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Investigating the role of Mobile Network Operators as platform providers in the Internet of Things

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Abstract—Internet of Things (IoT) is generally understood to be a realisation of the vision of ubiquitous computing, wherein any type of device will be connected to the Internet and will be controlled by remote software. The transition of Information and Communication Technology (ICT) ecosystem towards IoT is set to happen gradually over the next decade, with multiple independent sources predicting at least an order of magnitude increase in data traffic to and from connected devices. In particular, Mobile Network Operators (MNOs) are set to play an instrumental role in the IoT economy of the future, with the emergence of fifth generation mobile networks (5G). The transition to IoT, however, poses multiple challenges for MNOs who have to serve a large market of many industry segments (e.g. utilities, transport, agriculture), while simultaneously face commoditisation of their core services (i.e. voice, messaging and mobile broadband). In order to survive and thrive in the IoT economy, MNOs need to reconsider their role by repositioning themselves in the value chain. This paper, inspired from platform economics and successful examples of multi-sided platforms in the Information Technology (IT) industry, suggests a role of MNOs as mediators in a multi-sided market, connecting billions of devices on one end of the market with software providers on another end. The value of this idea is discussed by presentation of several prototypes that utilise MNO as a service provider.

I. INTRODUCTION

A prominent growth in the number and diversity of connected wireless devices ranging from sensors to mobile phones and tablets, has fuelled expectations for the materialisation of IoT. Even though the concept of IoT is not new, the emergence of a number of socio-technical trends, have contributed towards its popularity (see figure 1) - the analyst firm Gartner ranking it as one of the most hyped technologies of 2014 [1].

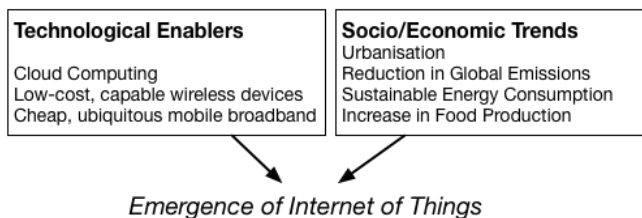


Fig. 1. Examples of prominent technological enablers and socio-economic trends contributing towards the emergence of Internet of Things [2].

Fifth generation mobile networks (5G) are seen as the next generation of mobile networks, designed to support the

Internet of Things [3] and are expected to be deployed from 2020 (see figure 2).

