

Harno, Jarmo

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## Scenarios for the Industry 4.0 ecosystem development

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# Scenarios for the Industry 4.0 ecosystem development

Jarmo Harno  
*Technology development*  
*Ficolo Ltd.*  
Helsinki, Finland  
jarmo.harno@ficolo.com

**Abstract**—This paper studies the competitive landscape in the developing Industry 4.0 ecosystem. Technology development and convergence within the ICT field has led to increased significance of technology platforms and ecosystems organizing around them. The question about the lead integrator, who will take the dominant position and capture the main value is of increased importance. The Industry 4.0 concept is extremely complex as combining so many technologies and potential stake holders. Utilizing technology platform analysis and value capture modeling, this paper sheds light on the strategic questions of the stake holders: Which kind of industry players have the biggest potential to capture the dominant platform player role and the biggest value in the forthcoming Industry 4.0 market? Which are the different opportunities and paths to be pursued by the industry players and service providers.

**Keywords**—5G, Industry 4.0, Industrial IoT, Industry ecosystems, Strategic analysis, Value Capture Model, VCM

## I. INTRODUCTION

The aim of this study is to investigate the Industry 4.0 market competition utilizing the quite novel approaches; the research on platforms that combines the technological and economic perspectives, and the Value Capture Model, VCM, whose practical application to real case studies is still in progress. The strategy analysis has until the last decades been concentrating too unilaterally on the competition in value chains and the strengths and bargaining powers in that context. In the modern complex industry ecosystems and platform economics, the cooperation, and the coalitions of different players to create together the highest added value, are often more important for the strategic analysis than the plain strength comparisons between the adjacent players in the value chain, or rivalries at one point of the value chain.

This approach opens possibilities to better consider in the analysis the importance of the cooperation, cocreation and even co-innovation as means for value creation and success in the mix of varying roles in the competitive landscape. The recent history has revealed that in the ecosystem game the visionary's reward might be abundant; the achieved winning platform position can quickly weaken the position of its rival platform providers who may lose the interest of the other value network players which are urgently needed to complement the provisioning. They all want to join the winning platform's ecosystem.

## II. THE PLAYERS IN THE INDUSTRY 4.0 ECOSYSTEM

### A. The new competition environment

“The fourth industry revolution” or “Industry 4.0”, also called “Industrial IoT” is a combination of several technologies that earlier have been considered separate markets. Industry 4.0 combines industrial manufacturing, its automation, maintenance and logistics to edge computing, machine learning and other AI (artificial intelligence) applications, cloud computing, and high speed, high reliability, secure, and low latency wireless data communications, especially the 5G. Industry 4.0 market differs greatly from the earlier markets as so many separate technology trajectories are now converging.

Since the early 2000s, industrial organization economics literature has begun to develop theory on platforms, which have been variously referred to as “two-sided markets”, “multi-sided markets”, or “multi-sided platforms” [1]. The platforms are viewed as special kinds of markets where platform providers facilitate the exchange of goods between different types of consumers or merchants that could not otherwise transact with each other efficiently. In [2] the two-sided markets are defined as “markets involving two groups of agents interacting via ‘platforms’ where one group’s benefit from joining a platform depends on the size of the other group that joins the platform”. The network effects are so central in these studies that [3] states that “in a technical sense, the literature on two-sided markets could be seen as a subset of the literature on network effects.”

In the engineering field, the study of complex systems led to the analysis of technology platforms and their importance in systems design and product development many decades earlier. However, the relationship with ecosystems as industrial (meta)organizations (beyond the firm boundaries) and the cocreation and innovation in this context was not emphasized until recently [1]. In addition to externalities and the economies of scale, also the innovation and economies of scope provided by the modularity and possibilities to add complementing or extending pieces upon the platform by cooperating ecosystem partners comes into the game.

