The triadic dimension of the AI, IoT and 5G ecosystems: its importance for innovative ecosystem strategies for non-digital native organizations

Abstract. Artificial Intelligence (AI), 5G and the Internet of Things (IoT) form a triad of converging emerging technologies, that mutually benefits each other's. The impact of such triadic dimension on the structuration of innovation ecosystems and on the definition on ecosystem strategy (notably for non-digital native players) become a variable considered as critical by the literature but that remain poorly empirically explored to date. In this article, we address this theoretical gap by exploring how three focal (non-digital native) organizations develop their ecosystem strategies regarding the AI/5G/IoT triad. Our results point at their capability to leverage infrastructural assets to position themselves at the centre of the innovation ecosystem they contribute to make emerge. They accelerate the integration of the triadic ecosystem by offering an opportunity to their partners to develop and test devices that articulate the three technologies in advance in comparison with other competitors. These results shed a new light on the literature of ecosystem strategies by highlighting the particularities introduced by the triadic dimension of the AI/5G/IoT ecosystems.

Keywords. Innovation Ecosystems – Ecosystem strategy – Internet of Things – Artificial Intelligence – 5G

Artificial Intelligence (AI), 5G and the Internet of Things (IoT) form a triad of converging technologies, that mutually benefits each other's (Storck & Duarte-Figueiredo, 2019; Medin & Louie, 2019; Sekaran Sekaran et al., 2021; Ahokangas et al., 2021). They prompt the emergence of ecosystems, i.e. "*the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize*" (Adner, 2017, p. 40), actors attempting to stabilize their strategy by imposing them as the central nodes of respectively the 5G, the IoT and the AI ecosystems. Incertitude remain about how the ecosystems would emerge and stabilize, as strong conflicts are arising between industrial as well as governmental players involved in these technologies and attempting to take the lead in their respective emerging ecosystems (Latif et al., 2017; Li et al., 2018; Ballard, 2018; Wang, 2020; Park & Park, 2020; Ahokangas et al., 2021; Ma et al., 2021; Mishra & Tripathi, 2021). But moreover, the interfacing of the triadic ecosystems raises questions, requiring new constructs to apprehend the modularity in-between ecosystems. It represents a critical issue on a theoretical as well as a business perspective for organisations wishing to engage in these technologies, and for regulators seeking to regulate their related conception and innovation processes and the applications they generate (Varga et al., 2020; Alhayani et al., 2022).

How does the triadic dimension of the AI, IoT and 5G impacts the ecosystem strategies? In order to answer this question, we performed three case-studies of ecosystem strategies, conducted respectively in the AI, IoT and 5G-driven ecosystems, and examined their articulation with the two other afferent technologies. We first expose how one of the world's largest consortium of hospitals, a medium-sized electronical manufacturer, and a major railway company, are securing their position by construing an ecosystem around respectively the AI, IoT and 5G technology. Typically, the consortium of hospitals valorise the massive and reliable amount of medical data they generate to position itself as the nexus of the AI-powered healthcare ecosystem. In this purpose, they invest in the creation of a data-department, produce databases generated for partners' AI-applications, promote in-house refined AI-based algorithms for a large set of applications, and facilitate meetings between partners in the ecosystem they seek to create. Similarly, the railway company tries to boost an 5G-based ecosystem by investing in 5G infrastructures in their maintenance centres and stations, positioning as a 5G-hub that can facilitate the early access for partners like start-ups to test then deploy 5G-based products. Finally, the medium-sized electronical manufacturer is partnering with major technology companies to make their electrical panels, which are present in most homes, become the home automation core interface, and thus position themselves at the heart of the smart-grids/IoT ecosystem despite their modest capacity in these new technologies in comparison with other major actors they partner with. We then elicit how the triadic dimension of the AI/IoT/5G ecosystems are contributing to the ecosystem strategies of these organisations that had seemingly no significant technological lead on the emerging technologies of AI, IoT or 5G, by favouring their intermediate position at the expense of pioneering and now technologically dominant organisations in AI, 5G and IoT such as GAFAM and BATX. In the discussion section, we reflect on these results and notably point at how the triadic dimension of 5G/IoT/AI ecosystem contribute to the literature of ecosystems of innovation (Granstrand & Holgersson, 2020; Beaudry et al., 2021) by setting the interfacing of several convergent emerging technologies as a critical factor for ecosystem strategies (Adner, 2017; Jacobides, 2019; et al., 2021; Bessagnet et al., 2020; Jovanovic et al., 2021).

1. THEORY. INTERFACING AI, IoT AND 5G ECOSYSTEMS

1.1 AI, IoT and 5G in a nutshell

AI, IoT and 5G are expected as game-changer technologies (Kaplan & Haenlein, 2019; Basingab et al., 2020; Munirathinam, 2020; WEF-PwC 2020; Mansell, 2021; Mendonça et al., 2022).

