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Actors in the Emerging Internet of Things Ecosystems

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ABSTRACT

This study investigates actors in the ecosystems of the Internet of Things (IoT). Previous research suggests that unstructured ecosystems make one of the greatest challenges for creating business models for the IoT. The present study concludes four contributions. First, the study reviews literature to develop a framework for role mechanisms in ecosystems and applies the framework to analyse data from fifteen interviews in six cases. Second, it identifies four diverse actor roles in IoT ecosystems: butterfly, ant and greenfly, spider, and the swarm of bees. Third, the study shows how actors take and make different roles in four emerging IoT ecosystems; product-, company-, industry-, and peer to peer ecosystems, which are structured in accordance with the identified actors' role behavior. Fourth, it suggests a new role pattern, role replication, where companies replicate their value designs and networks to other contexts.

KEYWORDS

Actor, Business Model, Ecosystem, Industrial Internet, Internet of Things, Role, Role Behavior, Role Mechanism

1. INTRODUCTION

Diverse everyday objects from cars to toothbrushes and buildings to baby monitors will be connected to the Internet and with each other. This Internet of Things (IoT) can be defined as a world where physical objects are seamlessly connected to the information network, and where these objects can take actively part in business processes (Haller et al., 2009). It integrates diverse technologies and systems (Fleisch et al., 2009) and creates a significant potential for companies, their customers and other stakeholders to produce, co-create and get better services cost-effectively. The networked infrastructure of the IoT enables incremental and radical innovation and business development (Bucherer & Uckelmann, 2011). Despite the vast potential the IoT holds, the business promise has not yet been realised (Bucherer & Uckelmann, 2011). New business models will be needed for this emerging highly-connected world. However, the diversity of objects, the immaturity of innovation, and the unstructured ecosystems are proposed to be primary challenges for developing business models for the IoT (Westerlund et al., 2014). Thus, more research is needed on how the technological opportunities can be realised from the business perspective (Haller et al., 2009; Leminen et al., 2012; Leminen et al., 2014).

In addition to calling for more research on the emerging IoT ecosystems from the business perspective (Leminen et al., 2012), recent studies argue that research on IoT business models should be widened from a single company point of view to an ecosystem perspective (Westerlund et al., 2014). Previous literature on innovation networks reveals different roles organizations may take or

make (cf. Gemünden, 1985; Gemünden & Walter, 1998; Walter & Gemünden, 2000; Herrmann et al., 2006; Gemünden et al., 2007). Similarly to many innovation networks, especially open innovation networks, emerging ecosystems consist of diverse stakeholders looking for new business opportunities (cf. Rohrbeck et al., 2009; Nyström et al., 2014). Furthermore, roles are coupled to structures and positions in networks (cf. Heikkinen et al., 2008; Leminen et al., forthcoming). Nonetheless, extant literature is focused on documenting existing and institutionalised ecosystems and organisational roles in them, rather than revealing emerging ecosystems (Iansiti & Levien, 2004a, b; Ballon, 2009). Therefore, it is particularly interesting to study actor roles in emerging ecosystems. Emerging IoT ecosystems offer up-to-date context for this. This study investigates actor roles, and adjacent business models, in emerging IoT ecosystems. Our research questions include: i) which roles can actors take and make in emerging IoT ecosystems?, ii) how are these ecosystems built?, and iii) how are the role options linked to the emergence of IoT ecosystems?

The paper is organised as follows. After this introduction, we review previous theories on ecosystems and roles, particularly the IoT ecosystem, and actor roles. Thereafter, we explain the methodology and present key findings. Finally, we conclude by discussing the key implications of our research both to practice and the theory, and provide avenues for future research.

2. LITERATURE REVIEW

Studying ecosystems and actor roles in them will become more and more important, because in the future, actors are increasingly interdependent through technical and business ties. In the future, a large number of small and specialised “things” (devices and sensors) will be connected to each other and to the Internet, expanding existing Internet applications and services and enabling new ones (Leminen et al., 2012). The IoT increases complexity, as network structures are transforming from centralised structures towards decentralised and distributed structures. As a consequence, businesses become participants of complex business ecosystems (Barabasi, 2002; Möller et al., 2005). Tarkoma and Katasonov (2011) argue that an IoT ecosystem is a community of interacting companies and individuals where the companies use a common pool of core assets, based on linkages of physical world of things with virtual world of the Internet.

Next, we briefly review literature on IoT ecosystems, particularly related to IoT ecosystems and their business models, as well as actor roles in those ecosystems.

2.1. IoT Ecosystems and Business Models

The concept of business ecosystem originates from James F. Moore in 1993. He emphasises that innovative businesses cannot succeed alone, but they must rely on various resources. Businesses need capital, partners, suppliers, and customers to create cooperative networks. According to the ecosystem view, a company is not just a member in a single industry, but a part of an ecosystem crossing multiple industries. In ecosystems, companies act cooperatively and competitively developing new products and satisfying customer needs together. Since Moore, ecosystems have been a popular topic in business and technology research.

Given the rapid development of the IoT, increasingly complex ties between things and actors highlight the importance of ecosystem view on studies of IoT business models. Leminen et al. (2012) note that the existing literature lacks sufficient understanding and empirical research on IoT business models and their connections to the underlying ecosystem. The authors (ibid.) propose a framework to visualise a variety of existing and potential IoT business models and to distinguish four diverse IoT business model categories. Prior research on IoT business models has identified versatile challenges related to the IoT ecosystems (Haller et al., 2009). For instance, Westerlund et al. (2014) mention the diversity of objects, the immaturity of innovation, and the unstructured ecosystems as challenges. The third challenge refers to the fact that participants and their roles are not yet clear in the emerging IoT

ecosystems. Thus, by focusing on the ecosystem approach of doing business it is possible to overcome the challenges and design successful IoT-enabled business models.