As the number of players in the ecosystems have been smaller compared to the vast potential Industry 4.0 ecosystem, the building of the dominant platform has been more straight forward. Thus, also the strategic analysis. For example, in the smart phone market, the main players have been the phone manufacturers (or technology platform providers like Google), who took

also the control of the application platforms, and secondly the network operators, who provide the standardized radio and core networks (in many cases also bundling the handset sales to the network access contract). Apple and Google have been clearly the dominant players so that operators and application developers have been dependent on those two companies in providing value to the customers. This is an example of very tight one-to-one connection between the end customer and the platform provider. Currently it is almost impossible to create a competitive new platform, or ecosystem, to that market. In the Industry 4.0 ecosystem the situation is very different, at least in this nascent phase, as so many players, from different fields of technology and markets are required to participate in forming the complete solution. In addition, the customers (firms in different industries) have very versatile requirements for the solutions and are themselves active participants in the building of the solutions.

The situation in the booming public cloud business has been much like in the smartphone ecosystem. The big hyperscalers (like AWS, Azure, Google Cloud, Alibaba Cloud, IBM, Oracle) have provided their own platforms with all needed infrastructure and tools to build, integrate and utilize business IT solutions. The formation of their platforms has been more straightforward than in the upcoming Industry 4.0 ecosystem, where the solution cannot situate fully in big datacenters, but can be dispersed in huge number of entities in different premises utilizing advanced communication networks. The trend seems to be turning again from centralized processing to distributed (edge) processing.

The telecom operators have once again the possibility to rise above the role of utility provider to the higher value solution provider or even platform provider role, but the competition is growing even harder, as new cloud computing players are coming to the telecom market and the emerging data networks are not necessarily operated by a public network provider.

### *B. Stakeholders and their relationships*

The different kind of stakeholder roles in the competitive Industry 4.0 ecosystem are presented in the Fig. 1 below. It should be noted that the list of presented roles is not intended to be comprehensive, but it is usable for the current analysis of the technology and market dynamics. Also, one player might have taken more than one of the presented roles, but that does not have a notable impact on the analysis. In the Fig.1 the abbreviation “OT” means operational technology<sup>1</sup>. It should be noted here that in the context of Industry 4.0, the convergence of IT and OT is taking place too. Also remark that the big industrial companies may have taken themselves the automation supplier role too.

Stakeholders like political decision makers or bodies have been taken into this picture, as they represent a substantial power in the formation of the competition. Their interest has increased in the recent course of events, where the large US based internationally operating ICT companies or “Tech Giants” like Alphabet (Google), Amazon, Apple, Microsoft, and Meta (Facebook) are seen threatening the fair competition and the privacy of the citizens due to their dominating platforms and thus management of huge amount of personal data.

EU has started, for example, programs to underpin the common European data spaces to keep companies and individuals, who generate and own the data, in control, through open and secure data interfaces and infrastructure, as well as open-source multi-cloud management services, enabling seamless integration of heterogeneous cloud environments of different service providers in a vendor-neutral manner<sup>2</sup>.

This means that, more than ever before, the political institutions of economic unions see this big transformation and new ecosystem formation as something they must get involved, for the sake of their citizens’ and business and public sector actors’ interests. However, at least in the western world, the free competition is an important economic principle to adhere, so the major force in the ecosystem formation would still be the economic value created through different cooperation and competition patterns, but not forgetting the incentives and constraints that the society can set to prevent the negative externalities, whether economic, social, or environmental, that it considers to be caused by unfavorable business activities; ex-ante influence by promoting and funding development projects and standardization, by regulations and legislation, and ex-post enforcement eventually by court rulings with substantial fines.

## III. VALUE CAPTURE MODELING

### *A. Strategic analysis of the firm competition*

For the strategic analysis of the position of the different players in the emerging Industry 4.0 market, we use here the platform and ecosystem development analysis as well as the value capture modeling (VCM). VCM goes beyond the Michael Porter’s famous five forces model that he introduced in his seminal 1979 article “How Competitive Forces Shape Strategy” [4]. Porter defines the opportunities of a firm by the power that other agents may have over it: bargaining power of the buyer, bargaining power of the supplier, threat of entry by new agents, threat of substitute products or services brought by existing or other agents, and rivalry from other similar firms.

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<sup>1</sup> Hardware and software that detects or causes a change, through the monitoring and/or control of industrial equipment, assets, processes, and events.

<sup>2</sup> E.g., European Strategy for Data; European Alliance for Industrial Data, Edge and Cloud; Gaia-X; Partnership on AI, Data, and Robotics – among many other initiatives.

