Game analysis: Cellular vs. WLAN

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Abstract

To date, the growth of mobile communications has been fuelled almost exclusively by voice calls. However, voice is becoming a saturated market, and with increasing competition forcing lower prices, leading to a trend of declining ARPU, mobile operators are seeking to introduce new services in order to maintain growth.

Industry forecasts predict that revenues from data traffic will compensate for the decreasing voice ARPU and will further grow to become an important portion of the overall mobile operator revenue in the future. From a technological perspective mobile operators can leverage their data service offering using cellular data networks such as GPRS, EDGE and WCDMA, wireless access networks such as IEEE 802.11b, or a combination of both wireless and cellular with various degrees of interworking capabilities.

This paper investigates mobile operator strategies in adopting wireless vs. cellular technologies for leveraging data services. The main purpose of the paper is to highlight the most relevant parameters that may be used in modeling mobile operator strategies in adopting network technologies enabling data service offering to their subscribers.

Keywords: *Mobile operator business, data services, wireless, cellular, WLAN, game theory*

1 Introduction

Until recently we have been living in a world of mobile voice[†] and fixed data. This is bound to become history leveraged by two development fronts coming from the cellular and wireless worlds, respectively. The cellular industry has chosen a gradual evolutionary path towards data services. In the GSM camp[‡] this evolution starts with the introduction of GPRS, offering packet switched cellular data, EDGE, offering enhanced data rates with the introduction of the 8PSK modulation technique, WCDMA, offering higher capacity for bandwidth intensive applications and HSDPA, boosting the downlink data rates further for WCDMA (Figure 2).

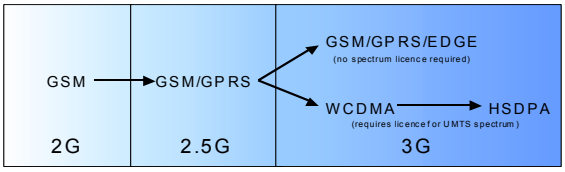

Figure 1 – Cellular data evolution in the GSM camp

The drive for this evolution is coming from declining mobile operator voice ARPU and industry forecasts predicting that mobile data services will become an important contributor to the overall mobile operator ARPU (Figure 2).

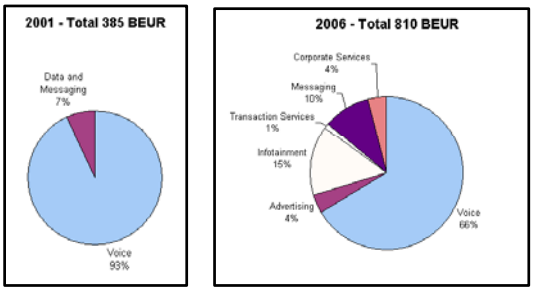

Figure 2 – Global Mobile Service Revenues [1]

In the meantime, IEEE has come up with a wireless LAN (WLAN) standard, IEEE 802.11b which is an extension of the most widely adopted LAN standard, IEEE 802.3.

While several mobile operators are struggling with huge investments required in order to roll out 3G services, other industry players are eagerly exploiting the significantly lower investments

[†] Most 2nd generation mobile networks such as GSM also offer limited CS data services e.g. SMS and dailup.

[‡] A similar evolution exists for the CDMA camp.

required to roll out public WLAN. This disruptive technology has allowed new players to move in on the wireless data opportunity: fixed operators, wireless ISPs, service providers, and premises owners.

This section briefly introduced the drivers behind data services. The rest of the paper is organized as follows. Section 2 presents and compares the enabling bearer technologies for data services, namely cellular and WLAN. Possible interworking scenarios are also introduced. Section 3 investigates possible operator strategies in adopting WLAN vs. cellular technologies and includes some typical pricing schemes. The findings in the preceding sections are utilized in section 4 in order to highlight possible shortcomings and improvement proposals in the way multi-radio operator strategies are provisioned for in the MOB game developed in HUT [7]. Finally section 5 gives a summary and conclusion.

2 Technology overview

WLANs offer high access data rates, but provide limited (hot-spot) coverage, whereas cellular mobile networks such as GPRS and UMTS offer widespread (typically nationwide) coverage at lower data rates. Figure 3 shows the region at which data-rates and mobility requirements intersect, which is where substitution can potentially take place. In reality however, ubiquitous cellular coverage compared to hot-spot WLAN coverage, makes WLAN suitable only for a small subset of data services that are possible over cellular (Figure 4).