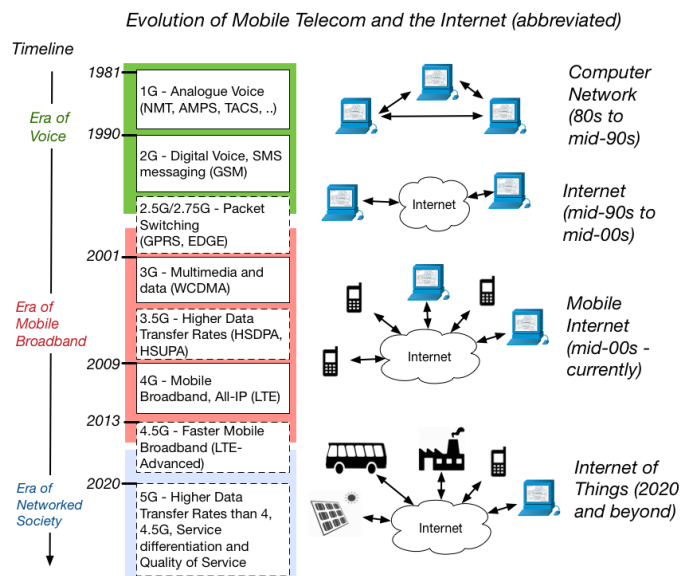


Fig. 2. This figure illustrates a timeline for evolution of mobile networks, in tandem with the evolution of the Internet. In parentheses in every generation of mobile networks are representative standards, designed and developed by the 3rd Generation Partnership Project (3GPP), with the exception of 1G standards. The authors identify three major phases in the evolution of mobile networks. The first phase, lasting from the beginning of 1980s until early 00s, is the era where the main service rendered in mobile networks is voice. The transition from circuit to packet switching that happened in late 90s, started the era of “mobile broadband”, where voice started to be phased out in favour of mobile data. The transition was complete with deployment of first 4G networks in late 00s, which were designed with IP connectivity end-to-end. Currently, LTE-Advanced networks are being deployed that address shortcomings and improve data transfer rates of early LTE 4G networks. Concurrently with the evolution of telecom networks, computer networks also evolved from local area networks, to the Internet. Although Internet was originally a domain of Personal Computers (PCs), currently mobile devices generate a considerable amount of Internet traffic, expected to increase tenfold between 2014 and 2019 [4]. Mobile networks are set to play an even more important role in the Internet of Things from 2020 and beyond, connecting heterogeneous devices across different industry segments (e.g. automotive, manufacturing, energy and utilities, etc.).

The International Telecommunications Union (ITU) has recently revealed its plan to standardise 5G by 2020, when the first commercial deployments are expected to appear [5],

however these standardisation activities evolve around achieving certain technological milestones (e.g. higher data transfer rates, lower latency, more efficient spectrum utilization, etc.). Even though standardisation activities on 5G will continue for at least the next 5 years, the opportunities for MNOs to evolve their business beyond being providing connectivity services for devices, is relatively unexplored. At the same time, mobile data revenue-eroding trends such as shift from voice conversations to messaging applications, pressure from competition such as Wi-Fi providers, pro “mobile data commoditisation” regulations¹, and transition of value from data to mobile applications, as messaging and voice services are delivered from over the top (OTT) players² [7].

This paper answers the research question of identifying a multi-sided market ecosystem for the Internet of Things, with a focus on the MNO role as platform provider. The authors argue that MNOs can be perceived as mediators in a two-sided market, decoupling the role of the service provider from the connected device owner. From one side of the market, there exist billions of connected devices. From another side, third party service providers can use a set of access functions to interact with any of these connected devices given proper authorisation.

The rest of the paper is structured as follows. Section 2 offers a background study initially on the research state of art of multi-sided markets and platform economics, and then proceeding to identify the market business and technical challenges for growth of these markets in key areas. Section 4 discusses how these challenges were met by presenting a set of use cases carried out in Ericsson Research with external partners, and generalises the findings to form a wider IoT multi-sided market perspective. The paper concludes by highlighting key findings and future work.

II. RELATED WORK

The concept of “platforms” has been defined by different researchers over the years. Boudreau provides a general definition of platforms as *a set of elements (such as physical components, software, sets of rules, etc.), that serve as a foundation upon which complementary components (e.g. technologies, products and/or services) can be developed*. These components can interact with each other, forming an ecosystem [8]. In Information Technology (IT), there exist a number of examples of successful platforms: operating systems, mobile app stores (prominent examples being IOS App Store and Google Play), cloud hosting services (such as Amazon Elastic Compute Cloud, Microsoft Azure and Rackspace). A common characteristic among all these platforms is the ability to for third parties

¹A prominent example for making mobile data cheaper is the June 2015 agreement (voted by European Parliament on October 2015), to end roaming charges by June 2017 across all European Union member states [6].

²In general, MNO pricing on mobile data are related to the amount of data trafficked over the network of an MNO, without regard for what application the data is for. This way, mobile subscribers can use messaging applications or Voice over IP (VoIP) services instead of SMS and voice services MNOs offer, for a fraction of the cost as the amount data required for these services costs less than paying for these services from the MNO directly.

to extend functionality of the platforms by building additional components (examples are mobile apps, cloud software, etc.). In fact, value in platforms is not created by the *platform provider*, but instead it is created outside the firm acting as platform provider³ [9].

Understanding platforms in greater detail requires understanding of “two-sided markets”. Rochet and Tirole provide a rough definition of two sided markets as *markets in which one or several platforms enable interactions between end-users, and try to get the two sides “on board” by appropriately charging each side* [10]. The definition can be generalized for markets that have more two or more (multiple) sides, in which case the market is known as a “multi-sided market”.

