TECHNOLOGY AND APPLICATION CONSIDERATIONS FOR 3G PROFITABILITY

Peter G. Cook (HYPRES, Inc. Elmsford, NY, USA pgcook@hypres.com); Stephen Hope (Orange PCS, Bristol, UK stephen.hope@orange.co.uk); James E Gunn (jimgunn@ieee.org)

ABSTRACT

As markets develop Wireless Service Providers are increasingly finding that there is an interaction between the architecture of the system they are using and the business model under which they are operating. The SDR Forum has investigated this interaction. SDRF has also made a number of documents available to its members that provide a wealth of quantitative information about the market. This paper offers an SDR Forum Business Model coupled with data originally from the Wireless Infrastructure Technology & Markets [1], hereafter Gunn, a document available to SDRF members. The specific numbers provided in this paper has been updated to reflect data available in 2004.

Significant investment has been made particularly by European Service Providers to purchase a license to operate third generation systems, in most cases, incurring significant debt. In the UK alone some £22Bn was raised by government and while the Service Providers had every intention to rollout the networks as soon as possible in order to start making some return on the investment, technical difficulties in the operation of the infrastructure and a lack of 3G handsets has meant that deployment has been much slower that originally envisioned, While existing GSM Service Providers in general have deliberately delayed the full 3G launch until the issues have been addressed, being supported by their existing revenue stream, greenfield operators have been forced to launch at an earlier stage of development and also establish mobile virtual network operator (MVNO) relationships with 2G Service Providers in order to establish a market position. 2.5G particularly in Europe and Asia already offers a wide variety of services and in order to establish a new 3G revenue stream in an already mature and highly competitive market place, the development of innovative 3G data services has become a key driver. This has lead to the involvement of many new actors and the formation of strategic partnerships which has subsequently lead to significant changes to the traditional mobile business model for everybody.

In this paper we look at the impact of some of these changes to the model, and suggest some of the considerations faced in optimizing network operations as the operating mix changes from predominantly voice and SMS towards the support of a wide range of applications with varying system impact and revenue potential. To support the delivery of such innovative services in a seamless manner "*Anyplace Anytime Anywhere*" the concept of end-to-end network reconfigurability encompassing the benefits offered by Software Defined Radio is also in development. Therefore this paper also introduces the idea of functional granularity as a parameter of end-to-end reconfigurability.

1. INTRODUCTION

Wireless systems initially provided a means of connecting to the wireline telephone networks from a mobile terminal, free of the constraints of a wired connection. A need for the same mobility with text messages also emerged in the form of pagers as separate devices. In areas where GSM technology was in use, however, the development of the short message service (SMS) using the same terminal for both voice and data has largely supplanted the Pager Market. Interestingly, the success of SMS as the key data revenue driver, now running at some 2Bn messages a month in the UK alone, was not perceived at all by the marketeers in the early days (only the engineers!).

Added features for more effective data handling led to 2.5G system developments according to the standards such as HSCSD and GPRS for GSM. More recently, EDGE, an enhancement of GPRS, is being considered by both GSM Operators and also CDMA IS-95 operators who do not have a "3G" license. Although EDGE offers comparable performance to 3G technologies, it has a greater cost per bit. The architecture of 3G systems was developed to provide significantly enhanced data services and increased system data capacity although it also offers cost effective voice capacity. In general, however, it is the enhanced data services for which 3G is seen to be the key technology.

