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Internet of Things and the network economics of operator platforms

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Summary

Disruption of tradition network industries and the emergence of innovative physical operator platforms provide challenging governance problems of contractual relationships among different actors involved. The problem solution competence of operator platforms (two-sided, multi-sided) is the entrepreneurial search for the required governance structures. Operator platforms need as input a combination of physical networks and network services with complementary (big data) virtual networks. The problem of division of labor between all-IP broadband network providers, virtual network service providers and platform operators arises concomitant with the implementation of adequate governance structures.

Keywords: Internet of things, operator platforms, governance, sharing economy

JEL classification: L51, L92, L96, 031

1. Introduction: From conventional network industries to operator platforms

Innovations in information and communication technologies (ICTs) became an important engine for the strongly growing interdisciplinary research on multi-sided platforms and markets (Sanchez-Cartas, Leon, 2019). Communication networks can be considered as platforms for information transportation services enabling the production of digital services and applications (Knieps, Bauer, 2016, pp.31-32). Online Platforms and online intermediation services encompassing online e-commerce market places, online software application stores as well as online social media are gaining increasing attention within the European Community. In this context the goal of competition between content providers on one side and access to content by consumers on the other side shifted the focus on the guarantee of non-discriminatory treatment of services operating on top of online platforms (Krämer, Schnurr, de Streel, 2017). EU rules on competition, consumer protection, transparency obligations etc. have been strongly focused on online platform-based services for content industries.¹ Online intermediation services organized via online trading platforms play an intermediary function for online exchange of goods, services or information between sellers and consumers typically without changing the items or information exchanged (Nielsen, Basalisco, Thelle, 2013, p. 5). Online platforms often emphasize their passive role of transmitting information without editorial input pointing out to the requirements of platform neutrality. Nevertheless, responsibilities and obligations of online platforms playing a more active role in managing content (e.g. banning “abusive behavior”) are currently under debate (Chander, Krishnamurthy 2018).

Digitalization in markets for network services is fundamentally disrupting conventional network industries; in meantime platform-based services become increasingly relevant in network industries (Montero, Finger, 2017). The focus of this paper is on the governance of operator platforms driven by the requirements of IoT applications and the future role of entrepreneurial decision making within operator platforms. Prosumer peer-to-peer activities as well as business-oriented market activities are organized via operator platforms in order to provide shared mobility services, transactive energy services connecting home networks via microgrids, cooperative networked vehicle services etc. New challenges and requirements for a variety of heterogeneous operator platforms arise, combining the requirements of physical IoT applications with complementary virtual networks enabling interactive machine-to-

¹ European Commission, Proposal for a Regulation of the European Parliament and of the Council on promoting fairness and transparency for business users of online intermediation services, Brussels, 26.4. 2018, COM (2018) 238 final. In February 2019 the European Parliament and the Council reached an agreement on the proposed regulation (EPRS Briefing EU Legislation in Progress 2019).

machine communication. Different virtual networks which are complementary for heterogeneous IoT application services are based on sensor networks, quality of service (QoS) requirements of all-IP broadband networks, geo-locational awareness and big data collection and processing within the local neighborhoods (Knieps, 2017a).

The transactions of platform operators are manifold resulting into more or less complex governance problems. Questions regarding the design of contractual relations between all-IP traffic service providers, virtual network providers and platform operators for physical IoT applications arise, including the role of bundling between virtual network operators and platform operators providing different physical IoT application services.

The complementary role of operator platforms organizing the production of physical network services and virtual networks evolving in the Internet of Things (IoT) is analyzed. IoT application services play an active role in the creation of new innovative markets of smart network infrastructures and physical network services. The IoT poses disruptive challenges for conventional network industries, enabling IoT applications for physical network services based on real time, adaptive and location-sensitive data. There is an open and ever-expanding set of physical IoT applications requiring operator platforms in their role as coordinators, aggregators and organizers of smart physical network services.

2. IoT and the dynamics of smart networks

The basic innovation of IoT is the pervasive interaction of the physical networks with complementary virtual networks enabling real-time, location-specific, adaptive capacity allocation decisions.

2.1 Complementarity between physical and virtual networks

The design and architecture of physical network infrastructures (roads, airports, electricity networks, gas pipelines, railway tracks, water pipelines) vary strongly each build to provide special purpose physical service networks (road traffic, airline services, electricity, water). In meantime the conventional special purpose narrowband telecommunication networks have shifted into a general-purpose technology characterized by QoS differentiated All-IP broadband networks enabling not only communication services but also are key for the disruption of conventional network industries into smart networks. Bi-directional metering, sensors,

actuators and remote control by interactive machine-to-machine communication in real time is the basis for virtual networks. Based on real time, adaptive, location specific scarcity signals markets for smart physical network infrastructure capacities as well as markets for smart network services may evolve. The growing role of prosumer activities in local electricity markets, increasing intermodal perspective of shared mobility markets, blurring boundaries between historically grown intramodal transportation markets are already indicating the potentials of smart physical network service markets (Knieps, 2017a, pp.241-243).