Platforms in multi-sided markets enjoy increasing returns to scale due to positive network effects⁴ (see figure 3).

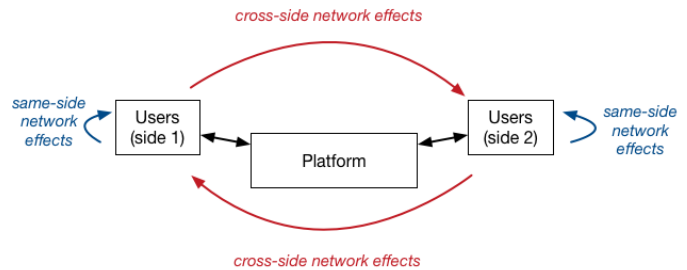


Fig. 3. This figure is a simple illustration of a two-sided platform, a platform being the mediator that enables interaction between two distinct user groups (for example a mobile app store platform connecting developers and consumers-phone owners). Growth of the platform can be impacted by same-side network effects (e.g. in case of the mobile app store platform example, the more developers that join the platform, the more attractive it will become for other developers to join), or cross-side network effects (for example more mobile application consumers may attract more developers and vice versa).

In pioneering work, Eisenmann, Parker and Van Alstyne suggest three major strategic issues that traditional product or service companies have to consider when transitioning to being platform providers [11]. The issues identified are:

- Pricing: Pricing is a balancing act for the platform provider, as both pricing impact on growth and user willingness to pay have to be factored in when setting the price for every side. In some markets, one side is subsidized to grow in order to create a positive cross-side network effect for the unsubsidized side to grow as well. Decision on the pricing model depends on the ability of

³Typically, value in platforms is created in-use, by customers of third party component builders (for example in the mobile app store platform, customers using mobile applications build by third-party developers). Platform providers may capture part of this value in different ways, such as taking a percentage off every mobile application sale (for example at the moment of this writing, Apple takes 30% of the profits from sale of every mobile application).

⁴According to the definition of network effects, the more users join to use a product or service, the more valuable this product or service becomes to users that have access to the service. Under certain cases, network effects can be negative, i.e. the value of a product or service dropping as it becomes more common. A simple example of network effects is that of the telephone service. As more people use the telephone, so does the value of the telephone service increase for all people who have access to it. However when too people join, there can be congestion to the phone network, thus decreasing the value of the service.

the platform provider to capture aforementioned cross-side network effects, the characteristics of the user base of every side in terms of price, quality demands and brand value, as well as awareness of same-side network effects.

- Competition vs Cooperation: Platform providers have to assess whether their target multi-sided market is destined to be served by a single platform or not and plan accordingly. In IoT, for reasons of scale, regulation and policy as well as technological reasons, MNOs will not be the only platform providers, but would instead have to cooperate with other platforms in the ecosystem (see section 3).
- Risk of envelopment, refers to the potential of “adjacent” platform providers with an overlapping user base, offering the same functionality (e.g. as part of a multi-platform bundle), thus posing the risk of losing business. In context of MNOs, an example may include fixed-line broadband vendors bundling deals with Wi-Fi network connectivity.

Later work by the same authors also discusses the issue of openness of the platform, which may relate on whether participation is restricted or unrestricted on the user sides or on the platform provider itself [12].

The next section examines all four aforementioned issues as challenges that the MNOs will have to face when transitioning to platform providers in the IoT ecosystem. The section begins by defining the IoT ecosystem, subsequently identifying the role of the MNO platform, and examining the aforementioned challenges in greater detail.

