The role of a mobile operator in the enablement of responsible consumption in smart residential communities

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***Abstract*— The fifth generation of mobile networks (5G) gives mobile operators the possibility of enabling the transformation of the different industries and society at large. To seize such an opportunity, operators need to make different partnerships and take an active part in or even initiate the creation of new ecosystems. This paper portrays the potential role of mobile operators in the new, smart residential communities. It outlines the contribution of the different Internet of Things (IoT) applications, enabled by 5G, in resolving urban challenges. The special focus is put on „*smart living*" services related to responsible consumption. The paper describes the operator's business model for such a scenario and the necessary technical and organizational prerequisites for it. As the business model and the business ecosystem are tightly interdependent, the paper also addresses the ecosystem creation, main interactions among the key actors, and the value created for each participant and the whole society.**

Keywords—5G, mobile operator, Internet of Things, responsible consumption, smart residential community

I. INTRODUCTION

The development of mobile technology has changed to a great extent not only the way we are communicating with each other, but also our shopping, entertainment, working, learning, and many other habits and preferences. The fifth generation of mobile networks (5G), which is currently being introduced worldwide and promising superior performances, is expected to make even more radical changes. Together with the technical capabilities to enable different high-bandwidth, ultra-reliable and latency-sensitive use cases, and to provide connectivity to the plethora of the different smart devices, the 5G gives the chance to mobile operators of going beyond the traditional roles of connectivity provider and the legacy business models [1]–[4]. Smart cities are undoubtedly among the domains that are expected to benefit from the development of mobile technologies. They are also an opportunity for the mobile operator to expand its offering beyond infrastructure and to monetize on new capabilities [5]–[7].

Recent academic and industrial publications that are exploring potential benefits of using 5G in smart environments are mainly focusing on providing conditions for smart production (smart manufacturing) or improving the functioning of various public and communal services (e-health, public safety, smart parking, public lighting, waste management, etc.) [8]–[11]. In contrast, this paper focuses on services intended for individual users and householders. The basic idea is to take advantage of the opportunities offered by the 5G network, but also other solutions that rely on advanced information technologies (e.g. big data, ML, AI, blockchain) and thus improve the offer and overcome the limitations of previous smart home/smart living implementations.

The paper aims to answer what are the prerequisites for the enablement of such services from the mobile operator's perspective, how the operator's offering should be positioned in the relevant ecosystem, and how to create a sustainable business model. It is organized as follows. Chapter II provides an overview of the new generation of smart urban environments and the needs of their residents, Chapter III gives a short description of the methodology used for designing a business ecosystem, and a corresponding business model and shows how the mobile operator can apply this methodology in case of service that enables responsible food consumption. Chapter IV discusses the advantages and limitations of the proposed model, its implication on the operator's business, and gives suggestions for future work.

II. SMART URBAN ENVIRONMENTS

A. Theoretical background

The concept of smart city and the relevant sub-topics have been attracting significant attention from both academia and the ICT industry in the last decade. The extensive analysis of the existing literature, made by Winkowska, Szpilko, and Pejic [12] has shown that a majority of academic work was focused on the technological aspect only. Such an approach caused many issues in the implementation of smart cities [12]. The same study and other recent works conclude that technology is necessary, but not a sufficient prerequisite for transforming a city into the smart one. For successful planning and implementation of the smart city, the real needs of the citizens should be the utmost priority, while advanced technology should be a tool for achieving goals [12], [13].

On a broader scale, this is recognized in the concept of a smart, networked society. The strategic program of the Government of Japan, the vision of the future society, Society 5.0, in which advanced technologies are an integral part of both business and social life, defines primarily as human-centric, ie a society in which the needs of the population come first [14]–[17]. To meet these needs of citizens and create new value for society, it is necessary to unite different entities that share the same vision and goals, and who are willing to cooperate, and that through this cooperation, each based on their comparative advantages, to achieve benefits for all participants. What is important in this

type of partnership is the need for joint leadership and incentives that for each of the participants should be aligned with a common goal. This type of association is called the human-centric ecosystem [18].