2.2 Heterogeneous requirements for virtual networks

The evolution of the IoT would not been possible without the rapid innovations in communication networks. Of particular relevance is the development of a Generalized DiffServ architecture within All-IP broadband networks with sufficient flexibility for an entrepreneurial design of a hierarchy of traffic classes. Quality of service (QoS) guarantees of data packet transmission within all-IP broadband networks can be based on deterministic worst-case criteria (e.g. maximal packet delay or jitter) implemented by broadband reservations as well as stochastic criteria based on prioritization of data packets. All-IP broadband service providers can offer QoS differentiated All-IP broadband capacities within Next Generation Networks (ITU-T, 2015, p.2). Price and QoS differentiation for a hierarchy of traffic classes can be specified providing deterministic as well as stochastic traffic quality for data packet transmission based on the opportunity costs of required traffic capacity (Knieps, 2015a, pp. 739-741; Knieps, Stocker, 2016). Of particular relevance is the division of labor between All-IP broadband service providers and the provider of virtual networks. Different virtual network providers combine the required broadband capacities within the geographical area of its virtual network with other dimensions of the virtual network required such as sensor networks, satellite-based ge positioning services, data processing as well as end-to-end responsibility for privacy and security requirements, depending on the specific requirements of the physical network services (Knieps, 2017a, pp.243f.). The fallacies of network neutrality regulations should be avoided, in order to enable the entrepreneurial search for new IoT applications and the required complementary innovations in all-IP networks (Bauer, Knieps, 2018, p.174).

3. Market driven innovations within operator platforms

3.1 The evolution of heterogeneous operator platforms

ICT based smart networks are characterized by large innovational potentials for changing the architectures of physical networks as well as changing markets for network services. Thus, market driven operator platforms for IoT applications are facing highly innovative markets with entrepreneurial opportunities to develop new innovative services and thereby disrupt conventional network industries. Disruption of conventional network industries driven by the IoT is concomitant with the emergence of innovative operator platforms. Platform operators can organize the provision of physical network services by cooperation with an appropriate virtual network provider or by integration with a virtual network provider.

Mobility as a service platform

Mobility as a service platform can be organized for physical intermodal transportation services from different providers (e.g. bus and train). Blurring boundaries arise between shared bus-on-demand services with flexible time scheduling and routing and public transit with scheduled services. Complementary to the changing markets for physical transportation services heterogeneous virtual networks for shared mobility services evolve based on a combination of mobile real-time communication, global geopositioning services and sensor-based data processing (OECD/ITF 2015b; OECD/ITF 2016). App-based operator platforms are coordinating and organizing the on-demand provision of mobility services based on real-time, location-based mobile communication services resulting into the convergence of markets for taxis, private-hire vehicles and ride sourcing services. An increasing need for technical regulations, such as specifications of safety and liability regulations in “mobility as a service platform” arise. Market entry regulations with licenses and public price fixing in the local/regional market hamper the search for new innovative mobility concepts and all legal entry barriers should be abolished. If public subsidies for loss-making network services are granted, platform operators should also be allowed to participate in the competition process for subsidies. Such subsidies for public transit should not be limited to providers specializing in a specific mode of transportation (Knieps, 2018).

Shared mobility markets can also contribute to reduce congestion and pollution depending on the degree of replacement of private car trips by shared on-demand mobility services (e.g. shared taxis, minibus on demand). In this context also a possible future role of a central

mobility dispatcher may occur who coordinates the matching of shared vehicles to passengers (OECD/ITF 2017).

Networked driverless vehicle platforms

The governance of operator platforms for various physical networked vehicle applications categories such as intelligent traffic information systems, conventional networked vehicle applications (e.g. road safety, traffic efficiency) as well as networked fully automated (driverless) vehicles requires a variety of heterogeneous complementary interactive broadband communication enabling the real-time processing and interexchange of big data (ITU-T, 2014; OECD/ITF, 2015a). The dimensions of big data virtual networks are based on heterogeneous latency requirements, geo-locational awareness, heterogeneous sensor networks as well as big data processing.

