ARCHITECTURAL IMPLICATIONS OF THE PCS WIRELESS BUSINESS CASE

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ABSTRACT

Continued growth in the Wireless PCS market is dependent on moving beyond voice conversations to applications using digital data transfer over IP networks. The basic source of revenue for all elements in the PCS value chain is user billings, so revenue growth must come from additional users and/or more service units sold per user. That usage increase, in turn, depends on a proliferation of applications and product offerings, appealing to both mass and niche markets, from existing service providers and third parties with special offerings.

Service providers want to maintain control of the customer interface, provide a common look and feel, and minimize the cost of providing user technical support. Application developers prefer to view the network as a delivery mechanism, and want an API that provides easy access. Resolution of this conflict will be embedded in numerous contractual arrangements, the terms of which depend on the ability of the network architecture to support a variety of relationships.

This paper proposes a business model of the market, identifies a variety of interacting roles, and examines how the architectural structure enables a variety of revenue streams to the different players.

1. INTRODUCTION

Wireless users benefit from the enhancement to their personal capability provided by wireless systems, and are transitioning from a perception of Personal Communications Service (PCS) as a wireless telephone to its use as a vehicle for delivery of mobile application services. As typical users broaden their horizons to utilize additional services, the revenue generated will increase. So the goal of participants in this mobile PCS market is to enroll more customers, encourage them to use more billable units, and provide services that have a higher price per unit.

In Figure 1 we propose a model of the marketplace for wireless personal communications services. The picture shows the participants, and has links to indicate their business relationships.

The net result of all this activity is to deliver services that enable the users have enhanced capability, to enable them to do things they could not do before those services were provided. The underlying assumption is that they will see the services as valuable, they will pay for them, and generate a revenue stream that can flow to all the participants in the market.

Transactions in the picture are indicated with lines. In general, transactions are bi-directional: one party delivers goods and services, and the other party pays for them. Exceptions may occur for one-directional transfers, for barter, or when offsetting transactions are pooled. Transactions between any two participants are possible, the prevalent ones are shown on the diagram. To designate a specific link, this document will use the originator followed by the recipient in the form: SP–Um.

2. PARTICIPANTS

The following are participants in this model as indicated in Figure 1. The role of each is described.

2.1 Wireless User (Um)

Individuals subscribe to PCS services, and benefit from their use. Users usually obtain a terminal and subscribe to a service that provides them with a telephone number and sometimes an IP address. With these identifiers the user can make telephone calls and access data based services.

Users willingly pay for services they find useful, and PCS service is making the transition from useful to essential, in much the same category as gas for their automobile. The market is very competitive, and users will readily change service providers if they perceive their service as poor, can find a better deal, or need to change to gain access to a particular application offering.

2.2 Network Operator (NO)

The organization that has an infrastructure to provide the fixed termination of the link to the mobile user. The NO operates the radio equipment, and faces the continuing challenge of offering adequate capacity in the designated coverage area in the face of growing demand, new service offerings, and a developing technology base. The NO may be a cost center within the SP organization, or an independent profit center that is paid for operating the

