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Abstract—**Mobile broadcast technology has matured to a point where commercial launches are either taking place or being delayed by issues related to regulation, content IPR or business models and revenue sharing. There are several competing radio technologies, mobile broadcast service platforms and numerous handset vendors are producing—or ready to start producing—mobile television capable terminals. In this situation we need to clarify the service concepts and operator roles so that both the academic and industry participants can formulate their views on a common ground, which is namely the purpose of this paper. In addition, the aim is to point out the features rising from the technologies used and the existing business environment, that have most significant consequences to the mobile broadcast value chain and revenue sharing.**

Keywords—**Mobile broadcast, revenue sharing, value chain, DVB-H, operator roles.**

I. INTRODUCTION

This year, 2006, we have seen mobile television systems being piloted and launched and several TV-capable mobile handsets have been introduced. Internationally there are about 20–30 pilot projects ongoing where mobile broadcast and namely mobile television services are being tested, with both technology and business issues under investigation. At the same time, the standardization and integration processes related to mobile broadcast—covering content encoding, IP datacast techniques, electronic service guide (ESG), content protection, purchase, and trust models—have proceeded, however not yet into a fully finalized status. In this context Nokia, world's largest mobile phone manufacturer, has chosen a market enabler strategy in mobile broadcast system integration by developing an IP-based end-to-end mobile broadcast platform, the Nokia Mobile Broadcast Solution (MBS) [1], which is likely to be used in many DVB-H-based (Digital Video Broadcasting – Handheld) mobile broadcast service launches in the near future. The terminology, platform structure, and the operator role definitions of the Nokia MBS are referred to as a starting point in this paper, in order to connect the findings to a relevant real-life example. The purpose of this paper is to define the basic structure of the mobile broadcast business environment, and propose a model on top of which future research on this topic can be accumulated. This paper concentrates on business dynamics, revenue sharing and company roles in the mobile broadcast service market.

A. Research Methods

Research methods used in this study range from case study approach to action research and literature study. In addition to the thoroughly studied case of Nokia Mobile Broadcast Solution 3.0 and its industry and market impacts, the findings have a strong base in writer's field work as a course lecturer for Nokia MBS server system at Teleware Oy and close co-operation with the Nokia mobile broadcast crew in Helsinki.

II. MOBILE BROADCAST OPERATOR ROLES

A. Content Provider (CP)

Content providers, also known as content aggregators, are the mobile broadcasters that run one or many mobile television or radio channels. In the value chain, content providers buy content from content owners (content producers, media houses, movie industry etc.) or produce content in-house. Content providers fund their operations either by pay-TV fees, advertisements or in the case of public broadcasting companies in some countries, television license fees. Within the mobile broadcast platform, the content provider is responsible for producing an encoded audio-video stream, and sending it to the mobile broadcast system [1] run by the datacast operator, and providing the platform with schedules and program information. In the Nokia MBS case, the encoded A/V streams are sent as IP multicast packets over a multicast network, covering the country or area where mobile broadcast services are available. There can be several content providers on one mobile broadcast platform, limitations coming only from the total broadcast bandwidth available in the system. In DVB-H systems using 16QAM modulation total bitrates close to 12 Mbps can be achieved, resulting in a channel count of 15 to 50 depending on the audio and video quality and the amount of bandwidth used for MPE-FEC error correction (Multi-Protocol Encapsulation – Forward Error Correction).

B. Datacast Operator (DCO)

Within the Nokia MBS operator role definitions, a datacast operator is the company responsible for the central

management of a mobile broadcast platform i.e. generating the ESG, orchestrating the IP datacast system (content stream control and management), and provisioning content providers and service operators. In the value chain the datacast operator buys mobile broadcast capacity from the broadcast network operator and re-sells that capacity to content provider companies. Broadcast capacity is a term for having a certain bitrate available for mobile broadcast services in a certain geographical area for a certain time.