III. IOT PLATFORM ECOSYSTEM

A. Platform Model

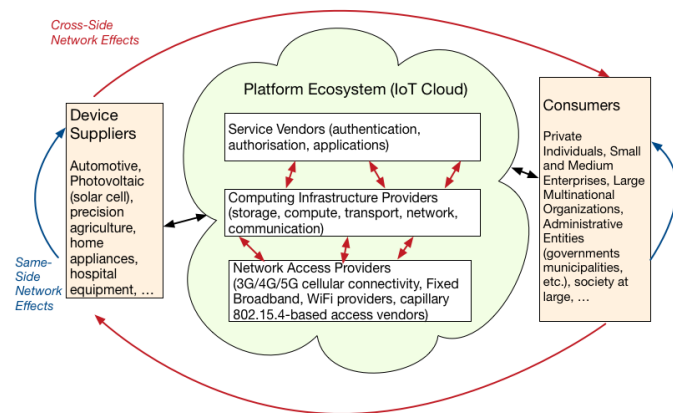


Fig. 4. IoT as a multisided-market with an ecosystem of platforms as a mediator between billions of heterogeneous devices and users of these devices.

Figure 4 illustrates a generalised view of IoT as a multi-sided platform, based on the suggested representative model of IoT suggested by Niyato *et al* [13]. This model was subsequently adapted by the authors as a multi-sided market, based on the definition and structure of these markets given in section 2.

In one side of the market there exist connected device suppliers. Note that the supply side as defined in this study, does not only include the Original Equipment Manufacturers (OEMs) for these devices but may involve a greater supply chain, from extraction of raw material, to integration of different components by the OEMs, all the way to distribution, wholesale and/or retail. By “devices” we not only include an array of physical devices (for example vehicles, smart meters, weather sensors, connected televisions, wearables, etc.), but also “virtual” devices. These include software systems monitoring and providing information about “virtual” environments, for example social media and customer-relationship management (CRM) systems.

The platform ecosystem in IoT consists of three layers, each layer serving a distinct function for the platform. There can be many individual platforms in the IoT ecosystem, each connecting distinct or overlapping groups of devices to consumers and serving distinct or overlapping consumer segments, however, every platform cannot be complete without inclusion of all three layers. Organizations⁵ may provide the platform on all three layers, or may collaborate with organizations on different layers in order to provide the platform. The platform packages devices with connectivity, computing infrastructure and software (applications hosted in computing infrastructure) to provide a *service* to consumers.

On the other side of the market there are consumers. This side includes all beneficiaries from connected devices. Consumers may own connected devices, or may benefit from these devices without having direct ownership. Also consumers as physical cover a broad range, from private individuals to small and medium enterprises and large multinational organizations.

The next section describes a case study for multi-sided platforms, based on a project that was previously carried out at Ericsson Research. This case study was picked because it represents a non-traditional telecommunication market, representative of the diversity found in IoT.

B. Example Case - Precision Agriculture

The use case we studied concerned agricultural crop production, and in particular the development of a system for precision agriculture. In general, precision agriculture is defined as *a process for monitoring fields using sensors, collecting and analysing information from sensors and subsequently improve the farming process based on the analysed data*. In the use case under study, a set of sensors were installed in fields, reporting some environmental data. A platform that included an MNO - cloud provider - service vendor partnership was established, which analysed the data from sensors and decided when the fields needed watering. Upon decision to water a field, instructions were sent to water pump actuators to start watering the field (see figure 5 for an illustration of the platform). We ran this project as a Proof of Concept with a participation of a few users from each side, an MNO and

⁵As “organizations” in the context of this study, we define a broad range of entities that in most cases are companies or corporations of any size, but can also be government entities, not-for profit organizations, or private individuals.

an Ericsson Research-provided cloud platform for a monitored period of 6 months.