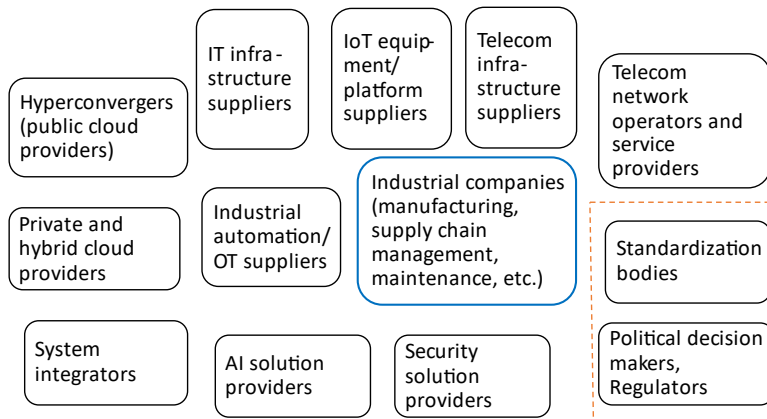


Fig. 1. Stakeholder roles in the Industry 4.0 ecosystem

More and more, the firms are creating the *value* in cooperating networks, and the ability of each player, in the other hand to *cooperate*, but in the other hand to *capture* its own share of the total added value, is a crucial question that Porter’s model is insufficient to cope with. It does not figure out the mix of competition and cooperation, the “coopetition”, prevalent in the current ecosystem games. The “Value-Based Business Strategy”, introduced by Brandenburger and Stuart in 1996 [5] opened new avenues for the strategic research. Since that date the value capture model (VCM) has been evolved to its current state.

In the VCM’s core is the axiom: “The value that any party can capture from engaging in transactions with a given set of parties is bounded by the value each of them can add to parties outside the set”, as formulated by Michael Ryall in [6]. This approach fits well to the task we have in analyzing the Industry 4.0 market, where the many cooperating players, taking different roles in the ecosystem, can form versatile sets of parties to provide together the full Industry 4.0 solution. So, the players in the field are competing on the most lucrative parties to cooperate with. Later in this paper we will look at the different benefits that the players may possess in the “competition of cooperation”. The most competed partner will capture the highest value (or share of the profit) for itself.

#### B. Example of strategic analysis with VCM

To illustrate the applicability of the VCM approach underpinned by the innovation ecosystem ideas - before we go to the actual research topic of the very complicated forthcoming Industry 4.0 ecosystem - we apply the VCM to a more straightforward case of the smartphone ecosystems.

Fig. 2 illustrates in a coarse way the smartphone ecosystem. The winning smartphone platform providers (clearly Apple and Google) have shown to be the most lucrative partners for the users and all other parties in the value network. (Apple having also the manufacturer’s role in addition to the platform role.) The VCM nicely unfolds the reason for why the platform provider has captured most of the added value in the smartphone ecosystem.

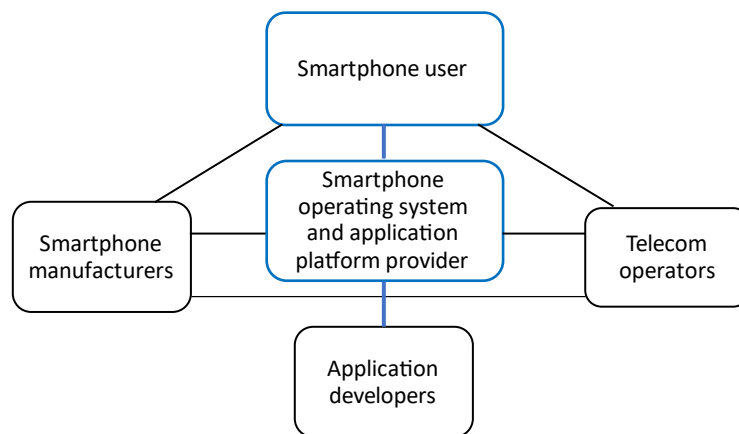


Fig. 2. The smartphone ecosystem

From the Application developer's perspective, the Google or Apple platforms were and are the most lucrative, because, on the other side, the cost to build the application was much lower than when coding it for e.g., the Symbian platform that Nokia was mainly promoting when these new platforms were launched. On the other hand, when thinking of the apps market, first Apple and then also Google's Android, grew much faster in number and in variety of applications and that boosted the usage and demand, and thus revenue potential for the developers. So, the virtuous circle accelerated rapidly the growth of power of the winning smartphone platform providers.

