



**HAL**  
open science

## Modelling multi-MNO business for MVNOs in their evolution to LTE, VoLTE & advanced policy

Rebecca Copeland, Noel Crespi

► **To cite this version:**

Rebecca Copeland, Noel Crespi. Modelling multi-MNO business for MVNOs in their evolution to LTE, VoLTE & advanced policy. BMMP '11: Third International Workshop on Business Models for Mobile Platforms: Access and Competitiveness in Multi-Sided Markets, Oct 2011, Berlin, Germany. pp.295-300, 10.1109/ICIN.2011.6081092 . hal-00766676

**HAL Id: hal-00766676**

**<https://hal.science/hal-00766676v1>**

Submitted on 18 Dec 2012

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Modelling Multi-MNO Business for MVNOs in their Evolution to LTE, VoLTE & Advanced Policy

Author: Rebecca Copeland, Core Viewpoint Ltd,  
Kenilworth, Warwickshire, United Kingdom

Co-Author: Noël Crespi, Institut Telecom, Telecom  
SudParis, Evry, France

**Abstract—** The MVNO (Mobile Virtual Network Operator) business in Europe is maturing, with growing pressure on margins. To cope, MVNOs seek independence and flexibility which they can gain by advanced 4G access agnostic technology. This evolution is supported by three overlapping MVNO models: 4G ‘Full MVNO’, Multi-MNO and ‘Always Best Connected’, which are all enhanced by advanced Policy functions. The paper assesses these models against top ten MVNO success factors and argues that the ‘Full MVNO’ model can provide independence from MNOs, that the Multi-MNO model allows flexible mix-n-match services for any taste, and the ABC (Always Best Connected) model gains in optimized costs. The paper also shows that 4G Policy enhances MVNO’s ability to attract users by service variations, variable pricing and aligning user pricing with the suppliers’ charging regimes.

**Keywords-** Full MVNO, MNO, VoLTE, QoS, QoE, LTE, EPC, EPS, IMS, Policy, PCRF, Always Best Connected, multi-MNO, MVNE.

## I. INTRODUCTION

For the past five years the MVNO business model has taken hold. Despite some notable failures and consolidations, MVNO numbers are increasing and their revenue share of the Mobile market is growing. Regulators around the world have issued MVNO guidelines (e.g. India, Ref. [14]), to encourage MVNOs and increase competition. MVNOs business types continue to diversify, but they are universally affected by the rapid growth of Mobile Data services, the squeezing of margins, and the impending rollout of 4G technology.

This paper evaluates the effect of these trends on MVNOs’ market share in several European countries and the drivers to adopt 4G technology that facilitates three models: a) ‘Full’ MVNO model, where virtual operators install their own core equipment, b) Multi-MNO model where MVNO connects to several network providers, and c) Always-Best-Connected model that automates the MNO selection for the MVNO. **Part II** analyses the MVNO market trends, comparing revenues Data and Mobile Voice. **Part III** looks at market drivers for MVNOs and MNOs to implement LTE and VoLTE. **Part IV** examines three complementary MVNO models: the Full MVNO model, the Multi-MNO model and the Always-Best-Connected model. In **Part V**, the role of 4G Policy in enhancing these MVNO models is analyzed. **Part VI** analyses these models against ten success factors, and **Part VII** provides conclusions.

## II. MVNO MARKET EVOLUTION

### A. MVNOs Grow and Diversify

The concept of network-less operators is now well established but it is evolving due to market pressures and new technologies. At the same time, the range of MVNO business models and styles has not narrowed (Ref [4]). MVNOs have spread to Asia and North America but the largest numbers of

MVNOs are found in Europe (Ref [2]). MVNOs specialize in niche markets (e.g. ‘Migrants’) and are quick to latch on to new opportunities (e.g. M2M – Machine to Machine). MVNOs relying on strong distribution and brand, such as supermarket chains, are merely ‘reseller’, as are retail departments of established Telcos, who buy ‘coverage’ from their wholesale department. Telcos also start up MVNO subsidiaries in order to use alternative suppliers or venture into other countries. Other Telcos become MVNOs in order to deliver triple play or quad play, combining IPTV or Fixed Line with Cable, WiMax or DSL access networks (Ref [12]).

