

ROLE ALLOCATION AND GOVERNANCE OF INTERORGANIZATIONAL NETWORKS IN MACHINE-TO-MACHINE-COMMUNICATION

Research in Progress

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Abstract

Machine-to-machine communication (M2M) is a fundamental enabler for a variety of products and services. Companies involved in the implementation and operation of M2M solutions are confronted with novel economic challenges with regard to the formation and management of interorganizational networks. Using case study research and associating theories of interorganizational networks with the (mostly technology-oriented) literature on M2M, we analyse how the distribution of resources and capabilities of firms determine M2M network characteristics and role allocation. We distinguish two characteristic roles (broker and supplier) and two network types (hierarchy and heterarchy). An actor's role is found to be determined by its coordination capabilities, its system integration capabilities and core technology ownership. The network type is influenced by the exclusivity of customer access, the customers' assembly costs and the relative size of the firm. The descriptive results of this case study research are a basis for studying the fit of a firm's resources and capabilities with its M2M strategy.

Keywords: machine-to-machine communications, interorganizational networks, network governance.

1 Introduction

The equipment of machines with digital microprocessors and sensors, their connection to telecommunication networks and the automated communication between the remote machines and central management applications (machine-to-machine-communication – M2M) are fundamental technology enablers for a large variety of new services and business models (HaborResearch 2013; Ryberg 2012; Whitehead 2004). M2M technologies have received considerable attention, particularly in the context of cyber-physical systems (Lee 2008) and the Internet-of-Things (Atzori et al. 2010).

From a technological perspective, the adoption of M2M technologies is driven by the miniaturization of electronical devices, the availability of low-cost computing devices, the growth of broadband coverage and the emergence of cloud-based services (Geng et al. 2011). The potential applicability of M2M technologies covers many sectors such as the industrial sector, healthcare, transportation, retail, energy and security (HaborResearch 2010).

In spite of the forecasted business potential, many companies are slow in providing M2M solutions due to considerable economic challenges, particularly with regard to the formation and management of interorganizational networks (HaborResearch 2013; Mendler et al. 2012). In order to implement and operate M2M solutions, companies from different and formerly disparate industries such as telecommunications, mechanical engineering, enterprise systems and microelectronics must cooperate in integrating their technologies and defining economic framing conditions (such as revenue sharing approaches).

The formation of interorganizational networks and their characteristics have been subject to extensive research (Burt 1995; Child et al. 2005; Provan et al. 2007; Provan and Kenis 2008). In this study, we adopt an interorganizational networks perspective to describe the design of M2M networks and the placement of individual actors within these networks. More specifically, we address the following research questions: (1.) How do different M2M networks differ with regard to the distribution of authority among the actors? (2.) How can actor roles within interorganizational networks in the M2M industry be characterized and distinguished?

2 Prior research

2.1 Value creation in Machine-to-Machine communication

The concept of M2M, according to Whitehead (2004), can be defined as follows: “Machine-to-machine is the automated communication between remote machines and central management applications. It provides real-time control and monitoring without human intervention, by removing the manual process and the associated 'paper trail'.” Whitehead highlights the following characteristics of M2M: networking of distributed devices, a centralized intelligence for the evaluation of machine communication in real-time, no or hardly any human intervention as well as a high degree of automation. Machines are equipped with sensors or actuators and often can be controlled remotely. The distributed machines, however, not always communicate with a centrally hosted server, but can also exchange and process information in a peer-to-peer mode (Kim et al. 2011). M2M is employed in many different scenarios, such as industrial automation, smart grids, tracking and tracing, in the automotive industry, in automated payment services, in the health industry but also in the field of consumer devices (Geng et al. 2011).

Value creation in M2M markets is characterized by the requirement to bring together know-how and technologies from different industries and a high degree of specialization of the M2M solutions in many scenarios (Laya and Markendahl 2013). Various authors have presented systematic structurations of value creation in M2M markets (Brazell et al. 2005; Glanz and Jung 2010; Gupta and Hirdesh 2007; Hase 2012). In summary, value activities in M2M markets can be grouped into four domains: The machine domain covers all value activities, which are required for the production and operation of interconnected machines. This includes the physical installation and integration of different components (sensors, communication modules, controls). The telecommunication domain covers all activities, which support the exchange of information between machines and (if applicable) a central server. If this includes the routing of data through telecommunication networks, this domain additionally covers the implementation and operation of a telecommunication network and the provisioning of communication devices. In many cases, M2M communication further requires secure connections, device management and billing. The M2M application domain covers the development and provisioning of M2M-applications as well as the provisioning of an underlying server infrastructure (if required). The M2M solution domain covers all activities, which are required for the provisioning of an end-to-end M2M-solution and the coordination of activities of the different domains. This includes the technical integration of the disparate systems, project consulting, marketing and sales as well as operations and after-sales services.