Westerlund et al. (2011) discuss business model management and propose that various business models and their differences in the ecosystem context can be studied by linking business models with the firm's external strategy and relationships. They also suggest a shift from business model of a firm to ecosystem business models (i.e. value designs). Westerlund et al. (2014) argue that further business model frameworks are needed to understand these value designs because existing frameworks focus on the architecture of the business model rather than capturing the dynamics of the model. The value design demonstrates how value is created and captured in an ecosystem, and it can be conceptualised by four pillars: value drivers, value nodes, value exchanges, and value extracts. Value drivers are motivations of participants to generate value, realize innovation, and make money. Involving stakeholders in a "win-win" relationship is important for designing viable IoT business models (Bucherer & Uckelmann, 2011; Westerlund et al., 2014). Value nodes can be actors, activities, processes, or networks of organisations linked with other nodes to create value. Value exchanges describe an exchange of value, i.e. resources, knowledge, and information. Value extract refers to a part of ecosystem that extracts value. Any part of the ecosystem's business model can be described with the value design. This part may be single activities, individuals, organisations, networks and value flows between these nodes.

Burström et al. (2014) point out that previous ecosystem studies focus on large companies. Hence, there is a lack of studies on the roles of small and medium sized organisations in ecosystems. Tukiainen et al. (2014, p. 9) classify ecosystem research into four streams: product studies, company studies, industrial studies and meta-studies. Product studies refer to research on ecosystems as e.g. "mobile phone ecosystem" or "microprocessor ecosystem," whereas company studies describe e.g. "Amazon's web service ecosystem" or "Google's innovation ecosystem." Industrial ecosystems may be, for example, "ICT ecosystems" or "automotive ecosystems." Meta-studies refer to wider studies of "business based ecosystems" or "technology based ecosystems."

2.2. Role Taking and Role Making

A role refers to expected behaviour of parties in particular positions (cf. Allen & van de Vliert, 1984). In open innovation networks, actors may engage in role-making by creating a role for themselves, thereby altering the structure of the innovation network, and/or they may engage in role-taking, by acting within a limited, predefined structure and assuming an existing role. (Leminen, 2015)

Heikkinen et al. (2007) identify roles by mapping actors' tasks in innovation networks. They (ibid.) find several role-related tasks: 1) the webber decides which actors should be contacted, 2) the instigator guides the actors' decision making, 3) the gatekeeper makes decisions and owns significant resources, 4) the advocate distributes positive information, 5) the producer contributes to development, 6) the planner gives resources for development, 7) the entrant interferes in development, and 8) the auxiliary takes an active part in the end of the process, 9) the compromiser balances actions and relationships, 10) the facilitator provides resources but does not interfere, 11) the aspirant aims at becoming a part of the network, and 12) the accessory provider promotes its products, services, and expertise. The actors' actions determine their roles, and some of the roles are more incremental or radical, or more expected or emerging (Heikkinen et al., 2007). In their study on open innovation networks, Nyström et al. (2014) confirmed seven previously identified roles (cf. Heikkinen et al., 2007), but also proposed ten new roles characterised by openness and user involvement: 1) the coordinator who is a focal network actor, acting as a "focal network hub," 2) the builder promotes close relationships between participants, 3) the messenger forwards and disseminates information, 4) the facilitator directs and motivates the users towards a specific direction, and provides them with intangible resources, 5) the orchestrator orchestrates the whole network of actors, 6) the integrator integrates knowledge, development ideas, technologies, and outputs of different living lab actors into a functional entity, 7) the informant is a user that brings users' knowledge and opinions to the living

lab, 8) the tester is a user testing innovations in real-life environments, 9) the contributor is a user collaborating with other actors to develop new products, services, processes, and technologies, 10) the co-creator is a user that co-designs a service, product, or process together with firms and other living lab actors. However, it is not required that all roles are active for a network to operate satisfactorily.

Nyström et al. (2014) argue that previous role theory research has three approaches: the structuralist, symbolic interactionist, and resource-based views. The structuralist approach proposes that a firm comes into an established social structure and fills a particular position. Symbolic interactionist roles are dynamic, describing what actors intend to do; in other words, actors in networks are active in constructing their operating environment. The resource-based approach argues that a role is a resource, so that it means a membership and acceptance in a social community, and access to different kinds of capital – social, cultural, and material. Based on innovation research, Nyström et al. (2014) suggest a fourth theoretical view to roles; an action-based approach. They claim that the prior literature views the innovator roles and tasks as actions that should be taken for innovation to occur. This can be seen as normative approach to roles. The authors (ibid.) also argue that in open innovation networks actors (individuals or organisations) must both take and make roles that benefit them and the network ('Role ambidexterity'). One example is that if users in living labs wish to solve problems in their everyday life, they need to change their "taken" tester roles into co-creator roles, and thus "make" their role. 'Role temporality' suggests dynamics of roles, so that actors should avoid getting stuck in their roles and pursue to their best possible roles. It is important also for the network that participants can adjust and adapt to the structural changes in the network.

