# Value Creation in the Internet of Things: Mapping Business Models and Ecosystem Roles

Heini Ikävalko, Petra Turkama, and Anssi Smedlund

> *He had brought a large map representing the sea,*
> *Without the least vestige of land:*
> *And the crew were much pleased when they found it to be*
> *A map they could all understand.*
>
> Lewis Carroll (1832–1898)
> Writer, mathematician, cleric, and artist
> In *The Hunting of the Snark* (1876)

The increasing connectivity provided by the Internet of Things (IoT) supports novel business opportunities for actors in overlapping service systems. Therefore, the co-creative nature of IoT business needs to be further studied. This article reports an empirical study on a European IoT initiative. It contributes to the understudied area of IoT ecosystem dynamics by describing different actor roles and activities in the IoT use cases, and their implications for value creation in IoT ecosystems. Our findings show how IoT ecosystem actors may take the roles of ideator, designer, or intermediary in different IoT design layers, and we recommend this perspective to better understand and describe ecosystem business models. We also discuss the theoretical and managerial implications of our findings.

## Introduction

The Internet of Things (IoT) has spawned emerging business opportunities as digital technology is embedded in previously unconnected objects (Turber et al., 2014). The IoT means physical or virtual devices capable of communicating in real time (ITU-T, 2012). The data is used in creating a virtual counterpart of reality for optimization, prediction, and control of systems (Främling et al., 2003). The IoT offers new business opportunities in domains such as transportation and logistics, healthcare, smart environments, and personal data (Atzori et al., 2010).

Business models, defined as "a simplified and aggregated representation of the relevant activities of a company" (Wirtz et al., 2016), provide structured tools for management and planning, and are increasingly being studied by academics (Magretta, 2002; Wirtz et al., 2016). Nonetheless, research on IoT business models remains limited. Earlier research proposes an increased relevance of customer and partner relationships (Magretta, 2002; Wirtz et al., 2016). Further, there is a shift towards an ecosystem perspective that differs from the firm-level perspective on business models (Turber et al., 2014; Westerlund et al., 2014; Iivari et al., 2016).

The IoT is characterized by complexity. In IoT ecosystems, the data and analytics not known in advance, satisfying the general definition of complexity (Johnson, 2001), where the actors have independent control logics, and the interactions are not pre-defined. Opportunities in the IoT include creating synergy and efficiency with connectivity of several service systems. In the resulting system of systems, service systems overlap and create new technical configurations, inviting actors to service creation with differing roles of providers and users. Identification and exploitation of the business opportunities in IoT ecosystems face challenges, such as the variety of objects, innovation immaturity, and structural ambiguity (Westerlund et al., 2014).

# Value Creation in the Internet of Things: Mapping Business Models and Ecosystem Roles *Heini Ikävalko, Petra Turkama, and Anssi Smedlund*

This article is motivated by the aforementioned challenges and opportunities of IoT ecosystems, and the limited empirical research in this area. Recent work on IoT ecosystem business models notes the transition from providing products to services (Iivari et al., 2016; Westerlund et al., 2014) and the relevance of service-dominant logic (Turber et al., 2014), yet leaves the role of collaborators in value creation unexplored or remaining at a conceptual level. Here, we argue for the mapping of the relevant actors, relationships, and activities to realize the potential business opportunities in IoT ecosystems. With the aim of understanding IoT ecosystem business models, we ask: How do different actors contribute to co-creation in IoT ecosystems? We extend the earlier literature by differentiating the IoT ecosystem partners' service co-creation roles and by showing how the different roles relate to ecosystem value creation. This article deepens the business model discussion by suggesting the archetype roles of ideator, designer, and intermediary in the ecosystem business model mapping. By providing an empirical illustration of the variety of actor roles and the reasons those actors choose to participate in IoT ecosystem value creation, we contribute to the discussion of IoT ecosystem management and business models.

The article is structured as follows. We review the relevant literature concerning IoT ecosystem business models and value co-creation. Next, we describe the methodology of the study. In the results section, we describe the activities and roles through which the different actors contribute to value co-creation in IoT ecosystems. Finally, we discuss the results and their theoretical and managerial implications.

## Literature Review

*Business models in IoT ecosystems*
The business model concept provides a suitable base for mapping the activities of IoT ecosystems. The extant literature on business models has developed towards a broader view, with an increasing interest in strategic and industry-level orientation (Wirtz et al., 2016). Along with digitalization, the focus shifts even more to the level of ecosystems, affecting the conceptualization of business models (Iivari et al., 2016; Westerlund et al., 2014). The ecosystem view answers questions such as: who are the collaborators, why do they participate, and where are the sources of value creation? (Turber et al., 2014).