### B. MVNO Market Share with 3G Data Volumes

The penetration of the MVNOs takes a different path within each territory, which suggests that MVNO business relies more on regional aspects than the generic service. However, MVNO business anywhere has benefited from the widespread usage of 3G data services in recent years. MVNOs thrive on differentiation based on Broadband Data, whether through their own services or through third parties content.

*Figure 1a* shows the MVNOs’ progress in seven European countries between 2004 and 2009 (based on data from Ref [1]). Despite good growth, in some countries the share of MVNO calls of the total mobile connections has declined slightly. See Germany and Sweden in *Figure 1a*. This is due to consolidations in maturing MVNO market and users returning to established MNOs if the MVNOs no longer demonstrate differentiating features. *Figure 1b* compares the ratio of change in the share of MVNO calls with the change in the number of VoIP subscriptions within the sampled countries. The ratio of growth in 3G Data services is generally high compared with VoIP subscriptions for the same period. The robust growth of MVNO business is not based on plain Voice, but on more intricate service propositions and on regional and niche market opportunities.

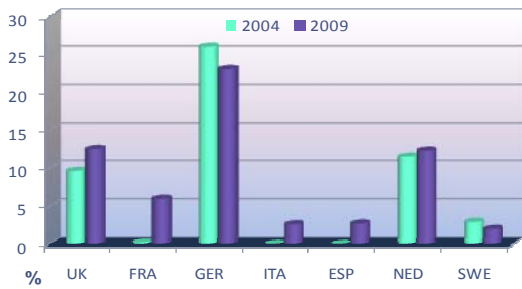


Figure 1a: MVNO share of calls 04-09. Source: Ref [1] data and own analysis

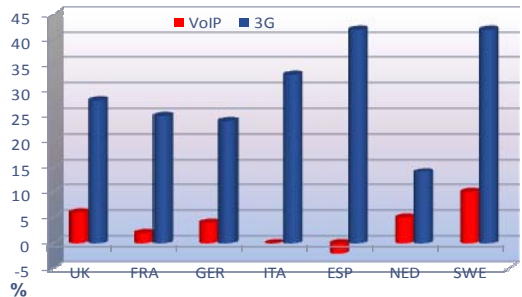


Figure 1b: Change ratio of 3G share of calls and VoIP subscriptions 04-09. Source: Ref [1] data and own analysis

### C. Voice and Data Revenue Levels

As stated by one major European MVNO, building up the brand needs launching new features frequently - every six months". So far, this has been largely achieved by Mobile Broadband Data Services and by Messaging, not Voice. This is reflected in the rise of Data Services revenues, shown in Figure 2a (own analysis using Ref [1] data).



Figure 2a: Data revenues ratio of Mobile Services revenues in 04-09. Sources: data from Ofcom/IDATE, Ref [1].

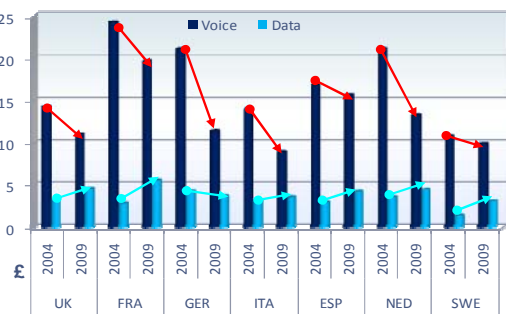


Figure 2b: Average monthly spend on Data and Voice in 04 & 09. Sources: data Ref [1].

The share of Data Services revenue in the total Mobile session revenues has risen considerably in the past five years, reaching average of 25.6%. The average Mobile Voice revenues suffered a sharp drop in this period, shown in Figure

2b, especially in Germany and Netherland. The average drop in Voice revenues is as high as 29.8%. As highlighted in Figure 2b, although Data services have been very successful, the rise in revenue is only modest or flat.

Despite the rapid rise in volumes, the rise in Data Services revenues does not fully compensate for the Voice revenue reduction. Yet, Mobile Voice revenues are still far higher than those from Data, and the average per month still amounts to 74.5% of the combined total revenues. This intensifies the pressure on MVNOs, particularly those who rely solely on lower prices and consequently cannot withstand margin erosion. What's more, the potential revenues of the high profile Data Services is now grabbed by OTT (Over-The-Top) players, such as Google and Facebook, and by independent handsets vendors, such as Apple, with their app stores and large eco system of apps developers.