This phenomenon also emphasizes the importance of investing early enough to a new technology platform, or better, to have a vision of a future use cases, demand and service ecosystem and start to pursue that, building the cooperation networks at the same time. This chain of events indicates that when the new service ecosystem starts to unfold, it might be impossible any more to successfully enter to the new market with a competing platform. Even heavy investments might be too late, as the virtuous circle mentioned above can quickly attract the other value network parties to the initiator's evolving ecosystem. The question is not only about the technology factors but also of marketing measures and viral phenomenon among the potential users. The "quick follower"-strategy does not work well enough in this kind of modern ecosystem rivalry.

From the telecom operator's side, it is easy to see that Apple was even from the first iPhone launch in 2007 a very attractive partner, because the new approach promised increasing data traffic revenues (underpinned by the hype Apple had created). The appeal Apple had been able to create resulted even to high subsidies by the operators for each iPhone sold.

It is clear too, that for the smartphone user the iPhone and Android provided a big added value, and thus willingness to pay, compared to the earlier mobile phone usage. The handset was not anymore only an equipment to make calls or exchange messages, or even connect to the internet, but the new app platform gave endless possibilities for new innovations.

In the Google's case the smartphone manufacturers and app developers were quickly drawn into the soaring new platform. For the platform owners all the other players were replaceable with other player of the same role – except, naturally, the end-users, whom they of course wanted to keep locked to their platforms (and for that they have created effective mechanisms). In the end, the competition led practically to a duopoly, where Apple and Google are sharing the customers between them.

In the end, the above presented axiom "The value that any party can capture from engaging in transactions with a given set of parties is bounded by the value each of them can add to parties outside the set" leads in this case to the conclusion that the platform owner will take the lion's share of the added value (the price that the end-user is willing to pay). There is in effect kind of a duopoly of Google and Apple also towards the complementing ecosystem partners. Outside the Apple camp, the operators or app developers can only go to the Google camp, but actually the best for them is to sit in both camps. Outside these camps they cannot do any comparable value i.e., income. The platform owners do not need to "buy" them to join to their ecosystem, so they need to give them only a minor share of the total profit from the end customers. This setting can be seen also in the huge valuation of those two players.

#### IV. MODELING OF THE COMPETITION IN THE INDUSTRY 4.0 MARKET

##### A. *The Industry 4.0 market players*

As we can see from the Fig. 1, the Industry 4.0 market is much more complicated compared to the smartphone case. However, we will apply the VCM approach to analyze the dynamics of the competition and the strategic positions and powers the different players can pursue.

It is hard to see that same kind of duopoly as within the smartphone market could emerge in the Industry 4.0 market because the smartphone market is basically a consumer market with quite unified needs as a whole, but the Industry 4.0 market consists of manufacturers etc. that are competing against each other and look for proprietary solutions, wanting to differentiate and keep their confidential information protected. Although taking a position of a globally dominant platform seems very challenging, there will surely be value networks where some players achieve the dominant position, so that all the other players will be even competing for the possibility to work with them.

These players are the ones that bring the highest and unique added value to the solution, this value being such that it is hard to catch up (ref. to the previous chapter) and differentiates them from the other players. To get this position, many of the players presented in the Fig. 1 are now heavily investing and broadening their scope or refocusing it based on their vision of the emerging market and technology solutions.

The end-customers are the industrial companies that are seeking for the new added value, and the others are the ones that are providing the means to get that value. The platform will then form the bridge to deliver this added value to the industrial companies, combining all the services from the platform provider itself and from the complementing suppliers. In the case of Industry 4.0, it is possible that even inside one case there will be several platforms more or less loosely coupled together but most probably there will be the central player, the platform leader who has the key role in the selection of the other players in the ecosystem. The other players are replaceable, but the platform leader owns the core innovations upon which the solution is built.