The IoT business model literature includes both practical (Hui, 2014) and conceptual interests (Iivari et al., 2016; Westerlund et al., 2014). The role of the value proposition appears essential in empirical (Dijkman et al., 2015; Ju et al., 2016) and theoretical (Turber et al., 2014) approaches. One of the major shifts is the changing role of data in the IoT (Hui, 2014). The four layers of the digital architecture provide sources for value creation in the IoT, suggesting that value is created on: i) device layers (physical layers such as hardware and logical capability layers such as operating system); ii) network layers (physical transport layers such as cables and logical transmission layers such as network standards); iii) the service layer; and iv) the content layer (Yoo et al., 2010). In this article, we follow the suggestion by Turber and colleagues (2014) by analyzing value creation in an IoT ecosystem across these four layers of digital architecture.

*Value co-creation in IoT ecosystems*
IoT firms rely heavily on outsourcing activities to external partners, such as app developers, hardware providers, and analysis providers (Dijkman et al., 2015), which increases the complexity of the ecosystem. This tendency calls for an understanding of partner revenue streams (Dijkman et al., 2015; Hui, 2014). The trend to transform firm-centric activities towards network-centric activities also suggests a change to service-dominant logic in the IoT (Turber et al., 2014). This shift further highlights the need to consider business models at the level of ecosystems instead of single firms.

In this article, an ecosystem refers to "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize" (Adner, 2017). This definition focuses on the configurations of activity around a value proposition (Adner, 2017) and fits with IoT ecosystems, in which building ecosystems around a focal actor is no longer the only solution.

As customers become collaborators through co-creation, the scope of a value proposition broadens to take into account collaborators' motives in addition to the traditional customer-specific value creation (Turber et al., 2014). This approach leads to inclusion of both monetary and non-monetary benefits, thus increasing the complexity of the ecosystem business model. Customer relationships in the IoT build on co-creation and communities thanks to the quick and personalized customer contact enabled by access to the customer data (Dijkman et al., 2015; Hui, 2014).

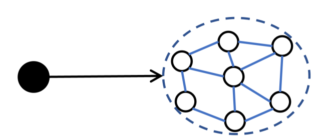
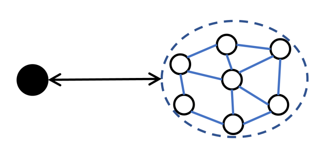
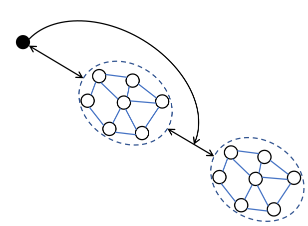
Despite acknowledging the relevance of value co-creation of IoT ecosystems (Iivari et al., 2016), the current literature lacks further conceptualization and empirical studies on the variety of actor roles in value co-creation within IoT ecosystems. Instead of simply describing who the collaborators are, we apply the differentiation of roles in service co-creation, as discussed by Lusch and Nambisan (2015) in their conceptual paper of digitally enabled service innovation.

Value co-creation in essence is the interactions between a firm and its customers (Prahalad & Ramaswamy, 2004), but can also include third parties, such as suppliers, business partners, or competitors (Kohlbacher, 2008). In light of service-dominant logic, value is co-created each time when capabilities, or specialized human knowledge and skills, are being applied for the benefit of the recipient (Vargo & Lusch, 2004; Vargo & Lusch, 2008). Service-dominant logic assumes that service is exchanged for service, and even a seemingly passive recipient provides input for the value co-creation relationship.

The recipient is the beneficiary of the value co-creation and can play many different roles (Lusch & Nambisan, 2015). Classification of the roles provides understanding of how value co-creation differs depending on the actors' orientation towards service innovation (Lusch & Nambisan, 2015) and the flow of knowledge (Smedlund & Toivonen, 2007). Defining the company's ecosystem role lays the foundation and defines the options for the company's business model design. The assumed role further expresses the service-exchange logic between the ecosystem partners.

The three identified role archetypes – ideators, designers, and intermediaries – have distinctly separate operating logic and activities in the ecosystems. First, ideators integrate current market offerings with their unique contexts and needs, and they provide input for service innovation by explicating these needs to the ecosystem with one-way communication. Second, designers mix and match existing knowledge components to develop new services with the ecosystem with reciprocal communication. Third, intermediaries cross-pollinate knowledge across many ecosystems and orchestrate service innovation with multi-way communication, affecting both the flow of knowledge and relationships. The intermediary role is especially important, because the intermediaries act as orchestrators by designing and facilitating the processes that allow ecosystem actors to collaborate with each other (Dhanaraj & Parkhe, 2006). Table 1 further illustrates the three roles.