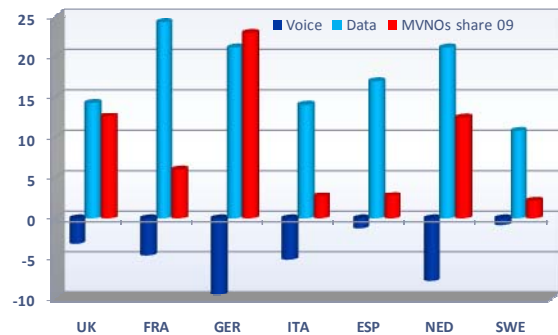


Figure 3: Correlating MVNO share and average revenues from Voice & Data

The decline in Voice revenues can be associated with the number of MVNOs operating within each country. Figure 3 (own analysis of data from Ref [1]) shows strong correlation between the share of MVNOs' Mobile connections and the fall of average Voice revenues. Note Germany at the high end of MVNOs' share and worst fall of Voice revenue compared with Sweden at the lowest share and a smallest decrease.

### III. MVNO / MNO MARKET DRIVERS FOR LTE / EPC

#### A. Drivers for MNOs Wholesale Business with LTE

The original motivation of partnering with MVNOs was the MNO's need to offset infrastructure costs and utilize spare capacity. With the explosion of Mobile Broadband, the spare capacity has disappeared, leaving MNOs with a capacity squeeze instead. LTE is contemplated for coping with high data volume, not for Voice. However, the installation of LTE infrastructure brings fresh CAPEX requirements and the need to reduce borrowing, therefore earning wholesale revenues from MVNOs is still a way for MNOs to fund infrastructure.

Even when MNOs hope that LTE will attract users to the faster service, in many countries this is challenged by the regulators. The spectrum license granted to established MNOs stipulates that they must open their Radio Access networks to new entrants who do not have sufficient coverage, and this is extended to network-less service providers, i.e. MVNOs.

### B. MVNO Drivers to Upgrade to LTE Access

Having established themselves in 3G, MVNOs' drivers towards LTE based Data Services are not apparent. On the face of it, MVNOs have no real reason to migrate to LTE access from the current GPRS/UMTS. They are only concerned with the MNO's ability to fulfill the agreed SLA (Service Level Agreement) terms, whether it is on 3G or 4G.

However, MVNOs addressing early adopters and youth may find LTE appealing to their subscribers, who are drawn to faster, more demanding multimedia web services. For this market, MVNOs can be more agile and more inventive than MNOs and provide niche solutions that exploit video streaming, imaging and web-on-the-go.

### C. The Incentives of Upgrading to Voice over LTE (VoLTE)

Upgrading the Core to Voice over LTE is perceived as risky by both MNO and MVNO. It involves radical transformation of Voice delivery, abandoning the well proven and reliable legacy Voice and Voice services. MVNOs need not hurry into it either. They can safely postpone the upgrade expense because they are assured that fallback to circuit based Voice will be on offer for a long time.

However, Voice revenue deterioration and OTT VoIP are seriously threatening MVNO margins, driving them to look for competitive solutions. In fact, VoLTE could bring more benefits to the MVNO than to the MNO. MVNOs specialize in niche market, convergence and innovative user services, where VoLTE and web applications can bring significant differentiation. In adopting VoLTE, MVNOs can benefit from the user-centric service environment and advanced media services that their young subscribers appreciate.

VoLTE also supports multi-terminal users that many MVNO require for their triple/quad play and enables blending services that are fertile ground for innovation. Therefore, MVNOs have stronger motivation to upgrade to LTE and VoLTE than the MNOs.

## IV. MVNO MODELS FOR 4G

### A. The 'Full' MVNO Model

MVNOs have a combination functions that they undertake in-house and those hosted by the MNO. The mix of these functions varies from reselling only to the full range. Ultimately they can run everything except the spectrum license and the wireless infrastructure, and become 'Full' MVNO.

Figure 4 shows a model of MVNO functionality (Ref [2], [10], [11], [12]). The 'light' MVNO model is sometimes considered not MVNO at all. The 'hybrid' ('medium' or 'intermediate'), has most variations of what equipment is owned and what is hosted. This model also shows the scope for MVNEs (Mobile Virtual Network *Enabler*) who offer to manage the equipment on behalf of the MVNO, but do not have access networks or spectrum licenses.