B. The needs of urban residents

In addition to well-known urban challenges, the COVID-19 pandemic has been redefining the way of working and living in urban communities and has increased the reliance on technology, innovations, and e-commerce [19]. The main needs of urban residents seen from the perspective of an individual inhabitant or household can be grouped in the following categories [19], [20]:

- Digital infrastructure for remote work and education
- Infotainment – access to information and entertainment
- Social contacts
- Health and wellbeing
- Mobility and transportation
- Homelife – including home security, home tasks, and consumption

To satisfy these needs and enable digitization of various day-to-day activities, significantly increases infrastructure requirements. Leveraging on the capabilities of 5G networks, operators can offer a powerful wireless infrastructure as a competitive alternative to fixed broadband. Fixed wireless access (FWA) or enhanced mobile broadband will be the core of mobile operators' offering to residential communities. Besides this, the operator can move up in the value chain and offer smart services based on this mobile infrastructure that would further meet the needs of citizens. To achieve this, the operator must participate in the different business ecosystems or even create new ones.

III. BUSINESS ECOSYSTEM AND BUSINESS MODEL DESIGN

A. Design methodology

Modeling of the business ecosystem, including key partners identification and designing of relationships and main interactions among them, is performed through several iterations. Following the best practices, this process requires constant verification if the ecosystem supports the creation and exchange of sustainable value for all participants [21], [22]. Sustainable value proposition design [23] is used in this work as a guideline for mapping and understanding the ecosystem's stakeholders.

Designing a business ecosystem should be done in parallel with the development of a business model of its actors. An innovative approach in the implementation of different aspects of the smart city requires innovation in the corresponding business models [24]. This paper leverages the study from 2019 which proposes an enriched version of the well-known Business Model Canvas (BMC). This new framework is called Smart City Business Model Canvas (SC-BMC) [25]. Whereas the original and well-known Business Model Canvas (BMC) is intended to support an individual organization to develop its business model, this new framework considers the holistic business model for a network of actors in smart environments (e.g. Actor 1: city, Actor 2: end-user, Actor 3: core partner, Actor 4: supporting partner). This network of actors is supposed to create, deliver, and capture value in a collaborative effort, and SC-BMC is intended to support all the participants in this ecosystem taking into consideration their relationships and interactions[25]. The SC-BMC integrates the concepts of co-creation and network-centric value creation, which simultaneously address the social and environmental dimensions of the solutions deployed. The building blocks in the new framework are the following: Network Beneficiaries, Value Proposition, Data, Deployment Channels, Actor Relationships, Revenue Streams, Key Resources and Infrastructure, Key Activities, Key Actors, Key Actors Offerings, Key Actors, Co-Creation Operations, Budget Cost, Environmental Impacts: Costs and Benefits, and Social Impacts: Values and Costs [25].

B. Business ecosystem and business model for the case of responsible food consumption

This paper addresses the citizens' need for a convenient purchasing of food and other commodities, and the goal of society for responsible consumption (United Nation Sustainable Development Goal 12)[18]. Despite the numerous options for online purchasing, existing alternatives are still fully dependent on human requests, thus delivery timing and the purchased amount might not be the optimal ones. Furthermore, existing purchasing patterns often lead to stockpiling and then to the waste of food, either in the households or in the stores, due to the expired validity.

A potential solution could be to trigger a purchase automatically when the quantity of groceries (e.g. eggs, milk, flour) is below a predefined threshold. This is not a new idea, similar scenarios are already described in different IoT-related papers and publications, including the website dedicated to the concept of Society 5.0 [16]. The novelty of this paper is that it analyzes the implementation of this use case from the perspective of a mobile operator, as well as its role in the ecosystem created around this scenario.

The basic assumption for the implementation considered in this paper is that each household will have a smart pantry. This is a storage space, which is located next to the apartment, e.g. on the same floor, but has a separate entrance to reduce security risk. Depending on the preferences of residents or the building owners, these pantries may have refrigerators or just shelves with relatively simple, 5G-enabled sensors that will control the amount of food.

In addition to the operator and the residents/households as the pillars of the new ecosystem, the other participants identified are food supplier(s) and the residential community itself.

The basic value offered to citizens through this scenario is simplified and optimal shopping. Additional value can be created by enriching the data on groceries offered through the mobile application, and personalized recommendations for recipes, in combination with the appropriate video content, taking into account the previously shared data on e.g. health condition, allergies, current/desired weight, etc.

Incentives for participation can be expressed through various products or services of other participants in the ecosystem: free internet traffic (operator), free groceries (food supplier), the right to use common land for "urban gardening" (residential community). Additionally, a loyalty scheme can be introduced.

The main value for the operator will be the new revenue stream coming from this service and monetization of both 5G infrastructure and other technological improvements that have required significant investment in previous years (e.g. investment in the IoT platform or the modernization of BSS solutions).