2.2 Governance and role allocation in interorganizational company networks

Interorganizational networks are characterized by complex reciprocal and relatively stable interrelationships (Contractor and Lorange 1988; Powell 2003). The relevant business processes of the involved companies are coordinated across the individual company's boundaries. The network actors are legally independent but strongly interrelated from an economical point of view. Interorganizational networks are formed due to various reasons such as a reduction of uncertainty, an increase of flexibility, capacity or speed or in order to provide access to new resources and information (Child et al. 2005).

Network governance characterizes the "institutions and structures of authority and collaboration to allocate resources and to coordinate and control joint action across the network as a whole" (Provan and Kenis 2008). With regard to the distribution of authority, Child et al (2005) distinguish two network types lying on the two extremes of centralization/decentralization: hierarchical and heterarchical networks. In a hierarchical network, one dominant firm owns the strategic leadership role and outsources value chain activities to other network participants on a regular basis. It maintains bilateral relationships to multiple, mostly small networks, which are just weakly interconnected or not interconnected at all. In heterarchical networks, firms are equally interconnected. They maintain close relationships among each other and cooperate in variable configurations and multiple projects.

Apart from the network level, prior research has also analyzed interorganizational networks from the perspective of individual actors and their roles. With regard to the influence of individual actors on the overall network, an actor's network position plays a major role (Provan et al. 2007; Thorelli 1986). Network centrality is defined as the number of ties an actor maintains (Freeman 1979). It is associated with dominance, among others, due to a better access to information and a higher visibility (Gulati and Gargiulo 1999). With regard to the centrality of individual actors Snow et al. (1993) distinguish a broker role of firms with a high centrality from complementary roles with low centrality (such as producers, marketers, distributors and designers). Brokers bridge structural holes in interorganizational networks and therefore take on positions with large network influence (Burt 1995). The position of a company in a network is mainly determined by the power of the company relative to the other network participants. Power, according to Thorelli (1986), results from differential advantages with respect to the ownership of capabilities and resources in five areas: economic base, technology, expertise, trust and legitimacy. As explained in the previous section, M2M solutions are most often provided by interorganizational company networks (M2M networks). Prior research in M2M describes value creation but lacks theory on how these activities are distributed amongst the actors and how M2M networks are characterized in terms of network governance and roles. In order to close this gap, we analyze and compare roles and relationships of companies in interorganizational M2M networks in the following.

3 Research methodology

Due to the investigative nature of our research we chose a case study research design (Benbasat et al. 1987; Paré 2004; Yin 2003). It is an objective of this paper to describe a contemporary phenomenon in its real-life context which previously has been largely unexplored (Yin 2003) (descriptive positivist case study). Following the argumentation by Gregor (2006), our goal is to "describe or classify specific dimensions or characteristics [...] by summarizing the commonalities found in discrete observations" and thus derive analytic theory. The unit of analysis is the roles and relationship of companies in interorganizational M2M networks.

We pursued a theoretical sampling strategy (Eisenhardt 1989; Glaser and Strauss 1967) and tried to cover a large variety of activities and roles in interorganizational M2M networks. To do so, we created

case heterogeneity with regard to the M2M networks the companies are involved in, the value activities of the selected companies, as well as company sizes. By analyzing different M2M networks, we expect to identify heterogeneous types of network governance and underlying patterns. By selecting companies with different focal value-adding activities and sizes we try to uncover patterns of role allocation and resource ownership. In order to keep cultural influences to a minimum, we focused on German and Swiss companies. Generally we expect similarities due to an overlapping or interrelationship of activities (literal replication) and differences due to a heterogeneity of competencies (theoretical replication) (Yin 2003). Our primary data collection method was face-to-face interviews with executive managers, because they are largely accountable for the management and design of M2M solutions and interorganizational strategies. To protect against individual bias and enrich the case data, we triangulated the interviews with third party data, company internal documents and further interviews. We prepared an interview questionnaire with standardized open-ended questions (Patton 2002) broadly covering the areas of M2M offerings, resources and capabilities, value activities, cooperation and competition as well as challenges. The interviews were recorded and transcribed. Table 1 provides an overview of the cases and sources.