The standardization bodies and political influencers are separated from others in Fig. 1 with dotted line, as they are naturally not wanting to get a provider role but want to influence indirectly by supporting or inhibiting some activities as discussed in the second chapter. Normally it is not considered fair to exclude any players totally, but the dominant position that is considered as preventing fair competition is tried to be uprooted. In this context, as referred above, the EU authorities are promoting the open interfaces, which might not be in the strategies of some of the players striving for the dominant position. Another concern is the protection of confidential data. Especially the hyperconvergers can be seen as dubious, since the experiences in the smartphone

and social media field have raised controversies, court rulings and fines to some of these “Tech Giants”. As considering the profound industrial transformation of an economic area, the concern might be of even higher level than in the case of the consumer market.

### B. Cooperation and value creation in the Industry 4.0 market

According to the VCM principles, the players should try to be able to create value, and thus develop competences, that give them the best position to also capture the highest value in the forming ecosystem. To achieve this, the firms should try to develop capabilities and capacities that make them the most lucrative partners for the other parties in the value network. In a market like Industry 4.0, it is evident that no player can thrive separately.

It is easy to observe from the press releases that the most potential platform or solution owners are all developing their platforms and launching cooperation projects with other potential ecosystem players. For example: IT infra-structure supplier cooperating with Industrial automation supplier [7], Hyperconvergers developing their Industrial IoT platforms [8], as well as the Telecom infrastructure suppliers [9], also cooperating directly with the Industrial companies [10]. Some System integrators are also developing their Industrial IoT platforms [8], and the Telecom operators are profiling themselves as IoT solutions providers [11] and are partnering with other Industry 4.0 players. Players from virtually all roles in the Industry 4.0 ecosystem are participating in the joint innovation consortiums like the 5G Open Innovation Lab to be part of the cooperating network [12]. This witnesses a transition taken place from proprietary product development towards the Open innovation concept that suits well to the value creating ecosystem business model and emphasizes the appropriateness of the usage of VCM in the strategic analysis.

One ingredient in the current ecosystem formation is the convergence happening in many dimensions - the IT/OT convergence already mentioned, but also the migration from special telecom HW solutions towards SW defined networks based on generic cloud computing platforms, so that the border between IT infrastructure suppliers and Telecom infra-structure suppliers is blurring. This of course affects the roles of the cloud infrastructure and services providers, who can serve the telecom operators, but on the other hand many telecom operators have taken the cloud provider role too. As the telecom operators are “centralizing” their functions to the cloud datacenters, a counter phenomenon is taking place, where the cloud providers are widening their provisioning towards the edge of the networks (the EDGE computing). The latter is fueled by the needs of Industry 4.0 solutions, where the massive real time computation has to be performed near the shop floor (e.g., video analytics based process control and optimization). The convergence increases the possibilities of different players to provide the core solution or platform, as that can be pursued from different directions.

### C. Differentiating strengths in the Industry 4.0 cooperation

Due to the above-mentioned factors, it is not easy to foresee the differentiating factors between the players. However, if the Industrial company, as the end-customer in the ecosystem, has close development cooperation with its automation supplier, then that company may in a way “own” the end-customer and become a very lucrative partner for all the other players, assuming that it is strongly investing in Industry 4.0 technologies, like IoT, VR/AR (virtual/ augmented reality), machine learning, etc.

As depicted in the Fig. 3, the closest cooperators for the Industrial automation supplier could be the Telecom operator or the Telecom infrastructure supplier and probably a cloud provider for the back-end AI model development. It seems that the Telecom infrastructure suppliers have the better chances to be a close partner as they have done bigger investments to the Industry 4.0 technology development and are thus more consultative and adding more to the co-development. The other role players might be utilized too, either directly or through partners, but the solution coordination would be in the hands of the Industrial automation supplier. This scenario requires, as mentioned, a strong bondage and trust from the Industrial company towards its automation supplier. The automation provider needs to have strong development investments to the Industry 4.0 technologies and solutions to be able to take this coordinating role.