The value identified for the food supplier(s) would be increased efficiency in handling the orders and managing the inventory. Moreover, this scenario is expected to positively impact customers' shopping experience.

The value proposition for the community is related to its public image. Enablement of responsible consumption would show innovation and environmental responsibility and in such a way improve the overall perception that current and future tenants have on this community.

New value for the whole society can be generated by analyzing with the help of artificial intelligence a large amount of data and information such as personal allergies, information on food products, the choice and quantity of food products stored in family pantries, stocks of retail stores, as and on market conditions [16].

A simplified version of the sustainable value proposition model is given in the picture below.

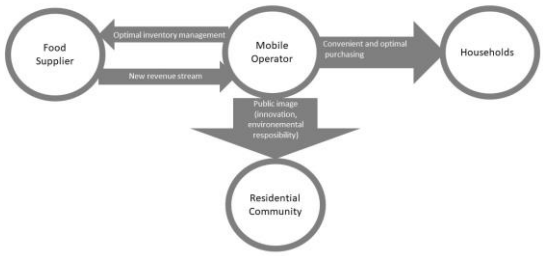

Fig. 1: Sustainable value proposition model

The contribution of mobile operator, in terms of assets and resources needed for the implementation, has been identified in the following areas:

- Sensors: Operators already have the organizational and processes capabilities that support the procurement of the various end-user devices and customer premises equipment (CPE), and their „bundling" with the basic packages. With the growing focus on the IoT business, some operators have already established partnerships that allow them to develop sensors tailored to their specific requirements. In addition, there are employees trained to install the CPE, who can also install the network of sensors necessary for this scenario.
- IoT platform: This scenario assumes that the operator will also provide a solution for device management (sensors), device data collection, as well as the exposure of interfaces and information to different partners in a configurable and controllable way.
- Mobile application and other channels for communication with end users: One of the operator's resource important for this scenario includes the existing channels for interaction with end-users, including existing human and technological resources for customer care. The mobile application is planned to be the main channel for interaction with end-users. The app must enable the users to define their purchasing preferences and thresholds, to get complete information about consumption, as well as about who accessed their smart pantry and when, and to give/withdraw the consent regarding the further sharing of data related to his/her household. As the basic idea is to accommodate the needs of residents, the application must provide them a possibility of giving feedback and influencing the improvement of services, both through the evaluation of existing suppliers and proposals for new ones and through suggestions for expanding the offer.
- Access protection and privacy: These are two important aspects for resident's acceptance of the service. Operators who have already started with the introduction and application of the blockchain infrastructure for their internal needs, can, with certain adaptations, offer a solution for an indisputable log of who and when accessed the individual smart pantry. Additionally, the operator can provide video surveillance of smart pantries, as an additional service that some households will be interested in.
- Consolidated Billing: Starting from the intention to facilitate and simplify the process of purchasing basic groceries for the end-user, the operator may offer to charge and invoice this service monthly, together with other services from its portfolio. This allows the operator to combine incentives from different offers (so-called cross-incentives), e.g. as an incentive or bonus to the users of this service, can be free minutes or free internet traffic.
- Reputation and trust: The operator by the nature of its business has the access to various personal and private data of its users. Even before data protection legislation (General Data Protection Regulation, GDPR, and similar laws), the business processes of operators and organizational culture included a high degree of protection of this data. This has been further improved in recent years by introducing new technological solutions and organizational measures and can be very useful for all the services intended to residential communities.

In the proposed model, citizens are not only passive users but also active participants in this ecosystem. Besides the evaluation of suppliers and suggestions for further improvements and development of the service, their role may include promotion of the service and support of other users in using the mobile application or understanding advanced options (example: older users).

A simplified version of the proposed business model is given below using the modified SC-BMC framework.

Adaptation of the Smart City - Business Model Canvas(SC-BMC) framework

Key Actors	Key Activities	Value Proposition	Actor Relationships	Network Beneficiaries
1. Mobile Operator 2. Households - end users 3. Food suppliers 4. Smart residential community/smart city	Deployment of smart pantries (sensors & surveillance); Development or customization of the IoT platform; Customization of mobile app; Configuration of the 5G NW slices; Integration to the Operator's OSS/ BSS infrastructure; Legal/contractual activities; Branding and marketing	To households: Convenient and secure way of purchasing food and other provisions To food supply chain: Processes streamlining, inventory reduction, waste minimization To residential community: Innovative, socially and environmentally responsible feature, which positively impact community's image	Existing Operator's relationships with both residential and enterprise (food production and distribution) customer segments to be reused and strengthened	Households and residential community Food supply chain Society

