform initiatives (cf. Figure 1). We emphasize three key learnings (i.e., 4, 5, 6) that play a crucial role for establishing and maturing an IIoT platform. The other three key learnings (i.e., 1,2,3) pertain growth adjacent aspects for IIoT platforms, thus guiding foundational managerial decision making.

1. It's a full stack game

IIoT platform managers stressed the inherent complexity of the IIoT software stack. Early attempts to build end-to-end platforms (such as GE's Predix) failed for good reasons. Implementing a three-layer IIoT software stack (edge, cloud, and application) might seem feasible from an outside perspective. However, underestimating the technical sophistication and the importance of deep domain knowledge has fatal consequences for any IIoT platform initiative.

> *"Nobody can afford to implement the whole IIoT stack. That's impossible and also no longer necessary." (I01)*

While on the one hand, implementing the entire IIoT software stack is not viable for a single company, simply focusing on one particular IIoT layer, like edge or cloud, is also not sufficient to survive the second wave of IIoT platform failures as customers mandate seamless and well-integrated solutions.

> *"Initially, we focused our platform efforts on apps for the edge, only to witness that developers moved them into the cloud. While you have to focus as a platform, you must not forget that it's ultimately about the overall stack." (I06)*

Hence, developing IIoT platforms is ultimately about managing a paradox. While edge and cloud were separated or just loosely integrated in the past, their convergence seems rapidly progressing. Therefore, IIoT platforms must be designed with the full IIoT stack in mind, while simultaneously staying focused with own developments.

2. Focus and tackle real customer problems

Focusing on specific customer problems and delivering well-targeted value propositions through minimal viable products is the essence of modern innovation and development approaches (Ries 2011). This essence is well known and accentuated in seminal research and practice, yet companies assume that platforms are different. Many of our interviewees highlighted that there is a veiled perception regarding platforms.

> *"In large companies, it's much easier to sell a platform on the basis of 'the more the better'. Platforms have this association of big, and more is better in your Excel sheet." (I04)*

However, a lack of focus and failing to provide genuine customer value has fatal consequences. While the potential of the IIoT is undisputed, the monetization of the IIoT has been much slower than anticipated (Ehret and Wirtz 2017; Porter and Heppelmann 2014).

> *"The only players that earn real money with IIoT are the hyperscalers. But not with their IIoT platforms. They just earn it with their standard cloud services. The IIoT data has to be stored somewhere. It's indirect monetization." (I02)*

This second wave of IIoT platform failure exhibits a significant number of IIoT platforms over pacing and investing too much, too broad, too short term, aiming for revolutionizing solutions without showcasing direct return on investments by solving their customers' problems. Thereby, stakeholders lost confidence early stage and IIoT platform initiatives got abandoned despite their eventual potential.

3. Be aware of the hardening parts of the ecosystem

The IIoT challenges existing industry boundaries across various domains (Porter and Heppelmann 2014; Weinberger et al. 2016). Prevalent value creation structures break up and novel ecosystems emerge (Adner 2017; Jacobides et al. 2018). However, the magnitude of change is often still underestimated by incumbent players.

> *"Initially, I never thought AWS and Azure would conquer this [IIoT platform] market, because it is a vertical business and major industry players with a huge industry footprint like Telecoms were already in the ring." (I01)*

Our interviews revealed that there is certainly more than a dichotomy of emerging ecosystem and established industry. While the IIoT platform dynamics were very intense and hard to anticipate around 2015, within five years, certain value creation structures settled and became apparent.

> *"With AWS and Azure becoming de facto standards, you must build your platform around these players. They have tremendous market access and are developers' natural first choice." (I01)*

While new industries are forming, it is essential to identify and leverage the 'winning' value creation structures early on (Adner 2017). Companies that failed in this respect were doomed to be become part of the second wave of failure.

Beyond these fundamental insights guiding managerial decision making towards establishing a sustainable platform core, our interviews revealed further mistakes that were made while maturing an IIoT platform. We acknowledged these additional insights from the second wave of IIoT platform failure and derived another three key learnings eventually supporting managers in preventing making the same mistakes. In essence, these learnings discern integrating partners and complementary functionality into the platform core (i.e., alliancing) and ensuing successive efforts of increasing the number of integrated partners (i.e.,

opening up). We attempted to conceptualize this notion (i.e., shifting from providing standalone value to orchestrating complementary value) in our preliminary model of IIoT platform growth below (cf. Figure 1).