**Table 1.** The three service exchange roles in IoT ecosystems (Adapted from Lusch & Nambisan, 2015; Smedlund & Toivonen, 2007)

| Role | Definition | Illustration |
|---|---|---|
| Ideator | • Brings knowledge about their own needs to the ecosystem.<br>• One-way knowledge flows.<br>• Providing input for service innovation. |  |
| Designer | • Mix and match existing knowledge components in the ecosystem.<br>• Reciprocal knowledge flows.<br>• Developing service innovation. |  |
| Intermediary | • Intermediate flow of knowledge and relationships in the ecosystem.<br>• Multi-way knowledge flow, orchestrating service innovation. |  |

To summarize our perspective, we build on previous literature and define an IoT ecosystem business model as internet-mediated activities among the service co-creation actors and connected smart objects, aligned for creating and capturing value both for each role in service exchange and for a shared purpose. Figure 1 captures the key elements for mapping roles in an IoT ecosystem business model.

## Methodology

Our study employs a multiple-case study design, which supports the goal of illuminating and extending the ecosystem relationships with an accurate approach (Eisenhardt & Graebner, 2007). The cases represent evolving IoT ecosystems in a Horizon 2020 initiative funded by the European Commission (Kubler et al., 2017). The case context for this study is a project called bIoTope (Building IoT Open Innovation Ecosystems; biotope-project.eu), which aims to accelerate innovation capacities for companies and public agencies with experimental large-scale pilots. The project builds on open standards and distributed value-creation models. Each pilot features use cases representing cross-sectorial IoT-enabled services.

The three selected use cases represent IoT ecosystems in a smart city context in Lyon, Brussels, and Helsinki. Qualitative data was collected mainly by participatory observation, co-working, and document reviews. The data consists of company and project documentation, meetings with project partners, project meetings, and presentations and informal discussions during the meetings.

We started mapping the IoT ecosystem business models based on use-case illustrations. We mapped the cases according to the dimensions described in the literature review (role, motivation, digital layer). After this within-case analysis, we proceeded to cross-case analysis. We summarized our findings concerning the service co-creation roles and reflected back to their relation to the corresponding business models.

## Results

*Case 1. Brussels / Safe school journey*
The bIoTope Brussels IoT ecosystem use case ensures the safety of children commuting to school in Brussels, Belgium. The commute affects and is affected by traffic management, including extent of traffic, traffic lights, speed limits, and routing of delivery and emergency vehicles. The IoT ecosystem connects different sources of information and enables a smooth and safe commute by traffic optimization, for example, through using dynamic traffic lights, informing drivers of school hours, and organizing the co-mobility of children with the assistance of a mobile application. The platform builds on open standards allowing scalability to future services. The main actors in the case are the children and their parents, schools, the regional information technology (IT) agency, the Brussels Regional Informatics Centre (a public interest IT agency), Orange (a telecommunications company), the traffic administration for the region, Brussels Mobility (a regional administrative body responsible for infrastructure, public works, and transport), and companies offering mobile application and website development as well as big data analytics (e.g., Waze, BeMobile, Cityzendata, Holonix).

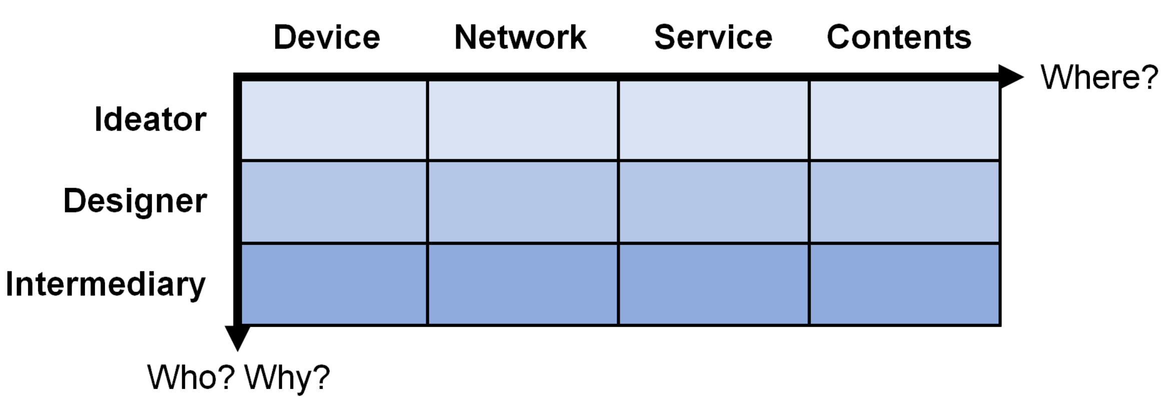



**Figure 1.** Key elements for mapping roles in IoT ecosystem business models

Ideators in this case are schoolchildren using a mobile application and volunteering their location data in exchange for the service. They operate in the content layer, bringing their context-specific request for service to the other actors in the ecosystem. They are motivated by non-monetary reasons such as increased safety and fun through the gamification of the app, as well as social motivators of treating the school journey as a collective activity. Their parents participate in the ecosystem by buying the application for their children and thus facilitating boundary crossing and acting as intermediary. Since their action is directly related to the end device, action takes place on the device layer.