Ecosystem literature documents different actors in ecosystems rather than focuses on actor roles. Burström et al. (2014) argue that the post-Moore (1993) research has not brought up too much knowledge about leadership and control of ecosystems. The main body of studies propose close links between technology development, platform leadership and ecosystem leadership. The ecosystem approach relies on an analogy with biological ecosystems (Moore, 1993; Iansiti and Levien, 2004a). As in biological ecosystems, participants in business ecosystems are interdependent with each other for their development and survival. Although some actors are stronger than others, a single actor cannot control the entire ecosystem. In fact, the ecosystem can be understood as relationships between actors where they take different roles as keystones, dominators, or niche players. Ecosystems also typically reach several domains, and they may have shared domains with other ecosystems (Iansiti and Levien, 2004a; Burström et al., 2014). Burström (2010) emphasises the importance of an inter-firm platform for firms' strategy, operations, and functions. Therefore, he claims that platform development should be considered critical for the development of various business ecosystems. Huang et al. (2009) in turn submit that small and medium-sized enterprises (SMEs) may need strong intellectual property rights and/or the possession of complementary capabilities that protect them from being overrun by platform owners in the ecosystem. Moreover, Burström et al. (2014) urge more research on issues such as what roles SMEs play in business ecosystems, and whether and how SMEs can collaborate and compete at the same time in business ecosystems.

Tukiainen et al. (2014, p. 15) suggest that there are both key actors and supporting actors in ecosystems. The key actors are large firms and SMEs, as the SMEs mainly work as partners or complementors for large firms that are, or want to be, platform leaders in business ecosystems. Tukiainen et al. (ibid.) also argue that besides these key actors there are supporting functions in ecosystems that can be served by universities, governments and funding agencies. They (ibid., 39) also note that companies may have different strategies related to ecosystems: in single ecosystem strategy, a company concentrates acting in one ecosystem only, for example as an application provider using ecosystem leader's distribution channels; in multiple ecosystem strategy, a company connects across ecosystem boundaries, but the boundary is not changed. For example, a system supplier could connect to various ecosystems without changing the rules of game in a particular ecosystem. In a multiple ecosystem strategy with boundary spanning, a company presents new ways of doing business that

change the rules of game and boundaries of the ecosystems. As examples of the last mentioned case Tukiainen et al. (2014, p. 40) mention Apple and its iOS ecosystem.

Tukiainen et al. (ibid., 23) use Gawer's (2009) framework for platform innovation and competition to categorise ecosystem companies into four groups based on low versus high autonomy to innovate and low versus high likelihood of competition in the ecosystem (see *ibid.*, 37-38). Group 1 companies produce software products in low technical and low or medium market uncertainty. The business is easy to start and based on exploitation, and the rules are known and followed. Group 2 includes platform wannabes acting in high market and technological uncertainty. There is no clear market, and rules of the game are unknown. Huge investments are needed for starting a business based on exploration; there are also huge risks and opportunities. Group 3 consists of service or system integrators. There is a low technical and medium market uncertainty and the business is easy to start based on exploitation, but it is difficult to internationalise. The rules of the game are known, but the company needs good customer relationships and various kinds of expertise. Group 4 comprise solution providers acting in medium to high technical and market uncertainty. Some of the rules are known, but not all. The business is based on exploration, and there are huge risks and opportunities.

We suggest that the structure, resources and dynamics of an emerging ecosystem take shape when actors looking for new business opportunities make or take their roles in the ecosystem. That is why, to understand the emergence of an ecosystem, it is essential to study actor roles, and how actors make and take their roles in the emerging ecosystem. Next, we will present a framework that helps understand emergence of IoT ecosystems, and apply the framework in analysis of six cases.

2.3. The Framework

Given our review on the role theory and research on actor types in ecosystems, the extant studies fail to integrate ecosystems and the role theory. In particular, there is a need for more research on actor roles in ecosystems. More understanding is needed on how actor roles take shape in emerging ecosystems – their structuring, dynamics, and resources – at both organisational and ecosystem levels. We aim at analysing role configurations and mechanisms in the context of the IoT, and in different types of ecosystems. The ecosystem types presented in the literature (e.g., Tukiainen et al., 2014), have not been linked to role configurations or mechanisms at the organisational and ecosystem level. Our framework makes this linkage. The framework of this study is based on two dimensions, namely organisational or ecosystem levels, and it addresses role mechanisms (role-taking and role-making) related to these dimensions. The two-dimensional framework helps to identify current and potential IoT ecosystems and various actor roles in them (Figure 1).

3. METHODOLOGY

This study drew empirical data from semi-structured interviews with fifteen interviewees in six case companies in emerging IoT ecosystems.

3.1. Research Setting and Research Design

We draw on a multiple-case study design approach with cross-sectional data from different industries to generate evidence on actor roles in the emerging IoT ecosystem. As suggested by Jensen and Rodgers (2001), we deploy snapshot studies on cases. We focus on case comparisons because each analysed case share similar elements, allowing us for typifying role characteristics, as well as different business models in the context of IoT ecosystems.

3.2. Data Collection

The empirical data were collected from 2012 through 2015. Our empirical data comprised fifteen in-depth interviews representing six cases in the emerging IoT ecosystems. Given that research is scant on SMEs in business ecosystems (Burström et al., 2014), we attempted to find such pioneering

Figure 1. A theoretical framework of role mechanisms in ecosy

SMEs in IoT ecosystems. Among the six studied cases in the ecosystems, four of them represented SMEs. All the six cases were chosen, because they actively looked for new business opportunities in IoT ecosystems, and covering all companies in ecosystems would have required a substantial amount of time and resources. The interviews were conducted to understand different types of IoT ecosystems and roles that actors can have in them. We followed an interview guide suggested by Patton (1990), and collected information on various themes. The themes include IoT ecosystem and networks, particularly organisational aims and views regarding IoT, emerging IoT ecosystem and networks, actors and their roles, business models, expectations, tasks and activities performed by the organisations, and key challenges. The interviews were carried out face-to-face, and each interview lasted between 60 and 120 minutes. The interviews were recorded and transcribed for the purpose of analysis. The interviewees offered different views organisations have in building or joining the IoT ecosystem, which enabled broader perspectives to actor roles in the IoT ecosystem. Table 1 gives an overview of the empirical material.