The socio-economical and organizational revolution fostered by AI is expected to be massive and multisectoral (Brynjolfsson & Mitchell, 2017; Barley et al., 2017; Makridakis, 2017; Kaplan & Haenlein, 2019), requiring organisations as well as individuals to adapt their strategies in the near future (McClure, 2018; Faraj et al., 2018; König, 2020; Kellogg et al., 2020; Krogh et al., 2021; Shrestha et al., 2019; 2021), and in particular in the innovation field (Verganti et al., 2020; Haefner et al., 2021). Artificial intelligence, in particular image recognition computation and language processing tasks powered by Machine Learning algorithms, including the now famous Neural Networks, offers indeed an unprecedented opportunity to automate routine tasks previously performed by operators (Raisch & Krakowski, 2021) – such as vehicle piloting (Ingle & Phute, 2016; Grigorescu et al., 2020), quality defect recognition (Hirschberg, et al. 2020), or harvesting (Lawal, 2021) –, and to support decision makers for specialised tasks – such as medical diagnosis (Esteva et al., 2017; 2020) predictive maintenance (Cardoso & Ferreira, 2020). Automation and support to decision makers can also combine, with the emergence of high skilled automated services performed by AI such as algorithmic trading (Hilpisch, 2020; Goodell et al., 2021), the detection of insurance frauds (Wang & Xu, 2018) or payment card frauds (Ryman-Tubb et al., 2018), and lethal autonomous weapons systems (Haner & Garcia, 2019; Sauer, 2021).

The Internet of Things deepens the cooperation between interconnected devices, facilitating the exchange and processing of information between them, so as to create universes that gain in autonomy (Madakam et al., 2015). In BtoC, home automation is certainly the most popular product of IoT (Zemrane et al., 2020). Smart home systems can be integrated into larger aggregated networks: smart grids in particular promise to improve the supply of electricity within households, improving expenditure, security, and providing information crucial to the intelligence of the integrated home automation system; but also to strengthen the allocation of energy supply at the scale of cities and regions by modulating line energisations and purchases/sales between operators or even between countries according to agglomerated demand forecasts (Siano, 2014; Kabalci, 2019). Beyond smart homes applications, other areas are also seeking to become more interconnected. This is particularly true of the “Factory of the Future” or “smart factories” (Rong et al., 2016; Basingab et al., 2020; Munirathinam, 2020), the first avatars of which are emerging notably in high-tech industries such as civil and military aerospace (Safran, 2021).

Last but not least, the 5G technology represents an infrastructural “cornerstone”, argue its industrial and (supra)governmental sponsors. 5G provides not only a the infrastructural connectivity to fluidify already deployed information systems, but also to drive the growth of new related technologies, such as IoT and AI, offering them a sine qua non sufficiently low latency data rate with sufficiently dense coverage in order to manoeuvre and exchange the massive data flows on which both AI and IoT depend in most applications (Gupta & Jha, 2015; ITU, 2015; EC 2016; Galinina et al., 2017;Ballard, 2018; WEF-PwC 2020; Mansell, 2021; Mendonça et al., 2022). In details, to AI-based systems, 5G offers the bandwidth to compile big data in large volumes, especially for centralized AI such as in some smart-cities models (Ullah et al., 2020; Smys et al., 2021). For AI and IoT, it offers the possibility of near-real-time interconnectivity, drastically limiting processing times, ensuring continuity of coverage with an acceptable throughput for these tools given the criticality of certain applications, such as for distributed networks of cameras for facial recognition in critical areas (Sadiq, 2022). As the core infrastructure of digital data technologies including AI and IoT, 5G brings together an ecosystem of related actors (Galinina et al., 2017; Storck & Duarte-Figueiredo, 2019; Medin & Louie, 2019) and forces some ecosystems such as mobile telephony to convert to it (Pujol et al., 2016). The criticality of the 5G technology is to be evaluated in regard to the revived competition locally between public and private interests to control comms streets infrastructures

(Ballard, 2018), and at an international scale by notably the US/China rivalry (Wang, 2020) for the leadership of industry.

1.2 AI, IoT and 5G: from three ecosystems to a triadic ecosystem

These technologies are contributing to the emergence of ecosystems around them, in a structural conceptualization of ecosystems "*which views ecosystems as configurations of activity defined by a value proposition*" (Adner, 2017, p.40). Around respectively AI, IoT and 5G, networks of players are generated, sharing not only a technology, but also connected business models, training and practice exchange spaces, and developing converging regulation and interoperability methods (Latif et al., 2017; Li et al., 2018; Ballard, 2018; Wang, 2020; Park & Park, 2020; Ahokangas et al., 2021; Ma et al., 2021; Mishra & Tripathi, 2021).

