Reducing the Cost to Serve the First WiMAX™ Subscribers

White Paper

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July 2007

Abstract

As more and more mobile carriers start deploying broadband wireless networks such as WiMAX, they are faced with the capital expenditures of the access network to provide coverage and that of the core network to provide connectivity. For small to mid-size deployments, the cost of the core network (ASN gateway plus IMS network elements) represents a large percentage of the initial CapEx. A radically consolidated, scalable core network architecture based on a new generation of multi-core processor technology from Sun Microsystems significantly reduces the cost of the core network thereby reducing the cost to serve the first WIMAX subscriber.

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Chapter 1
Introduction

Despite the promise of high speed services associated with evolving 3G and 4G networks, the challenge of lowering the cost to serve the first subscriber remains a fundamental issue for both carriers and Network Equipment Providers (NEPs). This challenge is particularly acute for carriers building networks in emerging markets or those markets where entrenched competitors can effectively limit the available capital for new build outs. The target market size for these new revenue opportunities is often less than 50,000 subscribers. Since these new networks are all typically built around an IMS core, the cost to serve the first subscriber of an IMS (IP Multimedia Subsystem) network needs to be examined as one of the first steps in attacking this fundamental cost challenge.

One of the virtues of IMS networks is the rich set of standardized interfaces between all the major IMS components that provide carriers more choice at lower prices than the legacy, vendor specific, proprietary networks IMS is starting to replace. However, one implication of IMS' emphasis on standards is the fact that entry level IMS networks require many different network elements before the first subscriber can be served. For instance, even an entry level network still requires three CSCF (Call Session Control Function) functions (proxy, interrogating, serving), an HSS (Home Subscriber Server), various gateways, network/element management systems, and various application servers before service can be provided to the first subscriber. More often than not, each of these network elements requires a pair of carrier-grade servers that hosts the vendor's IMS software in active/standby configuration. Each IMS network element typically equates to, at least, a pair of under utilized, carrier grade servers. This typically requires the carrier building a new IMS network to acquire 20+ servers for the 10+ IMS network elements needed to provide service to the new carrier's first subscriber. While initially a major CapEx challenge to the carrier, over time the cost to power, cool, administer and maintain all these disparate servers quickly becomes an OpEx issue as well.

Traditionally, legacy 2G and 3G networks were designed to scale up: the design challenge to the NEP was to cost effectively scale to millions of subscribers. Today, however, with virtually all major markets covered with several wireless networks, the greenfield opportunities for revenue are typically associated with carriers seeking to enter smaller emerging markets or enter established markets with new services (either 4G or enhanced 3G). In either case, the capital available to carriers to build new networks is significantly less than what was available several years ago at the dawn of 3G. Dominant carriers have, for the first time, begun to partner to build new wireless 3G infrastructure that competing carriers can share, thereby minimizing the capital either carrier needs to raise. In addition, as advanced services are expanded to second and third tier markets, the need to support core network functions in smaller networks puts a severe strain on capital needed to start up these deployments.

Since the greatest opportunity for revenue growth now presents itself in the form of smaller markets with less than 50,000 subscribers, lowering the cost dramatically to serve the first subscriber and to thereby lower the breakeven point in the carrier's business case becomes the carrier's first and foremost challenge. To satisfy these new market requirements, NEPs must re-think scalability; low- end scalability – the cost to serve the first subscriber – is now the fundamental engineering challenge facing the industry.

Chapter 2

Platform Implications of Low-End Scalability

To effectively address this low-end scalability challenge, platform technology must be developed that offers NEPs and IMS application vendors architectural options that do not require the redesign of all the existing IMS applications. For instance, multi-core processors coupled with powerful virtualization technology that enables the radical consolidation of all the physically discrete carrier-grade servers that today are required to build an IMS core network are a very attractive platform for low-end scalability. If processor cores can replace discrete servers with no change to the existing IMS application, a consolidated computing platform could effectively host all the IMS core network applications that today require 20+ physically discrete servers. Thus a pair of ATCA blades or a pair of carrier-grade rack mount servers could provide the platform for radically consolidating all the applications in an IMS core network. Replacing 20+ carrier-grade servers with either 2 ATCA blades or 2 carrier-grade servers based on multi-core processors represents a dramatic way to lower the cost of the core network elements required to serve the first subscriber; this type of radical consolidation represents at least a 10:1 reduction in initial CapEx, plus a comparable reduction in recurring operating expenses.