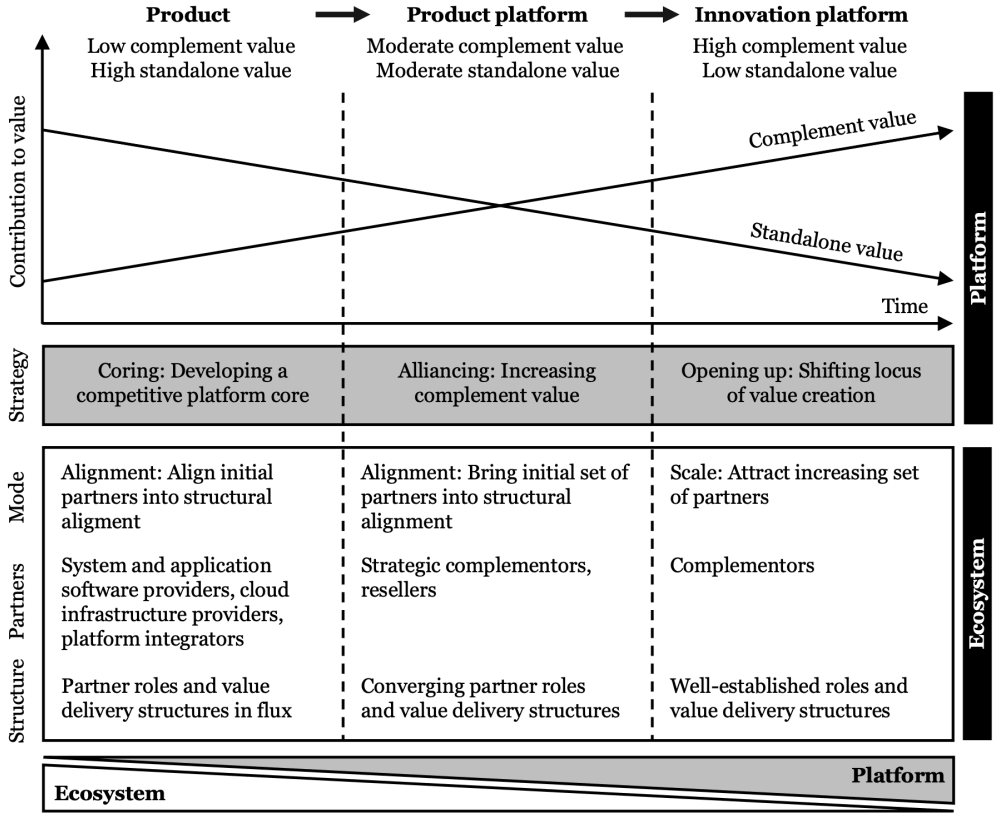

Figure 1: Growth path of IIoT platform initiatives

4. Start with a product

Our interviewees highlighted that most successful IIoT platforms start as a product and stay a product for a very long time. Their value proposition is built upon standalone rather than complement value. Network effects are not or hardly existing.

> *"AWS and Azure are named IIoT platforms. In reality they are rather software products on [top of] their cloud business. Who is using the AWS marketplace when it comes to IIoT?" (I01)*

Thus, to build up an IIoT platform, platform coring is of utmost importance (Baldwin and Woodard 2009; Boudreau 2017; Cutolo et al. 2021; Marheine and Petrik 2021). Developing a solid platform core before opening up the IIoT platform is crucial. This involves the careful alignment with selected strategic partners across the stack (e.g., AWS as a cloud partner, or Siemens as an edge partner).

5. Create an alliance of the willing

In a second step IIoT platform initiatives start extending the core via complements such as IIoT apps. Thereby, the ratio of standalone and complementary value shifts towards a more balanced mix. Our interviews highlight a crucial aspect of this transition:

> *"A lot of partners joined our platform because of FOMO [fear of missing out]. It's helpful to have big names on your website, but we should have focused on two or three partners that were really dedicated." (I06)*

With a growing number of IIoT complements, the IIoT platform becomes a product platform (Schreieck et al. 2022). Through careful alliancing (Ceccagnoli et al. 2012; Huang et al. 2013; Huber et al. 2017), an

extended set of complementors is integrated into a maturing ecosystem that is characterized by converging partner roles and value creation structures.

6. Mind the realities of opening up

Our interviews further revealed that only the last step of an IIoT platform journey is about opening up and truly shifting the value creation towards complementors (Constantinides et al. 2018; Cusumano et al. 2019). This step is often initiated way too early:

> *"We were deep in debate over how to price customers for connecting a million machines when the reality was, we barely had ten machines connected." (I04)*

Naturally, establishing a true innovation platform that involves a significant number of complementors requires time. Moreover, it is dependent on well-established roles and value creation structures. In order to scale, these structures have to be in place and alignment must have been achieved. In essence, before you can play the platform game, you must master the ecosystem game.

Contributions and next steps

Our research adds to the existing body of IS management and, most notably, to practitioner-oriented research focusing on IIoT platforms. First, we confirm existing evidence on the importance of focusing an IIoT platforms' core business to create hands-on customer value (Hodapp et al. 2022; Jacobides 2022). Second, we substantiate existing findings that careful partnering is critical to platform success (Adner 2021; Fuller et al. 2019). Third, we find that building a strong platform core (i.e., a product), is key to ultimately become a viable IIoT platform business. In addition, our interviews revealed that applying well-known platform strategies, such as alliancing or opening up (Boudreau 2017; Ceccagnoli et al. 2012; Huang et al. 2013; Huber et al. 2017), can severely jeopardize IIoT platform success, if applied too early. Overall, our interviewees argued that most IIoT platforms are still products (i.e., high standalone value, almost no complement value). While they serve as a technological foundation for customers to build IIoT solutions, they have not yet attracted a substantial amount of partners that provide complementary innovations. Also, our interviewees stressed the fact that the capability to form strategic alliances is core for maturing the platform early stage. In essence, we find that establishing a successful IIoT platform is much more about building a successful IIoT product in an emerging ecosystem than the existing seminal literature suggests.

This study presents initial findings and is part of a broader research initiative. Hence, we acknowledge existing limitations and will address them in subsequent developments. We will continue to conduct interviews with IIoT platform initiatives particularly focusing our case selection on IIoT platforms confronted with the challenge of maturing their business. Thereby, we will dedicate significant effort on better understanding the dynamics of alliancing as the first step of maturing an IIoT platform. We further emphasize a critical reflection on existing phenomena such as strategic partnerships and digital transformation. We recognize both phenomena potentially contributing nascent insights enriching our preliminary model as well as the existing body of (practitioner-oriented) platform research. Long term, we aim to transform our preliminary model of IIoT platform growth into a well-grounded framework that assists IIoT platform managers and executives in formulating their business strategies. We recognize the adoption of this preliminary model requires further in-depth investigation. Regardless, this short paper represents the first important milestone in our journey toward achieving that objective.

Acknowledgements

The present work is supported by the Bosch IoT Lab at the University of St. Gallen, Switzerland.

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