The most demanding big data virtual network is required for networked fully automated (driverless) vehicles. Networked driverless vehicle platforms provide highly interactive (co-operative) networked/automated vehicles with the support of high-volume location critical big data processing (edge cloud), where the function of driver responsibility is shifted to the platform operator for the transportation process. Operator platforms requiring big data virtual networks and fog computing, the role of 5 G and the tactile Internet, combining the highest QoS class in All-IP broadband network with locally based data collection and data processing and edge cloud computation (Knieps, 2019, pp 175-179). An issue which is gaining increasing attention is the future potential of shared self-driving vehicles as a new form of low capacity, demand driven public transport in particular in urban areas (OECD/ITF 2015c).

Microgrid platforms

A necessary precondition for the prosumer driven evolution of microgrids has been the liberalization of energy markets and the abolishment of legal entry barriers within and between European countries as well as in other countries worldwide (Knieps, 2017b). Microgrid platform operators organize the low voltage generation and consumption of electricity with a focus on renewable energy. The conventional value chain in electricity networks from large power planed generation, high voltage transmission networks, medium voltage distribution networks and local low power household networks is challenged, due to bottom up renewable energy production and consumption within home networks. Within (low voltage) microgrid platforms the generation, storage and consumption of electricity of different home appliances are aggregated into the load of a prosumer unit, irrespective of its location within the

microgrid platform. Resulting surplus or deficit result into outside requirements of import or export of electricity from other (neighboring) microgrids or distribution networks.

Participation within a microgrid platform is voluntary such that other prosumers in the local neighborhood either belong to another microgrid platform or are connected to a local/regional utility. Complementary to the physical microgrid platforms are virtual networks providing the ICT logistics of microgrids. Low latency requirements of data packet transmission within home networks are based on QoS differentiated All-IP broadband networks. The architecture of home networks is based on high-speed broadband multipurpose networks. QoS requirements are not limited to the low latency requirements of data packet transmission within microgrids, but also entail the communication networks requirements outside of a microgrid (ITU-T 2016a; ITU-T 2016b).

3.2 Platform based security and privacy requirements

Regulatory problems on the physical side of operator platforms such as liability, security, safety of the physical network services are to be differentiated from privacy and security issues within virtual networks. An increasing need for technical regulations, such as specifications of safety and liability regulations in shared mobility, ride sourcing and networked driverless vehicles application can be identified.

ICT based virtual networks with heterogeneous relevance of common dimensions are depending on the requirements of the physical networks. Security and privacy requirements vary strongly depending on the specific virtual network required for the physical operator platform. Complementary technical regulations for security and compatibility reasons as well as privacy and cybersecurity regulations become necessary to fulfill the requirements of the physical as well as the virtual side of operator platforms. Heterogeneous requirements arise for specifications of rules and regulations in different operator platforms on the physical side as well as virtual side depending on the details of home networks, shared mobility, networked driverless vehicles etc. For example, within the physical side of transportation service markets technical regulations for vehicle safety and social security are unavoidable.

4. The governance of heterogeneous operator platforms

The economic analysis of governance structures has already a long history. Governance is the way in which organizations can best manage their contractual relationships choosing between

spot markets, long-term contracts and hierarchies by adequate contractual safeguards (Coase, 1937; Williamson, 2002a). Although asset specificity of long run investment has often been considered as key driver for incentives for vertical integration (Klein, Crawford, Alchian, 1978) the emphasis on the information and bargaining costs of specifying complete contracts seems to be of particular relevance for the institutional choice (Williamson, 1979). Under complete information incentive compatible long-term contracts can be implemented as alternative to vertical integration even in the presence of relevant transaction specific sunk costs (Kleindorfer, Knieps, 1982). In contrast, as a consequence of idiosyncratic transactions due to nonverifiable knowledge problems parties involved may have incentives for vertical integration.²

Disruption of conventional network industries and the emergence of innovative physical operator platforms provide challenging governance problems of contractual relationships among different actors involved. The question regarding the proper governance arises focusing on the role of spot market transactions versus long run relationships as well as idiosyncratic relationships. The problem solution competence of operator platforms (two-sided, multi-sided) is the entrepreneurial search for the required governance structures. Operator platform need as input a combination of physical networks and network services with complementary (big data) virtual networks. The problem of division of labor between all-IP broadband network providers, virtual network service providers, and platform operators arises concomitant with the implementation of adequate governance structures.

Heterogeneous specialized providers of operator platforms fulfill the role as coordinators, aggregators, and organizers resulting into shared mobility platform operators, networked vehicle platform operators, microgrid platform operators etc. Organizational competence to combine physical network services with required virtual networks may be bundled in the hand of the platform operators to enable an entrepreneurial combination of the different dimensions of virtual networks within the virtual network required for the smart physical network services. The governance problems of operator platforms are manifold with different contractual relations between different actors.