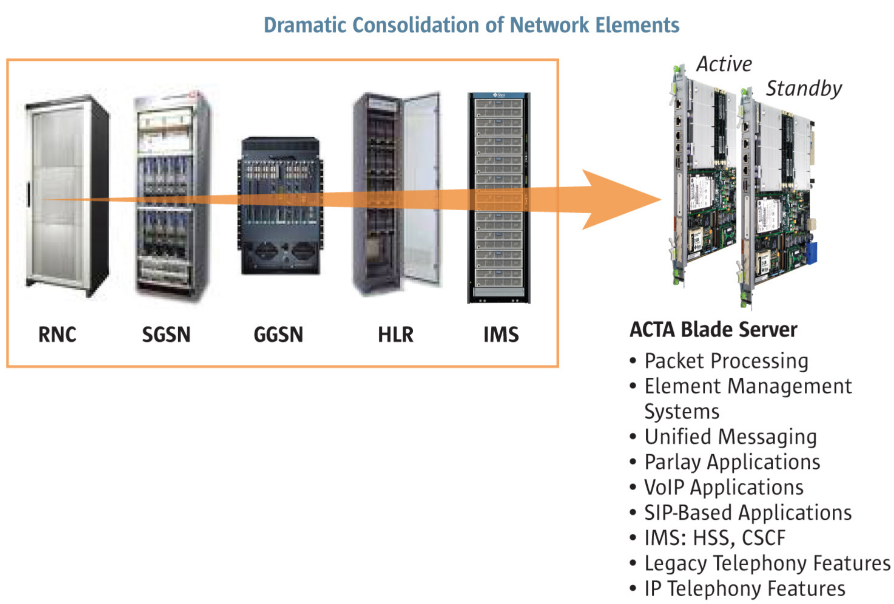

Figure 1. Consolidating Network Elements with the Sun™ Unified Network Platform

Figure 2. Typical Sun CT900 ATCA Chassis

And this is just the first step in network consolidation. If the base station controllers or WiMAX routers in the 3G or 4G access networks could also be virtualized to exploit the same multi-core processors used by the IMS core, a second major leap in network consolidation, with comparable reductions in costs, could be achieved. Since base station controllers and WiMAX routers perform packet processing tasks often defined by data plane standards, this second step in consolidation will require these multi-core processors to support a new operating environment that is more suited for packet processing than the traditional operating environments (e.g., Linux or Solaris) used for the IMS control plane applications. Sun has recently enabled a new paradigm for the development of network elements with the introduction of the Sun Unified Network Platform. Based on a new generation of multi-core processors called Sun's Chip Multi-Threaded (CMT) processors, coupled with powerful virtualization technologies (Sun's Logical Domains technology) and packet processing software (Netra™ Data Plane Suite), platforms can be created that enable the radical consolidation of all network elements – from both the control and data planes – resulting in new low-end scalability with dramatically lower costs associated with serving the first subscriber. Figure 1 illustrates the radical consolidation possible when commercial off-the-shelf technologies in the Sun Unified Network Platform are used.

Furthermore, this novel data plane architecture can evolve all the way to the high end of the deployment scale providing all the high end scalability large networks require, thereby allowing for new services to be added to the core network in much more affordable cycles.

Chapter 3

Carrier's Benefit from Radical Consolidation

While radical consolidation can dramatically lower the cost to serve the first subscriber, it can also dramatically alter the business and deployment plans carriers create for networks in new markets. For instance, dramatically lower first subscriber costs combined with the interoperability promised between new 3G or 4G standards with existing 3G legacy networks, allow the carrier to build new networks on a much more granular basis, targeting the coverage areas where new services are most profitable. In the past, new wireless networks were built on a regional, even national, basis where coverage was required across a large geographic footprint before the first subscriber was served. This was caused by the high costs of the core network infrastructure, combined with minimal interoperability between the new network and any existing wireless systems. Fortunately, the advent of new multi-mode mobile subscriber devices together with a dramatically cost reduced core network will make such granular deployments possible and profitable.

By dramatically lowering the cost to serve the first subscriber, new networks can be built on a campus or targeted community basis with new services tailored to the specific needs of these smaller, targeted markets. The dramatically lower costs of these new networks, combined with the savings resulting from a much more targeted coverage model, lower the risks new carriers face in building new networks in emerging markets. Lowering the initial capital outlay for the new network and lowering the initial network operating expenses, risks are minimized and the number of new subscribers the new carrier needs to acquire in order to break even is minimized as well.