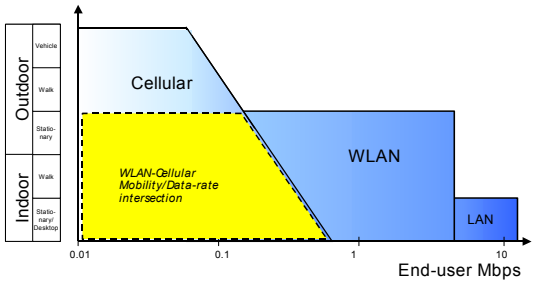

Figure 3 – Mobility vs. end-user data rates

If we take the service set presented in Figure 2 as a reference, then it is unlikely to see widespread replacement of voice and messaging services[§] from cellular to WLAN, simply because of the fact that end-users are accustomed to ubiquitous service availability, continuous reachability, and reliability (QoS) which WLAN cannot provide as a stand-alone technology (Table 1). Nevertheless, this leaves room for WLAN-cellular interworking scenarios where cellular coverage acts as an overlay on top of WLAN hot-spot coverage.

Table 1: WLAN vs. cellular properties

	WLAN	Cellular
Coverage	Hotspots, primarily indoors	Scalable to nation-wide coverage
Spectrum	Unlicensed (ISM)	Licensed
User data rates	Up to several Mbps	~20-500 kbps
QoS	Best effort, load sensitive	Planned and managed. Guaranteed QoS possible.
Mobility	Nomadic. Possibly also session continuity with Mobile IP	Full mobility. Seamless service.
System cost	Low cost. Low entry barriers.	High cost. High entry barriers.
Pricing schemes	Free / bundled / one off / prepaid	Telco model (prepaid / postpaid, etc...)

On the other hand, in the area of corporate and infotainment services, replacement is more likely. In the corporate area, data service availability is usually expected in limited hot-zones[**], which is exactly the domain of WLAN. Nevertheless, interworking with cellular, will be beneficial when compared to isolated hot-zone coverage (section 2.1). For bulk infotainment, such as ad-hoc web-browsing, the end-user *willingness to pay* is typically rather low, which renders such services suitable for WLAN substitution when coverage is available.

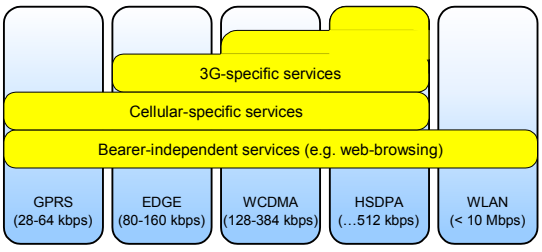

Figure 4 – Mobile service environment

[§] which collectively represent 76% of the projected global mobile service revenues in 2006 according to [1]

[**] such as corporate premises, airports, and hotels

2.1 Disruptive vs. complementary

WLAN and cellular access are not necessarily orthogonal technologies. It makes little commercial or strategic sense for mobile operators to invest in public WLAN as a standalone business. Integration of public WLAN and mobile cellular networks is clearly more persuasive. The different levels of coverage and performance afforded by different access technologies lead to a compelling vision of users always being connected via the best technology for a specific service, seamlessly switching between different data bearers when required.

WLAN-cellular has also been recognized by the main 3G standardization fora, namely 3GPP and 3GPP2, which are both investigating and standardizing WLAN-cellular integration. The 3GPP feasibility report on WLAN-cellular interworking [2] lists the following interworking scenarios, each representing different degrees of integration:

- **Scenario 1**: Common billing and customer care
- **Scenario 2**: 3GPP system based access control and charging
- **Scenario 3**: Access to 3GPP system PS based services
- **Scenario 4**: Service continuity
- **Scenario 5**: Seamless service continuity
- **Scenario 6**: Access to 3GPP CS Services

2.2 Risk of canibalization

Clearly, the adoption of WLAN may also be seen to impose certain risks to the mobile operator's core businesses, i.e. cellular voice and data. On the other hand, if mobile operators do not adopt WLAN technology they risk being outflanked by new entrants such as fixed-line operators and startups in the mobile service provisioning business. By adopting WLAN technology, mobile operators can mitigate the threat this technology poses to its mobile data business by preventing some of the revenue from being lost to other WLAN service providers. By exploiting synergies leveraged from their cellular offering, mobile operators are arguably also in a better position than other WLAN service providers in becoming major players in the public WLAN services market.

2.3 Roaming issues

Roaming is a familiar term in cellular network. In public WLAN, roaming gains even more importance due to the WLAN coverage characteristics. Figure 5 illustrates the cellular-WLAN interworking model as seen by 3GPP. In this model, WLAN roaming is leveraged by bilateral roaming agreements between mobile operators. This model provides clear advantages compared to bilateral roaming agreements between WLAN hot-spot providers. Mobile operators will most likely adopt this model, compared to centralized roaming-agreements involving a clearing house [4].