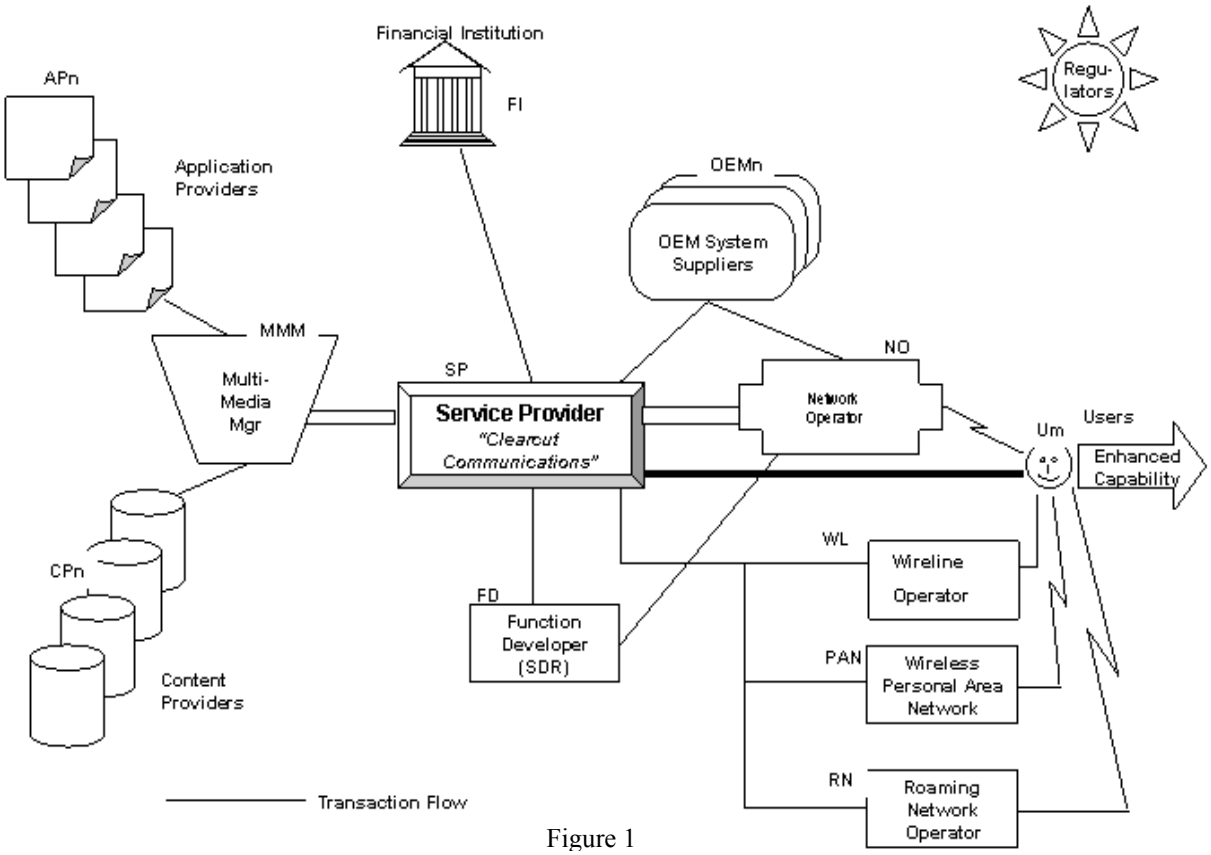

Figure 1

infrastructure. The NO may provide service to customers of several SPs and may operate its base stations using a number of waveforms or air interfaces. An important development for NOs is the availability of high performance RF sections for base stations that will greatly increase their ability to service multiple service providers.

For purposes of developing models of the business case in this paper we will assume that the NO is not a cost center. That is, it is either a subsidiary of an SP or an independent contractor selling services to multiple SPs.

2.3 Service Provider (SP)

The SP is center of entrepreneurial energy in the market. It offers a product, and establishes branding of the offering to the user. Often the service provider will supply the user's terminal. The Um views the SP as the vendor, and does not perceive an independent role for the NO. The SP has the financial responsibility for establishing the credit of the user and a means of payment for the services rendered. The SP authorizes delivery of service by entering the identity of the user and the terminal equipment into the Home Location Register (HLR), or equivalent master data base, that is checked by the NO before connecting any session.

When there is a problem with any aspect of the services, it is the SP that the user will look to for resolution. The Service Provider also maintains secure links with financial institutions.

2.4 Application Provider (AP)

There are a myriad of services that users can access from their terminals. Many of them involve some specific application capability, such as current stock market activity, sports results, weather, games, or an application offering aimed at a specific profession or discipline. The SP cannot hope to cover all the application possibilities. So it is the role of the AP to package their capability in a specific application area so that it can be accessed by the small screen and low-speed link of a wireless terminal.

2.5 Multi-Media Manager (MMM)

With a number of applications being offered, there is need to maintain a look and feel that is consistent so the user does not need to learn a number of different interface styles. The appearance must also be consistent with the SP branding program. So the MMM works with the APs to package their offerings, and with the SP to assist in marketing them.

The MMM is often an department within the SP organization.

2.6 Content Provider (CP)

A number of organizations maintain data bases of information in the course of their business. Access to this information can be an important part of some application offerings. The content provider may connect with the application provider or directly with the MMM to provide such access, often under a series of constraints.

2.7 OEM System Provider (OEM)

These organizations design and manufacture the equipment used in providing PCE services, including Base Stations and Mobile Terminals. They have the hardware and software design and development capability to field systems for use by the Nos. OEMs are responsible for the reliability and performance of their product offerings. They have traditionally been reluctant to open their systems to third party functions.

2.8 Function Developer (FD)

The FD develops or acquires software to run on network nodes and determines network functionality. As a supplier of functionality that may effect the RF characteristics of the system, the FD is a trusted individual who must operate within the bounds established by regulatory agencies and the security policy of the system. The FD also provides system interfaces that can be used by APs to deliver system application content. The FD relieves the AP of concern about details of system performance and functionality.