Company	SoftwareCo	ModuleCo	ConsultCo	TelCo
Activities	Software Consulting Integration	(Communications) modules	Software Consulting	Telecommunication Consulting Integration
Number of Employees	<250	<250	<250	>1500
M2M industry segment	Production, Logistics, Energy, Security	Industry, Vehicles, Transportation (digital signage, emergency calls), OEMs	Telecommunications, Energy, Chemicals	Transportation, Smart home, Energy, Tracking
Sources	Interview CEO (face to face, 1h), service offering descriptions, references	Interview product manager (face to face, 1h) interview product manager (face to face, ½ h), product sheets, mission of company	Interview management consultant (telephone, 1h), service offering description, strategy document	Interview head of M2M unit (telephone, 1h), interview manager partner management (face to face, 1h), product descriptions, M2M references

Table 1. Case studies: companies and resources

We identified four potentially relevant constructs, which are associated with our research questions, from prior research: value activity (Brazell et al. 2005; Glanz and Jung 2010; Gupta and Hirdesh 2007; Hase 2012), network governance (Child et al. 2005; Provan and Kenis 2008), network role (Burt 1995; Provan et al. 2007) and source of power (Thorelli 1986). The a-priori specification of constructs supports a consistent research design and construct measurement (Bourgeois and Eisenhardt 1988; Huang et al. 2010). Coding was done independently by a senior researcher and two master students. Codes were compared and merged in a second step (Dube and Pare 2003).

4 Preliminary results

4.1 Characteristics of interorganizational M2M networks

In the following section the characteristic bundling of activities (role profiles) in different instances of interorganizational M2M network are described, which we were able to identify in the case studies.

Table 2 provides an overview and further specifies whether a firm is exclusively responsible for an activity in the value network or whether it is a shared activity.

Company	SoftwareCo		Module Co	ConsultCo	TelCo		
Value activity* / Role profile	SC1	SC2	MC1	CC1	TC1	TC2	TC3
Provisioning of machine (incl. sensors)			s				
Production of communications module			e				
Construction and operation of telecommunications network, machine connection (e.g. SIM card issuance, device provisioning)					e	e	e
Device management (data security and authentication, machine tracking, data aggregation, billing support)					s	s	s
Provisioning of server infrastructure (hardware, software, operations)					s		
Development of M2M software	s	s		s	s		
Systems integration	e	s		e	e		
Consulting (project management, partner management)	e			e	e	s	
Marketing and sales					e	s	
Operations and after-sales services					e		
Network governance**	het	hie	hie	het	hie	het	hie
Role***	bro	sup	sup	bro	bro	sup	sup
*e = exclusive, s = shared; ** het=heterarchy, hie=hierarchy, ***bro=broker, sup=supplier							

Table 2. Role profiles, role interaction and network centrality

SoftwareCo offers software, systems integration, project management and consulting services for business customers. It focusses on M2M solutions in the production, logistics, energy and security sectors. In its home markets SoftwareCo usually carries out systems integration, project and partner management, it customizes and extends given applications (SC1). In external markets, it focusses on systems integration and software adaptation tasks (SC2). ModuleCo offers routers, which enable the connection of machines and their communication with remote servers. Its products are used in the industrial and mobility sectors. Its customers are either machine producers or integrators of M2M solutions, which assemble machines, routers and SIM cards. ModuleCo focusses on the production and integration of communication modules and is not involved in system integration, solution coordination or marketing and sales activities for the M2M solution (MC1). ConsultCo is a consulting firm with a focus on operational systems, which support a company's business processes, and reporting. It particularly has expertise in the management of M2M projects. It furthermore supports the development of customized M2M software and systems integration (CC1). TelCo is a large telecommunication firm with a traditional focus on operating and maintaining fixed and mobile communication networks. TelCo provides or enables M2M-solutions in the following segments: smart home, energy, tracking & tracing, fleet management, traffic and mobile payment. With regard to its involvement in the M2M market, it differentiates between two distinct strategies. In B2B-constellations, TelCo markets and sales a solution as a prime contractor and offers full support. It is fully responsible for project and partner management as well as for systems integration and the operation of the communication network. It furthermore coordinates the development of M2M and device management software as well as the provisioning of server infrastructure (TC1). In B2B2X-constellations, TelCo is not involved in coordinating solution development or system integration. It exclusively manages the communication network and is involved in device management (TC3).