As stated above, the technological difficulties of the infrastructure development and the lack of availability of 3G Handsets combined to delay the introduction of 3G W-CDMA services significantly beyond the originally

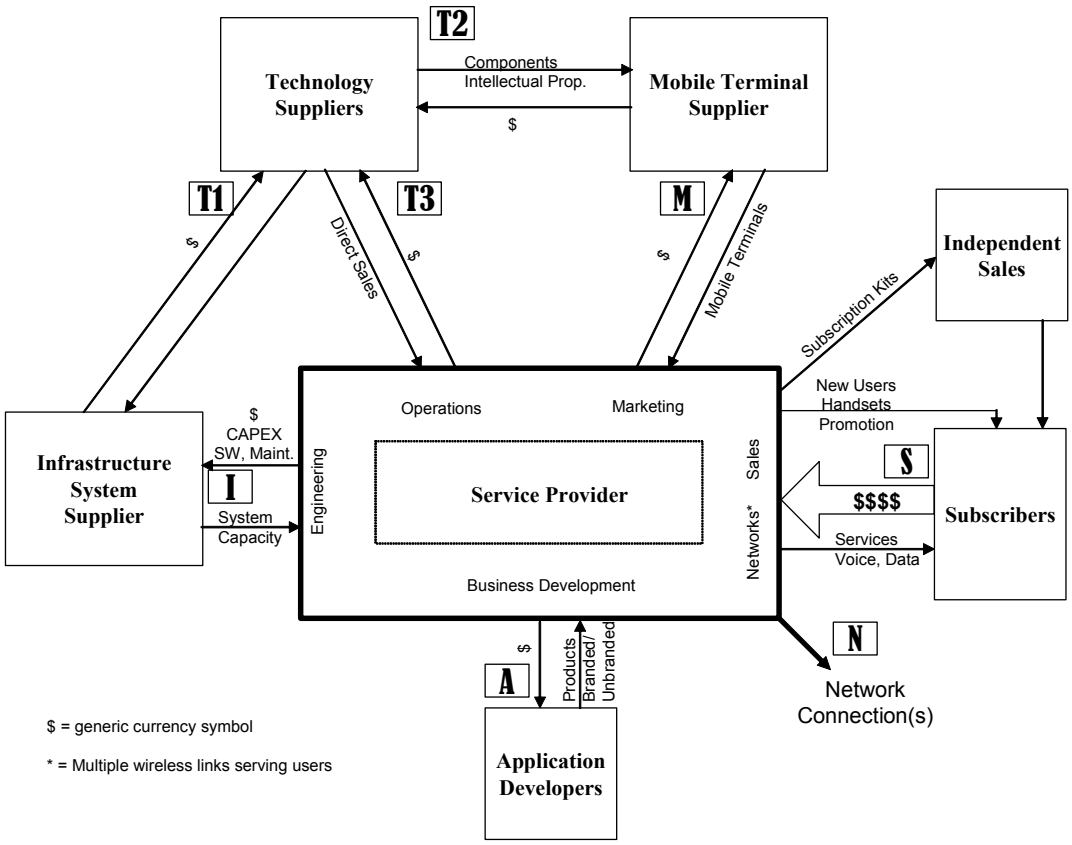

Figure 1. Wireless Business-Technology Model

anticipated timetables. Service Providers, although having established a number of framework agreements with selected suppliers, tended to delay orders for the new equipment while technological problems existed. Similarly, although the CDMA world was less impacted by technical problems in their introduction of CDMA-2000 they also suffered from the disrupted capital markets of the past five years.

The infrastructure providers were then caught by the double pressures of reduced sales at the same time they faced burgeoning development cost for the new systems and overcoming the technological difficulties. These problems in turn predicated a sea change in the market approach of equipment vendors. Out of necessity they have opened their architectures and interfaces to third party vendors rather than maintaining their prior completely proprietary stance. Operators' need to introduce a stream of features and capability enhancements to support marketing programs also introduced a demand for enhanced performance and more system flexibility on the infrastructure suppliers.

Demand for new applications was met by enhancements to existing systems, resulting in greater than anticipated dependence on interim solutions such as GPRS to transfer data. Some of the data to be transferred was the result of user activity with email and phones that take pictures, but much was provided by a new generation of application developers. Some of these organizations provided applications to be marketed under the Service Providers' brand, while others maintained their own application brand identify, and used the network as a delivery mechanism.