2.9 Wireline Operator (WL)

Wireline operators often provide backhaul and communications channel bandwidth to the NOs. They may also want to provide some level of SP branded service over their landline network telephones.

In some circumstances the users may wish to obtain services at a fixed location in addition to mobile access. If so, fixed operators may become involved , and participate in market revenues,

2.10 Wireless Personal Network (PAN)

In the future there will be locales in which a wireless network is available to offer services to users. The wireless PCS terminal is a logical device to interact with PANs, including providing payment of money stored in the handset in a fashion similar to smartcards.

2.11 Roaming Network Operator (RN)

When the user leaves the service area of the service contract, connectivity may be provided by network operators located there. The users home SP will pay the RN for providing such service, and may make an extra charge to the user for doing so.

2.13 Regulator

Regulators make the rules under which PCE systems operate. They also auction spectrum to Network Operators.

3. TRANSACTIONS AND REVENUE STREAMS

The following are comments on some of the transactions indicated in the model picture.

3.1 SP-Um

This is probably the most important link – the connection between a organization that is managing the market, the Service Provider, and its customer, the user that pays to use the offered services.. In this document we have given the SP the identity "*Clearcut Communications*" to indicate the importance of this relationship and the need for brand recognition. *Clearcut* will work hard to establish its brand presence, and to encourage the customer to both generate more billable units of service and to turn to *Clearcut* when they want additional services. They also want to provide a level of service that will retain users and lower the "churn" or departure of users to competitive services.

Among the transactions across this link are:

3.1.1 Service Initiation.
The SP must provide a distribution channel through which prospective users are signed up for service. Sales personnel may be installed in retail outlets or kiosks. Distributorship agreements enable other retail establishments to sign up customers. A variety of incentives may be provided new users to encourage them to sign a service agreement. All of these expenses are distribution channel costs.

3.1.2 Terminal and Accessory Sales.
In order to use PCE services, the User must have a terminal. SPs often subsidize the cost of the terminal to the user to encourage them to sign a longer-term agreement with a termination penalty. Terminal accessories are also available at the point of sale. These sales are not normally a major source of revenue for the SP.

3.1.3 Billing.
The primary revenue stream of the SP is from a monthly billing. Normally it consists of a fixed service fee, and a base number of units per month. Units are often minutes of air-time for voice calls, and packets for data. Usage over the base amount may result in additional charges on a per-unit basis.

For purposes of simplification in our model, we will assume that all *Clearcut* users pay $40.00 per month for 500

minutes of access anytime, and that they all use exactly that much. *Clearcut* makes no charge for night and weekend minutes as a marketing item, but usage then is still insignificant compared to weekdays.

3.1.4 Service Delivery.
The user receives services from the NO as authorized by the SP in their terms and conditions in return for the payments made to the SP.

The monthly bill is a continuing point of contact where the SP can reinforce the *Clearcut* brand identity, provide information about system use, and promote new services.

Wireless voice customers are typically on a monthly plan providing some number of base minutes at a fixed, or minimum monthly rate. The specifics of these plans vary widely with different market approaches by different wireless carriers. Most users stay within the monthly allocation, and so form a revenue base of the sum of their individual monthly base rates. That money is paid to the SP, who has a monthly cost in the order of $5 per customer for billing, administrative cost, support, and overhead. Additional revenue is derived from any per-minute usage over the base level.

An additional expense to the SP is the cost of network services provided to users by the NO, as described under the NO-Um link below.

3.2 NO-Um

The user operates with the NO in the home area. The user experiences a quality of service received is subject to quality of the RF connection, operation of hand-off between cells, and availability of service. As indicated previously, the user perceives that service is being provided by the SP, when in fact the NO may be the same as the SP or an independent subcontractor.

This station is capable of handling calls that will generate up to 18,000 billable minutes in its peak hour. Connections will become increasingly difficult to complete because the number of busy signals increases as traffic volumes approach capacity. 2% call blockage is the amount normally considered the maximum desirable in order to avoid user dissatisfaction and the resulting churn.

The NO can increase capacity by adding more base stations, or by improving base station performance. Traffic patterns are typically bimodal, having a morning peak, an afternoon peak, and very low minimum hour at night. Network planning has to concentrate on peak hour capacity, while marketing strategy tries to find ways to build non-peak hour traffic to increase revenues without impacting peak-hour loads..