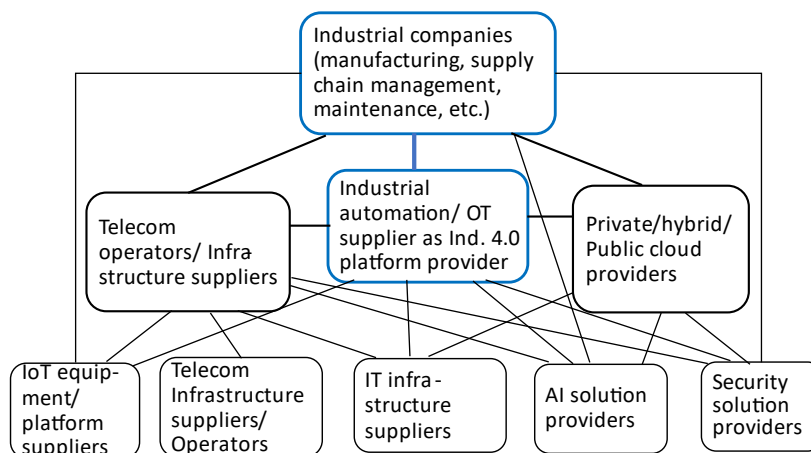


Fig. 3. Industrial automation supplier as the solution provider

As it is the only entrance to this particular business case, the players of the other roles are competing for being its partner - provided that the automation supplier's development project can create enough added value to the end-customer, so that all the participating players can at least cover their opportunity cost. The Industrial automation supplier itself has in this case the chance to reap a major part of the margin between the end-customer's willingness to pay and the costs of the provisioning.

In this scenario the solution as a whole is most probably not a kind of global platform, but the most important partners here may base their contribution on their platform solutions. In this value capture scenario these sub-platforms are, however, not given the controlling or value capturing position, but they are more like tools to create the solution. They are interchangeable with other available tools and cooperative partners in the market. This kind of scenario is most likely agreeable also for the politicians, as at least the "Tech Giants" are not dominating the competition - although may be part of the ecosystem. Finally, in this scenario, the big Industrial company may have itself also the automation supplier role, but it does not change much the dynamics, only that most of the added value stays inside the company.

The second scenario is that the Hyperconverger becomes the Industry 4.0 platform provider, as in the Fig. 4 below. This would probably mean a formation of a global platform and a competition dominated by the big tech companies.

As mentioned before, hyperconvergers are all investing heavily and building new competences and solutions in preparation to take this position. The hyperconvergers have created lucrative business by the public cloud and have huge resources to put in the development for this opening vast market. They know that in this kind of business the early entering to the market is crucial.

If the Hyperconverger can develop a platform that integrates all the tools and resources needed to create an Industry 4.0 solution fast and with minimal effort, it has the potential to be the most lucrative partner to all other players. Even in this scenario, the probable outcome may not be a monopoly or even a duopoly, but several of the strongest hyperconvergers could stay in the competition. In the contrary to the preliminary example of smartphone ecosystem, the other players do not cooperate with all the platform providers redundantly but must choose one of them to partner with for each competed customer case. From the perspective of the other players, it is lucrative to partner with a hyperconverger, if it reduces challenges with the complicated world of the advanced Industry 4.0 solutions. If this scenario realizes, potentially many of the players that have certain complementing role, want to utilize the hyperconverger's platform, who will capture a good part of the added value created in the form of reduced costs of these other players and the added value for the Industrial company in its increased productivity and lessened waste.

On the other hand, a global platform player having a major control over an Industry 4.0 solution can be considered a threat for the Industrial companies' essential need to control and secure their assets and intellectual property. In spite of the strong trend towards public clouds and colocation data centers, many industrial companies are still reluctant to move their data outside their premises and control. Lock-in to one provider's proprietary technology has a negative value and is a reason to select another partner and solution. Hence a private cloud solution might be preferred.

The Industry 4.0 applications are in many cases more related to the equipment and computing at the edge of the network, so that the processing in the remote big datacenter - the current core competence of the hyperconverger - is not the dominating part of the solution. The AI architectures and tools are developed by many providers and the AI related processing in the cloud could change from a crucial role to a utility that can be bought easily from different cloud providers – whether private, hybrid, or public cloud providers. For this reason, the hyperconvergers have all developed their edge datacenter and computing solutions. The proprietary environments with all the development tools are provided now also as HW/SW solutions that the customer may build in its own premises.

This strong relationship of the Industry 4.0 applications to the networks and ultrafast, low latency and highly reliable, secured data communications, leads to the next scenarios, where the telecom companies have the leading role. In the Fig. 5 is presented the case in which the Telecom infrastructure supplier has achieved the Industry 4.0 platform provider role.