Full MVNOs own or manage the full core. LTE enables Full MVNOs to separate the access from the core with clear

interfaces, which make integration with MNOs' network much easier. Full MVNO can add their own applications, at their own timescale, responding to market opportunities at their own pace, rather than wait for the MNO to upgrade. Maintaining full User Data, MVNOs can distribute their own SIM cards and fully manage subscribers without MNOs' knowledge or intervention. This enables the Full MVNO to manage triple/quad-play, setting up a structured user identity on multiple devices.

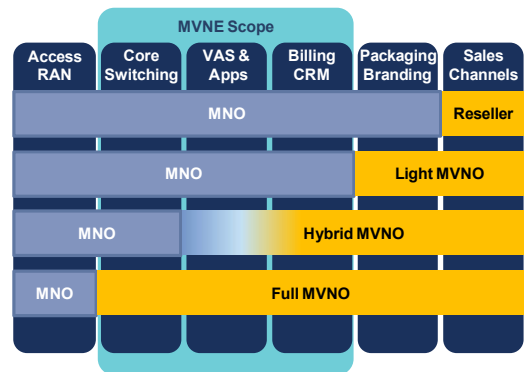


Figure 4: MVNO functional models and MVNE scope

Full MVNOs can set up QoS (Quality of Service) and verify for themselves the network performance against the SLA with the MNO. It also allows MVNO to influence routing and act as a 'visited' network i.e. as a roaming partner. They generate their own charging records and bill in-house, instead of relying on the MNO's billing records. They can manage subscriber relationship better and keep their business information private, even from their MNOs.

MVNOs are also concerned with exploiting user context instead of their MNOs. User intelligence is much sought after for targeted advertising. Full MVNO can use 'Home Routing' policy to route via their own monitoring gateways (instead of the MNO) to record user behaviour information.

### B. The Multi-MNO Model

MVNOs are looking to optimize their offerings and extend their 'reach' by contracting with several MNOs. In this Multi-MNO model, the MVNO is breaking the hosted service package into separate functions and sourcing them from different suppliers. This way, MVNOs can utilize their own capabilities more efficiently and complement their portfolio with 'best-in-class' in each area, as shown in Figure 5.

Multi-MNO MVNOs negotiate supply agreements with several MNOs, but assign each subscriber to only one MNO, who would receive all the hosted services from that MNO. With this model, MVNOs achieve some level of independence and operational choice, and the MVNO business becomes more 'opaque' to the MNOs. This multi-supplier scenario increases the MVNOs ability to negotiate competitive network charges, but decreases volume discounts since users traffic is spread over several MNO networks.

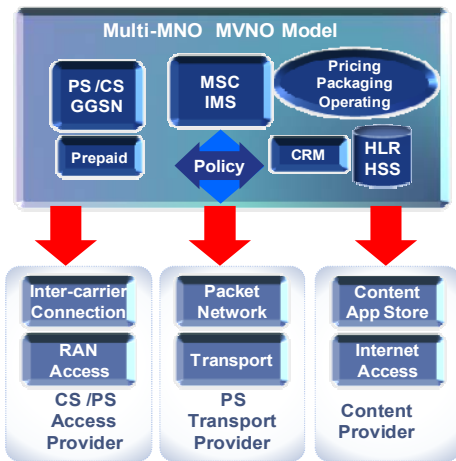


Figure 5: MVNO interfacing to a number of MNOs, with a variety of capabilities.

MVNOs who specialize in a particular field use this facility to vary how they supplement their services in different regions or market segments. This model may be favored by Light or Hybrid MVNOs who aim to leverage their position as a service brokers to multiple MNOs (see Ref [6]), and build up their relationships with third party service and content providers.

The need to connect to multiple different MNO systems in the Multi-MNO model is complex. This becomes much easier when the Full MVNO model is adopted. Alternatively, MVNO may opt for managed services by an MVNE. The MVNE offsets integration costs by providing managed services to multiple MVNOs. This rental service enables MVNOs to be ‘Full’ MVNO without owning the equipment.

### C. The Always Best Connected (ABC) Model

As MVNOs progress towards the ‘Full’ MVNO model, they can implement an advanced case of Multi-MNO model when they apply ‘Always Best Connected’ (ABC) service. The ABC model allows MVNO to choose the best MNO for each connection, not just each user, to reduce costs further (see Ref. [3] & [8]). MVNOs can establish policies for particular connections to carry traffic over different IP networks, including their own. The concept is similar to the Least-Cost-Routing (LCR) in legacy networks and in IP Exchange transit systems, where calls are routed to the network that offers lowest charges according to time and date and destination.