In the face of these developments mobile terminal sales have still remained buoyant, albeit with increased price pressure and a competitive race to support new applications such as cameras built into phones. Gunn reports (Table 4-13) that replacement phones represented more than half of the market in 2002, as users want newer features, size reduction, and performance enhancements. A consumer view of handsets as readily replaceable makes introduction of new features easier and provides additional sales for handset manufacturers.

A model showing interactions between these major players in the wireless market is shown in Figure 1. In the sections that follow we will look at the revenue flows for these major players, and explore implications of the 3G delay on their sales and system architectures.

2. THE WIRELESS MODEL

Figure 1 shows the principal players in the wireless market place and their interfaces. This picture is service provider centric as these organizations have provided the entrepreneurial impetus to establish this market. In the

future, as data becomes an increasingly important component of the traffic mix, the role of Service Provider could increasingly become that of connectivity provider for applications carrying their own brand.

Subscribers are the driving economic force in this market. Their annual use of and payment for services is over $500B. We will attempt to provide some indication of how those revenues are distributed across interfaces between the various players.

Subscribers connect to the network using a terminal. In the past there has been segmentation of network architectures, terminals, and applications. In the future those walls will disintegrate, with a user able to make a voice call, send a picture, or receive specific data over a cellular connection, an 802.11 hotspot, or a Bluetooth link connecting to a wireline circuit, an IP connection, or a local mesh.

As voice usage approaches saturation, market growth will depend on increased demand for applications. Subscribers will consume services up to some economic level for fun and personal convenience. Growth above that level will depend on introduction of applications that are perceived as real value.

Letters are assigned to the major interfaces between market players in this model. In the sections that follow we will attempt to quantify those interfaces using information from Gunn, updated for information available since the original report was issued. Our intent is to describe a format so that new information can be plugged in to refine the numbers as it becomes available.

3. SUBSCRIBERS

As we have indicated, revenues from subscribers fuel the wireless economic engine. Gunn provides us with information to describe just how much is involved. He indicates in Chapter 4 the Average Revenue per User (ARPU) for a number of different geographic areas for year-end 2001, here updated for 2003. Using weighted averages, we can derive the following:

2003 ARPU by Area		
Area	M Subs	ARPU
W Europe	310.1	$29.00
US	158.7	$49.50
China	269.1	$14.50
Japan	86.7	$69.00
Korea	33.6	$33.00
Total	858.2	$32.44

This value of $32.44 represents ARPU data for 63.4% of the world-wide total subscribers of 1,353M for 2003 based on updated estimates by Gunn for his Fig. 4-5 on page 115. Using the number of subscribers by year yields the following table:

International Wirelesss Subscribers & Service Revenues; from Gunn Fig. 4.5 (Updated)							
Year	2002	2003	2004	2005	2006	2007	2008
M Subs	1,136	1,353	1,525	1,690	1,871	2,058	2,244
$ B	442	527	594	658	728	801	874

So the revenues flowing across Interface **S** for the year 2003 are $527 Billion, a substantial amount of money for a twenty-year old industry.

4. MOBILE TERMINALS

In order to take advantage of these mobile services, the subscriber needs to have a terminal. These devices, once bulky, now fit conveniently in the palm of the hand. With improvements in battery technology and the power reduction made possible by transition to digital technology, handsets can operate for several days without recharging under normal conditions. At this point in time voice is still the primary application.

Handset Market, Update Gunn Table 4-19

Year	2002	2003	2004	2005	2006	2007	2008
Units (M)	411	515	605	700	803	908	1000
$B	66	76	85	95	104	116	127

In updates to Table 4-19, Gunn indicates that for 2003 overall terminal sales were 515 million units at an estimated average selling price of $147. Gunn then estimates the total handset market for 2003 to be $76 B across interface **M**.

5. INFRASTRUCTURE

Cellular infrastructure provides the landside termination for the mobile wireless link with its base stations and seemingly ubiquitous towers. Key to the cellular architecture is a dispersed set of base stations operating at low power instead of a centrally located high-power site. By keeping the power low, the same operating channel can be used in a number of dispersed locations at the same time.