C. Network Operator (NO)

The network operator is the owner of frequency licenses. NO operates the IP multicast network carrying the content streams from broadcasters' encoders to the transmitter sites. NO also operates the DVB-H modulators and transmitters in self-owned or leased transmitter sites. In addition, network operators own and operate the IP encapsulators [1] bridging the IP-based multicast traffic (the encoded A/V stream) to the DVB realm, practically transforming a stream of IP packets to a DVB transport stream (TS). The roles of DCO and NO can be assumed by different companies, but the tasks of DCO and NO can perfectly well be carried out by one single company. A Finnish example is Digita Oy, which received Finland's first DVB-H license in March, 2006 [2] and is taking both the NO and DCO roles, providing Finnish broadcasters with DVB-H capacity and platform services.

D. Service Operator (SO)

Service operator is the company responsible for content pricing and selling, as well as primary end-user support. Looking at the Nokia MBS technical architecture, a service operator would be running the Broadcast Account Manager (BAM), a platform component for selling channel bundles and pay-per-view programs to end-users and generating charging details for the purchases made [1]. On a Nokia MBS platform, BAM accepts purchase requests and sends related DRM (Digital Rights Management) rights objects to mobile terminals. Both the purchase requests and the DRM rights object delivery are realized using an HTTP connection, over GPRS, 3G data, WLAN or any available IP return channel.

The day-to-day tasks of service operators include price setting for those pay-TV sellable items (channel bundles, channels and pay-per-view programs) to which content providers have assigned the particular SO as the service operator. This is probably preceded by negotiations and content retailing contracts between the service operator and one or many content provider companies.

III. MOBILE BROADCAST VALUE CHAIN

In principle the value chain of mobile broadcast services is very straightforward. As stated, service operators are the ones who take care of selling, pricing and charging of mobile broadcast services. In addition, services can be branded for each service operator so that end-user gets the look-and-feel

created for the service operator company. Because the service operator takes care of all end-user interactions (purchases, charging etc), the users are likely to see the mobile broadcast service as a product provided by a particular service operator.

On the other hand, content providers are responsible for providing the actual content streams, which is what end-users are interested in and probably are willing to pay for. In between, the roles of DCO and NO are also very important and they have their respective business decisions to make, but for the considerations made in this paper their role is not emphasized. The tasks of DCO and NO are about providing a technical platform for mobile broadcast, and the end-users do not necessarily even know which DCO and NO is providing the mobile broadcast service used. Hence the roles of DCO and NO in the mobile broadcast value chain are confined to the business-to-business context. In this paper we concentrate on revenue sharing, pricing, and perceived end-user value, and for that reason we emphasize the content provider and service operator roles in the value chain. However, the investment decisions related to DVB-H network building are in the very core of the mobile broadcast business logic, and as such they should not be overlooked in future research.

FIGURE 1
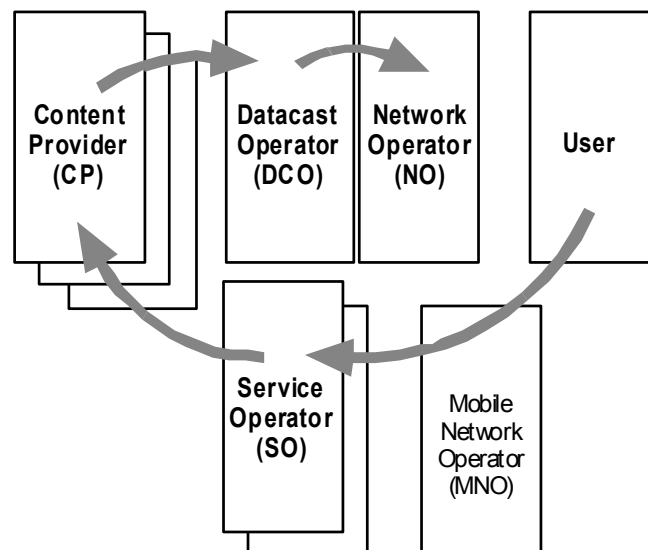MOBILE BROADCAST PLAYERS & REVENUE SHARING

Figure 1 shows how subscription fees are paid by the end-user. Payments are collected by the service operator, which in turn buys content from one or many content provider companies. Content providers buy broadcast capacity and mobile broadcast platform services from the datacast operator. DCO buys physical DVB-H network capacity from the network operator, the owner of the frequency license. Some external money flows are missing from the picture, such as the network investment made by the NO, content procurement costs for the CP companies, and end-user's mobile network usage costs. In a scenario where SO is not a mobile network operator, the cost of end-user billing service should also be added.

