Business Models for Mobile Network Operators Utilizing the Hybrid Use Concept of the UHF Broadcasting Spectrum

Seppo Yrjölä[1(✉)], Petri Ahokangas[2], and Pekka Talmola[3]

[1] Nokia Networks, Oulu, Finland
seppo.yrjola@nokia.com
[2] Oulu Business School, Oulu, Finland
Petri.Ahokangas@oulu.fi
[3] Nokia Technologies, Salo, Finland
Pekka.hk.Talmola@nokia.com

Abstract. This paper explores and presents business models for mobile network operators (MNOs) in the novel hybrid use spectrum sharing concept of the Ultra High Frequency broadcasting spectrum (470–790 MHz) used for Digital Terrestrial TV and Mobile Broadband. The created business models indicate that MNOs would benefit significantly from the more flexible use of the UHF bands. New business models would enable them to gain faster access to new potentially lower cost, licensed, below 1 GHz spectrum in order to cope with increasing data traffic asymmetry, and to offer differentiation through personalized broadcasting and new media services. As a collaborative benefit with the broadcasting domain, the concept opens up new converging business opportunities in delivering TV and media content using MBB network with means to introduce this flexibly. Moreover, it will significantly re-shape the business ecosystem around both broadcasting and mobile broadband by introducing new co-opetitive business opportunities in business and technology towards 5G.

Keywords: Broadcasting · Business model · Mobile broadband · Mobile network operator · Spectrum sharing · UHF · 5G

1 Introduction

The mobile broadband (MBB) usage is growing at an increasing pace [1], placing growing needs for the scarce radio spectrum resource. As mobile data traffic is increasingly consisting of downstream video [2], asymmetry in mobile broadband traffic is increasing: the average downlink traffic in Europe is eight times the uplink. Changing consumer usage habits and high capacity demand anytime and anywhere put Mobile Network Operators against a disruptive change. At the same time, Digital Terrestrial Television (DTT) as the main delivery vehicle for the TV media content has been challenged by the alternative content delivery mechanisms, Over the Top (OTT) services and higher spectrum fees for all using the UHF band. Even if consumers' interest in TV content remains and even increases, the ways how TV content is delivered and consumed

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will, and has, already started to change. Users are increasingly receiving TV content via cable, satellite, fixed broadband and, especially, via MBB, and at the same time, changing their consumption habits from linear real time to non-linear usage with the growing demand for interactivity [3].

With these sights to the future, spectrum regulators are, on one hand, considering gradually compressing and withdrawing some DTT licenses of lower demand and repurposing these frequencies for MBB. On the other hand, in order to continue fulfilling the national Public Media Service (PSM) obligations, the most used and, in particular national broadcasters', DTT licenses will continue to the foreseeable future as long as required. The traditional spectrum auctioning & re-farming process is becoming increasingly difficult in the future due to high costs, time needed, and difficulties in finding unused exclusive spectrum needed for the re-allocation process. Spectrum sharing where systems operate in the same spectrum band, has lately received growing interest among regulators considering new ways of fulfilling the different spectrum demands and to meet the mobile traffic growth while maintaining the rights of the original incumbent systems operating in the bands [4]. This business environment transformation influences the broadcaster spectrum holders, and opens up new business opportunities, as well as risks due to increasing pressure for innovative flexibility and sharing in the spectrum usage. To date, broadcasting (BC) community has not been offered incentives to change their spectrum usage. On the contrary, we have seen unilateral acts from regulators and MNOs towards further compressing DTT bands to give room for new MBB spectrum. The UHF broadcast spectrum was originally from 470 to 862 MHz, and 800 MHz band (790–862) is now been deployed for MBB use throughout the Europe. The World Radiocommunication Conference (WRC) already in 2012 made a decision on the 700 MHz band to be used for the MBB after the WRC-15 [5]. As a part of new IMT spectrum identification point of discussion, the WRC'15 addressed the co-primary allocation with mobile of the lower UHF band (470–694 MHz) that currently has a primary allocation to broadcasting [6]. Further, the FCC in the USA has lately made a decision on 600 MHz incentive auctions [7].