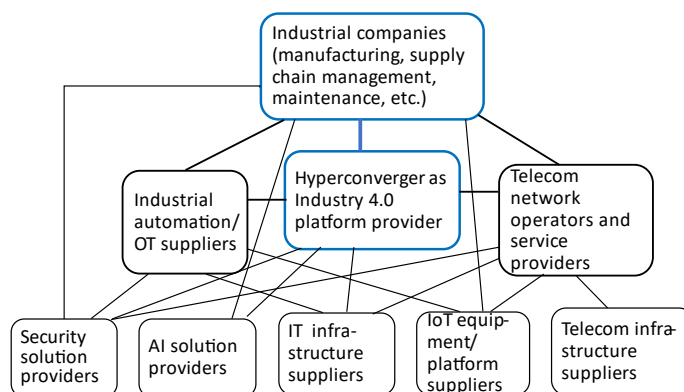


Fig. 4. Hyperconverger as the platform provider

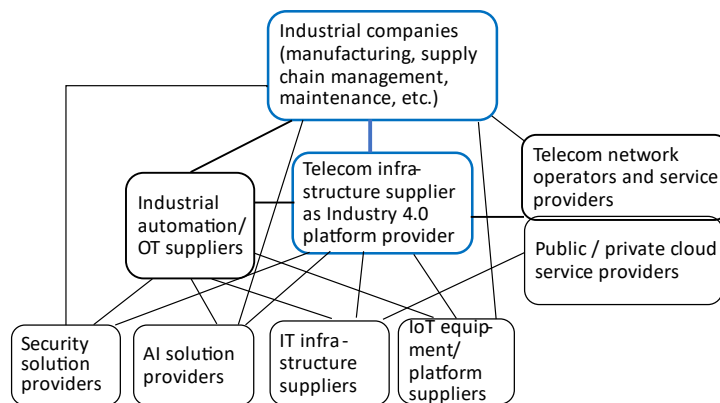


Fig. 5. Telecom infra-structure supplier as the platform provider

Although not all Industry 4.0 applications are built utilizing 5G radio network, it is one of the key elements of the future Industry 4.0 solutions enabling the ultrafast, low latency, high reliability networks that are needed for the real time control of machinery or autonomous robots or vehicles communicating with each other. The Telecom infrastructure suppliers are the players deepest involved in the development of the 5G networks, and are, as noticed above, building platforms, and launching cooperation projects with the industry players on Industry 4.0. solutions [9], [10].

Here the most probable scenario is that the Telecom infrastructure supplier cooperates closely with an Industrial automation supplier/big manufacturer and a Telecom operator or Cloud service provider to provide the Industry 4.0 solution. Telecom infrastructure suppliers have had strong partnerships with telecom operators, aka communications service providers (CSPs), which are their major customers. For this reason, they are ready to cooperate with them also in the Industry 4.0 arena. But in the Industry 4.0 cases it is often mostly question of private networks, where the public network operator does not necessarily have the major role. This might create a tension in the future between these two players and in some cases they might become competitors. On the other hand, the cloud service providers are coming closer and closer partners as the network and computing functions are converging. Especially the hyperconvergers are developing valuable assets in the integration of the OT, IoT networks, AI and other Industry 4.0 computing resources. This may make them more important partner than the telecom operators for the platform leader in this scenario.

The three biggest telecom infrastructure suppliers have each the capacity to build Industry 4.0 solutions with the Industrial automation suppliers, but do they have the potential to build a platform that all the other players will want to join in? Their competences are still focused on the network technology, although cooperation with the more general computing platform tech companies is increasing. Nokia e.g., has been active in the ETSI Multi-Access Edge Computing (MEC) initiative that promotes open interfaces and provides a point where operators can collaborate with enterprises and application providers [13].

This scenario is probable in the cases where the initiative comes from the network deployment side. If no clear differentiation in the provisioning, the Telecom infrastructure supplier is competing evenly with the other major suppliers, which indicates that smaller part of the added value goes to it. But in the situation where some of the Telecom infrastructure suppliers succeeds to create a portable platform that gives the Industrial companies exceptional value, faster than other solutions, even reducing the other parties' development/deployment costs, the value capture potential is high. Pursuing this position implies hard competition between the infrastructure suppliers – in the first place in the innovation and, if no surpass takes place, in price.