But questions remain about the stability of the AI, IoT and 5G ecosystems strategies – the ecosystem strategy being defined "*by the way in which a focal firm approaches the alignment of partners and secures its role in a competitive ecosystem*" (Adner, 2017, p. 47) – and the role of key actors, notably non-digital native ones, within these ecosystems (Latif et al., 2017; Jacobides et al., 2021; Mendonça et al., 2022). Indeed major actors are trying to take the lead of these ecosystems, either to reconfigure previously existent ecosystems around them – for instance, telecom companies trying to stabilize the mobile phone ecosystem throughout their dominance of the 5G infrastructure (Pujol et al., 2016; Ballard, 2018) –, or to secure an already pioneering position within these technologies – such as Facebook, Google, Amazon, IBM, Apple, Baidu or Huawei trying to take advances on their current platform-based AI-related applications to take the lead of the AI-ecosystems and impose their standards on the industry (Jacobides et al., 2021; Rikap & Lundvall, 2021; Jacobides & Lianos, 2021). In this perspective, governmental influences play a critical role to push actors to take the lead of the AI, IoT and

5G ecosystems (Jacobides et al., 2020), raising important tension and even reviving rivalry between geopolitical blocs such as the USA and Chine (Wang, 2020).

While the literature brings detailed depiction of the different ecosystem strategies performed by actors to take the lead of the AI, IoT and 5G ecosystems, those have been considered mostly separately, despite the significative if not critically strategical importance of their interplays (Storck & Duarte-Figueiredo, 2019; Medin & Louie, 2019; Sekaran Sekaran et al., 2021; Ahokangas et al., 2021).In particular, few attention has been brought to the triadic dimension of the convergent AI, IoT and 5G ecosystems. The AI, IoT and 5G technologies being developed relatively separately in distinguishable innovation departments, their relative independence at a lab perspective masked their deep interdependence on an industrial level, both for BtoC and BtoB (Medin & Louie, 2019; Park & Park, 2020; Ahokangas et al., 2021).

How does the triadic dimension of the AI, IoT and 5G impacts the ecosystem strategies?

In order to answers this question, we performed three case-studies of ecosystem strategies, conducted respectively in the AI, IoT and 5G ecosystems, and examine their articulation with the two other afferent ecosystems.

2. METHODOLOGY. THREE FOCAL ACTORS TO EXPLORE TRIADIC ECOSYSTEM STRATEGIES

The selection of the case studies rests on the standards of the case-studies based theory-building approach (Einsenhardt, 1989; Eisenhardt & Graebner, 2007). In this perspective, the case study selection is based on the following criteriums:

- We focus on organisations that are not AI-, 5G- or IoT-native. They constitute the focal actor – i.e "the actor from whose perspective the analysis *is conducted. It is through the focal actor's interactions with the other actors on whom the materialization of the* value *proposition depends. Hence, "focal" is determined by the choice of perspective, rather than by power or traditional measures of network centrality*" (Adner, 2017, p. 56).

- Focal actors are representative of an innovative ecosystem (IE). IE are notably characterized as the incorporation of "*an actor system with collaborative and competitive relations with or without a focal firm, and an artefact system with complementary and substitute relations*" (Granstrand and Holgersson, 2020, p. 3).

Each focal actors are determined by a core technological entry, i.e. the technology from the AI/IoT/5G triplet upon which they especially build their ecosystem strategy. We then elicit the role of the triadic dimension of the AI, IoT, and 5G ecosystems on their ecosystem strategy. The following table resumed the core characteristics of the three focal actors studied.

Core technological entry	**Focal actor codename**	**Focal actor type**	**Focal actor related industry**	**Number of employees**
AI	**Hippocratus**	One of the world's largest consortia of hospitals	Medicine, including public healthcare professionals and doctors, as well as research and teaching activities	Ar. 100 K employees
IoT	**Vestalia**	A medium-sized European electrical installation manufacturer	Electrical installations for BtoB and BtoC	> 10K employees
5G	**Zephyr**	A major railway company	Railway services for passengers and freight and maintenance of rail infrastructure	> 200K employees

The dataset constituted from these three case-studies encompasses strategy-reports, press reports, and selective interviews from actors within these organisations. Interviewees are either members of the teams dedicated to the implementation of AI/IoT/5G technologies within their company, or more top management executives in charge of the determination of the strategy on the long run. Additionally, observations (1 year long) have been ruled in the partnership with one of the focal actors selected (Zephyr).

The data analysis aim then at eliciting the ecosystem strategy of the case studies, which means "*the way in which a focal firm approaches the alignment of partners and secures its role in a competitive ecosystem*" (Adner, 2017, p. 47).