A. Revenue Sharing and Asset Ownership

Important factors affecting the mobile broadcast revenue sharing model are content ownership and customer ownership. Content providers—mobile television broadcasters—are the content owners, and hence they have a key role in the value chain. Their broadcast content is what end-users may decide to pay for, and for that reason they have a strong say on mobile broadcast revenue sharing. The more end-user appeal the provided content has, the more bargaining power that content provider company has in negotiating contracts with one or many service operators willing to include the content (typically television or radio channel) in the SO's service offering.

Customer ownership, however, lies in the hands of service operators: SOs take care of all end-user transactions, customer support, pricing and selling services. In addition, the task of SO may be assumed by a mobile network operator (MNO), in which case the SO has a direct access to mobile subscriber records.

IV. DIGITAL RIGHTS MANAGEMENT

A key point in mobile broadcast business is how pay-TV purchases are reliably accounted to a particular end-user, a person ready to actually pay the bill, and how to ensure that the delivery and use of the viewing rights is secure. In principle one could implement any kind of online subscription mechanism, users filling in their contact details and subsequently receiving some kind of digital keys or rights for viewing the content. However, in this scenario we would have to rely on the terminal devices (and users) not to distribute the purchased keys, or viewing rights, to others.

A. CMLA

In order to establish trust between content owners, service operators and end-users, a company called CMLA (Content Management License Administrator) [3] has been founded to function as a trust authority for digital content delivery services. According to CMLA webpage, founder companies Intel, Nokia, Panasonic and Samsung are aiming at providing a trust model for Open Mobile Alliance (OMA) DRM 2.0 technical specification [4]. In short, the main task of CMLA is to certify the DRM implementation robustness of the devices (both end-user terminals and the server side) used in digital content delivery. An example would be a scenario where CMLA gives licenses to DVB-H enabled mobile phones and the service operator's server system, or namely the Broadcast Account Manager (BAM) in the Nokia MBS case. This licensing results in setting up a public key infrastructure (PKI) where CMLA generates a private key—public key pair for each individual terminal, and functions as the key repository and trust provider.

B. OMA DRM 2.0

OMA DRM 2.0 is one of the contemporary digital rights management standards, created by the Open Mobile Alliance organization. It is described here because OMA DRM 2.0 is the DRM specification of choice in the Nokia MBS platform, together with the CMLA trust model.

In OMA DRM 2.0 the digital content is protected with encryption, but the decryption keys are separated from the content to rights objects (RO) which are received separately. In the Nokia MBS case the protected content is delivered over a broadcast medium (DVB-H network) whereas the rights objects are requested and received over an IP-capable return channel such as GPRS, 3G data or WLAN.

The rights object contains a key for decrypting the broadcast content, but the key (CEK, Content Encryption Key / OMA DRM 2.0) is further protected by encrypting it with the terminal's public key, using the public key infrastructure backed by CMLA.

V. TERMINALS AND USERS

In order to convince the content owners and content providers of the content protection mechanisms used on a particular content delivery platform, we have to implement a DRM system and somehow enforce it. Adopting OMA DRM 2.0 and CMLA is a real-life example of this, resulting in trusted devices and secure DRM rights object delivery.

However, the end-users have to be recognized as well. A rather straightforward way of identifying a mobile TV user is to use his/her mobile subscriber identity, the IMSI (International Mobile Subscriber Identity). IMSI is stored on the SIM card, accessible to the terminal whenever a purchase request is made. In addition to IMSI, each mobile phone has an IMEI code (International Mobile Equipment Identity), a unique code identifying the individual device. These two codes, IMSI and IMEI, can be reliably used for recognizing the user and the terminal. The IMSI, in addition to uniquely identifying the mobile subscriber, also contains MCC (Mobile Country Code) and MNC (Mobile Network Code) codes. By looking at the MNC terminal knows the mobile network operator of the user, which makes it possible for the terminal to decide which parts of the available broadcast services are shown for the particular end-user.