The co-existence between MBB and DTT on Digital Dividend (DD) spectrum has been widely addressed in regulation and standardization forums and supported by extensive research. The DD1 at 800 MHz and interleaved UHF spectrum concept has widely been studied by the Federal Office of Communications (OFCOM), e.g., [8, 9], focusing on the performance of the DVB-T receiver in the presence of interference from real LTE signals. In [10], co-existence of the DTT and the LTE in the 700 MHz band was analyzed based on system level simulations, and in [11] extended through laboratory measurements and link budget analysis. In [12], the analysis of the interference between the digital terrestrial multimedia broadcast (DTMB) and the LTE below 698 MHz was discussed. In the reference [13], generic requirements for the co-existence between DVB-T/T2 and LTE for fixed outdoor and portable indoor DTT reception is summarized based on the system level Monte Carlo simulations. In [14], Antonopoulos proposed additional physical infrastructure sharing deployments and architecture scenarios. Regulatory and system architecture scenarios towards 5G are discussed, e.g., in [15, 16].

In the recent European spectrum debate, the European Commission (EC) set up a High Level Group consisting of mobile and broadcast sectors to deliver strategic advice

on the future use of the UHF spectrum. Accordingly, The European Conference of Postal and Telecommunications Administrations (CEPT) set up Task Group 6 (TG6) "Long term vision for the UHF broadcasting band" [17], to identify and analyze possible scenarios for the development of the band, taking into account technology and service development. In this paper, we focus on analyzing the scenario of *hybrid usage of the band by DTT and MBB*. In support of this scenario, the EC released a decision proposal in February 2016 to limit the terrestrial use other than BC on this band to downlink-only [18]. We considered the hybrid use of UHF, and its key enabling technologies in general, to represent one of these new emerging concepts that are expected to reshape business models and whole business ecosystems within the BC and MBB sectors [19]. This reshape is expected to provide new opportunities for value creation and capture with innovative business models for the key stakeholders. Previous works on business models for shared DTT spectrum use are limited as focus has been on TV White Spaces (TVWS) concept, e.g., [20, 21]. The general business drivers, enablers and potential impacts of the spectrum sharing on the MBB market were described in [19] and incentives and strategic dynamic capabilities for the key stakeholders in the hybrid use of the UHF were discussed in [22]. Furthermore, there are several studies on the optimal contract design, e.g., [23]. However, in earlier research there is no complete MNO business model related to the hybrid use of UHF discussed, as the focus has been on identifying the opportunities and discussing the business model only regarding a limited amount of business elements. The purpose of this paper is to explore and discuss MNO's business model transformation when they are doing business based on hybrid shared used of the UHF spectrum. Particularly, we are focusing on the European regulatory regime. This paper seeks to answer the following research questions:

(1) What are the business opportunities the hybrid usage concepts could open for MNOs?
(2) What are the key changes it may bring to MNOs´' current business models?
(3) What kind of business models MNOs may build on the identified business opportunities?

The research methodology applied in this paper is the anticipatory action learning in a future-oriented mode [24]. The business models presented are developed by utilizing the capacity and expertise of the policy, business and technology research communities.

The rest of this paper is organized as follows. First, the hybrid DTT MBB usage concept is presented in Sect. 2. Theoretical background for business models is introduced in Sect. 3. The research methodology applied and the business models for MNOs in using hybrid concept are derived in Sect. 4. And finally, conclusions are drawn in Sect. 5.

2 The Hybrid Use of UHF Broadcasting Spectrum Concept

In their vision work, the CEPT Task Group 6 created the following scenarios how the UHF band 470–694 MHz can accommodate the delivery of the TV content as well as provide additional capacity for the MBB [25]:

- Class A: Primary usage of the band by existing and future DVB terrestrial networks.
- *Class B: Hybrid usage of the band by DVB and/or downlink LTE terrestrial networks.*
- Class C: Hybrid usage of the band by DVB and/or LTE (including uplink) terrestrial networks.
- Class D: Usage of the band by future communication technologies.