3.3. Data Analysis

The empirical data were organised according to the informant, the date of interview, and the type of informant. Two researchers independently analysed and coded the interviews. They searched for words associated with business networks, ecosystems, business models, actor roles, role expectations and role activities by using the content analysis technique. The aim of the coding and content analysis was to better understand the cases (Roberts, 1997; Neuendorf, 2002). The empirical material was first coded by two authors, and the identified business models, networks, ecosystems, roles, expectations and activities were compared and discussed in the team. In the second phase, we analysed more thoroughly the actor roles in the emerging IoT ecosystem. This involved a second round of coding using content analysis with the aim of understanding the emerging ecosystem, different types of ecosystems and related actor roles, expectations and activities. At this stage, we analysed three diverse ecosystem types, product ecosystem, company ecosystem, and industry ecosystem presented by Burström et al. (2014) and Tukiainen et al. (2014), and role mechanism, particularly role taking and role making (cf.

Table 1. Overview of the empirical material of the study

Cases	Role of informants	Date of interviews
CASE A Component manufacturer Case A is a Finland-based component supplier for the construction industry. The company is interested in opportunities of the IoT in connected buildings, and is developing the product and service offering. However, the company is aware that if unable to add connectivity to the products, it probably will lose deals to competitors that may be ahead in satisfying high-end customers' advanced needs. Turnover about 63 million Euro.	Director, Research and Technology Director, Research and Technology, and Director, Marketing	19.1.2015 16.3.2015
Case B, Multinational network company A Nordic-based multinational company offering network solutions. The company sees both opportunities and threats in the IoT. Although the company is used to offering hardware and services to multiple business ecosystems, it has not become an active actor in building new business networks. Turnover about 30 billion Euro.	Business Manager Program Manager	09.04.2014 26.11.2015
Case C, Multinational telecom operator A Nordic-based multinational telecom operator providing network access and telecommunication services, enthusiastic of being actively involved in building business networks to employ opportunities of the IoT. The company is already offering machine-to-machine (M2M) communication services to their business partners, and aims to become more proactive in regards to the IoT. Turnover about 10 billion Euro.	Director Regional Sales Manager Manager	26.03.2012 01.10.2013 13.03.2014
Case D, Local telecom operator A Finland-based small telecom operator operating on a local market. The company is considered to be as an active business network developer or accelerator in the local community, aiming to build networks and business models that can be replicated in other contexts. Turnover about 0.3 million Euro.	CEO CEO CEO CEO CEO	27.03.2014 17.12.2014 03.03.2015 21.05.2015 03.03.2016
Case E, Sensor manufacturing A small, Finland-based technology start-up developing sensor-based solutions. The company wants to be closely connected to users and user communities with whom the company wants to develop IoT-based products and services. Turnover N/A.	Manager	26.11.2013
Case F, IoT Service developer A Finland- based service developer startup specialized in IoT and sensor network technologies. The company focuses on monitoring and improving its customers' environmental efficiency and creating a patented environmental measuring system to collect data through third party sensors and mobile devices for better efficiency. Turnover about 2.2 million Euro.	CEO CEO	17.12.2013 12.05.2015

Biddle & Thomas, 1966; Turner, 1988; Herrmann et al., 2004). We also wanted to identify in detail the case-specific roles the actors were taking or making roles. Then we analysed value designs in the IoT ecosystem as represented by Westerlund et al. (2014), i.e. value drivers, value nodes, value exchanges, and value extracts. After comparing our interpretations with prior research on roles and ecosystems, we identified four new actor roles in the IoT ecosystem and one new ecosystem type, peer-to-peer ecosystem. Table 2 gives an overview on our data analysis and the phases of the study.

Table 2. Data analysis process

Data analysis phases	Tasks	Outcome
1. Open coding	<ul style="list-style-type: none"> • Organise IoT expert interviews • Identify main topics in each case 	Overview of expert views on the emerging IoT ecosystem, actors and business models
2. First round focused coding	<ul style="list-style-type: none"> • Compare data to theory 	Comparing the diverse ecosystem types by Burström et al. (2014), and role mechanism, role taking and role making (cf. Biddle & Thomas, 1966; Turner, 1988; Herrmann et al., 2004).
3. Second round focused coding	<ul style="list-style-type: none"> • Describe actor roles, and value designs in each type of ecosystem 	Classification of roles, types of ecosystems and descriptions of value designs by Westerlund et al. (2014)
4. Identifying roles and types of ecosystems	<ul style="list-style-type: none"> • Analyse actor roles in different types of IoT ecosystems • Compare data to theory 	Detecting previously one unknown type of ecosystem and four actor roles in the emerging IoT ecosystem
5. Theorising the codes	<ul style="list-style-type: none"> • Synthesise phases #1-4 	Characteristics of actor roles in the emerging IoT ecosystem

4. FINDINGS

Previous studies suggest that unstructured ecosystems make one of the greatest challenges for creating business models for the IoT. Our literature review on the role theory illustrates how actors make or take roles in ecosystems on the ecosystem and organizational level. We draw on the three previously identified ecosystems: product ecosystem, company ecosystem, and industry ecosystem (cf. Tukiainen et al., 2014; Burström et al., 2014) and suggest an additional new type of ecosystem, peer-to-peer ecosystem based on the case studies. Based on our data analysis from fifteen in-depth interviews, we identified four diverse roles for actors in different IoT ecosystems. Our case study shows that these roles are typical in four distinct types of ecosystems. As a result, the framework puts forward four different ecosystems and couples them to roles in ecosystems. We label the roles as: (i) butterfly, (ii) ant and greenfly, (iii) spider and (iv) the swarm of bees. Figure 2 illustrates the connection of role mechanisms on the ecosystem and organizational levels in four diverse ecosystems. Next, we will discuss the findings of this research by presenting each role configuration in the corresponding emerging IoT ecosystem.