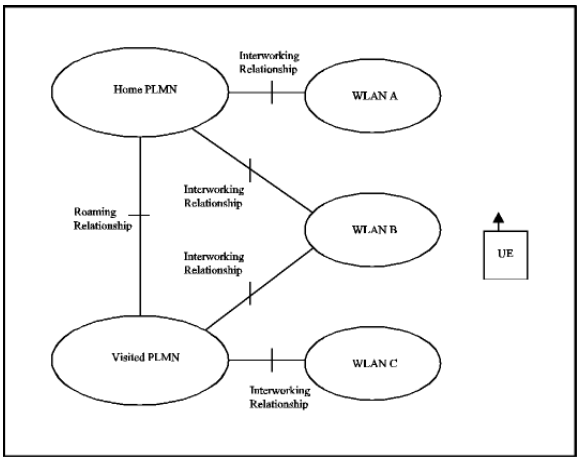

Figure 5 – 3GPP-WLAN interworking model [2]

2.4 Terminal issues

Whereas single-mode WLAN terminals may be considered as a threat by mobile operators, multi-mode WLAN/cellular devices have started to emerge[††]. Such hybrid terminals may also take benefit of the SIM card as an enabler of WLAN authentication by reusing the cellular authentication infrastructure.

[††] for example the Nokia D211 multi-mode PCMCIA card

3 Operator strategies

Having studied the opportunities and threats associated with WLAN, we now proceed to explore potential mobile operator strategies with respect to WLAN. These can be broadly classified as *compete*, *co-habit*, or *combine* [5]. The following sub sections elaborate on each of these strategies.

3.1 Strategy A: compete

The first strategy available to mobile operators is to tackle WLAN service providers head-on by competing directly for *nomadic* (semi-mobile) customers. This could be achieved solely using cellular technologies, or by adopting their own WLAN access service. The first option arguably has some flaws in terms of price competition vs. WLAN.

Operators which can be seen to adopt this strategy are Hutchison 3G with their cellular offering and Telia which competes directly with its own WLAN offering.

3.2 Strategy B: co-habit

The premise behind this strategy is that cellular and WLAN technologies serve essentially different markets. Therefore, although there is some customer crossover, mobile cellular operators may not initially view the public WLAN as lucrative enough to invest in WLAN infrastructure. If and when WLAN gains sufficient momentum, these mobile operators may pursue roaming agreements with WLAN access providers and possibly resell WLAN access provider services from third-party partners to their corporate customers.

This strategy can be pursued as a low-cost, low-risk, short-term solution by some mobile operators. However as the WLAN revenue grows, it is more likely that mobile operators will be forced to become directly involved.

In year 2003 we have witnessed several Operators shifting away from this strategy towards one of the other strategies.

3.3 Strategy C: combine

In this strategic scenario, instead of rolling out their own WLAN infrastructure from scratch, cellular mobile operators may form alliances with WLAN access providers. These partnerships could take several forms:

- Strategic alliance based on Memorandum of Understanding
- Strategic alliance based on the acquisition of a direct stake in the WLAN access provider, which retains its brand
- Acquisition of the WLAN access provider which is then re-branded under the mobile cellular operator's own brand.

Operators who have adopted this strategy include T-Mobile USA who have acquired WLAN assets from the bankrupt public WLAN pioneer Mobistar, and Swisscom who has acquired and combined two leading startup public WLAN operators in Europe – Megabeam and WLAN AG.

3.4 Pricing Schemes

Figure 6 shows a typical subscriber payment model for public WLAN service and how the revenues are split between various stakeholders.

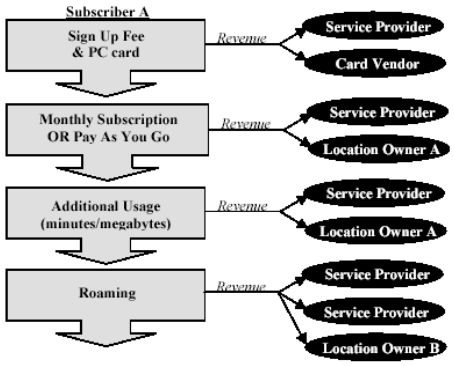

Figure 6 – Public WLAN payment structure [5]

Table 2 compares public WLAN (*flat rate*) pricing levels from different operators, globally. In reality most operators also offer one or more block pricing packages. Usage-based charges are typically time-based, but some operators use traffic-volume as a parameter.