Gunn provides the following table representing the total flow of funds across the **I** interface, with international estimated service provider expenditure with network equipment vendors, total base stations in service, and average infrastructure expenditure (including core network and services) per station. assuming that 1/3 of installed base stations are either new or upgraded to 2.5G or 3G

technologies. Value of electronic equipment is taken as 25% of the $K/BS figure.

Total Infrastructure vendor payments, Installed BS, $ per BS -Gunn Table 4-33 (Updt)							
Year	2002	2003	2004	2005	2006	2007	2008
$B Rev	45.9	43.8	45.1	47.6	50.5	53.6	55.1
K BS	711	771	830	899	986	1,096	1,175
$K/BS	194	170	163	159	154	147	141
$K Elec. Equip./BS	48.5	42.6	40.7	39.7	38.4	36.7	35.17

In addition to the electronic equipment, the cost of a complete base station includes site acquisition and construction, a tower, antennas, and other items. Gunn's numbers for total cost to operators at the **I** interface vary from less that 50% (existing cell site upgrade) to 2 to 3 times the cost of electronic equipment for greenfield deployments. Even with the cost of base stations falling significantly, the investment to field 3G capability will probably stay in the $25-35B and eventually more area for the next several years.

These lean years have been a pothole in the road for infrastructure developers, and have provided an interesting example of the interaction between the business case and architecture of cellular infrastructure. In the past the system providers maintained tight control over internal interfaces within the system, and made all of the internal components proprietary. With this decline in sales, the system is being opened up so that third party vendors can provide major units such as power amplifiers. New organizations, such as the Open Mobile Alliance (OMA) and Open Base Station Architecture Initiative (OBSAI), have been formed to promote these ends. In Europe the End-to-End Reconfigurability (E2R) Consortium is working on integrated but heterogeneous network architectures.

Infrastructure investment and management is a key performance area for network operators and service providers. The wrong investment results in idle capacity, and revenues inadequate to repay the capital investment. Inadequate capacity leads to inability to support system load demands, lost opportunity for revenue, dissatisfied subscribers and higher churn. These decisions are particularly difficult when equipment replacement is involved in moving capacity into new incompatible protocols.

Flexibility available from SDR has significant potential for reducing both the cost and problems associated with capacity as the desired reconfiguration can be accomplished with software rather than hardware changes. Problems often associated with newly developed services can also be relieved by software modifications.

Improved system performance provides an opportunity to generate more revenue for the same amount of capital expenditure. HYPRES superconductor micro-electronics (SME) technology is particularly promising in base stations. Very high-performance analog-digital converters provide a means of converting directly from channel frequency to baseband. Correlation-based receivers offer improved sensitivity and selectivity, and can operate in real-time with SME implementations. SME also offers performance sufficient to pre-distort transmitter input to cancel out transmitter and power amplifier distortion. These capabilities reduce the noise floor, correct for multi-path, reduce interference, and improve channel capacity.

Another enhancement to system architecture is the ability for a single high-performance infrastructure to support multiple services. Within the SDR Forum this capability has been called the network-oriented base station (NOBS). With the concept telephone, public safety, and telematics applications could operate over the same infrastructure using completely different protocols.

Functional granularity for reconfiguration is a measure of the flexibility of network systems. At a coarse level of granularity large functional blocks, such as an entire GSM BS are treated as a single element. At a fine level of granularity, individual functions, such as a receiver module, can be incorporated to meet operating requirements. Finer levels of granularity require a more open system, and a much larger number of well established interfaces. These concepts are also being developed within the E2R consortium.

So with prospects for greatly improved flexibility and performance, improvements in infrastructure architecture are opening the door for additional services and revenue sources. The historic silo structure of the market is showing radical change.

6. APPLICATIONS

Voice has been the dominant application of the first two decades of the wireless telephony market. Gunn (Table 4-2) indicates that most cellular markets in Europe are in the range of 60-80% penetration. Although the US, at 45% and China near 30% penetration still have significant room for growth by adding subscribers, those substantial markets with already high penetration can increase revenues only by providing new services that either carry higher billing rates or increase billable time.