In particular, the spectrum sharing scenario in the class B introduces a flexible way of transferring TV channels to mobile use while maintaining capability to deliver TV content both in conventional living room large screen use cases as well as in new mobile use cases on smart phones and tablets. In the following analysis, TV media content, consumption and delivery mechanisms are considered as different matters, and they need to be separated. Although the users interested in the TV media content remain at the same level or even increases, the ways how TV content is delivered and received will be and have already been changed. Increasingly, users are receiving TV programs via cable, satellite, fixed broadband and, especially, via MBB. In addition, non-linear usage is greatly increasing as well as the demand for interactivity.

Recent studies show that the demand and the value for DTT as the main delivery mechanism of TV content will decrease [3]. Based on this, it could be assumed that some 'underutilized' and lower valued TV frequencies will be reassigned and or shared with mobile use. As the freed TV channels can be different in different geographical areas and countries, we propose them to be assigned first for the MBB supplemental downlink (SDL) use only. The SDL is more compatible, compared with the traditional Frequency Division Duplex (FDD) or the Time Division Duplex (TDD) use, with the remaining DTT to be used in the country or across the national borders. The freed TV channels could be taken into mobile use in a flexible way by using functionalities that are already developed for shared spectrum access like, e.g., recently widely discussed Licensed Shared Access (LSA) concept [25], allowing different time schedules in different regions and countries, if needed. The SDL Carrier Aggregation (CA) technology [26] allows both the 'traditional' MBB DL and the LTE evolved Multimedia Broadcast Multicast Service Broadcast (eMBMS) [27] flexibly used for optimizing the capacity on demand. The SDL use would also support the trend that the future MBB traffic is strongly asymmetric towards downlink direction.

The evolution scenario of the hybrid use concept of the UHF spectrum can follow the market demand. Potential evolutionary scenarios for Europe are illustrated in the Fig. 1. Already in the first phase, the hybrid SDL CA concept could speed up the take-off of the 700 MHz through better co-existence characteristics with across-the-border TV transmitters. The spectrum usage can evolve so that the DTT use could be moved towards the lower end of the 470–694 MHz band, as more spectrum is freed from DTT. It should also be noted that as the SDL base stations start replacing the DTT frequencies one by one locally, there is no change in the availability of interleaved spectrum used for example for Program Making and Special Events (PMSE). Depending on the national regulation and market demand, it should also be possible in the long term vision to fully migrate to the LTE using either the SDL and/or the eMBMS to deliver TV content and hence completely replace current DTT technologies with converged delivery platform [28].

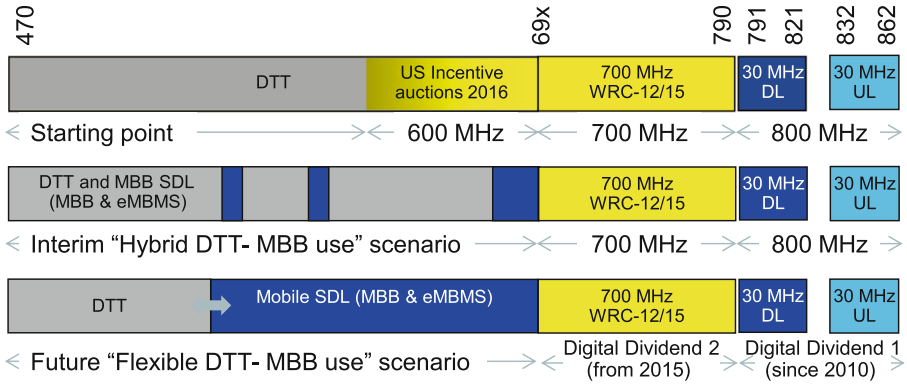

Fig. 1. Evolution of the UHF band usage with the novel hybrid use scenario.

3 Business Model Elements

Business research provides us with numerous examples of business model concepts and elements utilized. Often referred to [29] defines the business model as consisting of nine elements: key partners, key activities, key resources, value proposition, customer relationships, customer segments, channels, cost structure and revenue streams. The other view widely used in analyzing new ventures is to refer business model to comprise of the elements: strategic choices, value proposition, value creation and delivery system and value capture [30]. Traditional approaches, however, include several limitations; they do not build around the business opportunity, have only weak linkages to the systemic complexities of the business context, depict structures rather than activities, and lack the element locations prevalent in current businesses. In this paper, for the MNO we adopt the approach and conceptualization presented in [31], that helps to answer to the concerns discussed above in business modeling, and consists of the following elements:

(1) *What*: Offer, value proposition, customer segmentation, unique differentiation
(2) *How*: Key operations, basis of competitive advantage, mode of delivery, selling, marketing
(3) *Why*: Base of pricing, way of charging, cost elements and cost drivers
(4) *Where*: Location of activities/elements perspective (i.e., are activities carried out internally of by external partners) of all the preceding items.