Additionally, by tailoring new services to new target markets, the revenue generated by the initial subscribers of these new networks can be maximized. New carriers will also have new options to differentiate themselves from the incumbent carriers, rather than simply offering comparable services at lower prices. Finally, the extended scalability spectrum radical consolidation creates enables carriers to create a pay-as-the-carrier-grows business model that optimizes the financing of the network as the carrier grows beyond its initial granular deployment. All of these carrier virtues are the direct benefits of the new low-end scalability enabled by radical consolidation.

Chapter 4

Business Case Benefits from Radical Consolidation

We will use WiMAX as the wireless access technology to illustrate the virtues of a radically consolidated core network and study its implications on a WiMAX carrier's business plan.

The business case for every WiMAX carrier is unique and is impacted by several hundred variables that influence the carrier's financial metrics. These metrics often include ROI (Return On Investment), IRR (Internal Rate of Return), NPV (Net Present Value), free cash flow as well as valuation matrices. Typically, a WiMAX operator's business plan is analyzed over a 10 year period. In order to consider a business plan attractive, a key financial indicator that is often monitored is the number of years it takes for the plan to yield a positive NPV.

In a typical WiMAX network deployment, the first years of operation require a balancing act between minimizing the cost of access coverage while maximizing subscriber capture. These deployments require large amounts of capital to build the network early in the project before subscriber revenues begin to support that capital investment. A streamlined radical consolidation of the core network greatly reduces the amount of capital needed to deploy new WiMAX networks. In the case of small and medium size networks, a lower capital cost is the difference between a profitable deployment and a loss.

Some of the key input parameters that influence the business plan include the CapEx, OpEx and Revenue assumptions used. Obviously, a profitable business plan will have relatively high levels of revenue, coupled with a relatively low CapEx and OpEx.

The CapEx section consists of the costs of cell sites, base stations, cables and antennae, backhaul equipment, backhaul provisioning, the core network, as well as a myriad of other items. Some of these cost items are fixed in nature, while others are variable. For instance, the number of cell sites, and thereby the cost of equipping a cell site, is directly related to the desired coverage area. If an operator desires to cover a 1000 square kilometer area and the average area covered by a cell site is 10 square kilometers, then 100 cell sites and therefore 100 base stations are needed to provide this coverage. Initially, during the deployment of a network, cell sites are added for coverage reasons. During the life of the network, as the number of subscribers and associated traffic increases, certain cell sites or additional channels are added in a base station for capacity reasons. Every time a new cell site is added for either coverage or capacity reasons, there is a direct relationship to the number of new subscribers added that generate new revenue. For this reason, cell sites, and thereby base stations, have a scaleable element to them.

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The Customer Premise Equipment (CPE) is unarguably a variable cost element because for each CPE there is a related Service Level Agreement (SLA) that is sold, which generates monthly revenue to the service provider. In general, the cost of a WiMAX CPE has a significant impact on the pricing of an SLA and thereby on the business case. However, because the cost of a CPE is scaleable, its impact is uniform regardless of the size of the WiMAX deployment.

The core network, on the other hand, is primarily a fixed cost element in the CapEx calculations and therefore greatly influences the cost of serving the first subscriber. This impact is more significant for small and medium size networks than large national networks.

Figure 3 shows an example of a traditional WiMAX network. The WiMAX core network consists of the ASN (Access Service Network) as well as the CSN (Connectivity Services Network). The key function of the ASN gateway is to aggregate the base stations and manage handoff of devices from one BTS to another. The CSN is at the core of the WiMAX network architecture that provides control and management for the ASN and subscribers with services such as DHCP server, AAA, FTP, inter-operator, and inter-technology roaming services, along with other applications. The CSN also includes the IMS services support, capable of offering Internet access, location-based services, Internet Multimedia and Multimedia Broadcast/Multicast MBS and voice services. In addition to the hardware elements of the core network, a complete business case must account for the software and engineering costs as well for the network.