4.1. Role Configurations in Ecosystems

4.1.1. *Butterfly*

In our empirical study, we found four roles that actors can have in the emerging IoT ecosystems. A butterfly focuses on relatively compact issues, and this role configuration leads to limited but rather safe business model choices. Case A recognises the nodes (customers) and flows (possible products and services) of the new business model. Case A is a Finland-based component supplier for the construction industry. The company is interested in opportunities of the IoT in connected buildings, and is developing its product and service offering. However, it is aware that being unable to add connectivity to the products, the company probably will lose deals to competitors that may be ahead in satisfying high-end customers' advanced needs. No specific IoT ecosystem is needed because the IoT solutions are add-ons offered in prevailing ecosystems (cf. Figure 3, butterfly, point of time 1 and 2). The company concentrates on one customer relationship at a time, and in providing IoT-enabled products and services in these relationships. This is an example of role-taking: the butterfly takes a predefined organisational role in an existing product ecosystem. It focuses on creating links (value designs) with single nodes in the network, and on replicating these links into as many relationships or

Figure 2. Illustrating roles in ecosystems

networks it can. Referring to Tukiainen et al. (2014), we argue that the rules of the game are known or easy to learn in this kind of “Product ecosystem”: There are only minor technical or market risks. No large investments are needed, and the actors can easily take a predefined organisational role in an existing product ecosystem.

It is very important for us that we don't compete with our customers. (Case A, Component manufacturer, Director, Research and Technology)

We have a number of partners worldwide. Our value chain has several steps, wholesales, installation etc. There are many kinds of integrators involved – it is a very multifaceted model. After we have managed to specify our products into a project, after that it is quite straightforward. Preparations are crucial. Our competitors don't use our components. (Case A, Component manufacturer, Director, Research and Technology)

4.1.2. An Ant and a Greenfly

An ant and a greenfly refers to a role configuration in which a company may lock itself into larger “company ecosystems,” similarly to an ant sucking sap from a greenfly. The ant can start sucking sap as soon as the network (the greenfly) has been established (cf. Figure 3, Ant and Greenfly, point of time 2). Ant views and compares a variety of supplementary nodes and links between companies that are not utilised at a particular moment. It wants to define (make) its role so that it can easily take a similar role in as many future networks as possible. Case B is a multinational company offering network solutions. The company sees both opportunities and enormous threats in the IoT, and has not yet found significant business opportunities or lucrative roles to position itself in the IoT ecosystem. Although Case B is used to offering services to multiple business ecosystems, it is either unable or reluctant to become an active actor in building new business networks. We describe the role configuration of Case B as an ant and greenfly. Case B wants to understand the motivations

Figure 3. Role configurations and emerging networks and ecosystems, part 1

and business logics of different actors, but the company thinks that several actors, and particularly intermediaries, are still missing in the emerging networks. Case B wants to grasp the opportunities by offering infrastructure services for actors in several networks. Case F is a service developer startup specialized in IoT and sensor network technologies. The company focuses on monitoring and improving its customers' environmental efficiency. It develops a patented environmental measuring system to collect data. Case F sees opportunities in attaching into operator ecosystems, and tries to develop modular replicable value designs that could be matched to operator ecosystems all over the world in the future. For the moment both companies feel a bit frustrated because they cannot do anything else but wait until the company ecosystems have been built by the focal actors. As soon as the challenges have been overcome and the IoT-based networks start to mature, the ant may offer boundary crossing services for several networks. The ant takes the roles that open up for it in the emerging ecosystems, but at the organisational level the company makes (defines) its role itself.

Apple and Google ecosystems make examples of large "Company ecosystems." The rules of the game are known, but given by the ecosystem owner. Other actors can only take roles that open up for them in the ecosystem. If the ecosystem is just emerging, or new actors are otherwise needed, they can make their roles at the organisational level to best fit into the new ecosystem and to support other actors.

We cannot sell networks if we don't know how they are used. (Case B, Multinational network company, Business Manager)

The telecom operators don't want to develop IoT services. That is why we now have to discuss directly with their customers. Probably there is an actor missing, an intermediate. (Case B, Multinational network company, Business Manager)

Did the revolution already happen, but we just do not know it yet? If big companies don't wake up, small companies will take over. (Case B, Multinational network company, Business Manager)

We have this metering system and we can digitalise the data, do data mining and give guidelines... but we have to be very careful about not to go too deep into industry specificity. Without expertise about the industry, it would be very difficult to say to ... that you have to heat the furnace now into a certain temperature to save energy tomorrow. (Case F, IoT Service developer, CEO)

Originally we expected that in the project we could get a picture about what is the business model in the energy and environmental efficiency and in the hub architecture, so that when we would then go to a different country – Sweden or, say, France – we could compare this ecosystem picture to the local situation and see what is different there, what has to be changed, whom to contact and so forth. (Case F, IoT Service developer, CEO)