The participating schools have a dual role as ideators and intermediaries. As ideators, the schools orchestrate the activities and communicate needs to developers. As intermediaries, they facilitate the exporting and importing of knowledge across boundaries. Their level of contribution to the ecosystem is at the service and contents levels, as they operate with data and knowledge. Their value proposition comes in a non-monetary form, as increased safety around their school and improved safety awareness.

A telecommunications operator (Orange) and data operators (Waze, BeMobile) as well as the company providing data analytics (Cityzen Data) act as ideators in the content layer. Orange provides information about the global flow of people in the Brussels Capital region around the schools, thus making it possible to address the needs of the application users. Consequently, Waze and BeMobile provide information about data flows concerning, for example, the current local traffic situation. Cityzen Data provides the analysis of the data provided by the mobile application and other sources (e.g., traffic information), thus making the knowledge embedded in data explicit for service providers. They all share a monetary motivation and are financially compensated for their work.

Another company (Holonix) develops the application for school kids to use during their school commute. Acting as designer, it develops the graphical user interface as a commercial service at the device layer, and mixes and matches existing knowledge components to develop new services. The University of Luxembourg acts in the role of designer on the network and content layers. The university enables the data flow in the network by enabling system interoperability through an O/MI-O/DF (an open messaging interface standard) wrapper connection to the application programming interface (API).

The regional IT agency (BRIC) collects and sends all the information to a central database in order to create a historical database in the IoT ecosystem. Acting on the network layer, it acts in an intermediary role as it exports and imports knowledge across ecosystem actors with the open API. Brussels Mobility acts as an intermediary in the ecosystem, providing the sensors and traffic data on both the network and content layers. Table 2 summarizes the actors' roles and layers of their contribution.

*Case 2. Lyon / Sustainable bottle bank management*

The bIoTope Lyon IoT ecosystem provides a sustainable waste management service in the Lyon region of France. It concerns bottle bank recycling and optimization of the collection truck routes. Previously, the collection frequency and routes were managed by the collection companies themselves. Now, the IoT ecosystem aims to use sensor data from the bottle banks to optimize the routes and collection schedule, thereby providing savings and environmental benefits. The system can be scaled to include additional information on weather, events, and traffic. The main actors are: citizens as users of the bottle banks, the regional mobility actor in the metropolitan area of Lyon (Métropole de Lyon), the municipal IT operator Data Grand Lyon, and the bottle bank collection company.

**Table 2**. Roles and layers in Brussels use case

| | Device | Network | Service | Contents |
|---|---|---|---|---|
| Ideator | | | School, children | Schools, children, Orange, Waze, eMobile, CityzenData |
| Designer | Holonix | University of Luxembourg | Holonix | University of Luxembourg |
| Intermediary | Parents | BRIC, Brussels Mobility | | Schools, Brussels Mobility |

The value proposition for the citizens demonstrates itself in the form of better quality of life resulting from a cleaner, less polluted, and less noisy city. The citizen activities lay on the content level as they, by using the bottle banks, create data in the IoT ecosystem, thus acting in the role of ideator in service co-creation.

The city actor, Métropole de Lyon, has multiple motivations for participating. Monetary motivation arises from the logistics cost savings and application of additional services for the created platform. Non-monetary reasons include improving quality of life for citizens. The city actor has a dual role as an ideator and intermediary. It provides both the sensors in the bottle banks, as well as a metropolitan data platform for sharing information about, for example, bottle bank location and traffic, thus acting as intermediary. It also orchestrates collaboration among parties as the case owner. The ideator role is demonstrated through contribution to knowledge conversion both in the network and content layers.

Data Grand Lyon is the city-owned IT provider for the internet infrastructure. It develops the O/MI-O/DF wrapper connection to the API provided by the route optimizer. Thus, it acts as intermediary in the network layer, enabling data traffic.

The designers in this case are the truck company providing collection services and the company providing route-optimization services for them as subcontractor. They both contribute to the ecosystem by developing services by mixing and matching knowledge components. Their motivations to participate in the ecosystem are monetary-driven as they are financially compensated for their tasks. Their activities contribute to the service level. Table 3 summarizes the actors' roles and layers of their contribution.

*Case 3: Helsinki / Promoting the use of electric vehicles*
The bIoTope Helsinki IoT ecosystem promotes the use of electric vehicles. The use case focuses on charging electric vehicles, because the lack of related infrastructure is one of the major use barriers. The few existing charging service providers have proprietary systems (authentication, payment, booking, etc.), which are not connected with car manufacturers or city systems and platforms. In Finland, the existing electrical infrastructure for pre-heating cars in winter provides an underutilized opportunity for a slow charging service. To advance the use of electric vehicles, the aim of the project is to create a systems of systems (SoS) connecting information from different sources and providing interoperability for service suppliers through a common standard. The system is labeled IoTBnB, because the vision for the system is to ultimately grow into an Airbnb-type service system with independent providers posting their services, including additional ancillary services. The main actors in the case are the city, represented by the municipal innovation agency Forum Virium, the IT operator Helsinki Region Infoshare, users of electric vehicles, charging stations, Aalto University, and a company providing data analytics (ControlThings).