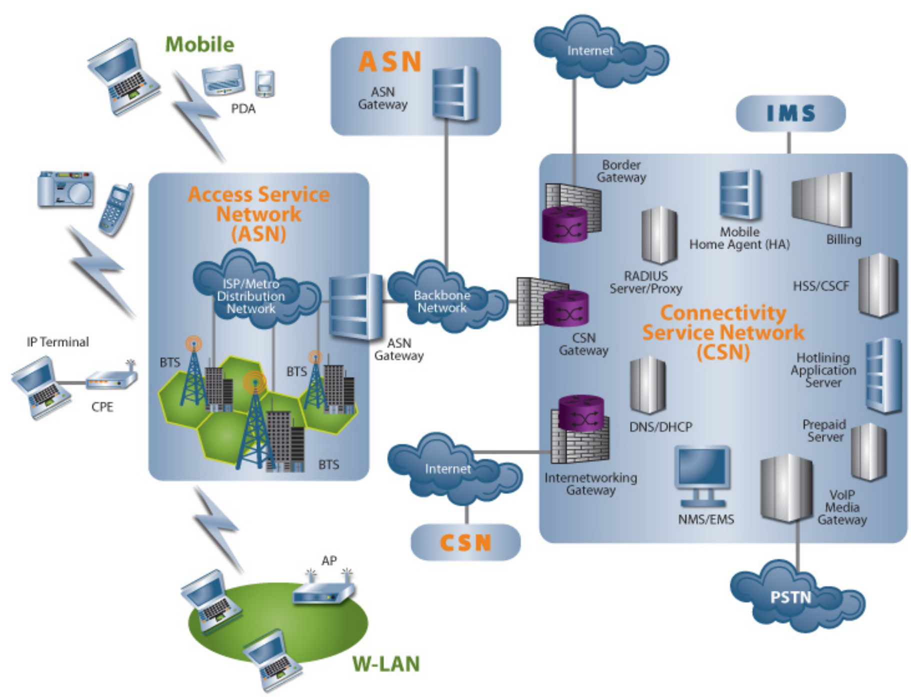

Figure 3. Traditional WiMAX Core Network Architecture

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Table 1 lists the key components that are considered part of the core network in this analysis associated with a WiMAX network.

Table 1. WiMAX Core Network Components

Core Network Elements
IP Core Router
IP Aggregate Router
ASN Gateway
HA – Home Agent
Firewall
DHCP Server
AAA Server
Billing Server
NMS/EMS Server
VOIP Servers

Although most of the market hype surrounding WiMAX has focused on a few large deployments that are taking place in the US and Korea (Sprint and Clearwire in the US and KT and SKT in Korea), the vast majority of WiMAX networks being deployed in the world are relatively small networks. For the purpose of this analysis we will define a small network as one which has less than 100 cell sites and where the number of subscribers ranges between 800 and 900 per cell site at the end of a 10 year period. Table 2 shows a variety of WiMAX networks to enable us to analyze the business case for prospective WiMAX carriers.

Table 2. Typical WiMAX Network Parameters

			Number of Subscribers			CapEx			
Network	Km^2 Covered	Number of Cell Sites	1st Year	5thYear	10th Year	Cell Site	Traditional Core Network	Consolidated Core Network	Percent Reduction
A	20	2	104	1,112	1,722	$150K	$3,000K	$600K	76%
B	60	6	312	3,336	5,166	$450K	$3,000K	$600K	70%
C	120	12	624	6,672	10,332	$900K	$3,000K	$600K	62%
D	240	24	1,248	13,344	20,664	$1,800K	$3,000K	$600K	50%
E	500	50	2,600	27,800	43,050	$3,750K	$3,000K	$600K	36%
F	800	80	4,160	44,480	68,880	$6,000K	$3,000K	$600K	27%
G	1000	100	5,200	55,600	86,100	$7,500K	$3,000K	$600K	23%
H	5000	400	26,000	278,000	430,500	$37,500K	$3,000K	$600K	6%

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For simplicity, the assumptions made herein are as follows:

- Cell Coverage Area = 10 Km^2
- Cost of deploying a cell site = US $75,000
- The number of subscribers on years 1, 5, and 10 are uniform per cell site.
- The cost of a traditional core network is US $3M and can serve up to 100K subscribers.
- The cost of the consolidated core network is US $600K and is equivalent in functionality to the traditional core network.
- The core networks include all the functions outlined in Table 1 above.
- The software and engineering services costs for the traditional network and the radical consolidated network are the same. The only difference is the hardware savings.