Furthermore it sometimes opens its sales channels for the M2M-solutions and supports partner management (TC2).

A cross-case analysis of the given role profiles reveals significant patterns with regard to network governance and the actors' roles. M2M networks differ in whether there is a single or there are multiple consumer relationships and whether the operational responsibility for the M2M solution is concentrated or not. A single consumer relationship and a high concentration lead to a hierarchy with a single contractor for the M2M solution. Multiple relationships and distributed operational responsibility lead to a heterarchy. Roles in networks are distinguishable by the degree to which an actor interacts with other actors in the course of system integration and project management. A high level of interaction characterizes the broker role, a low level characterizes the supplier role.

4.2 Role allocation in M2M networks

With regard to an actor's role (broker or supplier), three resources and capabilities were identified as relevant: coordination capabilities, system integration capabilities and core technology ownership. *Coordination capabilities* are required to bring together companies with complementary resources and capabilities required to realize and operate M2M solutions. In three role profiles (SC1, CC1, TC1) brokers consider network *coordination* as one of their core capabilities. "Defining the solution and finding the adequate partners to realize M2M-solutions are the main challenges in the M2M market." (management consultant, ConsultCo). TelCo (TC1) runs a dedicated competence center for managing and maintaining a network of technology partners. Power in interorganizational networks, according to Cook (1977), is determined by the value of resources received from an actor and the option to receive equal value from alternate sources. Coordination capabilities potentially increase both, the value of an interrelationship (through facilitating access to external resources) and the flexibility to switch to alternate sources (though a broader network of potential partners).

System integration capabilities are required to bring together the different technological components of M2M solutions (i.e. machine, communication module, communication network, applications) and to ensure that they interoperate properly. SoftwareCo (SC1) bridges machines and enterprise systems (such as ERPs) by programming software interfaces. "We custom-build interfaces to ERP systems, machines, communication modules or other third party systems. Large system providers themselves are too slow in offering such a level of integration" (CEO, SoftwareCo). System integration capabilities, from a transaction cost perspective, lower the specific investments, which are required to assemble a dedicated M2M solution, and as such individual transaction costs (Williamson 1981).

Thirdly, the *ownership of a core technology*, which provides a unique selling proposition of the M2M-solution, is an enabler for the broker role. ModuleCo (MC1) supplies communication modules to machine producers: "Brokerage is taken over by the machine provider, which owns the core technology and integrates our module" (product manager, ModuleCo). The core technology of an M2M solution may be its hardware, a software implementation or even a specific communication technology. It determines the uniqueness of the overall solution. Its owner is therefore not substitutable by alternative providers. For suppliers, gaining access to the core technology is critical and the main motivation for participation in an interorganizational network (with the provider of the core technology in its center) (Van Gils 1984).

4.3 Governance in M2M networks

In the case studies, we identified three resources and capabilities, which determine whether a network is a hierarchy or a heterarchy: the exclusivity of customer access, the customers' assembly costs and the relative size of the firm. The *exclusivity of customer access* describes the relative ability of an actor to establish sales channels, generate customer awareness and maintain customer relations. TelCo

(TC1), for example, establishes hierarchical networks for M2M solutions, which address their exclusive customer base. ConsultCo (CC1) lacks exclusive customer access and thus operates in heterarchies: “Customer ownership is always a central issue in M2M cooperations.” (ConsultCo, M1). Following the argumentation of Pfeffer and Salancik (1978), interorganizational networks allow companies to gain access to critical external resources without risking their own autonomy. Since customer access represents a critical resource to the majority of actors, such constellations result in highly central M2M networks. From the broker’s perspective, interorganizational networks allow the exploitation of its customer access without the requirement to internalize all surrounding functions, which are required to assemble M2M solutions (Jarillo 1988).

The *customers` assembly costs* are determined by the overall costs of the customers for procuring components and assembling solutions themselves in comparison to procuring assembled solutions. ModuleCo, for example, does not preassemble solutions due to the risk of disintermediation: “In the position as a single contractor you can build a nice solution. This does not help you, however, if the customer decides to assemble the solution components independently due to cost sensitivity” (ModuleCo, MC1). TelCo (TC3) is part of a hierarchical network which produces and offers navigation devices in a B2C market. End customers cannot configure software or telecommunication access on such devices, as this is exclusively done by the M2M solution provider. From a theoretical perspective, higher transaction costs in heterarchical networks generally may be overcompensated by lower production costs and vice versa (Jarillo 1988).