A side effect of using IMSI for recognizing the users is that the IMSI must eventually be mapped to a real person with a name and a billing address. This mapping is only available in the MNO's subscriber register where IMSI is mapped to a phone number (MSISDN) and personal contact details.

If IMEI and IMSI are used for recognizing users, as is the case on the Nokia MBS platform, MNOs are given an important role in the mobile broadcast value chain: either MNO companies would have to take care of the SO role, or non-MNO companies as service operators should make contracts with MNOs for getting the mapping of IMSI to subscriber contact information. If a non-MNO company would want to be a mobile broadcast service operator and stay independent from the MNOs, IMSI could not be used for subscriber identification. Instead a separate subscriber

register should be created, using eg. an online registration system. However, also in this case the terminal would have to be trusted by the trust authority (such as the CMLA). This example shows how two different approaches—two different systems—are needed: one for content protection (DRM, trusted devices, a trust model) and one for end-user billing (recognizing users, billing and charging, subscriber registers).

FIGURE 2
MOBILE BROADCAST TRUST MODEL AND RIGHTS DELIVERY
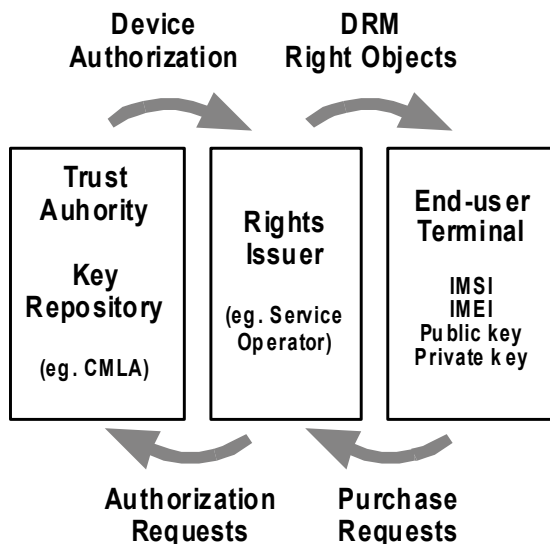
VI. BUSINESS DYNAMICS – INCUMBENTS IN NEW ROLES

Thus far we have discussed the different roles and their respective strengths in the ecosystem, but the interesting point is how to map these roles (CP, SO) to real-life companies such as television broadcasters and mobile network operators (MNO). From these premises we can arrive into three different basic scenarios: the broadcaster approach, the mobile network operator approach, and the co-operation approach [5], [6].

A. Broadcaster Approach

In the broadcaster approach, the mobile television broadcaster company not only provides the channel content but also takes care of end-users. In this scenario the broadcaster company acts both as content provider and service operator. Technically this means that in addition to producing an encoded content stream, the broadcaster has to run the selling, charging and customer support functions as well. In Nokia MBS terms, the broadcaster should run the Broadcast Account Manager [4] for pay-TV service fulfillment (key delivery, charging etc.). MNO networks would only be used for opening an HTTP connection (e.g. over GPRS) from the terminal for the purchase requests and DRM rights object acquisition. In value chain terms this

scenario would be very simple, the challenging part being how to map mobile TV subscribers to real persons, the users of the mobile TV terminals.

In principle the broadcaster company would have three options: to establish a connection to MNO billing and charging system and outsource the end-user billing part; start acting as a virtual mobile network operator (MVNO) with SIM card issuing capability; or implement a billing and charging system totally independent from mobile subscriber information. In the latter case IMSI could not be user for recognizing customers, and a subscriber register system would need to be built up from scratch.

B. Mobile Network Operator Approach

In the MNO approach both the roles of service operator and content provider are taken by an incumbent MNO. A natural benefit of this model is the existence of mobile subscriber base and billing and charging systems. A challenge for the mobile operator would be to establish the processes for providing the channel content, to function as a content aggregator (or producer), which would be an act of significant diversification for most of the existing MNO companies. The value chain would remain simple, especially if DCO and NO roles were taken by a single company.