Note that for networks A, B, C & D the traditional core network priced at US$3M represents a much larger cost item as compared to the cost of equipping cell sites. Even for networks E, F & G the cost of a traditional core network represents a significant percentage of the total CapEx cost. In addition, note that networks take a long time to reach their full subscriber penetration and during the first few years in the life of a small network, the number of subscribers is relatively small.

In general, a radically consolidated WiMAX core network priced at US$600K represents a much smaller percentage of the total CapEx cost. Networks B, C, D, E, and F & G will greatly benefit from the cost savings offered by a consolidated core network. For some of these networks, it may not be cost effective to deploy these networks with a traditional core network architecture. But with the advent of a radical core network architecture, operators in many small to medium size markets have an option to consider that will greatly lower their initial capital outlay in the first years of their operation. These are the networks whose business cases will show significant improvements in the key financial indicators such NPV and ROI.

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Chapter 5

WiROI™ - The WiMAX ROI Business Planning Tool

WiROI is a WiMAX ROI business planning tool for use by WiMAX service providers planning to deploy a WiMAX network. It provides an easy to use, interactive graphical user interface which allows the user to fine tune the variables of a network in order to optimize key financial parametrs of a WiMAX business case. The tool provides a dynamic dashboard style interface which enables the user to easily control the key input parameters of choice and instantly visualize the results. WiROI was created by WiMAX20/20, LLC, an independent WiMAX market research and consulting firm that specializes in advising WiMAX operators on network deployment strategy and options. The tool has been used extensively to help prospective WiMAX operators analyze the impact of various key assumptions on the operator business model. WiROI is also being used by WiMAX equipment vendors as a sales enablement tool to help illustrate how certain features and benfits brought about by their WiMAX network equipment can impact the overall business case of an operator.

WiROI Inputs

WiROI incorporates over 250 input variables that impact a WiMAX operator business plan. These input parameters include market statistics for various deployments, demographic information, geographic input, classification of the geographic coverage areas by urban, suburban or rural, classification of the natural topography as hilly, moderately hilly or flat, as well as a determination of the number of households and businesses in each area.

The service offering parameters include detailed descriptions of the residential as well as business SLA's contemplated by the WiMAX operator, along with monthly subscription rates which can vary year over year for the duration of the 10 year business plan. The penetration numbers, i.e. number of subscribers per SLA, is also provided as an input parameter.

The financial parameters include interest rates, tax rates, depreciation and amortization parameters, valuation parameters as well as starting cash balance and starting net operating loss.

The CapEx parameters include base station costs, site acquisition cost, backhaul equipment as well as backhaul provisioning costs and all core network costs.

The OpEx input parameters that are incorporated in WiROI include all recurring costs for leases and monthly backhaul, fixed and variable marketing costs, subscriber acquisition costs, VoIP and international termination and interconnection costs, recurring spectrum leases as well as various G&A and overhead costs.

WiROI Outputs

WiROI generates a wide variety of financial as well as performance outputs to guide the WiMAX operator in the business planning process. The outputs include a consolidated financial statement showing detailed revenue assumptions as well as sources of revenue, network operating expenses, sales and marketing expenses as well as engineering and G&A expenses. The financial statement further includes an annual EBITDA, EBIT as well as interest calculations which are used to generate the Net Operating Income. Free cash flow, cumulative free cash flow, working capital as well as depreciation and amortization outputs are provide on an annual basis. Economic and valuation summaries highlighting operating profit, NPV, ROI and IRR are also calculated.

Operating statistic such as coverage parameters, traffic parameters, capacity parameters as well as normalized revenue metrics are provided for analysis and benchmarking purposes.

Subscriber statistics, such as Cash Cost Per User (CCPU) and Cost Per Gross Add (CPGA), are calculated and the number of months for breakeven is analyzed on an annual basis.

The Sun WiROI

The Sun version of WiROI is used primarily to illustrate the potential benefits attained by using the radical network consolidation made possible by the Sun Unified Network Platform (SUN-P) consisting of multi-core, multithreaded processors with, virtualization, and carrier-grade systems technology described in this paper. It compares two Core Network implementations which allow the user to visualize the benefits of a lower cost, consolidated core network.