The city actor Forum Virium acts as an ideator in the case. Forum Virium initiated the case and articulated the user need in the conceptual and content layers. The users of electric vehicles act as user–developers, providing service providers with their personal data in the content layer. The charging providers broadcast their data to the IoTBnB in the content and service layers.

ControlThings is a company providing an IoT service catalogue (IoTBnB) for the IoT ecosystem, acting as designer in the service and device layers. Aalto University acts as designer, developing the interface standard API and the O/MI-O/DF wrapper for connecting all the in-

**Table 3.** Roles and layers in Lyon use case

| | Device | Network | Service | Contents |
|---|---|---|---|---|
| **Ideator** | | | Métropole de Lyon | Citizens, Métropole de Lyon |
| **Designer** | Truck company | Data Grand Lyon | Truck company, route optimizer | Data Grand Lyon |
| **Intermediary** | | Data Grand Lyon | | Métropole de Lyon |

formation within the ecosystem. The municipal digital services provider Helsinki Region Infoshare acts as intermediary in the network level by offering a dashboard and sharing the information concerning the charging stations. Table 4 summarizes the actor roles and layers of their contribution.

*Ideators, designers and intermediaries for value creation in IoT ecosystems*

The ideators in every use case represented the end users: the actors for whom the system-level service (SsS) was developed. These actors volunteer their data, thus providing one-way knowledge flow from them to the IoT ecosystem in exchange for added value that can be monetary or non-monetary. Individual users (i.e., citizens) benefit from improved service and, later, additional services that the platform can scale up to provide. The ideators mainly operate in the content and service layers, where the concrete service is consumed and where less technical expertise is required for its delivery. The ideators must perceive enough value in the exchange to be willing to pay for the developed service. Business model implications for commercial parties include new opportunities in terms of channel, value proposition, and partnership innovations.

Cities as ideators and intermediaries benefit from increased capability to perform their mandate as public service providers, and thus promote greater citizen satisfaction, cost efficiency, and public profile. They further improve citizen perceptions of the city through citizen engagement and participatory development. Cities can also concretely benefit from the accumulated data for future planning purposes and development of additional service on top of the platform by commercial parties. Cities can collect commission for transactions and thus sustain the services as well as facilitate the further use of the data for commercial parties for a fee.

Other intermediaries in the cases included the IT departments of public agencies and organizations. The public agencies enabled and orchestrated collaboration in the ecosystem in both providing knowledge to the ecosystems and establishing knowledge sharing between separate ecosystems. The IT departments of technology companies and cities enabled collaboration in technical terms, as in the case of the Lyon bottle banks, where they enabled the data flow from the banks and trucks to the city traffic management system to make decisions to optimize the operation. The major role for these commercially motivated companies was the data integration through a standard API to enable interoperability on the one hand and, on the other hand, data analysis for knowledge contextualization for the services. Typical layers were the network, device, and service layers. Their motivation for the ecosystem participation is the collected data and analytic tools, which enable enormous opportunities for scaling up the innovations and designing additional services. Direct impacts on business models can be achieved in terms of reaching out to new customer segments, channels, and value propositions.

Designers in each IoT ecosystem were represented by commercial actors developing user interfaces and apps for accessing the data. They were compensated for their activities, as in the case of Control Things deriving revenue from the electric vehicle charging app. Both actors provided knowledge and received it in reciprocal collaborative relationships with the ecosystems. The added value for the designers in the bIoTope-type ecosystems, building on open source standards, is that they bypass the dominant commercial technology platforms, and thus provide new opportunities and freedom in service creation. This also opens up new opportunities for niche providers, especially in the network and device layers, where entry barriers are currently high due to the required investments.

**Table 4.** Roles and layers in Helsinki use case

| | Device | Network | Service | Contents |
|---|---|---|---|---|
| Ideator | | | City of Helsinki, charging service providers | City of Helsinki, users of electric vehicles, charging service providers |
| Designer | Control Things | Aalto University | Control Things | Aalto University |
| Intermediary | | Helsinki Region Infoshare | | City of Helsinki |

# Value Creation in the Internet of Things: Mapping Business Models and Ecosystem Roles *Heini Ikävalko, Petra Turkama, and Anssi Smedlund*

These companies also benefited from free access to data, which enabled them to develop commercial applications with reduced cost and created opportunities to access a broader customer base. The open standard enabled several paths for scalability and increased profitability through network externalities and access to new partners and customers, as in the case of Brussels traffic safety, where additional traffic management services could be added. Table 5 summarizes the three roles and their main activities.