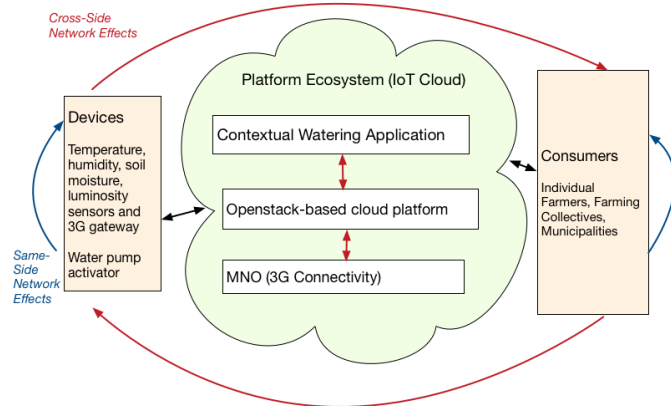


Fig. 5. Platform built for the precision agriculture use case, enabled a “contextual watering service”. The platform serves a two-sided market with devices on one side and consumers on the other. In this case, devices are environmental quality monitoring sensors and water pump actuators, while consumers are farmers and municipalities (municipalities were interested in water consumption from all farmers, in particular regarding the amount of water this contextual watering service would save when compared to the traditional watering cycle which was to the discretion of every farmer). The platform bundles a contextual watering service, which is software hosted in an Openstack-based cloud platform (in this case the infrastructure was provided from Ericsson Research), together with MNO M2M network connectivity services.

One of the characteristics of this use case was that the periodical sampling time interval for the sensors was quite large, ranging between 5 and 8 minutes, as the conditions monitored (e.g. temperature, humidity, moisture, etc.) changed at a slow pace. As a result, this amounted to a few kilobytes of data per minute transmitted from crop field gateways to the contextual watering application and over the MNO’s network. On the other hand, other players in the platform ecosystem such as the cloud provider (due to continuous data processing and access) and the application itself enjoyed much larger utilisation rates.

Pricing of the MNO in this scenario was a traditional charge by volume of data approach. As a result revenues from the service were unevenly distributed, the overwhelming majority of those revenues shared almost evenly between the cloud provider and the application. A different pricing strategy (for example a percentage from the revenues from every user of the contextual watering application, or a repositioning of the MNO role to include a cloud platform) could have been a potential solution.

Additionally, we observed that at times, the service was not available due to intermittent connectivity from the sensors and actuators on the field. This could be attributed to a combination of poor coverage in some areas which we monitored, in combination with bad weather issues which limited reception. This reinforced cross-side negative effects from the consumers (who were not getting the service they paid for) to devices (which were becoming unpopular because the demand for

the service dwindled). Additionally, same-side negative effects on consumer side because of viral spread of the unreliability made consumers who did not have any connectivity problems question the reliability of the service. On a survey we did at the end of the 6-month period, we found that there was a strong demand for consumers on data quality, and that they would be willing to pay extra for it.

The market we examined based on the platform we build was open from both sides from the start. We found that the benefits of an open platform allow both sides to grow horizontally (i.e. in terms of devices from different vendors and number of farmers, farmer collectives and municipalities). We also found that the platform can grow vertically, in terms of devices of different type and other consumer segments) provided that the platform can be “rebundled”, i.e. with a different application, hardware infrastructure, network access resource configuration. The concept of automation in platform “rebundling” is important in order to reduce service deployment lead-time and is something we discuss extensively in section 4 of this paper.

C. Challenges and advantages for MNOs to become platform providers

MNOs have unique advantages to capitalise on a multi-sided IoT market (see section 3). First, they already have established relationships both towards device suppliers (e.g. through partnerships of Machine to Machine - M2M - type of solutions), but also consumers (i.e. large numbers of mobile subscribers can have direct access to the platform via their mobile devices).

Additionally, MNOs already have deployed mobile network infrastructure on a large scale (both spatially but also in number of supported devices/mobile subscribers) and have the expertise to manage this network infrastructure. Network connectivity on top of this infrastructure is based on well-developed, globally popular standards. In many cases, MNOs monopolise affordable, long-range wireless access due to leasing (and therefore exclusively using⁶) part of the spectrum dedicated for this type of communication.