4 Analysis of the MNO Business Models

The research methodology applied, business models created and their analysis are summarized in this section.

The Business model scenarios presented in this paper were created utilizing the Anticipatory Action Learning (AAL) approach that is a particular action research

method conducted in a future-oriented mode [24]. In developing foresight, the method represents a unique style of questioning the future from transformational point of view, using business model as the unit of analysis. In this interactive and collaborative approach, conversation and dialog among cross-disciplinary participants, from multiple domains concerned with the research project is essential.

The business model elements presented in this paper were created in a series of future-oriented workshops in 2015, organized by the Finnish Future of the UHF (FUHF) research project utilizing the capacity and expertise of the policy, business and technology research communities. The research process comprised (1) identifying the critical change factors, (2) assessing their impact and possible consequences on key stakeholders, (3) building and selecting the scenario axes, (4) creating the business scenarios, and (5) evaluating them. Foresight, by definition, is future focused and its reliability and validity cannot be controlled. Instead, the qualitative focus of research is in how probable, plausible, and preferable the outcomes appear. Also, the collaborative and conversation based method how the futures were created was regarded as way to ensure the quality of the research. [32]

4.1 Business Models

Using the above summarized, future-oriented action research method. We created business models for MNOs deploying the hybrid UHF concept applying the business model framework from [31]. Potential changes in the business models caused by the deployment of the novel spectrum sharing concept were analyzed by creating foresighted business models. In the traditional model, the MNOs are using exclusively licensed IMT spectrum possibly including upper DD spectrum bands (e.g. 800 MHz). The future hybrid UHF business scenario is based on the additional flexible shared access to lower UHF spectrum. The business models were created applying the above discussed format where elements responding Why, What and How questions, are presented in the form of rectangles inside the sector in question. Internal and external operations, the Where question, is depicted in the locations of the rectangles as shown in the Fig. 2.

MNO business model in the traditional exclusive UHF licensing case.
We started with sketching business models for the MNO in the traditional case, where exclusive spectrum bands without additional downlink UHF bands are utilized. The developed business model is shown in Fig. 2. In general, an MNO wishes to maintain and grow its current market position. The overall opportunity for the MNO is to serve as a "Mobile data pipe" or a "Mobile smart data pipe" corresponding to acting merely as an access channel or providing services on top of the access, respectively.

In the *What* element of the business model, the offering is MBB services that guarantee mobility, high data rates and services to customers. Both in consumer and enterprise customer segments customers at large may be treated as a mass. MNOs' offering mainly consists of voice, messaging and data services. Traditionally, customer lock-in has been achieved via subscription. Lately, Quality of Service (QoS), in particular data speed, as well as the bundling of subscriptions and services has become important elements of value proposition and in achieving customer retention.

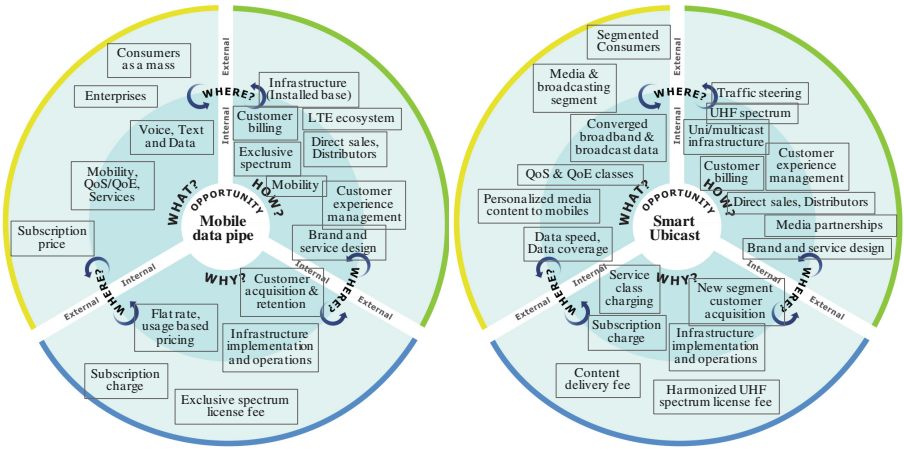

Fig. 2. MNO's "Mobile data pipe" business model in the traditional exclusive license case and the Smart ubicast business model scenario for the hybrid UHF usage case.