**Table 5.** Summary of roles and activities in IoT ecosystems

| Role | Main Activities |
|---|---|
| **Ideator** *(Contents and Service layers)* | • Articulate need<br>• Volunteer data<br>• Consume commercial service |
| **Designer** *(Device, Network, and Service layers)* | • Analyze data<br>• Develop commercial service<br>• Deliver commercial service |
| **Intermediary** *(Network and Contents layers)* | • Coordinate activities<br>• Enable access<br>• Control platform |

## Discussion and Conclusion

Our research question was: How do different actors contribute to co-creation in IoT ecosystems? We have answered the question by exploring and describing the activities and roles of different IoT ecosystem actors in digital layers. We identified the activities of ideators, designers, and intermediaries in three cases and suggested patterns in their activities.

Our study makes several contributions to the understanding of the IoT ecosystem business model components and actor dynamics. Overall, we provide empirical evidence of the variety of activities that may take place in value creation in IoT ecosystems. We contribute to the so-far mainly conceptual IoT ecosystem business model discussion with an empirical case.

By defining different roles for the ecosystem actors in service co-creation, we extend the discussion on ecosystem business model mapping, which so far has not made explicit the role variation in service co-creation. Service-dominant logic is essentially about the application of capabilities, knowledge, and skills for the benefit of the recipient (Vargo & Lusch, 2004, 2008), and making sense of the roles provides a better understanding of value co-creation and specific business model options for each role archetypes in business ecosystems.

The finding that ideators are the beneficiaries of the developed services supports the user-driven development paradigm and earlier findings on the emphasized role of user data in service creation. Thus, the IoT ecosystem can be considered an ad hoc alignment structure for the approximation of designer resources and ideator needs for new value creation.

By adding the role variation to the previous contributions with digital layers and motivations of different actors (Turber et al., 2014), we expanded and advanced the existing discussion on IoT ecosystem business models. A better understanding of actor drivers clarifies the diversified and unstructured nature of IoT ecosystems and addresses the challenges identified by earlier literature (Westerlund et al., 2014). The structuring of activities around role archetypes may further the understanding about how ecosystems appear and evolve.

Our study supports earlier notions of the relevance of the ecosystem-level value proposition discussion (Dijkman et al., 2015; Hui, 2014; Ju et al., 2016; Turber et al., 2014). Our empirical cases demonstrate how value creation in these IoT ecosystems was constructed around a shared purpose, which expressed the values the actors wished to promote by their activities. This finding is in line with the recent "ecosystems as structure" perspective (Adner, 2017), which argues for the relevance of activities aligned according to a value proposition.

Our findings also suggest that cost reduction may not be the explicit shared purpose at the IoT ecosystem level, although it is sought for at the level of organizations (Dijkman et al., 2015). Our findings support earlier theorizing (Turber et al., 2014) that different ecosystem actors may have monetary or non-monetary drivers for their contribution to value creation in IoT ecosystems. Excluding non-monetary drivers and contributing activities might overlook relevant parts of the IoT ecosystem.

Our study provides empirical evidence for the earlier argument that value in the IoT context can be created in four layers (Turber et al., 2014). In addition, it adds to the earlier argument that one of the major changes in IoT business models is the change in the role of data (Hui, 2014; Ju et al., 2016). Our study adds to these notions and shows how sensors and analytical capabilities contribute strongly to value creation in IoT ecosystems.

We extend the previous conceptualizations of the IoT ecosystem business model (Turber et al., 2014). The combining of the digital layers and service co-creation roles captures the key elements of IoT ecosystem business models, and it brings a new definition into the discussion of IoT ecosystem business models.

*Managerial contribution*
Our study offers insights for the planners and managers of IoT ecosystems. The detailed descriptions of the activities related to roles of ideators, designers, and intermediaries also make explicit the exact points of managerial intervention.

Increased awareness of the different roles supports strategy planning and visualization of business opportunities for firms participating in IoT ecosystems. The illustration of the ecosystem business model creates an opportunity for shared sensemaking, thus acting as a cognitive tool for business model design. Thus, it can provide firms a conceptual tool (Magretta, 2002; Osterwalder et al., 2005; Wirtz et al., 2016) for orchestrating the activities among the different actors (Pikkarainen et al., 2017) and for addressing complexity and integration in the ecosystem (Phillips et al., 2017).

Application of service-dominant logic to IoT ecosystems can provide highly relevant avenues for practitioners in the IoT. Lusch and Nambisan (2015) argue that, in service co-creation, it is necessary not only to define the roles but also to create supportive environments for the integration of resources. According to them, this can be done by “focusing on (1) mechanisms that facilitate interactions among diverse actors, (2) adapting internal processes to accommodate different actors (roles), and (3) enhancing the transparency of resource integration activities in the service ecosystem” (Lusch & Nambisan, 2015). This kind of ecosystem mapping can be a valuable tool for ecosystem actors as an architecture or strategy of participation (Lusch & Nambisan, 2015), as well as for the design of future IoT ecosystems and interfaces.

*Limitations and further research*
As with any research, this study has its limitations. Regarding the identified roles and their activities, other cases in different contexts could further the generalizability of the results. The increasing interest in the IoT in a smart city context lays opportunities for future research in this area. Other avenues for further research can be found in IoT ecosystems operating in different contexts, such as smart agriculture.