Licensed spectrum is also the reason why MNOs are in a good position to offer network quality of service (QoS), something that can be important for many classes of IoT services, especially those that are mission critical (for example, emergency response services, automotive-telematics, etc.). On the other hand, competitors operating in the unlicensed spectrum such as WiFi vendors cannot provide the same level of QoS guarantees, as such parts of spectrum are free for anyone to use and therefore potentially interfere with the WiFi service.

A major challenge MNOs face when transitioning towards being a player in the IoT ecosystem is the pricing and particularly the fact that in IoT and M2M, there is generally very low average revenue per user (ARPU), as opposed to

⁶Note that there can be cases where the spectrum is shared, as is for example the case with Mobile Virtual Network Operators (MVNOs), however the MNOs that sign agreements with the MVNOs to use part of their leased spectrum still maintain control over who they sublease this spectrum to.

voice and data services (an example was discussed in section 3.B). Part of the reason for the low ARPU is due to the fact that MNOs only operate on a network level, using the same pricing methods they apply to data services (i.e. charging by volume of data transferred on top of the MNO’s network).

A solution for MNOs is to move up the “provider ladder” and therefore participate to a greater extend in building IoT platforms. This means that in addition to network connectivity, providing applications and/or the cloud hardware infrastructure to host these applications (see figure 4). In this way, MNOs can get higher share of revenue for a service, as they can also charge for traditional cloud computing services (e.g. compute, store, host, etc.) but also for use of the application.

Another solution is for MNOs to implement, guarantee and start charging for Quality of Service (QoS), which, as previously described in this section may be required from certain classes of mission-critical services. There exist some technological barriers with this type of guarantees, with 3G and 4G networks of today in a sense that they were designed for best-effort mobile broadband traffic without any provisioning for such QoS guarantees (with the exception of Voice over LTE - VoLTE - service).

An additional challenge for MNOs is the inability to take advantage of the “openness” of the IoT market, and in particular the lack of standardisation that prohibits this “openness”. This applies to on-boarding new devices from suppliers, bundling of providers inside the platform to create a service, and finally exposure of the service for the consumers to use. In current M2M implementations, services are implemented vertically, with specific agreements and proprietary interfaces governing all parties participating in rendering these services. IoT services will require horizontal architectures, able to perform automated tasks in order to create platforms automatically, reducing the need for complex processes that govern services today.

In the next section we introduce the concept of platform bundles, and provide a reference architecture currently under development to deal with the aforementioned challenges.

IV. PINPOINTING THE ROLE OF MNOS IN AN IoT MULTI-SIDED MARKET

In order for MNOs to become platform providers, they have to fundamentally transform their business model. Table 1 uses Alexander Osterwalder’s “business model canvas” categorisation, to illustrate the transformation in different parts of the business model [14]. The transformation of an MNO to a platform provider is essentially based on reconceptualisation of the function of its Business Support System (BSS) and Operations Support System (OSS)⁷.

⁷Business Support Systems are components that an MNO uses to run business operations towards customers. These components include order and customer management systems, functions that are predominantly executed by humans. Operations Support Systems are components that an MNO uses to run its day to day operations such as fault management, service provisioning and network configuration. These systems also involves to a large degree human engineers, dealing with operation, maintenance and expansion of the MNO’s network.

TABLE I
BUSINESS MODEL OF MNO AS IoT PLATFORM AND TELECOM PROVIDER

	Traditional MNO (telecom)	Platform MNO (IoT)
Key Partners	Mobile Phone Manufacturers	Connected Device Manufacturers
Key Activities	Mobile broadband, voice and video services	IoT application network connectivity and hosting services based on a Service Level Agreement (SLA), Platform Development
Key Resources	Licensed Spectrum, Equipment (access and core network), Land (cell sites)	Licensed Spectrum, Equipment (access and core network), Land (cell sites), cloud infrastructure
Value Proposition	Connectivity for mobile device users	Applications platform for Industry and Society
Cost Structure	Core and Access Network CAPEX and OPEX (significant human-in-the-loop involvement)	Cloud, Core and Access Network CAPEX and OPEX (automated)
Revenue Streams	Mobile data and voice	Mobile connection quality of service, IoT application hosting and use
Customer Channels	Retail and Wholesale chains	APIs and/or web portal
Customer Relationships	Human staffed sales organization	Self-Service or Automated-Service
Customer Segments	Telecom (mobile subscriptions for private individuals, organizations)	Industry verticals (agriculture, energy & utilities, automotive, manufacturing, etc.)