The key operations in the *How* element that the MNO wants to keep under its own control are customer interface and billing. In this case, competitive advantages are based on infrastructure and exclusive spectrum licenses, which guarantee QoS for end users and operational long-term certainty needed for the large infrastructure investments for the MNO. MNOs seize the harmonized and scaled 3GPP LTE ecosystem within their infrastructure. Exclusive long-term licenses and installed base infrastructure provide a strong position against new entrants who would need big investments to support full services (and coverage) to customers. The traditional sales mode include direct sales, own shops and distributors such as retail chains. MNOs exploit their existing customer base and related customer data in marketing, sales, and service design and are in unique position to leverage customer big data analytics, which offers them an opportunity to strengthen their position against new entrants.

Considering the *Why* sector, pricing is based on flat or usage based prices with regular subscription charges. The key technical cost drivers include expenditures related to implementing and operating the infrastructure with the real estate of the mobile broadband spectrum license fee. Customer acquisition and retention play essential role in the heavily competitive MBB industry.

MNO Business Model in the Hybrid UHF Case.
After the common insight on the present business model state-of-the-art, we developed a new business model for the situation where new spectrum bands based on the hybrid shared use with DTT on the UHF spectrum becomes available as presented in Fig. 2. The basic opportunity for the MNO with UHF is to gain access to lower cost spectrum and seek growth when courting to meet the growing mobile broadband data traffic needs. Gaining faster access to new licensed low frequency UHF spectrum presents an opportunity for the MNO to build data coverage with favorable propagation, and build market penetration more cost-efficiently than what would be the case of densifying the existing

infrastructure in the current exclusive higher spectrum bands. Additional downlink only spectrum in particular helps an operator to cope firstly with rising downlink asymmetry mainly caused by the video content. Secondly, it helps to open up a real option to deliver media and traditional broadcasting content in their MBB networks. An additional benefit of the early introduction of the co-primary hybrid use of the UHF bands, compared to traditional exclusive licensed, is in the avoidance of the lengthy spectrum re-farming, clearing and cross-border optimization process, which provides faster access to new spectrum on a harmonized basis.

In the *What* element, the MNO continues to offer MBB services to consumer and enterprise customers. With new additional UHF downlink capacity and coverage, the operator would differentiate in the competition by offering enhanced data rates and tailored different QoS level classes to different customer segments. The MNO can take advantage of the new spectrum so that to balance the capacity demand and service supply. As discussed earlier, content is increasingly provided independent of the platform and today's consumers have a choice of DTT and MBB platforms to be used as a delivery vehicle for the linear and non-linear media content. As a collaborative benefit, the concept opens up new business opportunities in delivering TV and media content using MBB network with the means to introduce this flexibly. A combination of the broadcast eMBMS and unicast with the SDL CA technology could generate a very efficient and flexibly integrated platform for delivering personalized media content as well as traditional broadband services to mobile users. The availability of user equipment that support the new spectrum bands and enabling SDL CA and eMBMS technologies is essential in introducing the new services. However, the intended technologies are globally harmonized, standardized and under deployment in other spectrum bands.

The basis for the offering of new services and service level in the *How* element to segmented customers lies in the dynamic load and traffic management based on both network parameters as well as the customer experience data. This combination of existing and new flexible downlink unicasting/broadcasting resources enables traffic steering between different radio access technologies and spectrum bands to offer personalized and enhanced Quality of Experience (QoE) to segmented customers. Service level differentiation can be based on strong existing spectrum and infrastructure assets to realize the full benefits of the additional spectrum. The subscriber data management and customer experience management will be unique assets in the design of new services and service levels. In order to expand offering to media distribution with collaborative benefits with media content, providers such as national TV broadcasters and content aggregators distribution channels should be expanded from still valid direct sales and distributors to broadcasters and content providers.