The ABC model in option 3, though advantageous, is difficult to implement. The technical issues include connecting to multiple MNOs, sometimes for only small volumes. Operational difficulties include provisioning subscribers on multiple MNO networks for the same service and managing multiple bills. Commercial issues include weakening the case for volume discount and managing numerous agreements.

### D. Using ABC model for User Packages

The Multi-MNO model and ABC model enable MVNOs to choose from the following options:

- MVNOs can offer users a choice of MNOs, but connect only to the one chosen for each subscription.

Although this choice of networks may attract subscribers, the MVNO cannot differentiate from each MNO’s service package, and users are aware of the serving MNO.

- MVNOs can bundle services from several MNOs (Ref. [3]), to get the best deal *per service* and create mix-and-match packages that address different customer segments. This means that users connect to different MNOs for specific services, but they cannot switch between networks per session. This is more complex to manage but MVNOs are able to launch new offerings frequently and differentiate them from any one MNO package.
- The MVNO connects each subscriber to several MNOs and dynamically switches user service requests between MNOs, without the user being aware of it (ABC model). The network selection is performed according to network congestion, bulk discounts, off peak rates etc. and perhaps also according to automated measuring of QoE (Ref [8]). The MVNO differentiates the service not by the service package but by improved delivery and satisfaction.

	Differentiate & re-package	Invisible to users	Opaque Business	Lower cost
1x MNO per Sub	N	N	N	N
1x MNO per Service per Sub	Y	Y	N	Y
1x MNO per Session	N	Y	Y	Y

Table 2: Comparing options for Multi-MNO/ABC

These models enable MVNOs to gain operational independence and business confidentiality. They also enable MVNOs to fine-tune costs and launch services at their own pace, as summarized in Table 2.

## V. 4G POLICY FOR MULTI-MNO MVNO

### A. The Policy Server for a Multi-MNO Model

Policies define not only the Quality-of-Service, but also when and where better quality is needed. Policies also include charging rules and security rules and can affect traffic routing. Policies are used to manage quota and usage capping, trigger alerts and create context-based services.

4G policy is access agnostic. It is a core function, not embedded in access nodes. Therefore it could be incorporated into the Full MVNO platform and used to decide which MNO to use per subscriber (Multi-MNO model) or per session (ABC Model). Like MNOs, MVNOs can also select best MNO based on the type of service or select according to user identities and service profiles. This means that MVNOs could vary their offerings much more by delivering a preferential service to VIP and high-spenders, or better security for Enterprise users.

The range of Policy options depends on the particular MVNO. Figure 6 illustrate one such example, where the MVNO has its own transport - fixed networks, DSL/Broadband or PSTN. The MVNO also connects to partners’ transport, and need to select when to do so. In this example, this MVNO also has a customer base with WiFi hubs, which is used to access

Broadband Data services as an alternative to Mobile 3G/4G. Therefore the MVNO could optimize the access technology to be used for each type of service.

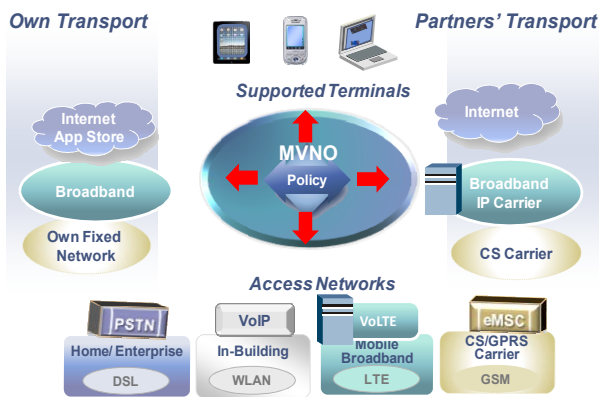


Figure 6: MVNO Policy Server (PCRF) controlling which route to take and which partner to use.

### B. MVNO's Ability to Enforce Routing Policies

The standards were originally conceived with the assumption that the MNO controls both access and core. In this case the same entity that sets up the policy is also enforcing it over the transport network. With a Full MVNO model, the MVNO core seems to the MNOs as another network, therefore the session parameters are negotiated between the MNO's Policy Server and the MVNO's Policy Server.