The user receives services by accessing the network operated by the NO, but the presence visible to the user is that of the SP. User satisfaction will depend on the quality and reliability of that service delivery, and the utility of services made available.

3.3 SP-NO

The SP and NO work closely together to deliver a seamless package to the user, and in some cases they are the same organization. The NO maintains the wireless link with the user according to SP requirements, exchanges information with the SP, and is paid by the SP under terms of their operating agreement.

Transactions across this interface are:

3.3.1 Service Initiation.
The NO must receive information as part of a sign-up to authorize delivery of service. This registration provides information about the user and the users terminal necessary to initiate an HLR entry and maintain system security.

3.3.2 Payment.
The SP may pay on the basis of the number of enrolled users, on the basis of a fraction of system capacity reserved, or on actual air-time consumed or packets handled. As we will explore below, the NO cost structure has no elements that vary with load, so all the costs can be considered fixed up to the point where incremental capital is required to meet the offered load.

The NO maintains the network, adding capacity to meet the offered demand. The cost structure is primarily that of operating base stations to provide coverage.

As an example, we will look at a scenario for the *Clearcut* system in a metropolitan area of 160 square miles where they have installed 100 base stations to provide service to the population of 2 million in the area. Average capital cost to install a typical base station that will provide 300 voice circuits to its served area is $600,000. Typical marginal monthly operating cost is (see [2], pg. 180 ff.):

Utilities	$400	
Maintenance	175	
Software	175	
Comm. Lines		2,000
	$2750	

Capital recovery is carried as a monthly expense over a five year amortization period at an additional charge of $11,600. So the base cost is $14,350.00 per base station. In addition there is a monthly charge of $42,494 as the amortized cost of the rest of the network, and an overhead rate of 20%. The total monthly cost to operate this system, including amortization, is $1,764,494. None of these expenses are dependent on the call volume, so the entire cost structure can be considered fixed.

These base stations provide an average of user 300 channels 45 hours a day, so the total available airtime in the *Clearcut* system is 12,960,000 minutes per month. System usage is not evenly distributed, however, exhibiting a diurnal pattern with a late morning and early afternoon peaks, and secondary peaks during commute hours. It is useful to consider a "busy hour" that reflects usage during the busiest hour of the day. Every hour has the same capacity, but the offered load for the month is typically during the busy hour. Experience indicates that *Clearcut* users expend 25% of their monthly usage during the busy hour.

We now have information to compute the break-even load on the network. Keeping in mind that the system capacity per BS is 12,960,000 minutes per month and busy hour capacity is 18,000 per BS, Table 1 shows the breakeven point number of subscribers and demand in minutes for three different monthly prices

Table 1.

Monthly Charge	$20.00	$30.00	$40.00
Breakeven subs	88,225	58,816	44,112
Mo. Demand/BS	441,124	294,082	220,562
Peak hr. demand	5,251	3,501	2,626
% peak hr use	29%	19%	15%
% overall use	3%	2%	2%

From these numbers we can see that the *Clearcut Network* has substantial amounts of spare system capacity at the breakeven point for network operations.

There are, of course, a number of other billing, marketing and operating expenses that must be covered after network operations are paid for, and we will not consider here the cost of spectrum.

It is, however, apparent that the amortization is by far the lion's share of the monthly cost. Reducing the cost of the base station significantly and/or the number of base stations reduces the monthly cost, and hence the "break-even" cost, above which the payments are all profit. Ideally, if capacity could also be increased, the range of profitability to the operator would also be increased, providing the opportunity for enhanced number of users and enhanced profitability. Base station electronics which provide these benefits clearly are the optimum choice.

How the SP and NO proceed to generate revenues to provide profits over breakeven is the story of entrepreneurial activity. If the NO has installed a high-performance SDR based network they can offer a variety of services outside the *Clearcut* PCS band. For *Clearcut,* there are opportunities to sign up more customers, or to generate more revenue per customer by offering application services, such as messaging, Internet access, pictures, and professional services.

3.4 OEM-NO

OEMs are developers and manufacturers of the equipment and software that permit the system to function. They take a strong position in the development of standards, and to a large extent control the offerings that SPs can make to their customers.

Transactions across this interface include:

3.4.1 Delivery of Systems Infrastructure.
The OEMs build the equipment necessary to operate the system, and deliver it to base station sites provided by the NO. The SP typically has a strong voice in the selection of equipment and system operating characteristics.