Following Adner (2017)'s "*grammar*" for ecosystem, we especially focus on the activities entailed by the new technology, i.e the "*discrete actions to be undertaken in order for the value proposition to be created*", the positions, i.e the "*specified locations in the flow of activities across the system*", and the links, i.e. the "*transfers across positions, which may or may not include the focal actor*". (Ibid, p.44).

Data have been initially collected in English, French, German. While some original versions are not in English, verbatims provided below have been translated.

3. RESULTS. LEVERAGING INFRASTRUCTURAL ASSETS TO ENSURE A CENTRAL POSITION IN THE AI/IoT/5G ECOSYSTEMS

1.3 Becoming a hub for the AI/IoT/5G innovative ecosystems.

1.3.1 Valorising owned and reliable datasets for powering an AI-based ecosystem: the case of one of the world's largest consortiums of hospitals.

Hippocratus is a university hospital consortium, one of the largest in the world. Receiving an average of 10 million patients per year, it represents an organisational challenge in terms of medicine but also of human resources and supply chains management, requiring the production of vast and interconnected information systems. As a teaching hospital, Hippocratus is also in charge of training for all health professionals, from nurses' aides to surgeons. Combining seven colleges of medicine, Hippocratus conducts also innovative programs in medicine in almost every healthcare disciplines.

To fulfil these objectives, Hippocratus has long invested in data management, notably for billing, for clinical research, and for supply chains planning. Its IT department have been enriched with a data department in charge of collecting, storing, and securing databases. Recently, the consortium of hospitals has claimed its wish to better valorise the massive and reliable amount of medical data generated daily in the organisation. In this purpose, a 10 years long IT project resulted in the constitution of a vast data lake pooling 11 million anonymized patients' files.

This data lake offers the opportunity to federate industrials, academics, and public authorities into common R&D programs. In particular, the size and the diversity of the data lake, and the reliability and traceability, is a strong asset for developing AI-based health devices. *"On this basis, we are continuously injecting AI and new sources of data or very varied documents and creating and testing search and cross-referencing algorithms with various partners. We then extract from this mass of scientific studies and findings that can help research but also be inserted concretely into patients' care pathways to make prevention, analysis and diagnosis assistance."* explained the Director of IT Department in 2020.

This data lake position Hippocratus as the nexus of the emerging AI-powered healthcare ecosystem. For example, Hippocratus has launched a program in partnership with several other academic institution and a major consulting group specialized in IT project that is expected to contribute to strengthen medical decision-making within 24 hours of a serious health trauma, especially haemorrhagic shock and head trauma. The objective is dual: beyond the core issue of enhancing medical diagnostic, the program aims explicitly at cementing the ecosystem around Hippocratus and cross-fertilizing partners in terms of expertise. Thus, this program "*represents a unique opportunity, and a great privilege, to see collaboration between partners from very different backgrounds in action. Not only does it allow us to explore new approaches to patient care and answer scientific questions, but it also allows us to learn and broaden our* *horizons*." claims the cofounder of the program. "*In addition to the opportunity to develop methods in a situation where the data have all the flaws (heterogeneity, missing data, so that no known method is well adapted), the project is a catalyst for interactions between doctors and researchers or engineers, between researchers of different disciplines or expertise*" adds the head of a research unit involved in the program.

In order to speed the number of AI-based programs launched from this platform, Hippocratus has created a department in charge of preparing databases for processing by AI. We interviewed this team. They explicitly expressed to us their objective of providing Hippocratus' partners turnkey tools for enhancing AI-based devices. They notably invest in the elaboration or refinement of clinical and of supply chain anonymized databases and in-house refined AI-based algorithms to be delivered to both internal and external agents. They also organize meetings between potential partners (start-ups, medical research centres, practitioners, and state services requiring new automated office solutions) to promote their databases and algorithms but also to foster partnerships. Their wish is to go fast enough to secure a central place of Hippocratus within the ecosystem they help to create. *"We have to move fast. There is competition for all players, you become obsolete quickly in the health tech sector. So speed is a major argument for attracting partners, who need to produce POCs* (Proofs-of-Concept) *in record time if they don't want their funding to go elsewhere. Sometimes speed counts even more than the quality of what you have proposed. Then, we say to ourselves that when a partner is linked to us, he comes back to tell us when he has a new need, rather than going to do his business elsewhere. It's a win-win situation."*

1.3.2 Early equipping its industrial and public infrastructures with 5G to host the innovative 5G ecosystem: the case of a major railway company

Zephyr[1] is a major European railway company. Its functions include operation of railway services for passengers and freight, and the maintenance and signalling of rails. It operates in several countries. Its core activities are based mainly within the European country the company has been founded a century ago, but also in other European and Asian countries in which its subsidiaries are implemented.