² ... “transactions of an idiosyncratic kind where the immediate parties have deep and nonverifiable knowledge and for which continuity of the exchange is important are ones for which simple market exchange is poorly suited”.^{FN} (Williamson, 2002b, p.438).

Governance between All-IP network providers and virtual network providers

Contractual relations between (application-blind) multipurpose All-IP networks and (application-aware) virtual networks for operator platforms can be based on market transactions and competitive market prices.³ A hierarchy of stochastic and deterministic traffic classes is required to fulfil the various QoS requirements of different virtual network operators (see section 2.2).

Governance between platform operators and virtual network providers

Of particular relevance for the governance of operator platforms is the contractual relationship to virtual network providers. Such a contractual relation may vary in the degree of complexity from market transaction to long-term contracts and possible incentives for vertical integration. Whereas the applications of mobility Apps in shared mobility markets can be implemented via short term spot markets, real time adaptive organization of import/export of electricity within microgrids may best be carried out via long-term contracts. Incentive for vertical integration between (physical) platform operators and virtual network providers may arise due to strong idiosyncratic kind of unverifiable knowledge problems between physical and virtual services.

Governance between platform operators and physical infrastructure providers

Contractual relations between platform operator and physical infrastructure providers are driven by the requirements of intermodal market transactions of network access with choice of intermodal combination of shared mobility services etc. Access of platform operators to physical infrastructure capacities (e.g. airport slots, track capacities) may be organized by spot markets or long-term contracts. Since the interoperability between network service provision and infrastructure can be guaranteed by adequate standards the necessities for vertical integration to internalize idiosyncratic knowledge problems do not hold. A key question is whether the interaction between platform operators and the providers of the underlying physical infrastructure raises market power problems, which then would require regulatory interventions. It is to be expected that operator platforms will not require a new paradigm of market power regulation. Although direct and indirect network externalities as well as the potentials of economies of scale are significant for operator platforms, they are in their very nature

³ For a comparison of architectural choices comparing application-blind networks with application-aware networks the reader is referred to MacKie-Mason, Shenker, Varian (1996).

network service markets with potentials for active and potential competition. In contrast, physical infrastructures may have the characteristics of a monopolistic bottleneck (natural monopoly in combination with irreversible costs) and thereby possess network specific market power. Sector specific price-level regulation of access tariffs and accounting separation is required to guarantee non-discriminatory access to monopolistic bottlenecks (Knieps, 2015b, chapter 8). Only if platform operators as well as conventional physical network service providers gain access to complementary physical infrastructures at non-discriminatory access charges undisturbed competition on the markets for network services can evolve. As it turns out intramodal regulation of monopolistic bottleneck infrastructures is a precondition for undisturbed intermodal platform competition which should be enabled by access regulation to monopolistic bottleneck infrastructures. For the case a platform operator would also own an (upstream) monopolistic bottleneck infrastructure disaggregated market power regulation should also be applied.

Governance between platform operator and participants of the platform

Contractual relations between platform operator and participants of the platform (producers, prosumers, consumers) may vary depending on the design and requirements of heterogeneous operator platforms. Ride sourcing platforms may only provide the organizational platform such that individual car rides are matched with the need of passengers without owning the vehicles. Alternatively, a shared mobility platform can also own a fleet of vehicles (e.g. mini-buses) which they own and operate in a centrally dispatched transportation mode. The interaction between users of operator platforms and platform operator may require related admission procedures, obligations to provide sensor-based metering data for billing procedure, share user data for aggregator/operator activities as well as liability rules for insurance purposes of platform operators. Platform user conditions may also vary in their specifications of obligations regarding metering information and sensor equipment within home networks, black box equipment for car security or IoT application equipment, insurance, health conditions etc.

5. Conclusions

ICT based smart networks are characterized by large innovational potentials for changing the architectures of physical networks as well as changing markets for network services. Thus, market driven operator platforms for IoT applications are facing highly innovative markets

with entrepreneurial opportunities to develop new innovative services and thereby disrupt conventional network industries. It is to be expected that operator platforms will not require a new paradigm of market power regulation. Although direct and indirect network externalities as well as the potentials of economies of scale are significant for operator platforms, they do not result in network specific market power. If the owner of a network infrastructure has network specific market power, he should be obliged to guarantee non-discriminatory access to platform operators at regulated access charges.

The shift from conventional network services providers to operator platform providers is a gradual evolutionary process. Competition between conventional network service providers and platform operators requires a discriminatory free treatment of all providers. Of particular importance is the discriminatory free access to (upstream) physical infrastructures. Conventional network service providers such as providers for rail services and bus services or regional electricity utilities may gain an increasing role within future ICT based intelligent networks with a more flexible, real time and location based adaptive allocation of service capacities.

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