The *relative size* of a company describes its relative ability to provide financial or human capacities in comparison to its partners in M2M networks. The ability to provide financial or human capacities might, for example, be required to establish dedicated sales and service channels for an M2M-solution. ConsultCo argues, that in many cases M2M customers only accept large M2M providers as full prime contractors (and not small companies like ConsultCo which operate in heterarchies): “If we are talking about the areas of security and remote monitoring...Who has the responsibility for malfunctionings?...Large customers definitely prefer large prime contractors.” (management consultant, ConsultCo, CC1). Even though both being part of hierarchical networks, TelCo (TC1), in contrast to ModuleCo (MC1), due to its size, has the ability to establish dedicated capacities for operations, maintenance and support. SoftwareCo follows a differentiated approach: Due to limited capacities outside of its core countries, it just serves as a supplier for large companies in hierarchical structures there (SC2), whereas in its core countries it establishes heterarchical network structures without the necessity to involve larger companies (SC1). From a resource dependency perspective, investments into dedicated capacities might be required in order to balance mutual dependency, e.g. for risk underwriting (Pfeffer and Salancik 1978).

5 Discussion and future research

The case studies allow a differentiation of two different types of interorganizational M2M networks (heterarchies and hierarchies) and of two different roles (broker and supplier). Table 3 provides a summary of the identified predictors for the role in and the governance of interorganizational M2M networks. It furthermore names the individual role profiles (in parentheses), which support our findings.

Predictor	Value			
Coordination Capabilities	high (TC1)	high (SC1,CC1)	low (MC1)	low (-)
System Integration Capabilities	high (TC1)	high (SC1)	low (MC1)	low (-)
Core Technology Ownership	internal (-)	internal (SC1)	external (MC1)	external (TC2)
Role	Broker	Broker	Supplier	Supplier
Exclusivity of customer access	high (TC1)	low (SC1,CC1)	high (TC3,SC2,MC1)	low (TC2)
Customer`s assembly costs	high (TC1)	low (SC1, CC1)	high (TC3, SC2)	low (-)
Firm size distribution	uneven (TC1)	even (SC1, CC1)	uneven (MC1, SC2)	even (TC2)
Governance	Hierarchy	Heterarchy	Hierarchy	Heterarchy

Table 3. Predictors of an actor`s role and governance of M2M networks

The presented case study research is descriptive and provides insights about the critical resources and capabilities which determine network governance and role allocation. Providing M2M solutions, for many companies, requires the cooperation with new partners and the formation of interorganizational networks. Our results enable an initial assessment of internal resource ownership, the aspired role and the planned mode of cooperation.

Main limitations of the study are related to a narrow perspective on network governance, the sampling strategy applied as well as the case study approach. The network governance perspective adopted in this research is limited to the distribution of authority. As discussed in the IT governance literature (De Haes and Van Grembergen 2009; Weill and Ross 2005), many other aspects such as procedural approaches for planning and steering or relational aspects (such as interpersonal ties) are important components of network governance as well and deserve further attention.

With regard to our sampling strategy, we selected companies with differing value activities and M2M networks. Even though this strategy enables a broad analytic perspective, it makes a clear matching of role and governance characteristics to underlying actor or network properties difficult. In further research, we will include a machine provider to extend our argumentation (based on the logic of theoretical and literal replication) across the complete M2M-value chain and also plan to study a single M2M network as a whole.

With regard to the research results and their (management) implications we plan to move from a derivation of merely descriptive to explanatory theories (Gregor 2006). We further plan a generalization by means of suitable theories, such as exchange (Cook 1977), resource dependency (Pfeffer and Salancik 1978) and transaction cost theory (Williamson 1981), to increase external validity (Eisenhardt 1989; Yin 2003). The further elaboration of case studies is a basis for deriving hypotheses on the predictors of performance of individual actors in interorganizational M2M networks (compare e.g. (Huang et al. 2010)). This will allow a differentiated perspective on the fit of a firm`s resources and capabilities with its M2M (positioning) strategy (Venkatraman 1989).

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