By selecting different size WiMAX deployments from the Market Statistic list, the user can then switch the Core Network selection between Traditional and Sun and witness how the NPV is affected. Other key parameters such as base station prices and site acquisition costs can also be modified in order to suit WiROI to specific regional market conditions. As one lowers the cost of base stations and site acquisition, the benefits of the consolidated core network are further magnified. By selecting different size WiMAX deployments from the Market Statistic list, the user can then switch the Core Network selection between Traditional and Sun and witness how the NPV is affected. Other key parameters such as base station prices and site acquisition costs can also be modified in order to suit WiROI to specific regional market conditions. As one lowers the cost of base stations and site acquisition, the benefits of the consolidated core network are further magnified.

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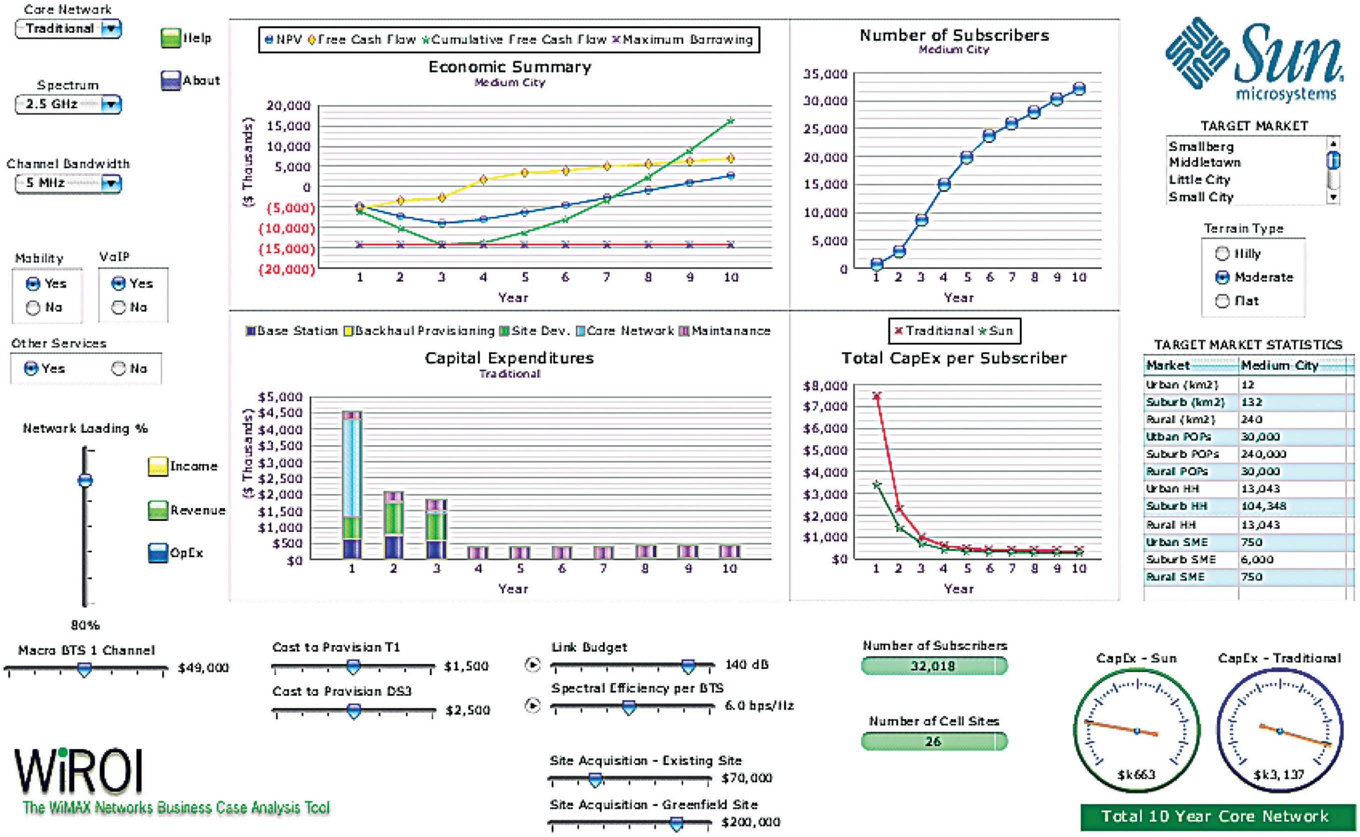

Figure 4. Snapshot of the Sun WiROI GUI

The terrain type selector allows the user to select among Hilly, Moderate and Flat terrains. This tool uses the Erceg-Greenstien propagation model to estimate the number of base stations needed for various coverage areas. As the user varies the terrain type, the number of base stations indicator is updated. The two gauges in the lower right hand corner constantly show a comparison of the total core network CapEx for both the Sun and the traditional core network implementations.