An extreme of the MNO approach would be a situation where all the roles (CP, DCO, NO, SO) would be assumed by a single company. Real-life examples of this can be seen in the U.S. and Italy, where MediaFLO and DVB-H based mobile television services are planned to be offered by companies like H3G Italy/RRD and Verizon Wireless. In Italy the services have been launched as of June 2006.

C. Co-operation Approach

In the co-operation approach the existing companies would more or less stay in the areas where they have the best existing leverage: broadcasters in content aggregation and mobile network operators in subscriber management and charging. Revenues would be shared between the service operator (MNO), content provider (broadcaster) and the datacast and broadcast network operators. From a real-life process viewpoint the co-operation approach is clearly the easiest to implement, but from revenue sharing viewpoint it is probably the most challenging.

In the co-operation approach the steps needed before mobile broadcast service launch are minimal compared to the previous approaches, because most of the infrastructure and systems is already in place (CP's content aggregation mechanisms, broadcast stream production, content schedules and program information systems, MNO's billing and charging systems, subscriber base, customer care functions).

D. Pricing

A key goal in many of the recent mobile television pilot projects [7] has been to find out about end-users' willingness to pay for mobile broadcast services [8]. Some initial results [9] indicated that monthly payments of 5 to 10 euros per

month would represent a realistic average for mobile broadcast spending, creating a 10-20% increase to current ARPU figures [10] in many European countries.

However, very recent experiences from Italy are showing that customers are in some cases ready to pay surprisingly high monthly payments for mobile television. With already more than 140 000 users [11], the WalkTV service (provided by 3 Italia) has gained popularity despite monthly fees in the range of 20 to 30 euros.

A special question in mobile TV pricing is the availability of clear-to-air channels, either advertisement funded or publicly funded. For example how to treat the viewing rights of channels provided by public broadcasting companies remains an unresolved question in many countries. In Great Britain a normal television license (a license for fixed television viewing in the homes) will also be required for mobile TV viewers [12], and the same applies in Finland.

Another factor influencing the mobile broadcast ecosystem is the IPR (intellectual property rights) for the content that is broadcasted over e.g. DVB-H. In many countries this as well remains an unresolved question. In Finland a law was passed in June 2006 stating that simulcasting the same content in DVB-H as in DVB-T would not require additional IPR payments, but new "only-for-mobiles" broadcasting would [13].

VII. CONCLUSIONS

In addition to the DVB-H frequency licensing and content IPR issues, the revenue sharing mechanisms for the different scenarios is among the most important issues to solve. The three scenarios model presented in this paper works as a starting point, leaving all three on the table as viable choices, suited for different market situations in different countries and regions, in different business environments.

Overall, there seems to be a big momentum in the market moving mobile television closer and closer to mass market adoption. Technical issues have been solved; remaining ones deal with business models and regulation. All competing mobile broadcast standards (DVB-H, DMB, ISDB-T, MediaFLO) are on their own behalf bringing mobile TV to the end-user's wish list worldwide, while it seems probable that only a couple of standards will become truly global.

The first commercial DVB-H launch was seen in June 2006 in Italy [14], and in Finland the commercial DVB-H launch is anticipated to take place in the beginning of 2007 [15], still among the first countries in Europe.

Looking at the revenue sharing models, the presumption of using mobile phones and mobile subscriber identities as the basis for billing and charging has evident effects on the value chain: in this scenario MNOs or MVNOs must have a role in revenue sharing. However, neither CMLA nor OMA DRM 2.0 forces the terminals to be mobile phones. On the other hand, in order to make mobile TV service purchases, the terminal needs to have a return channel—a triviality for modern mobile phones, but not too easily implemented for other kind of devices. Accessible WLAN hotspots do not exist ubiquitously, and the mobility of the mobile TV experience is hence easily compromised. However, unconnected (that is, without return channel) devices for clear-to-air mobile TV reception may well appear in the future.

VIII. RELATED ISSUES AND FUTURE WORK

Issues of great importance but no coverage in this paper include DVB-H transmitter network investment calculations, and quantitative modelling of the presented revenue sharing scenarios.

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