It is a bit boresome to wait because we should be going around replicating the model. We already have this connectivity and utility ready. So this is that you have to have patience of a saint when you operate with operators. (Case F, IoT Service developer, CEO)

4.1.3. Spider

A spider weaves its own network in the IoT ecosystem. It may aim to become a key, hub, or leading part of the network. In this case, it could be described as a “platform wannabe” (cf. Tukiainen et al., 2014, p. 38). However, the spider can also take a minor role after the network has matured. Cases C and D wish to take active roles and build IoT-based company networks (cf. Figure 4, Spider types 1 and 2, point of time 1). Case C is a multinational telecom operator enthusiastic of being actively involved in building business networks to employ opportunities of the IoT. The company is already offering machine-to-machine (M2M) communication services to their business partners, but aims to be more proactive in regards to the IoT due to the threats coming from large global actors such as Google. However, Case C perceives challenges in understanding the differences between building business relationships in the M2M vis-à-vis the IoT context. The role configuration of Case C is termed as a spider. Case D is a Finland-based telecom operator operating on a local market. The company is considered to be as an active business network developer or accelerator in the local community. Moreover, Case D aims to build its networks and business model(s) that can be replicated in other contexts. Thus a spider makes its role on the ecosystem level but takes it on the organizational level. Similarly to Case C, we describe the role configuration of Case D as a spider. Case C also pursues becoming a focal actor in the ecosystem (Spider type 1, point of time 2). On the contrary, the most important driver for Case D is to get the network going, after which the company can take any role that is suitable for it (Spider type 2, point of time 2). The case companies aim at replicating their network models into different contexts, either geographically or into other industries. Thus, the spider concentrates in building a viable network, and in replicating this network structure with all its value designs into different contexts. The rules of the game are at least partly unknown, investments are needed, and there are risks related to technology and market. However, by being active in building the ecosystem, Cases C and D try to manage the risks and guarantee that the emerging rules of the game will be beneficial for them. Cases C and D cannot cooperate, rather consider each other as competitors. For the time being there are many open opportunities, and genuine IoT-based new networks crossing multiple current industries (for example health, wellbeing and IT) are still emerging. We call these “IoT-based industry ecosystems.” Some of the rules are known, but not all. The business is based on exploration, and there are huge risks and opportunities. The ecosystem roles are all emerging, and the actors can offer their expertise (or roles) to be taken part of the emerging ecosystem.

We have a big partner network. We have asked them to build applications for us. So, our partners build the solutions. We also have a partner who has built us the platform and we sell it to our customers. (Company C, Multinational Telecom Operator, Manager)

The model will be same in every country. Services cannot stop in the border of the country. (Company C, Multinational Telecom Operator, Manager)

We can build business models, where we use local actors as partners. In our region there is knowhow related to sensor technology in universities, and there are small software companies, etc. Partnering with them will guarantee that knowhow stays in the region. However, these should be concepts that we can replicate to other similar regions. For this purpose we have started to build a developer business model and a piloting environment. (Case D, Local Telecom Operator, CEO)

We have to test things at local level first. Then we can go forward. (Case D, Local Telecom Operator, CEO)

Figure 4. Role configurations and emerging networks and ecosystems, part 2

4.1.4. A Swarm of Bees

New kinds of value designs may emerge for a swarm of bees. For example, bottom-up models may arise from the IoT user and developer communities, where users share their own expertise and knowhow and become producing actors (Fleisch, 2010; Kortuem et al., 2010). The case companies were not yet actively involved in these kinds of networks, but our interviewees mentioned some examples. Case E, a small technology start-up, was very interested in involving user community in its product development processes. Case E is a small, Finland-based technology start-up developing sensor-based solutions. The company wants to be closely connected to users and user communities with whom the company wants to develop IoT-based products and services. In terms of role configuration, we view that Case E is involved in a swarm of bees. Actors in these networks have “swarm intelligence” which can be described as collective behaviour of decentralised, self-organised systems. This concept was introduced by Beni and Wang (1989) in the context of cellular robotic systems. The actors in a swarm follow very simple rules, but local interactions lead to the emergence of “intelligent” global behaviour, and the swarm being able to adapt to changes in the environment. There may also be some division of work (roles) between the bees of the swarm, i.e. explorative work can be done by scout bees in addition to local exploitative work done by other bees (cf. Pham et al., 2005; Karaboga, 2010). In “peer-to-peer ecosystems,” technological and market uncertainties are great, but at least part of the risks can be shared with collaborative models by the community. As each actor makes its own role by defining the role at the organisational level, the actors configure the ecosystem and make the roles of the ecosystem together and evenhandedly. As mentioned earlier, in order to succeed, the IoT business models need to motivate all actors, including customers and end-users. Therefore, this landscape of cooperative ecosystems is not easy for big companies. However, they can build their business models around cooperative ecosystems. For example, Über and AirBnB have built their business models so that they involve the community in the value creation process, and at the same time distribute a share of the profit to the community members.