The number of subscribers line chart is updated as the user changes the market statistics selections. The CapEx per subscriber statistic is updated as the user varies the core network as well as cell site related controls. As the number of subscribers grows from year 1 to year 10, the CapEx cost per subscriber comes down. The initial CapEx cost and the final CapEx cost per subscriber are key measures of the affordability of the network. Here too, the cost savings from the consolidated core network will have significant impact on the CapEx cost per subscriber especially in smaller network and especially in the early years of a network deployment.

Chapter 6
Consolidation Opportunities for WiMAX Networks

The initial wireless access technology most often associated with “4G” is, arguably, WiMAX. The following example highlights the business benefits in planning a new WiMAX deployment built, using the Sun Unified Network Platform, to facilitate the radical consolidation of the initial network elements. Sun’s ATCA blade servers based on Sun’s CMT multi-core processor technology is assumed as the platform for the consolidation of all the network elements required to serve the first WiMAX subscriber. Specifically, the WiMAX access router plus all the network elements in the IMS core are consolidated onto three pairs of CMT blades. Pairs of blades are used, since most of the applications to be consolidated use a simple active/standby redundancy model for high availability. These IMS applications are consolidated using the powerful, transparent virtualization provided by Sun’s logical domains (LDoms) virtualization technology. Figure 5 illustrates how various IMS applications can be partitioned using the Sun Unified Network Platform

Performance and cost estimates for this consolidated WiMAX network are included in the WiROI business planning model described in this paper. Finally, comparisons are made between the costs, risks and breakeven subscriber requirements of the WiMAX network built exploiting radical consolidation versus a WiMAX network built with more traditional network elements – the functionality is the same, while the business implications and options afforded the carrier are dramatically different.

Over the past year, Sun has partnered with several prominent network equipment providers (NEPs) to create proof-of-concepts (PoCs) for several of the consolidation options described in this whitepaper. While the details of the PoCs are proprietary, each PoC implemented different aspects of a WiMAX network, including the requisite IMS core, through prototypes that consolidate key WiMAX network elements using virtualization (LDOMs) on multi-core processors (Sun’s CMT processors). The performance of the resulting consolidated network elements was then benchmarked using 3G/4G traffic models to measure the overall throughput of the consolidated network. Projections of the number of subscribers the network could support were then based on these network throughput measurements.

In the first PoC, a 3G/4G access controller was prototyped using a lightweight run-time environment for packet processing (Sun’s Netra Data Plane Suite) executing on the computing resources (individual threads and/or cores) of Sun’s CMT Niagara processors. The packet processing performance of this lightweight run-time environment executing the various access protocols defined in various 3G or 4G standards was then measured. The results showed that individual threads running in this execution environment could process these 3G and 4G protocols at wire speed – 1 Gbps when 1 Gbps load generators were used and 10 Gbps with 10 Gbps load gen-

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erators. Additionally, as traffic increased, the access controller could simply scale by assigning more threads and/or cores to execute the packet processing protocols defined in the 3G or 4G data plane standards. Since the CMT processor provided more computing resources than the data plane portion of the access controller required, the additional cores and threads were used to prototype the control plane aspects (e.g., mobility management, OA&M, etc.) of an access controller. It is important to stress that by using Sun's LDOMs virtualization technology, both the control and data planes were executing concurrently on the same processor with specific threads and/or cores assigned to each plane– the data plane was implemented using a highly optimized execution environment while the control plane was implemented using Solaris. Data was shared between all components of the access controller by simply passing pointers to memory that both the control plane and data plane application software could access.

Based on the throughput measured with this access controller PoC, one ATCA blade with a single CMT processor has more than enough performance to process the packets generated by the dozens of base stations typically attached to an access controller. By using a simple active/standby or active/active high availability model, all facets of a 3G or 4G access controller can be implemented on a pair of ATCA blades, based on Sun's multi-core processors and LDOMs virtualization technology. The ATCA blades used to implement the access controller could be in the same ATCA shelf containing additional ATCA blades used for the other network elements (e.g., an IMS core network) in a consolidated WiMAX network; which is exactly what the second PoC addressed.