Further, the study is limited by the fact that the studied IoT ecosystems are in their early phases where the focus is predominantly on products rather than processes and business models. Therefore, a longitudinal analysis of the evolution of the IoT ecosystem business models would be beneficial for furthering the discussion.

## Acknowledgements

The bIoTope project and this research have received funding from the European Commission. This article was developed from a paper presented at the Hawaii International Conference on System Sciences (HICSS), January 2–6, 2018.

# Value Creation in the Internet of Things: Mapping Business Models and Ecosystem Roles *Heini Ikävalko, Petra Turkama, and Anssi Smedlund*

## About the Authors

**Heini Ikävalko** holds a Doctor of Science degree in Technology from the Helsinki University of Technology's Department of Industrial Engineering and Management in Finland. She has worked as postdoctoral researcher at the Helsinki University of Technology and the Aalto University School of Science. Her current research at Aalto University's School of Business Center for Knowledge and Innovation Research focuses on business models, innovation management, and strategy in the digital transformation.

**Petra Turkama** is the Director of the Center for Knowledge and Innovation Research (CKIR) at Aalto University in Finland. She worked for Nokia in Finland and Germany for 10 years before moving to academia and receiving her PhD in Science from Lappeenranta University of Technology in Finland. She is an active contributor to research and conferences in the area of service and technology management and innovation and entrepreneurship. She serves as an adjunct faculty to several universities in the United Arab Emirates.

**Anssi Smedlund** is a Postdoctoral Researcher at the Center for Knowledge and Innovation Research (CKIR) at Aalto University in Finland. He received his PhD in Industrial Engineering and Management from the Aalto School of Science. He has acted as a principal investigator in numerous service science and innovation management research projects and has held visiting positions at Tokyo Institute of Technology and UC Berkeley Haas School of Business. Dr. Smedlund has published various peer-reviewed publications in the journals, conferences, and books in the fields of knowledge management, service science, and information system science.

## References

Adner, R. 2017. Ecosystem as Structure: An Actionable Construct for Strategy. *Journal of Management,* 43(1): 39–58. https://doi.org/10.1177/0149206316678451

Atzori, L., Iera, A., & Morabito, G. 2010. The Internet of Things: A Survey. *Computer Networks,* 54(15): 2787–2805. https://doi.org/10.1016/j.comnet.2010.05.010

Dhanaraj, C., & Parkhe, A. 2006. Orchestrating Innovation Networks. *Academy of Management Review,* 31(3): 659–669. https://doi.org/10.5465/AMR.2006.21318923

Dijkman, R., Sprenkels, B., Peeters, T., & Janssen, A. 2015. Business Models for the Internet of Things. *International Journal of Information Management,* 35(6): 672–678. https://doi.org/10.1016/j.ijinfomgt.2015.07.008

Eisenhardt, K. M., & Graebner, M. E. 2007. Theory Building from Cases: Opportunities and Challenges. *Academy of Management Journal,* 50(1): 25–32. https://doi.org/10.5465/AMJ.2007.24160888

Främling, K., Holmström, J., Ala-Risku, T., & Kärkkäinen, M. 2003. *Product Agents for Handling Information about Physical Objects.* Report of Laboratory of Information Processing Science Series B, TKO-B, 153(03)

Hui, G. 2014. How the Internet of Things Changes Business Models. *Harvard Business Review,* July 29, 2014. Accessed March 1, 2018: https://hbr.org/2014/07/how-the-internet-of-things-changes-business-models

Iivari, M. M., Ahokangas, P., Komi, M., Tihinen, M., & Valtanen, K. 2016. Toward Ecosystemic Business Models in the Context of Industrial Internet. *Journal of Business Models,* 4(2): 42–59.

ITU-T. 2012. *Series Y: Global Information Infrastructure, Internet Protocol Aspects and Next-Generation Networks: Next Generation Networks–Frameworks and Functional Architecture Models.* Recommendation ITU-T Y.2060. Geneva: International Telecommunication Union, Telecommunication Standardization Sector (ITU-T). http://www.itu.int/rec/T-REC-Y.2060-201206-I

Johnson, S. 2001. *Emergence: The Connected Lives of Ants, Brains, Cities, and Software.* New York: Scribner.