The opportunity is introduction of new applications that users will use and pay for. Sometimes services that are initially incremental establish themselves as indispensable. Voice itself has made that transition, so although competition has reduced prices considerably, the

average subscriber, as we have indicated, pays $32.44 a month for service, for the most part without worrying much about justification.

There are a number of applications that will be supplied under the Service Provider's own brand, and not independently marketed. Weather, telephone number information, yellow pages, traffic reports, financial market information, and sports scores are generic offerings of interest to a wide audience. They can be offered by the service provider to build revenues.

There is another class of application where users value the service as part of their work, and consider the resulting billings as part of the cost of doing business. Many thousands of small niche opportunities exist for application development using the service providers as a communication link, but carrying their own branding, and perhaps even separate billing. Real estate agents are one example. They currently subscribe to the multiple listing service, usually in book format. An incremental application could be an alert system, where notification was available for any transaction involving a specific house. The agent could subscribe to alerts on a house under consideration by clients, and if a competitive offer was made could mount a response.

Surveyors devote effort to differential GPS, establishing the current corrections need to improve GPS position accuracy. A service offering might be to provide those corrections over the wireless network in a given locale.

Marketing to such specific application needs, and providing support for connectivity through their networks is a significant opportunity because the number is large, not because any one of them can generate major revenue.

Inherently, however, it is likely that there are some of these niche services might develop into "killer applications". Secure financial transactions are one such possibility. In this application the mobile handset replaces the familiar credit card. The user applies to either the service provider or a bank for a credit "card", which we can call a credit access method (CAM). Rather than a conventional card, the services are installed in the phone. When a local charge is to be made, a Bluetooth link to a desktop unit replaces the familiar credit card swipe.

A transaction from home can be made with a phone call or through the Internet by providing a WiFi connection so the terminal is on a home LAN. A handset menu option allows the CAM number to be transmitted digitally with security protection. A new architectural feature for this interesting new market is for the receiving merchant's system to initiate a call or data message back to the purchaser's phone, where a secure protocol confirms the CAM's authenticity, and advises the user of the charge. The subscriber can also be asked to approve the charge using the phone. Fraudulent CAM use is precluded with this system because the approval mechanism can be cancelled if the phone is lost or stolen.

Each financial transaction under such a system would be charged at a small rate, perhaps $.10-25. If such a system could achieve 10% of the 109M Visa credit card transactions made each day, a ten cent charge would generate $1.09M revenue per day. To the subscriber with 20 such transactions, the $2.00 charge would seem quite reasonable for the security provided.

At present information is not readily available about the revenue at the A interface. It is clear, however, that third party applications are a major potential source of market growth for wireless systems.

7. MARKET MIX OPTIMIZATION

There are a number of different applications that a Service Provider can offer. Some of them have little impact on the system loading, while others consume a much larger bandwidth. Looking at another dimension of application consideration, there are some applications that are highly valued by users, while others are of casual interest.

Figure 2 shows a picture of the space described by these two attributes. One dimension shows system impact, the other revenue potential. (The positioning of applications in this picture has not been confirmed with operating data.)