From Zephyr's perspective, 5G represents on first sight a technology with a dual usage.

First, it brings high speed internet to train stations. Train stations constitute important hubs, combining train passengers but also other associated mobility services: bus station, subways, taxis, etc. Implemented mostly in the core centre of cities, the use of the Internet is particularly important in train stations. Passengers waiting in stations are major consumers of video and internet contents. Commuters, who are increasingly numerous, require high-speed connections with maximum reliability and continuity of service, particularly in the context of remote work and teleconferences. Some stations also represent important commercial centres, whose non-marginal revenues also significatively structure Zephyr's activity of logistic support for travellers and consumers within their infrastructures. These mauls hosted in train stations require Zephyr to consider the importance of connectivity in an era of increasingly digitalized points of sale. Finally, the digitalisation of services within the station, and in particular the digitalisation of train tickets, requires internet coverage throughout the station in order to operate the ticketing and ticket control activity.

Second, 5G is a prerequisite for the emergence of IoT within factories and train stations. To run its nearly 15,000 trains a day, Zephy require an organisation that is able to collect and process a growing amount of data on a continuous basis and generate rapid organizational answers.

[1] Pseudonym

Continuously adapting to this data requires reliable, multiple sensors, efficient processing centres with teams capable of operating reactively throughout the railway network, but also, in between, a connectivity infrastructure enabling the connection between the sensors at the peripheries of the signalling chain and the processing centres at the heart of the maintenance system. *"Transmitting this data rapidly to the maintenance centres in order to improve responsiveness in identifying faults and preparing maintenance actions is a productivity and ultimately a quality-of-service critical issue*." explains the former Head of the Connectivity & Networks department. Observations we ruled this year within Zephyr connectivity department confirm that the use cases envisioned include for instance process control, remote control of logistics carts, offloading of operating data, the use of mobile cameras to monitor equipment movements, and real-time video analysis to detect graffiti or hatches left open after a maintenance cycle. 5G represents then the core connectivity infrastructure that enable products and services that are then powered by the data flowing through 5G but incorporating other technologies including AI and IoT.

The connectivity solutions of previous generations (wifi, 4G, etc.) suffer indeed from several disadvantages that limit the massive integration of IoT and certain related digital technologies in the Zephyr industrial environment. The maintenance factories are tangles of rails, trains in metallic structure, beams and bars supporting the equipment, which limit the spread of electromagnetic waves. Besides, trains maintenance factories have to be capable of accommodating several trains and are by definition very large spaces covering several hectares. Such large and crowded spaces would require an inordinate number of wifi hotspots to be networked, with little result in terms of connectivity. 5G permits to overcome most of these constraints: "*With its low latency enabled by the 26Ghz and 2.6Ghz bands, this connectivity supports Industry 4.0 with the promise of a seamless digital experience for* (Zephyr) *agents*" resumes the Director of Connectivity in the Group's Digital Department.

The commercial activities and reception of the public in stations, logistical management, and industrial maintenance of trains on the network and within maintenance factories require then Zephyr to operate a qualitative leap in its connectivity infrastructure. 5G has become then a core challenge for Zephyr, and its departments involved in innovation and connectivity issues. But rather than passively following industry developments, Zephyr has taken a proactive approach to 5G. As stipulate the Head of the Connectivity & Networks department in 2020: "*The nature and diversity of our activities favour an organisation adapted to the long term, unlike the world of telecoms, which is increasingly shortening its cycles, driven by virtualisation and "softwarisation". Delivering future services in line with customer demand (B2B, B2C, B2B2C) requires understanding this difference and working at the right pace in the ecosystems. My teams accompany, advise, sponsor and guide decisions and projects according to these criteria."*.

Zephyr' objective is therefore to play a central and driving role within the 5G ecosystem, to drive a development that takes into account the long-time horizons related to Zephyr's industrial constraints rather than following the shorter cycles of the telecom industry's tech ecosystems. In this perspective, Zephyr has built partnerships with a major Telecom company to install in advance 5G antennas in stations and in maintenance factories. These installations would serve as experimentation labs, that welcome industrial and commercial initiatives, from start-ups to major companies, to test in vivo and proactively their products and services. "*We launched a 5G programme with the aim of opening up to this ecosystem and working with telecommunications operators and other partners in a spirit of experimentation. We wanted to validate in a real environment, and not in a laboratory, the feasibility of various uses relevant to* (Zephyr) *and encourage the emergence of these platforms in the regions. Our first aim is to create a common knowledge within the ecosystem and to co-construct the technological,* *economic, legal and operational modalities possible tomorrow, as soon as possible.*", explained the Head of the Connectivity & Networks department.