The MVNO can monitor the execution of the policies via Traffic Detection function if the session is 'Home' routed, i.e. if the traffic is routed via the MVNO's packet network gateway. The performance of each MNO can then be monitored and taken into account when setting up routing policies and in SLA negotiations.

### C. MVNO Charging Policies

The standard PCRF, the Policy and Charging Rules Function (3GPP R8, Ref [7]), combines QoS and Charging Rules functions that were previously separated in GPRS. This PCRF Server sets up parameters for charging and can apply charging rules, according to the type of service, context (e.g. location), user's profile and preferences. It operates in real-time and can initiate event-based changes of policies even in session

mid-stream, if the underlying network has the ability to enforce the policies.

MNOs in Europe have had to install a facility to avoid bill shock and alert roaming users when they exceed a threshold of 3G Mobile Data changes. MVNOs need to comply too, but they do this via their MNOs. They have to convey to the MNO the change in policy when the user reached the threshold. This can be resolved by communication between MVNO and MNO policy servers or by the MVNO Prepaid service system interacting with the MNO transport gateways (see Ref. [15]).

Using the Policy Server charging rules, MVNOs could set up variable pricing to encourage usage at off-peak periods, for example, when the MNO's charges are lower. Prices could also vary according to volume of usage and reflect exactly the MNO's charging regime, thus retaining the margin. Service quality and choice of MNO networks can be made on class of users or type of service. Flat rate could still be offered to users of an MNO that charges flat fee, but usage-based charging should be applied when carriers charge by volumes. Similarly charging policies can help MVNOs to refine charging users for perceived value and move away from the destructive effect of the flat fee (Ref [5]) which causes users to lose the correlation of valued service with what they pay. By giving users a choice, users' satisfaction is raised, and their retention is bolstered.

Controlling QoS and Charging in the same function provides an easy way of linking quality and priority with pricing, and both can be triggered by the same events. Since these rules and conditions can be set by non-technical staff as frequently as they wish, the MVNOs can create a great variety of services by merely entering pricing structures and sets of conditions. This means that even Light or Hybrid MVNOs, not just Full MVNOs, could create policies for their subscribers.

## VI. ASSESSING THE MODELS AGAINST SUCCESS FACTORS

To assess the effects of the three MVNO models and the 4G Policy, a list of MVNO success factors was compiled from the author's customer experience and Ref [10] and [12]. See a summary in Table 3 below.

- Competitive low pricing: offering cut prices for differentiation from established MNOs. Full MVNO model enables independent charging records. Multi-MNO brings different level of pricing, while ABC does so dynamically.

	MVNO Success Factors	Effects of Full MVNO		Effect of Multi-MNO		Effect of ABC	
1	Competitive low pricing	Match charging regime	▲	Lower prices per MNO	▲	Optimised cost	▲
2	Innovative services	AS & media	▲	No effect	○	No effect	○
3	Tariff packaging	Independent charging	▲	Tariff per user/MNO	▲	Unrelated to MNO	▲
4	Niche markets	No effect	○	Selecting suitable MNO	▲	No effect	○
5	Bundling services	Multi-terminal	▲	Higher flexibility	▲	More efficient	▲
6	Promotions	No effect	○	Temporary MNOs	▲	Automated	▲
7	Lower cost base,	Higher CAPEX	▼	Lower MNO charges	▲	Least Cost	▲
8	Favorable regulations	Clear interfaces	▲	National Roaming	▲	Standard connection	▲
9	Benefits to MNO	Less integration	▲	No MNO loyalty	▼	MNOs compete	▼
10	Reach & ubiquity	No effect	○	Fill gaps with alternative	▲	More efficient	▲

Table 3: Effects of Enhancements on Success Factors Advantage ▲ Disadvantage ▼ Neutral ○