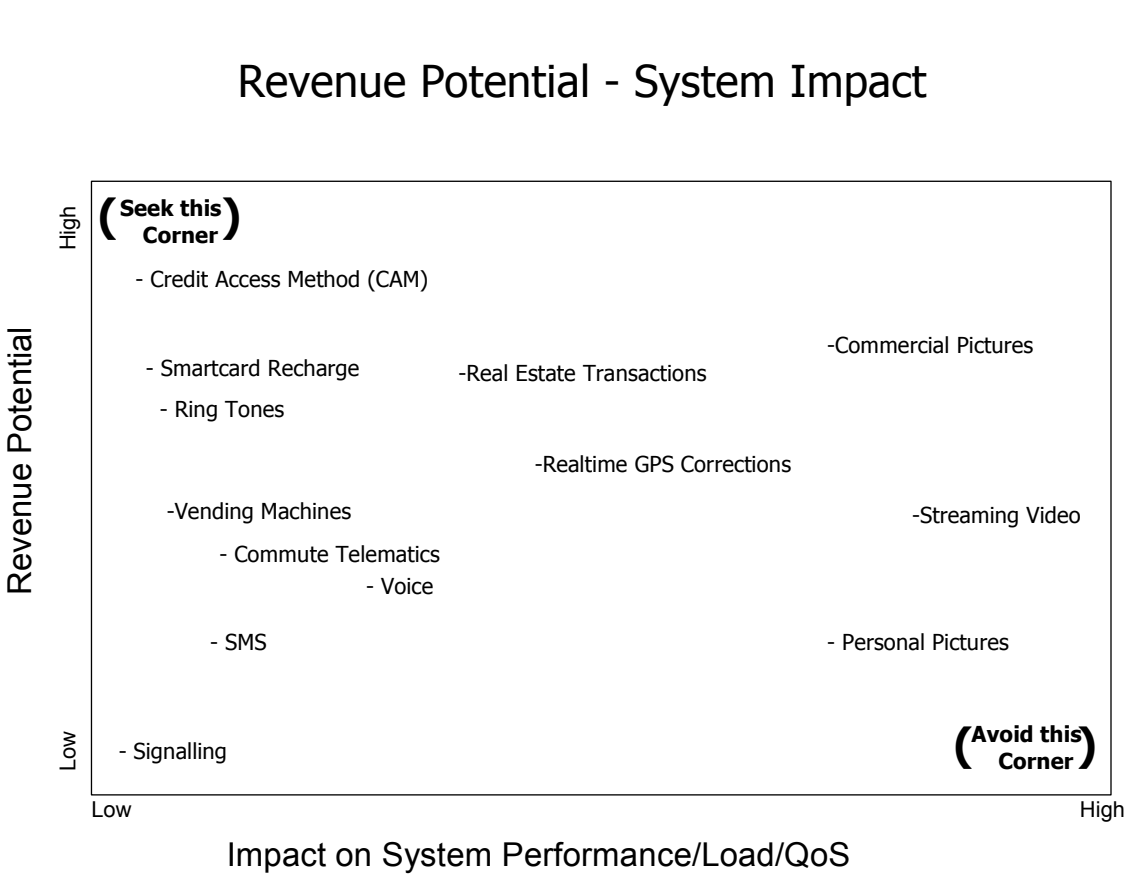

Figure 2. Revenue and System Impact

One scenario for vending machine control has a cell phone user approaching a drink machine with a phone that has both Bluetooth and smart-card capability. The phone screen displays a control panel for the machine, and permits selection of a product followed by payment, deducting from the fund balance in the phone. The machine also has a wireless terminal inside, and is called nightly to upload funds received and manage merchandise inventory. This is an application that has low system impact by operating at off-peak hours, and generates revenue through service charges. The benefit to the machine owner is in knowing just when to restock the machine, avoiding both empty machines and unnecessary (and expensive) machine servicing by the driver.

Cell phones with picture-taking ability have become widely available. As resolution of the pictures is increased, the number of bits required to transmit them increases rapidly. In the chart we assume that they have a significant impact on system performance. We suspect that casual users transmitting pictures for fun will have a price sensitivity that would send a large number at five cents apiece, and just a few at one dollar each. A real estate agent, while offering the same system load per picture, would probably not resist paying $1.00 each if they were instrumental in selling a house to a client relocating from a different city. Thus high resolution personal pictures are an application to be avoided.

System loading is another consideration, however, and could provide another dimension to the model. If the service provider was just introducing a new service, such as 3G in an area, a limited-time offer of inexpensive pictures might offer good returns in the form of added sales of camera-phones and user migration to the new service. This is particularly true if the new service was lightly loaded and there was more than adequate system capacity.

10. REFERENCES

[1]Gunn, James E. Wireless Infrastructure: Technology and Markets, Forward concepts, 2002