This experimental platform is expected to position Zephyr at the centre of the innovative ecosystem it is contributing. The approach inscribes and extends a tradition of innovation partnerships formed by the company to maintain its dominance in the domain of train maintenance and train stations management. Zephyr « *has always been a land of innovation, both for our services to customers and for our industrial excellence, and the (Experimentation Lab) confirms this vocation. This new stage of experimentation extended to our industrial activities is strategic because it opens the way to innovations that can be decisive and give us a head start, especially for the reliability and competitiveness of our maintenance*. » confirms the Deputy Director General for Digital of the Group. The model of non-transactional partnership aims then at fuel and cement a community that benefits but also lies on the Zephyr infrastructure, inversing the dependence relationship between Zephyr and the innovative ecosystems externs to its core activities (trains). "*Today, our main challenge is to develop this co-construction approach and increase the number of partnerships. The first platforms were deployed vertically, with* (Zephyr) *on one side and the telecom operator and the equipment manufacturer on the other, for cases that are intrinsically related to* (Zephyr) *use. The next step is to set up cross-vertical use cases to develop new synergies. The main objective is to federate other manufacturers to invent and deploy use cases that would be able to provide clear benefits for all stakeholders. These cooperations must be built in a non-transactional model where each party contributes its assets so as not to risk prematurely blocking the definition of the service model. I think it is important to get to know each other before entering into these economic dimensions."* announced the former Head of the Connectivity & Networks department. To date, the privileged access we have obtained within this experimentation lab confirms the non-transactional dimension, which is considered as a sine qua non condition for a long-term dynamic.

1.3.3 Benefiting for its ubiquity to becomes the nexus of the IoT ecosystem: the case of the electronical manufacturer Vestalia.

Vestalia, a European binational manufacturer that mostly operates in electronics: it supplies one of the most widely deployed electrical panels in homes in Europe. This activity requires to master how to make metal layers that change shape at a certain intensity/heat so that the switch breaks, with good reliability but without too much untimely interruption of the current, and to assemble these blades into electrical panels at a lower cost. Distributing them require adapting to norms and in compliance with the legislation, evolutive habits and uses from the building industry, in an inevitably competitive market. While industrially renowned on the manufactural side, the company initially does not shine in terms of its advance in AI/IoT/5G. The emergence of home automation has changed the situation for this manufacturer, which has been obliged to position itself in relation to the emergence of these technologies.

Vestalia's objective was to take advantage of the fragmentation of technologies and players operating in the home automation sector to position itself at its centre. "*What was seen as a utopian vision even ten years ago has now become reality: numerous intelligent devices, the so-called connected objects, are increasingly conquering the various areas of life. Many well-known manufacturers and innovative start-ups offer attractive IoT products to make our daily lives easier. Unfortunately, these are often independent systems with their own individual applications. As a result, these objects intended to assist us in our daily lives only complicate them. But with the* (Vestalia) *IoT Gateway, or IoT Controller, it is now possible to bring many of these different systems under one roof and combine them together*." promotes the company on its website.

The automation home industry is greatly benefiting from the recent advance in IoT, in AI, and in 5G, explained interviewees. The greater accuracy of sensors in particular, and their lower manufacturing and replacement costs, pave the way for better integration of the devices deployed as IoT in a building (or a network of buildings). 5G should facilitate the exchange of data between these devices, which until now have suffered from difficulties in connecting to each other because of walls and obstacles that impede the spread of electromagnetic waves in buildings. Finally, AI is increasingly used for tasks such as image processing or voice recognition, at the heart of many home automation devices. As mentioned by a manager of Vestalia, "(t)*hese technologies are combined. However, home automation players usually focus on one of these three technologies, which becomes the driving force of their added value*. (…) *They cannot reasonably position themselves as leaders in all three technologies. They need to form partnerships, and the right ones if they do not want to be swallowed whole in the near future".*

To stay in the race, Vestalia has chosen to take the IoT turn: the company relies on the fact that the panels are already positioned in homes, accessible by an operator, and at the heart of the electrical network. The aim is to take the turn to the smart grid, and then to home automation. To do this, Vestalia is partnering with the big players of the domain (Amazon for the virtual voice assistance, Philips Hue for automatic lightening, etc.) while ensuring that it remains the headquarters of the home automation system.