In previous work, we suggested that automation in BSS and OSS will help MNOs grow as platform providers in the IoT ecosystem, and described how the IoT application lifecycle management, from negotiation of a Service Level Agreement (SLA), to deployment, monitoring during operation and subsequent decommissioning can be automated through use of 5G lifecycle management technologies [15].

The aforementioned study considered MNOs in isolation, as the sole platform providers for IoT services. While this may be the case for certain categories of services, the ability for MNOs to cooperate and collaborate with other platform providers is key towards growth and unlocking of value from positive network effects from both sides of the IoT market.

Figure 6 illustrates the role of MNOs in the context of this study. The MNOs have a lifecycle management function, which automates many of the BSS and OSS processes and allows them to collaborate with other vendors to form platform bundles. The lifecycle management function has two basic functions. Each of these functions is automated, and is implemented in software.

- Management of Provider Partnerships: This function allows the MNO to negotiate partnership with other

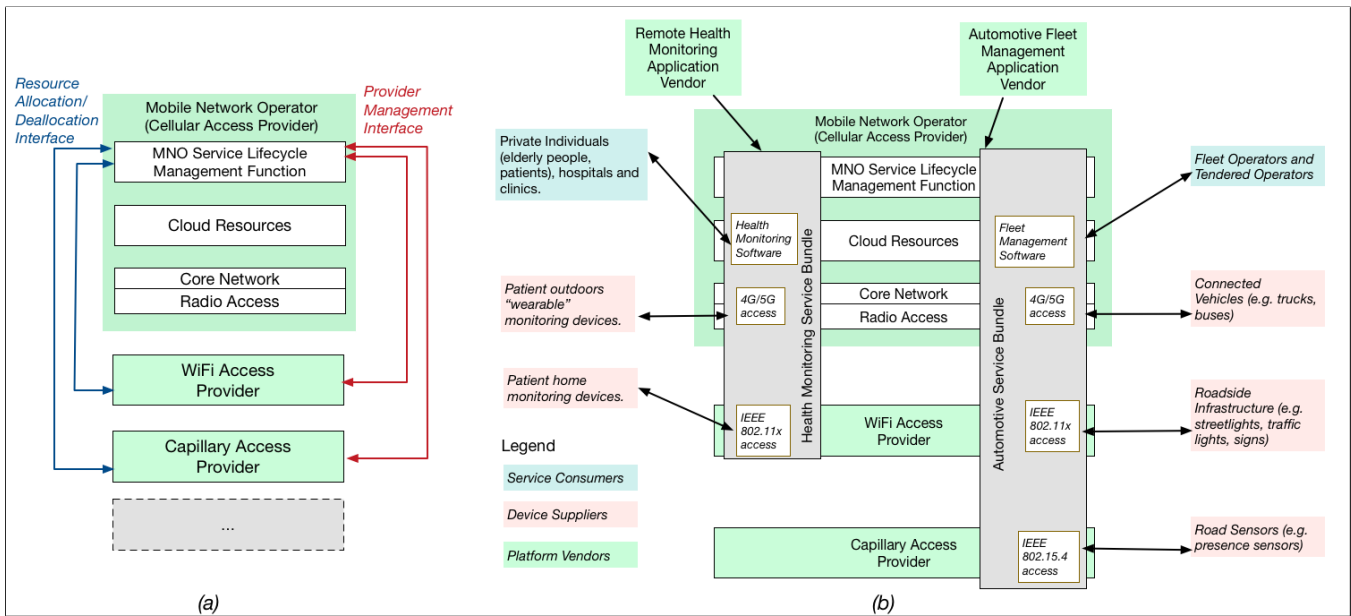


Fig. 6. This figure illustrates architectural concepts the authors are currently considering for enabling MNOs to be platform providers. The addition of an automated, software-based “lifecycle management function” allows MNOs to partner with other providers and create platform “bundles” to provide the necessary infrastructure to support specific services. This lifecycle management function is responsible for managing partnerships with providers (including establishment of partnership, upgrade/downgrade of partnership as well as teardown of partnership), and ordering allocation and freeing of resources with already partnered providers. Services are composed of applications, the network and cloud infrastructure to support these applications as well as two market sides - device suppliers and service consumers. Depending on the application requirements, the lifecycle management function of the MNO may interface with different providers to form a platform bundle to support a service. This interfacing is designed to be automated, thus removing a lot of the complexity. In the example illustrated above, two services, an automotive fleet management service and a remote health monitoring service are deployed over two different platform bundles. In case of the remote health monitoring system, patients wellbeing is monitored by devices both at home (using residential WiFi) but also outdoors (using cellular connection). In this case MNO partners with a WiFi provider. Another platform bundle serves an automotive fleet management application. In this case, operators remotely manage a fleet of vehicles (e.g. trucks or buses). In addition to WiFi and cellular connection, this scenario requires also a capillary network provider, for devices with low-power, low-range radios. Note that in this figure, the MNO is also the cloud vendor, hosting the applications from application vendors. This is not the only alternative for MNOs as there can be cases where MNOs do not own their own cloud, but instead can use their lifecycle management function to partner with a cloud vendor.