People will have more knowhow, so that in the future they will be able to build IoT devices for themselves. However, you cannot assume that everybody who has a personal problem, say a heart condition, is a technology wizard; therefore there is a challenge, how we can offer easy enough tools for every possible user, not just for the nerds. (Case E, Sensor manufacturing, Manager)

The culture of open hardware and open software is getting stronger. People want to become “makers.” There are many bottom-up opportunities in the IoT, and if you can provide a good solution to a

particular user group, you can easily replicate it to a different group. This is difficult for big companies, and therefore there are many opportunities for small companies. (Case E, Sensor manufacturing, Manager)

There are services in the internet where people can do things themselves for free. This could have been a business opportunity for somebody, but when people learn to do things themselves, these business opportunities become extinct. (Case E, Sensor manufacturing, Manager)

Even if you have scarce people resources, you can reach the right resources through the peer-to-peer network. We don't want to get involved in high volume business, because top-down models don't work in a high cost country. We have started from the open hardware culture, and it is a rather strong trend globally. The main point is openness. (Case E, Sensor manufacturing, Manager)

4.1.5. Concluding Remarks

In our interviews, although the interviewees thought that there is a great potential in the development of new cross-industry services and value creation based on the IoT, efficiency was mentioned as the most common driver of adapting IoT at company level. For developing new cross-sectoral IoT-enabled products and services, the actors must step out of their current roles. Companies that mention efficiency as the greatest driver for developing IoT-enabled products and services, generally deploy the role of a butterfly, or, in some cases, the ant and greenfly. Companies' current organisational structures create challenges, because they are designed to support current business models and for delivering products and services for present customers or sectors efficiently. Therefore nobody has responsibilities to develop new cross-sectoral IoT solutions, and nobody has incentives to sell them. IoT solutions are not easy to sell because nobody knows yet exactly the real benefits of using these solutions. Some of the experts we interviewed perceived the IoT as 'business as usual' for their company, as M2M solutions have been around since the 1990s. Companies that try to add IoT into their current products and services, deploy the butterfly's role.

However, at least some of the interviewed experts saw possible disruption in their own networks due to the global nature of the IoT business. We interviewed both local SMEs and multinational companies wishing to build IoT solutions together with partners. In particular, smaller firms who develop IoT services in close cooperation with the customers. The local telecom operator (Case D) we interviewed pursues a role as a local business developing company working with local partners (thus, a role of a spider). It is especially interested in offering services for municipalities. However, there are challenges for the telecom operators, because there are not enough promising IoT service developers available for their networks. Furthermore, in the IoT field, there will be also global actors who act according to their own logics and rules. Thus, there will not be lack of wannabe spiders. In our interviews, the experts claimed that some industries have factors that slow down the development; for example, there may be regulation that creates barriers for entering the market, or there are strong incumbents, or the market structure is fragmented. One of the most interesting, but also problematic areas is the health sector, where all the factors mentioned above are valid. There are strong incumbents, fragmented markets, and strict regulation.

Regulation in the public sector makes it fragmented, and it is very difficult to develop services or to get customers there. (Case Company D, Local Telecom Operator, CEO)

Bottom-up models of the IoT will increasingly be emerging, because peer-to-peer communication becomes easier and cheaper, but also because big companies have certain inertias that slow down their innovations. The experts we interviewed mentioned some examples of bottom-up models; for example after the disaster at the Fukushima nuclear plant a group of citizens who did not trust information

provided by authorities, organised radiation follow-up with their own sensors and published their observations in the Internet. Other examples referred by the experts are weather detection networks, e.g. Lightningmaps (www.lightningmaps.org), which are communities of volunteers. The value drivers for an individual bee taking part to these bottom-up swarm models can be getting trust-worthy information services cost-efficiently, or getting money by selling their own expertise or resources to other users. This means that users may share their own expertise and knowhow and become producing actors (Fleisch, 2010; Kortuem et al., 2010).

5. CONCLUSION

This research aimed to investigate actor roles in the emerging ecosystems of the Internet of Things (IoT). The four theoretical contributions put forward the discussion of roles and ecosystems, particularly how IoT ecosystems are structured. The findings contribute to our understanding of the IoT by suggesting that actor roles are limited by the type of an ecosystem, and, subsequently, emerging IoT ecosystems are structured in accordance with actor role behavior. First, the paper suggested a new framework for analyzing roles in ecosystems, particularly IoT ecosystems. Second, the study identified four new roles companies can use in IoT ecosystems namely: butterfly, ant and greenfly, spider, and the swarm of bees. Third, this study identified four different types of possible ecosystems in the context of IoT: product-, company-, industry-, and peer to peer. Fourth, this study identified new role pattern, namely ‘Role replication,’ which refers to replication of roles by value design and network structures in IoT ecosystems.

5.1. Conceptual Framework

The developed framework sheds light on how role mechanism, particularly role taking and role making on the ecosystems and organisations feature roles in IoT ecosystems. The two-dimensional framework includes two dimensions; the role mechanism on the ecosystem level (“role taking” versus “role making”) and the role mechanism on the organizational level (“role taking” versus “role making”). The study proposes that designing and analysing business models for the IoT ecosystem require new frameworks. Actors in the emerging ecosystem are still searching for their roles, and the ecosystem lacks many actors, especially new kinds of intermediates. By using the role theory as a tool for analysing the emerging IoT ecosystems, we show that actors may take or make roles that actors can have in the IoT ecosystems. This study shares the view of prior studies, which document role mechanism as processes (cf. Biddle & Thomas, 1966; Turner, 1988; Herrmann et al., 2004). Previous studies reveal role mechanism of organizations in networks (Nyström, 2008; Nyström et al., 2014; Leminen et al., 2015). In contrast to them, this study proposes to expand role mechanisms (role taking and role making) to both ecosystems and organizations.