3.4.2 Payment.
Payment for system equipment is a major funds transfer in this model.

3.5 OEM-SP

The SP has a strong influence on the selection of services from the OEMs product offerings. The SP also offers terminals to users, typically working with multiple OEMs to have a variety of product offerings.

Transactions across this interface include:

3.5.1 Delivery of Terminals
Terminals are provided by OEMs who may or may not be the same as provided the network infrastructure. Terminals are usually tailored to reflect the brand image of the SP.

3.5.2 Payment.
The SP buys terminals from the OEM, and either resells it to the user, or provides it free of charge on the basis of future service commitments.

3.6 FD-SP-NO

The FD works with the SP to define system functionality, and with the NO to install it.

3.7 Apn-MMM-SP-NO-Um

Continued use of the system by users is dependent on their perceived value of the services received and used. No one organization can hope to fulfill all of the potential niche applications for specific groups of users. For that reason the architecture of the system must accommodate independent application providers. These organizations develop software that is delivered by the network to mobile users.

There are two models of the economic relationship between the SP and Apn.

3.7.1 Application Development Service.
In this model, control of the application space remains with the SP, and the AP is under contract to develop and deliver the service to SP requirements. Control remains with the SP, and the SP markets the service. SP retains a large portion of the revenue.

3.7.2 Independent Application Developer.
The AP provides the entrepreneurial thrust in this case. The AP defines and develops the application, and the SP provides a delivery mechanism. The MMM provides application development tools, and assures that the final result meets the SP standards for applications on their service.

The AP markets the service, and receives a commission on any service initiations resulting from users signing up for the SP service as a result of wanting the application. The AP retains control of the product, and receives the revenue from it after paying for carriage by the SP.

3.8 CPn-MMM-SP-NO-Um

This path is similar to the previous one, except that the CP is the owner of data that users want access to. The CP receives revenue based on amount of data demanded and paid for by users.

3.9 FI-SP-NO-Um

Financial institutions are providing alternate ways for consumers to pay for goods and services. Credit Cards and Smart Cards are two of the innovative approaches that could take advantage of the capabilities of a wireless system.

An institution issues a credit card to a user, permitting the user to purchase goods and pay for them later after receipt of an itemized bill. The mobile terminal can provide the same services by using a wireless link to establish the users identity and authenticate the credit line.

Under the Smart Card concept a supply of money is carried around in the mobile terminal. Spending these funds results in a reduction in the amount in the terminal's internal "purse." The chief difference between these approaches is the ability to make an anonymous purchase.

4. ARCHITECTURAL IMPLICATIONS

The architecture of PCS systems has evolved from the initial goal of providing wireless telephone service. Now enhancements are being made to both the infrastructure and handheld terminals to provide more adequate data handling and enable new applications.

The emergence of new technologies will greatly enhance the potential for extension and enhancement of existing networks. New, ultra high-performance base stations will be able to support many applications operating on a wide range of frequencies. Addition of new capability is accomplished by downloading new software to reconfigure the RF interface and provide application processing. These new technologies also permit greatly increased receiver sensitivity and spectrally pure transmissions with the attendant improvements in spectral efficiency and system performance.

There are a wide variety of applications in a number of markets that can be serviced by the NO in conjunction with APn. The SP may or may not be involved, depending whether the application is part of the SP's brand and product portfolio or not. Some of the terminals might be specially designed for specific applications, and not even look very much like our normal concept. For example, surveyors might use the wireless infrastructure to capture all of their instrument readings and the ambient GPS error at the time of the measurement. The entire data set of a days surveying could be assembled and delivered to the home office. Telematics are another application, with automobile on-board computers communicating through the network without driver intervention.

Development of such currently ignored application opportunities depend on two things. One is detailed knowledge of how the specific discipline operates, and how to structure the application offering to practitioners. Those specialists understand the application domain, and are likely to engage in entrepreneurial efforts.

The other thing needed is application programming interfaces in the system at the boundary between the PCS system and the application. That requirement may involve access to interfaces in the system that are not internal, buried within the system code. In designing future systems, the needs of existing and future applications need to be reflected in the architecture so that the needed access is made as an external interface. Some interfaces in the system are naturally open, including the air interface, but others need to be opened to take advantage of all the possibilities for extensions in the capability of the network, and to take advantage of the enhanced capabilities of future generations of base stations.

10. REFERENCES

[1] SDR Forum Document SDRF-02-W-0007-V0.01
[2] Harte, Lawrence, Morris Hoenig, Daniel McLaughlin & Roaman K. Kta, CDMA IS-96 for Cellular and PCS McGraw-Hill, 1999