providers. The negotiation process can be triggered by the lifecycle management function administrator, or the function itself can trigger the process when a new provider is required. The negotiation process involves two sides exchanging capabilities and agreeing on a pricing model. Established partnerships can be renegotiated upon from both sides.

- **Management of Service Lifecycle:** The term service encompasses the application, the network and cloud infrastructure to support this applications as well as access to the application from two market sides - device suppliers and service consumers. The management of the service lifecycle function includes service creation, monitoring during operation and service teardown. This function is distributed, as the service may be using resources from multiple providers. Upon creation of a service, the providers that partner in the platform order to support the service are known as “platform bundle”. Every “platform bundle” is isolated, i.e. it is not affected other platform bundles which may be using resources from the same provider or providers.

Readers should note that different resource vendors in the platform may be owned by different organizations and

therefore manage their resources independently.

Even though the presented architectural concepts are straightforward, resource allocation is a challenge. This is especially true in radio access in context of MNO networks, where radio resources are bounded by the range of the licensed spectrum. Therefore there is a considerable amount of research to be done in allocation of radio resources, in addition to defining and standardising the interfaces of the lifecycle management function.

V. CONCLUSION

In this paper, we consider the role of MNOs as platform providers in IoT. Instead of serving the needs of a rigid, intangible telecom market of increased competition and declining revenues, we recapture the role of MNOs as partners in a platform acting as mediator of a two sided IoT market, connecting devices to services and service consumers.

Based on investigation of an IoT use case in the agricultural industry, we identify the ownership of spectrum and mobile network infrastructure, as well as existing mobile subscriber user base as the unique advantages that MNOs have in order to be a significant part of a future IoT platform. At the same time, challenges such as the low ARPU in IoT, as well as the lack of standardisation, hinder the transition to platforms.

For the former challenge, we suggest that the MNOs move up the value chain, not only providing connectivity services, but also providing to cloud hosting and being applications vendors - in which cases they can capture a larger share of the revenue of the platform.

For the latter challenge, we suggest an architectural concept centered around a lifecycle management function that automates large part of MNOs operations and customer-facing interface, as well as collaboration with other resource vendors in the platform. We suggest that focusing on standardizing the cross-vendor and intra-vendor interfaces of this lifecycle management function will help accelerate transition to platforms.

In the future, we plan to work on evolving and refining our understanding on IoT platforms and the role of MNOs, as well as on defining early prototypes of the interfaces of the lifecycle management function.

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