In the business model *Why* element, the service level differentiation could lead to new service level based pricing models charged via subscription fees. Converged media distribution services will introduce new opportunities for revenue sharing e.g., with venue owners, event organizers, content and service providers and advertisement partners. These distribution services could be further expanded to applications, firmware software and Internet of Things updates and content deliveries. The business model cost drivers and elements continue to include infrastructure, implementation and operational expenditures. However, spectrum license costs resulting from the hybrid licenses may

differ from those of today's auctions. In fact, the license costs of the hybrid UHF bands will be lower due to restrictions in the conditions of using the band, but at the same time, they could be free from, e.g., coverage obligations.

4.2 Discussion

The developed future MNO business models are summarized in Table 1. The transition in the business model with additional flexible downlink data capacity is not only about avoiding costs, or scouting further growth within the mobile data, but to expand business towards ubiquitous customer experience in the merging media and ICT era. Faster access to QoS licensed below 1 GHz spectrum without mandatory coverage obligations could allow the operators to strengthen their existing market position and enabling new more personalized service level based offerings with enhanced QoS and QoE to different customer segments. New downlink bands complement the current spectrum assets, and offer improved QoE by allowing load balancing and traffic steering to match best the personalized user demand with the network capacity supply.

Table 1. Summary of developed business models.

Case	MNO business model
Traditional exclusive spectrum	Be cost effective mobile "data pipe" or mobile "smart data pipe"
Access to hybrid UHF spectrum	Seek growth through "Smart Ubicast"

The following service opportunities enabled by the flexible UHF business model were identified: (1) Extra *Mobile Broadband capacity and coverage* to cope with asymmetric data traffic benefit, (2) *Public Service Media service* to broadcast aggregated TV channels flexibly via broadcast or unicast, as demand can be met most efficiently, (3) *Live TV/Radio Broadcast*, similar to PSM, with different coverage, content, content protection and funding models, (4) *Event & Venue Casting* delivers premium content services at key events, high density locations like sports stadiums or local service businesses, (5) *Media on Demand* allows numerous users to subscribe to relevant content, e.g., news, sports, stock, weather, and a variety of user generated content either through live broadcasts or device caching, to view them at their convenience, (6) *Off-Peak Media & Software* delivers high demand pre-recorded content, e.g., TV shows, movies, YouTube, subscription content, e.g., eNewspapers, eMagazines and music, applications and firmware updates at off-peak times, and (7) *Internet of Things (IoT)* connects to the clouds to provide ease of management, location-based media services, updates and content deliveries, e.g., smart meters, public TV terminals, connected cars).

5 Conclusion

In this paper, we have developed business models for mobile broadband network operators utilizing UHF spectrum bands with the hybrid shared concept with broadcasting DTT. The concept allows MNOs to access new supplemental downlink UHF licensed

QoS spectrum bands to respond to the growing asymmetric video and new media driven downlink data traffic. In this paper, opportunity driven business models were developed to address the basic questions of a business model: What, How, Why and Where to act regarding the business. The concept discussed could open up new business opportunities for MNOs through dynamic load and traffic management of the significantly increased downlink capacity that can be used to provide different service levels to different customer segments. The lower frequency hybrid UHF bands are a cost-efficient solution for the MNO to respond to the growing data traffic demand in a flexible and timely fashion.

Moreover, the concept could help operators to win over new customers by offering personalized mobile broadband data and "ubicast" media delivery services to selected customer segments. With MBB broadcast concept on hybrid UHF spectrum, e.g., linear, traditional TV broadcast can be extended to mobile devices providing the flexibility to combine linear and non-linear TV, on-demand and interactive TV. This can significantly re-shape the business ecosystem around the mobile broadband and media, and open up new converging and co-operative business opportunities with transforming media and TV industry towards 5G. MNOs are optimally positioned to explore new business model opportunities in parallel with traditional business model.

In the future, hybrid UHF usage concept business modeling studies will need to be expanded to cover also other key stakeholders. In particular, co-operative business model with broadcast domain will be an important aspect to scout.

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