- Innovative services: frequently launching attractive new services to appeal to youth and early adopters. This is enabled by Full MVNO supporting any application server. 4G Policy Server allows context based services varied by policy.
- Tariff flexibility and packaging: providing ‘creative’ services re-packaging to fit different interest groups. This can be managed via charging rules on 4G Policy, for Full MVNOs. Flexibility is only per MNO chosen for each user, but with ABC the tariffs and packages are unrelated to any one MNO.
- Niche markets: adjusting the service package for multiple MVNO brands for special needs groups. In a Multi-MNO model, MVNO can select a suitable MNO for the niche market, for example MNO that has geographic presence in the right countries for immigrants. Special rules per user can be set-up to enable specific service variation.
- Bundling services triple/quad play: serving multi-terminal users with consistent policy and charging rules, not just combined billing. Full MVNO integrated user data is needed to manage users’ service profiles for the different terminals by the same policies and charging rules. The ABC model enhances efficiency in different access technologies, automatically selecting the best connection.
- Promotions & regional schemes: creating regional or time-limited variations of charging as marketing campaigns. Though a Full MVNO system may not be needed, the Policy Server alone could automate campaigns. Multi-MNO agreements can facilitate temporary discount agreements, and ABC can automate the MNO selection.
- Lower cost base, higher margins: keeping costs down and retaining margins. The Full MVNO model requires CAPEX investment and effort costs. However, the hosting network costs will be reduced due to MNO competition in Multi-MNO and ABC models.
- Favorable regulations, Standards: using facilities that are defined in the standards to reduce risk and cost. All models are based on standards and benefit from universal standard implementation. ABC in fact is not feasible if MNOs interfaces are not standard.
- Benefits to MNO: keeping up MNOs’ motivation to provide MVNO with a good service. While MNOs welcome the easy integration of Full MVNO, the Multi-MNO and ABC models instill inter-MNO competition and could drive their charges down.
- Reach & ubiquity: achieving good geographic coverage, delivering service wherever users are. Instead of connecting via the MNO’s own interconnect agreements, MVNOs can increase their ‘reach’ by contracting directly to several MNOs. The ABC model can make this more effective.

## VII. SUMMARY

The market analysis in this study shows that the MVNO market is maturing while margins are eroding, and that the growth of Broadband Data revenues does not compensate for the drop in Voice revenues. These market pressures lead MVNOs to invest in ‘Full MVNO’, ‘Multi-MNO’ and ABC models. These three models are greatly enhanced by 4G architecture. While MNOs upgrade to LTE to resolve Broadband Data capacity issues, MVNOs could implement VoLTE early in order to gain an advantage. They can exploit the Policy Server to deliver greater flexibility, manage user centric policies, and link charging rules with the level of service from multiple MNOs. Policies are essential tools for implementing Multi-MNO and ABC capabilities. Policies can be used to select the best connection and implement service variations, for promotions and niche services.

The analysis of the three models and 4G Policy against top ten MVNO success factors indicates that they bring significant value although the higher CAPEX of Full MVNO is a major drawback. In particular, 4G Policy brings advantages to all three models, with no major drawbacks.

## REFERENCES

- [1] “International Communication Market Report 2010” [Ofcom UK](#).
- [2] T. Bassayiannis, Dr. Gregory Yovanof, “MBIT Thesis: Mobile Virtual Network Operator (MVNO)” 2008, [Athens Information Technology](#)
- [3] M.P.de Leon, A.Adhikari “A User Centric Always Best Connected Service Business Model for MVNO”, ICIN2010 proceedings
- [4] “MVNO market size by region & category” [Wireless Intelligence Q2 2010](#)
- [5] David Vorhous, Arindam Banerjee “The multifaceted role of Policy: PCRF and the Personalisation Imperative”, Yankee Group, July 2009
- [6] Johan Hultell et al, “Business models and resource management for shared wireless networks”, Vehicular Technology Conference, 2004 VTC2004-Fall. 2004 IEEE 60th
- [7] 3GPP TS 23.203 Policy and charging control architecture
- [8] Jens Schumacher et al, “Providing an User Centric Always Best Connection”, [PERIMETER project](#)
- [9] “Common Position on symmetry of fixed call termination rates and symmetry of mobile call termination rates”, [European Regulation Group \(ERG\)](#) February 2008
- [10] N.P. Singh “Growth Strategies of Mobile Virtual Network Operators in Oman”, Management Development Institute, Gurgaon, India, Dec 2010
- [11] Mobile Virtual Network Operator basics, [Valoris, October 2008](#)
- [12] Graham Friend, ColegoConsulting “MVNO critical success factors” 2009
- [13] “MVNO Directory” <http://www.telecomsnetworks.com/home/mvno-directory> Blycroft 2011-04-01
- [14] Telecom Regulatory Authority of India “Recommendations On MVNO” 2008
- [15] Rebecca Copeland “Resolving Ten MVNO Issues with EPS Architecture, VoLTE and Advanced Policy”, ICIN2011 proceedings.