The core advantage of Vestalia is first that the company master the manufacture of electrical panels, but also its distribution networks and the several actors involved in its installation. Second, Vestalia promotes the integration of the home automation technologies within a common framework, the KNX protocol. KNX is one of the most used open standards for commercial and domestic building automation. Its implementation rests on interworking models with standardised datapoint types and objects, modelling logical device channels. The

KNX protocol is administered by a Belgium non-profit organisation formed in 1999 and is approved by European (CENELEC EN 50090 and CEN EN 13321–1), US (ANSI/ASHRAE 135), Chinese (GB/T 20965), and international (ISO/IEC 14543-3) standard organisations. Vestalia has then invested in the structuration of the home automation ecosystem to merge into this standard, as the KNX protocol guarantees a simple installation for installers who already master this language. To ease the diffusion of the home automation IoT products integrated within its own products, Vestalia has developed formation and apps to guide the installation of products in accordance with this protocol. The company offers also training courses on the gateway and on IFTT to promote the development of skills. "*In addition, there is an increasing number of new connected objects with new functions that need to be integrated into the smart home. With the possible integration of more than 1000 functionalities, the IoT Controller, in combination with KNX, is ready for this interconnected future. It already includes numerous pre-installed and continuously updated product interfaces. The IoT Controller thus opens up completely new perspectives and paves the way for an interesting and promising business sector*." ensures the company. These investments combining adaptation of their electronic devices and promotion of protocols they master permits then to Vestalia to position as a platform to connect all IoT devices performing home automation together, without competing on a technological dimension with (notably AI-powered) companies they federate.

1.4 The triadic ecosystem: an argument for AI-, IoT-, and 5G-non-native organisations to secure their position within the innovation ecosystems.

1.4.1 Becoming a petri dish for the triadic IA/5G/IoT ecosystems: securing its centrality in innovative ecosystems by leveraging on its infrastructural assets.

Our results point at three cases with converging ecosystem strategies. Hippocratus, one of the world's largest hospital consortia, promotes the data lake it constituted along the past decades to attract the health tech multiple in multipolar synergizing partnerships in which Hippocratus is at the centre. Zephyr, a major railway company, proactively equips its infrastructure (train stations, factories) with 5G antennas to serve as a test base for the ecosystem. Vestalia, manufacturer of electrical panels, is using its domestic ubiquity (almost all buildings are equipped or likely to be equipped with its products) to position itself at the centre of IoT home automation. By relying on a resource to which they hold the key, these non-digital native players succeed in positioning themselves at the heart of the innovation ecosystem linked to the 5G/IoT/IA triad. In the words of a Hippocratus's manager, the strategy for the three focal actors we investigated is to use the infrastructural assets to become a "*petri dish* [2]" for the 5G/IA/IoT ecosystems in their related sectors (namely, health tech, railway, and home automation).

In this perspective, these players rely on one of the three pillars of the AI/IoT/5G triad. In each case, it is remarkable that these players (Hippocratus, Zephyr and Vestalia) manage to put the technology to which they have a secure access at the centre, and the other technologies in a dependent relationship. For Zephyr, 5G in maintenance centres is expected to power applications that will also run on AI; and is intended to contribute to a Factory of the Future, which relies on IoT that is highly integrated with industry. Similarly, the home automation IoT ecosystem, at the centre of which Vestalia is trying to position, will also run with AI applications, and probably 5G connectivity. The goal of an IoT-integrated hospital is further away, but the lead Hippocratus is taking in AI applications, not only in terms of medical devices but also in automated office processing in the reception and follow-up of patients inside and outside the hospital, is certainly a first step in IoT in the health industry.

Arguably, other players could seek to reverse the balance. For example, in the case of Zephyr, competitors could expect to promote AI as the reference technology in the domain of the

[2] A dish that biologists use to hold growth medium in which cells can be cultured.

Factory of the Future and to relegate 5G and IoT as mere support technologies. For the focal actors we investigated, there is a clear need to find a balance between the three technologies. Indeed, what they master are mainly resources allowing a short-term coupling link between the technologies of the triad, more than a mastery of a particular technology. For example, Zephyr allows us to set up the 5G infrastructure and the collection of data that will pass through the network, to produce and deploy AI or industrial IoT applications. The same goes for Vestalia with its ubiquity in home automation, or for the Hippocratus with its data lakes.

The sustainability of their ecosystem strategy rests then on the fact that the innovative ecosystem they contribute to make emerge are seemingly deliberately open-innovation oriented and equilibrated in term of dominance of actors. Typically, significative efforts are paid by our three focal actors to maintain a balanced contribution of key major partners (major telecom company, Gafam, Batx, etc.) to their projects. The non-digital native nature of Vestalia, Hippocratus and Zephyr contribute to position them as guarantors of some fairness within the innovative ecosystems they fuel, which may contribute to their success ultimately.

1.4.2 Dominating the early coupling of the technologies of the triadic ecosystem

Others may contest their control of the innovative ecosystems they are contributing to build. But Vestalia, Hippocratus and Zephyr have a clear advantage in the race of securing a dominant position in their respective innovation ecosystems: their ability to offer early access to develop and test in vivo newly conceptualized AI-, IoT- and 5G-powered devices. An early access on which the partners in the ecosystem are in fact dependent. Other players in the innovative ecosystems we investigated are indeed characterized by a lead in terms of innovation in one of the three pillars of the AI/IOT/5G triad but has relatively limited access to the other two. Hippocratus, Vestalia, and Zephyr offer a unique opportunity to testing and implementing their solutions within the two other technologies constituting the triad. The capability of operating an "early" triadic integration of AI, IoT and 5G, is then a clear distinguishing feature of our focal actors.