Key Actors Offerings	Key Resources and Infrastructure	Data	Deployment Channels
Operator: Bundle related to smart responsible consumption; Billing on behalf; marketing and customer care Food suppliers: Optimized home delivery Residential community: Smart pantry	Sensors; Mobile network infrastructure; Security and video-surveillance infrastructure; IoT platform; Mobile app for the end users; Operator's BSS; Operator's workforce; Brand name and associated trust	Data about food consumption patterns in the smart residential community Data about food suppliers' performances	Reuse of Operator's existing channels for interactions with the end-users New option in the existing operator mobile app or web applications enriched with the data/information related to the food consumption, households' preferences/requests for next period, data disclosure consent
Key Actors Co-creation Operations			
Operator and food suppliers: Bundle creation Operator and households: Evaluation and selection of the suppliers			

Budget Cost - Operator's perspective	Revenue Streams - Operator's perspective
Sensors and surveillance & security infrastructure; Development/customization of IoT platform and mobile app; OSS/BSS adaptations and integrations	Operator's share from the revenue coming from the bundles offered to the households Revenue from the data sold to 3rd parties
Environmental Impacts	**Social Impacts**
Reduction of non-degradable packaging material in the waste Reduction of CO2 emission due to the reduced number of rides related to individual purchases	Responsible consumption (UN SDG 12) Facilitation of daily life for elderly and people with reduced mobility Open data to be used for responsible food production

IV. Discussion and Implications

A. *Implementation Considerations*

Although the connectivity in the proposed scenario could be based on the different wireless technologies, this proposal assumes the use of a 5G. This is primarily due to the expectation that the residential space will have a high density of different connected devices and that good 5G indoor coverage will be already provided to enable FWA. Additionally, the proposed scenario may further evolve towards more complex and sophisticated applications for which the 5G infrastructure will be necessary.

The main limitation of the proposed model is related to the current availability and price of 5G-enabled sensors, but this is expected to be overcome in parallel with the ongoing worldwide rollout of 5G.

Implementation of the proposed scenario requires the operator to fulfill numerous technical/technological and organizational prerequisites. In addition to the 5G network infrastructure and IoT platform discussed in previous chapters, the role of Operational Support Systems / Business Support Systems (OSS/BSS) is also the crucial one [26]. OSS have to ensure that even with an almost exponential increase in the number of connections, network performance remains at the required level, while BSS solutions, have to provide support for different multi-sided business models [26], such as B2B2C or B2B2X, to ensure proper revenue sharing with the partners or invoicing and billing on behalf of someone else.

Organizational changes are equally important for the successful deployment of 5G services. They become inevitable with the operator's participation in the new business ecosystems and new partnerships. 5G requires agile business [26]. Innovation, launching of new, 5G-based offerings, managing a large number of end-to-end logical networks (network slices), and a large increase in the number of connections, require close cooperation of legacy IT with both the legacy network function and the business function. Traditional organizational structures of operators are not suitable for this. A potential way forward could be to create multifunctional teams or to adopt DevOps principles to ensure agility and partner orientation [26].

Finally, the readiness of the citizens for accepting this type of service is of utmost importance for the success of the proposed model. This will be the subject of our future work and evaluation will be based on a modified Smart Cities Stakeholders Adoption Model (SSA) [27].

B. *Operator as the successful player in a 5G ecosystem*

Although quite simple, the proposed scenario allows the operator to gradually develop its portfolio related to smart living services. A stepwise approach has the following advantages:

- It allows testing of the operator's technical and organizational capabilities to support the development of 5G ecosystems before starting deployment of more complex scenarios
- Positioning in other verticals (e.g. food industry) and creating preconditions for further development of ecosystems and development of offers for the business users segment
- Development and testing of a strategy related to the handling of data collected through such use cases
- Breaking the prejudices and resistance that exist in one part of the population towards 5G technology by showing value to citizens and society as a whole.

Examples of future 5G-based offerings that are leveraging this scenario are AR/VR-enabled cooking classes for residential users or smart warehouses and using of autonomous vehicles in the grocery retail supply chain.

The main contribution of this work is that it outlines the key values and differentiators that a mobile operator can bring to a smart living ecosystem, as well as the technology, platform, and business enablers needed for successful engagement with the partners. This could be a good starting point for the feasibility studies of operator's positioning in broader ecosystems in the future, such as participation in the data marketplace or linking with smart agriculture ecosystem.

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