5.2. Actor Roles in IoT Ecosystems

The study identified four new actor roles companies can use in IoT ecosystems namely: butterfly, ant and greenfly, spider, and the swarm of bees. A butterfly focuses on compact issues, leading to limited but rather safe business model choices for a company. An ant may attach itself into a larger “company ecosystem” (greenfly), as soon as it has been formed. A spider weaves its own network in the IoT ecosystem. It may aim to become a key actor (spider type 1), or it can take a more modest role in the network (spider type 2). New kinds of value designs, bottom-up models, may emerge for a swarm of bees, in which the users share their own expertise and knowhow and become producing actors. An extant study offers comprehensive descriptions on stakeholder roles in closed innovation networks (Heikkinen et al., 2007). Such study assumes that a network is established and consisted of predefined stakeholders. Nyström et al. (2014) in turn document comprehensive descriptions on stakeholder roles in open innovation networks. Similar to Nyström et al. (2014), this study proposes that identified new roles assume simultaneously different role theories. An open innovation network

assumes that a network has a commonly shared intent, may incorporate new organisations, and even its objectives may be steered based on the innovation activities. The studied emerging IoT ecosystems in turn feature that organizations do not necessarily know each other, or in which ecosystem they belong, or whom to work with. Thus, there exist numerous combinations in which the companies may interplay with each other. The extant, scarce role descriptions assume that organizations have or have not power position in the existing ecosystems (cf. Iansiti & Levien, 2004a, b; Ballon, 2009). However, this study specifically focuses on analyzing roles on the emerging ecosystems. Therefore, this study developed new roles rather than applied existing role descriptions.

Proposition 1: Role mechanisms and selected roles limit the type of an ecosystem companies may have.

5.3. IoT Ecosystems

The study suggests that a company chooses an ecosystem, where to be a part of, and its role in it. More specifically, a company decides how active it is, and how to make or take its role(s) in the ecosystem. The results show that each of the identified four roles is associated with a specific type of ecosystem. We distinguish between four types of ecosystems: product-, company-, industry-, and peer to peer. The first three of them were identified in prior research (cf. Burström et al., 2014), and this study suggests an additional ecosystem, peer-to-peer ecosystem to the literature. This study demonstrates that these types of ecosystems have different value design logics, and different logics of taking and making roles. Because the studied cases show that SMEs particularly participate product-, and peer to peer IoT ecosystems, the study sheds lights on SMEs' roles in business ecosystems. There are many different parallel ecosystems at work with respect to cases, sectors or social areas, where organisations apply IoT technologies for different purposes, rather than a single IoT ecosystem. This result is in contrast to prior research, which proposes on a single IoT ecosystem comprising different companies (Tarkoma & Katasonov, 2011; Mazhelis et al., 2012). Given that IoT ecosystems feature different roles, companies may take or make roles on the ecosystem and organization level. This is in accordance with Iansiti and Levien (2004a), who argue that ecosystem typically encompasses several domains but may share them with other ecosystems. Therefore, this study proposes a framework comprising four identified ecosystems in the IoT, as a general ecosystem model for the IoT (Figure 2).

Proposition 2: Emerging IoT ecosystems are structured in accordance with actor role behaviour on the ecosystem and organization level.

5.4. Replication of Roles by Value Design and Network Structures

Fourth, this study showed how actors can aim to replicate their role-based value designs (butterfly and ant), or (a) whole network structure(s) containing value designs (spider). Prior studies claim that network development and its outcomes is reciprocal referring to that created outcomes may be used in further network development (Brass et al., 2005). Similar to that, Nyström et al. (2014) identified 'Role reciprocity' among the four role patterns in open innovation networks. Nyström et al. (2014) refer role reciprocity as actors' roles lead to positions and vice versa. The replication on value design and roles has similar features as role reciprocity, where a similar structure including roles and positions is replicated to other contexts or industries. However, this study suggests an additional role pattern, 'Role replication' to role theory in order to illuminate the replication of roles by value design and network structures in IoT ecosystems.

For managers, this study increases understanding of the role configurations that companies can have in the emerging IoT ecosystem. More specifically, this study underlines that by role mechanisms, and particularly by making and taking roles on an ecosystem and organization level, company limits the possible types of ecosystems in the IoT. Further, this study explains, how companies can make or take their roles, and how the roles are connected to business model opportunities and challenges in the

ecosystems on the organizational and ecosystem levels. The global nature of the IoT may bring forth new global actors, but also user-centric bottom-up models emerge. Thus, there are many possibilities for disruption of the current models. We argue that the major challenges in emerging technology fields and in emerging business ecosystems, such as the IoT environment, do not lie at the company level, but at business network or ecosystem levels. It is challenging to design business models based on new radical technologies, because the technologies have not yet matured into products and services, and the actors and their roles are not yet formed in the evolving ecosystem (cf. Westerlund et al., 2014). This study offers some tools for analysing these issues.

Each and every study has its limitations. First, the literatures on emerging ecosystem models and particularly their roles are under developed. Thus, there is not an overarching, proven theory base available to explain the differences between different emerging ecosystems and roles companies may take and make. Second, there may be a bias on the emerging IoT ecosystem, when analyzing data collected through interviews with a limited number of organizations in a single European country rather than comparing a large number of organizations globally. To date, there are few examples available of IoT businesses. However, due to several research gaps, ecosystem business models and actor roles in the IoT ecosystems should be studied more in the future. Also, there is a need for more research on the dynamics of ecosystems, and development of actor roles over time. The analysis methods presented and tested in this paper constitute first attempts to show how ecosystem business models and actor roles in ecosystems can be analysed. Thus, more research on emerging ecosystem models is needed as the IoT field evolves in various countries, and about whether there exist any further roles or types of ecosystems. To conclude, due to limited amount of data, and keeping in mind that the ecosystem roles were identified in the single country, further studies are needed to confirm the identified roles, but also to show how the roles are coupled to certain types of ecosystems in other countries as well.

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