The second PoC consolidated all the various network elements in an IMS core network onto two pairs of ATCA blades. Since most of the application software used in this second PoC was based on a classic active/standby availability model, pairs of blades were used as the target porting environment. Using the same platform technology used in the access controller PoC, as well as IMS application software from leading IMS application vendors, a consolidated IMS core network was created by assigning each IMS application to discrete CMT processor threads and/or cores. Sun LDOMs virtualization technology was used to create discrete, virtual servers for each IMS application, thereby eliminating the need to change any application software. In fact, the active/standby clustering mechanisms used by each IMS application were also virtualized, with no changes to any application. This second PoC resulted in the consolidation of all the key IMS network elements – including the CSCF, HSS, various gateways and application servers – on two pairs of ATCA blades.

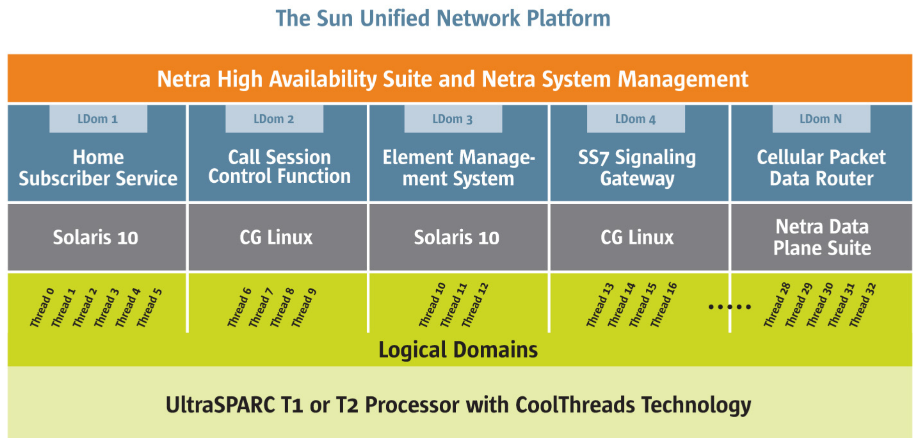

Figure 5: Consolidating the Core Network Dramatically Lowers the Cost of the First Subscriber

The performance of this consolidated IMS core network was then benchmarked using call and traffic models derived from existing IMS networks. Based on this benchmarking, measured IMS core network throughput on a pair of CMT-based ATCA blades exceeded 100K BHCA (or, equivalently, over 30 IMS SIP calls per second). Since the performance of the second PoC was well balanced with the throughput measured in the access controller created in the first PoC, most of the network elements required to deploy a complete WiMAX network serving 50K+ subscribers can be implemented in a single ATCA shelf using 3 pairs of ATCA blades partitioned with the functionality described in the first and second PoCs. By consolidating all the key WiMAX network elements onto a single ATCA shelf configured with 3 pairs of ATCA blades, the cost to deploy new WiMAX networks can be dramatically reduced. The resulting cost to serve the first WiMAX subscriber is also dramatically reduced, thereby providing the WiMAX carrier all the benefits described earlier in this whitepaper.

Chapter 7

Conclusion

One of the major planning challenges for the development of advanced networks is the justification for the capital outlay. The core network function is a fixed cost capital item that must be included in all networks. In a large metropolitan deployment, the core network is a relatively small portion of the total capital outlay. But in a small or medium size network, the cost of the core network could easily constitute 50% or more of the total capital needed. In large networks, the radical consolidation of the core network architecture reduces the capital outlay, and allows for a more efficient use of capital, especially in the critical early years of a network build out. For smaller networks, even more significantly, this critical savings could be the difference between having a viable business case or not.

The change in the development of advanced networks, such as WiMAX broadband wireless networks, is accelerating at a great pace. As these next generation networks are built, new IMS core networks are needed to support their service requirements NEP's are looking to the radically consolidated core architecture to enable them to offer the capacity, flexibility, and services options for network growth. By replacing discrete servers with processor cores, the radical consolidation architecture, will not only greatly reduce the initial capital outlay, but will also future proof the core network for long-term growth.

The Sun Unified Network Platform also creates a great opportunity for carriers. As noted earlier, while many of the larger proposed 4G network developments get much of the hype, most of the actual deployments, such as early WiMAX deployments, are being developed in small and medium size markets. These are exactly the types of deployments where the benefits afforded by radical consolidation are most profound. Simply stated, contemporary computing technology, such as that provided by the Sun Unified Network Platform, has a profound impact on the business case for next generation broadband wireless networks.

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