Table 2 – Public WLAN pricing [6]

Top PWLAN operators	Unlimited access (US$/month)	Region
Telia	176	Nordic
BT	134	UK
Megabeam [1)]	119	Europe
WLAN AG [1)]	94	Germany
T-Mobile UK	74 [2)]	UK
Regional average	***119***	***Europe***
AT&T Wireless	70	U.S.
Boingo	50 [3)]	U.S.
T-Mobile USA	30 [4)]	U.S.
Wayport	30	U.S.
Surf and Sip	20	U.S.
Regional average	***40***	***U.S.***
Hanaro	24	South Korea
KT	20	South Korea
NTT DoCoMo	16	Japan
NTT Communications	13	Japan
Softbank/Yahoo!	13	Japan
Regional average	***17***	***Asia Pacific***
Global average	**59**	**All of above**

Notes. 1) Acquired by Swisscom in March 2003
2) Promotional tariff
3) Reduced from $75/month
4) Reduced from $40/month
Prices converted to US$ using rates on 31 March 2003
Regional averages are for major operators listed, not all operators in region
Source: Planet Wireless Hotspot Operator Database

Several operators have announced plans to bundle WLAN access with their cellular offering. Sonera already offers a bundled *Company Data* service that includes access via GSM, HSCSD, GPRS and WLAN for a monthly fee plus usage charges (**Table 3**).

Table 3 – Sonera Company Data Service Pricing

Subscription	€3.36/mo.
Bundled services	**Usage charges (€)**
GPRS	1.95/MB
wGate	0.37/min. (FIM2/min.)
HSCSD	0.18/min. (1 channel), 0.26/min. (multichannel)
SMS	0.14/message

Note: Prices do not include VAT.
Source: Sonera

4 WLAN vs. cellular strategies in MOB game

MOB is a mobile operator business game developed in HUT [7]. The game simulates mobile operator business environment. MOB includes a various cellular technologies and WLAN as access technologies.

This section highlights some possible shortcomings and improvement proposals in the way multi-radio strategies are provisioned for in MOB game.

4.1 Market players

As it has been highlighted earlier in this paper, when it comes to WLAN service offering, mobile operators are not only competing between themselves, but other competitors are also present in the battle. Fixed-line operators and startups, are not taken into account in the MOB game, for example.

4.2 Licensing issues

Operator strategies with respect to WLAN may vary depending on whether the operator holds a 3G license or not. Operators that do not hold a 3G license may arguably see less risk in WLAN, and see it more of an opportunity. This leads to a higher likelihood for such an operator to choose an early adoption strategy for WLAN. In the MOB game, all operators are inherently assumed to hold a 3G license, which is not the case in reality.

On the other hand, due to the fact that WLAN spectrum is unlicensed, early and quick adaptation of WLAN is essential if operators want to gain footprint over prime locations, such as airports.

4.3 Degrees of WLAN-cellular inetworking

Section 2.1 presented interworking scenarios various degrees of integration between WLAN and cellular systems as seen by 3GPP. Depending on the interworking scenario the impact on the mobile operator will be different. For example, interworking-scenarios 4 or 5 leverage cross-fertilization across the access technologies, possibly resulting in an overall data market size bigger than that which can be sustained with isolated access technologies.

4.4 Mobile Operator Strategy

Section 3 presented a broad classification of possible operator strategies with respect to adopting WLAN. *Strategy A* (compete) and *strategy B* (co-habit) can be easily modeled in MOB. *Strategy C* (combine) is however currently not possible in MOB, since mobile operators are the only modeled market players in the game.

4.5 Pricing Schemes

Typical public WLAN pricing schemes have been investigated in section 3.4. When compared to MOB, the block-pricing using time-based surcharges scheme which appears to be the most commonly utilized scheme in practice, is missing from the MOB game. In addition, we believe pricing models bundling cellular and WLAN access will predominate amongst cellular mobile operators with a WLAN service offering.

4.6 Service offering

Cellular data goes beyond raw-bitpipe services to the Internet. In the coming years we shall witness the introduction of several new cellular data services such as *Push to Talk over Cellular (PoC)* [8] and *See What I See (SWIS)*. Person-to-person messaging services will benefit from interworking with other access technologies, but one can hardly imagine widespread replacement taking place, since subscribers are accustomed to ubiquitous service availability, continuous reachability, and reliability (QoS) which WLAN cannot provide as a stand-alone technology.

4.7 MOB Game: Improvement proposals

Modeling of the multi-radio game between mobile operators is a complex task, particularly at this early evolutionary stage of the mobile data battle. Nevertheless we believe that the licensing issues presented in section 4.2 and the pricing schemes presented in section 4.5 (particularly the cellular-WLAN bundled package model) should be rather straightforward to implement in MOB. We believe these additions will improve the way in which MOB models the multi-radio game with a higher correlation to the real-world.

5 Summary and Conclusions

In this paper we have presented the multi-radio dilemma that mobile operators are currently faced with when executing their mobile data strategies. We have presented a broad classification of possible operator strategies which was first introduced in [5]. Finally we have investigated how the multi-radio game between mobile operators is modeled in HUT's MOB game, including possible shortcomings and improvement proposals. In essence the multi-radio game in MOB is somewhat over-simplified when compared to reality. On the other hand, reality is way too complex, particularly at this early evolutionary stage of mobile data the battle. We thus limit ourselves to propose only a subset of the identified divergences between MOB and the real-world.

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