The last scenario handled here is the case where the Telecom operator is in the central role in the Industry 4.0 solution provisioning. It is illustrated in the Fig. 6. below.

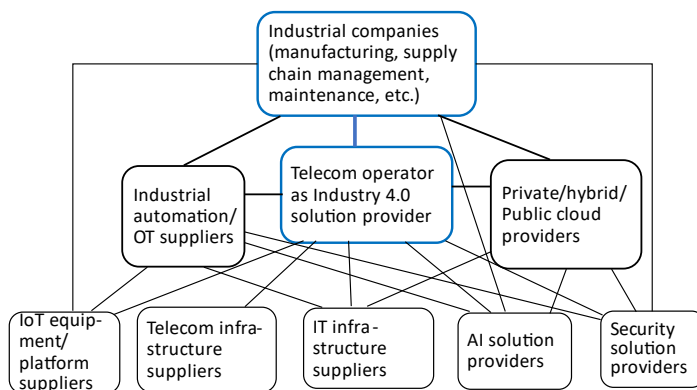


Fig. 6. Telecom operator as the solution owner



Telecom operators have currently a widespread role in the information and communications technology (ICT) realm. Many of them have broadened their scope from communications service providers to data center colocation providers and then to cloud service, and even information security solution providers.

However, technology development is not in the core of the operators' business. In every region there are several competing telecom operators, so why would some of them be extra attractive partners for the other role players – to whom the VCM suggest a good share of the added value? There are examples that operators are cooperating with some leading tech companies to develop and test Industry 4.0 solutions, e.g., Verizon and IBM are testing the 5G Industry 4.0 solutions together [14] and TIM with a large tech consortium [15].

Most operators are now heavily investing in deployment of the 5G networks. Due to the network slicing features, they will have a good infrastructure base to provide also for the customer specific Industry 4.0 networks. But as the competing operators are also deploying their own 5G networks, this is not as such enough for a good position in the “coopetition”.

One of the valuable assets of the telecom operators is the ownership of customer relationships with many potential Industry 4.0 companies as a connectivity provider. If the operator has developed good cooperation relationships with computing and AI technology developers, it has an opportunity to become a key player in the Industry 4.0 provisioning. It can then act as the creator of a consortium to build the solution for the industry customer. This kind of position will make the operator a lucrative partner for the other players of different roles, who will compete to be selected to the cooperation. Having a position where the operator (and maybe its key technology partner) can select the other partners enables it to capture a major part of the added value produced in the Industry 4.0 solution.

It is, however, possible that the Industrial automation supplier has an even closer relationship with the customer, giving it the position to select the other partners. For this reason, it is important for the operator to try to fasten its relationship with the automation supplier beforehand and have a shared ownership of the Industry 4.0 solution project. And at the same time to deepen its technology competences in cooperation with the best partners at the same time investing in joint marketing and customer relations. If the Industrial company itself has the automation developer role, then the relationship should be developed directly with it, and early enough.

An advanced Industry 4.0 requires not only progressive communications technologies but in the long run also the high-performance computing (HPC) facilities with AI and big data architecture. There also the energy efficiency and environmental aspects are of growing importance and public interest. For this reason, a cloud computing partner would probably be in an important role in the solution. Many AI and ML (machine learning) solution developers rely on tools and computing environments provided by the public cloud providers (the hyperconvergers), but also private/hybrid cloud providers have developed their computing provisions to support HPC, as well as AI, ML and big data handling. This alternative could provide even better possibilities to implement segregated and customized computing environments, with more open interfaces.

Telecom operators may implement the cloud provider role inhouse, but in many cases they may not consider it their core business. Even the telecom functionalities are under migration to the cloud, and there are more and more cases where the operators are cooperating with the cloud computing providers. E.g., Deutsche Telekom and Telenor are going to utilize AWS' cloud technologies [16], [17].

## V. FINAL REMARKS

The results derived from the analysis give some important perspectives to the cooperation and competition in the forthcoming Industry 4.0 ecosystems and about the strategies of different players in pursuing for maximal value creation and value capturing.

The analysis is not intended to be exhaustive, rather being the initial gauge to figure out scenarios for different industry players at this point of the technologies and market development. Much additional analysis, increasing coverage and details, is needed, as the uncertainties at the same time gradually unfold.

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