Ju, J., Kim, M., & Ahn, J. 2016. Prototyping Business Models for IoT Service. *Procedia Computer Science,* 91: 882–890. https://doi.org/10.1016/j.procs.2016.07.106

Kohlbacher, F. 2008. Knowledge-Based New Product Development: Fostering Innovation through Knowledge Co-Creation. *International Journal of Technology Intelligence and Planning,* 4(3): 326–346. https://doi.org/10.1504/IJTIP.2008.0201

Kubler, S., Robert, J., Hefnawy, A., Framling, K., Bonnercherifi, C., & Bouras, A. 2017. Open IoT Ecosystem for Sporting Event Management. *IEEE Access,* 5: 7064–7079. https://doi.org/10.1109/ACCESS.2017.2692247

Lambert, S. C., & Davidson, R. A. 2013. Applications of the Business Model in Studies of Enterprise Success, Innovation and Classification: An Analysis of Empirical Research from 1996 to 2010. *European Management Journal,* 31(6): 668–681. https://doi.org/10.1016/j.emj.2012.07.007

# Value Creation in the Internet of Things: Mapping Business Models and Ecosystem Roles *Heini Ikävalko, Petra Turkama, and Anssi Smedlund*

Lusch, R. F., & Nambisan, S. 2015. Service Innovation: A Service-Dominant Logic Perspective. *MIS Quarterly,* 39(1): 155–175.

Magretta, J. 2002. Why Business Models Matter. *Harvard Business Review,* 80(5): 86–92

Osterwalder, A., Pigneur, Y., & Tucci, C. L. 2005. Clarifying Business Models: Origins, Present, and Future of the Concept. *Communications of the Association for Information Systems,* 16(1): 1.

Phillips, M. A., Harrington, T. S., & Srai, J. S. 2017. Convergent Innovation in Emerging Healthcare Technology Ecosystems: Addressing Complexity and Integration. *Technology Innovation Management Review,* 7(9): 44–54. http://doi.org/10.22215/timreview/1105

Pikkarainen, M., Ervasti, M., Hurmelinna-Laukkanen, P., & Nätti, S. 2017. Orchestration Roles to Facilitate Networked Innovation in a Healthcare Ecosystem. *Technology Innovation Management Review,* 7(9): 30–43. http://doi.org/10.22215/timreview/1104

Prahalad, C. K., & Ramaswamy, V. 2004. Co-Creating Unique Value with Customers. *Strategy & Leadership,* 32(3): 4–9. https://doi.org/10.1108/10878570410699249

Smedlund, A., & Toivonen, M. 2007. The Role of KIBS in the IC Development of Regional Clusters. *Journal of Intellectual Capital,* 8(1): 159–170. https://doi.org/10.1108/14691930710715114

Turber, S., vom Brocke, J., Gassmann, O., & Fleisch, E. 2014. Designing Business Models in the Era of Internet of Things. *International Conference on Design Science Research in Information Systems,* 17–31. https://doi.org/10.1007/978-3-319-06701-8_2

Vargo, S. L., & Lusch, R. F. 2004. Evolving to a New Dominant Logic for Marketing. *Journal of Marketing,* 68(1): 1–17. https://doi.org/10.1509/jmkg.68.1.1.24036

Vargo, S. L., & Lusch, R. F. 2008. Service-Dominant Logic: Continuing the Evolution. *Journal of the Academy of Marketing Science,* 36(1): 1–10. https://doi.org/10.1007/s11747-007-0069-6

Westerlund, M., Leminen, S., & Rajahonka, M. 2014. Designing Business Models for the Internet of Things. *Technology Innovation Management Review,* 4(7): 5–14. http://timreview.ca/article/807

Wirtz, B. W., Pistoia, A., Ullrich, S., & Göttel, V. 2016. Business Models: Origin, Development and Future Research Perspectives. *Long Range Planning,* 49(1): 36–54. https://doi.org/10.1016/j.lrp.2015.04.001

Yoo, Y., Henfridsson, O., & Lyytinen, K. 2010. Research Commentary—The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research. *Information Systems Research,* 21(4): 724–735. https://doi.org/10.1287/isre.1100.0322

**Citation:** Ikävalko, H., Turkama, P., & Smedlund, A. 2018. Value Creation in the Internet of Things: Mapping Business Models and Ecosystem Roles. *Technology Innovation Management Review,* 8(3): 5–15. http://doi.org/10.22215/timreview/1142



**Keywords:** Internet of Things, ecosystem, business model, value co-creation, role

Technology Innovation Management Review

timreview.ca

## Academic Affiliations and Funding Acknowledgements

Canada

The Federal Economic Development Agency for Southern Ontario (FedDev Ontario; feddevontario.gc.ca) is part of the Innovation, Science and Economic Development portfolio and one of six regional development agencies, each of which helps to address key economic challenges by providing regionally-tailored programs, services, knowledge and expertise.

- *The TIM Review receives partial funding from FedDev Ontario's Investing in Regional Diversification initiative.*

Carleton University

TIM

Technology Innovation Management (TIM; timprogram.ca) is an international master's level program at Carleton University in Ottawa, Canada. It leads to a Master of Applied Science (M.A.Sc.) degree, a Master of Engineering (M.Eng.) degree, or a Master of Entrepreneurship (M.Ent.) degree. The objective of this program is to train aspiring entrepreneurs on creating wealth at the early stages of company or opportunity lifecycles.

- *The TIM Review is published in association with and receives partial funding from the TIM program.*