4. DISCUSSION AND CONCLUSION. THE IMPORTANCE OF THE TRIADIC DIMENSION OF AI/IoT/5G INTEGRATED ECOSYSTEMS IN THE STRUCTURATION OF ECOSYSTEM STRATEGIES

The particularity of the triadic ecosystem strategies we observe is in this article is based on two dimensions. On the one hand, the triadic dimension of the IA/IoT/5G ecosystems, with three technologies emerging simultaneously, obliges the players to seek to integrate as quickly as possible not with one technology, but with a set of three technologies combined. To this end, players who allow triadic integration have a greater chance of imposing their central position within the ecosystems. Secondly, by combining three technologies, this triad multiplies the players involved, and therefore the sources of competitive threats, favouring the centrality of players "balancing" the ecosystem. This is for example the case of our three case studies who are non-digital natives and mainly value their infrastructure and their ability to test new technology early and in real contexts.

This article contributes then to the literature of ecosystems, especially innovative ecosystems (Granstrand & Holgersson, 2020; Beaudry et al., 2021) and ecosystem strategies (Adner, 2017), by presenting the triadic dimension as a critical characteristic for ecosystem strategies. This article also contributes to a better understanding of the development of these emerging technologies in the socio-productive spheres, by considering the importance that apparently technologically non-pioneering organisations may take in the heart of the AI/IoT/5G innovative ecosystems. The latter can indeed play the role of intermediary facilitating the interfacing of these technologies. This study then adds another layer of understanding in the forecasting of the structuration of the ecosystems related to these three technologies (Benitez et al., 2020;

Jacobides et al., 2021), by shedding a fresh light on the role of the coupling of the three technologies together and the intermediation of non-digital native players in this process.

The triadic dimension of AI, IoT and 5G permits then AI-, IoT- and 5G-non-native organisations to take the lead of related innovation ecosystems by securing an intermediating position on the coupling of these technologies. Such coupling is even more critical for innovative ecosystem. The early access to the triadic integration of the technology is critical for the organisations that are only specialist of one of these technologies and need to test and refine their products and service early in real condition, which means to secure an access to a place in which their flagship technology is deeply interconnected with the two other technology of the AI/IoT/5G triplet. This offers an opportunity for organisations that have a role to play in the coupling of the technology in the real life: by investing early to interconnect them, they provide a strong competitive advantage to many of the organisations involved in AI/IoT/5G and can use this opportunity to position themselves at the core of the nexus of the triadic innovative ecosystem.

Innovative ecosystems are dynamic structures (Adner, 2017; (Granstrand & Holgersson, 2020; Beaudry et al., 2021; Jacobides et al., 2021): the triadic dimension of the AI/IoT/5G on ecosystem strategies for outsiders is as significative as they invest early. But they need to secure their coupling position on the long run. Two options can be envisioned: having continually an advance in the integration of the three poles of the triadic ecosystem; or benefit from an early central position to turn into a regulatory force (notably by playing a role in the enactment of ethical and industrial standards) among the ecosystem they have helped to create.

As ecosystems evolve, ecosystem strategies are rarely static (Jacobides et al. 2018; Dattée et al., 2018; Jacobides, 2019). Remains then the question of the evolution of the AI/IoT/5G triadic ecosystem strategy for non-native digital player in the long term, which constitutes a clear area for future research. Clearly, one way to succeed in stabilising their position is to maintain a triadic integration always one step ahead. The other way is to position themselves as a regulatory force, as suggested by the literature on the role of regulations on innovation ecosystems (Jacobides & Liano, 2021). Typically, Hippocratus with its data lakes, and Zephyr as a trusted third party with the idea of a charter, are already clearly positioned in this niche. Vestalia could participate in the arbitration between IoT applications, if only mechanically, through the role of circuit breakers and energy distribution, which is becoming a growing issue for this technology. The company may also seek to influence favourably the strengthening of standards. Ethics could also represent a key but double-edged lever to secure their position on the long run, as scholars increasingly point at the role of ethics in the formation but also the fragmentation of innovation ecosystems (Liu & Stephens, 2019; Appio et al., 2019; Alam et al., 2022), notably AI (Jacobides et al., 2021; Stahl, 2022). These changes in strategy nevertheless remain to be studied in the future, with particular attention to the possible particularity of the triadic dimension of the ecosystem on its evolution, and the success of its actors.

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