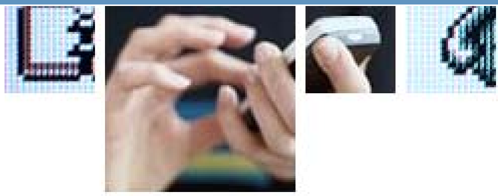
Wireless Data Developer Program



Migrating from CDPD to GPRS

Developer Guide

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welcome to mlife

AT&T Wireless

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Revision History

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Date	Revision	Description
10/31/02	1.0	Initial release

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1. Introduction

This document explains how developers and customers can migrate applications from Cellular Digital Packet Data (CDPD) to General Packet Radio Service (GPRS), an evolved and powerful wireless-data technology.

CDPD technology has proven to be an extremely effective wireless technology, enabling a multitude of mobile applications over nearly a decade. CDPD revolutionized wireless data communications, being the first packet-data service to operate on cellular networks and to support the Internet Protocol (IP). In conjunction with CDPD, AT&T Wireless (AWS) has offered digital PCS voice services based on the ANSI standard 136 (See Section 1.3, Resources).

Over this same period, Global System for Mobile Communications (GSM) has become the most successful cellular technology worldwide, representing over 70% of the global cellular market, with 747 million subscribers in September 2002 (Source: GSM Association, see Section 1.3 Resources). Originally deployed in Europe, GSM is now available in nearly every country around the world. AWS has made a strategic decision to migrate its technology from TDMA and CDPD to GSM, which includes GPRS packet-data service. As discussed below, GPRS provides its users with significant advantages over CDPD.

For developers and customers using CDPD today, AWS is providing thorough support to facilitate the migration of applications from CDPD to GPRS, including both WAP and non-WAP applications. For most customers, this migration will be relatively straightforward as the capabilities of GPRS are essentially a superset of those of CDPD. This document describes the principle considerations and approaches in this migration. The document is in three sections: Technology Overview, Software Considerations, and Integration and Deployment Considerations. Appendices are included that provide additional reference information. This document also references supporting documents and information that aid in this migration.

1.1 Audience

This document is intended for use by AWS alliances, enterprise customers, and independent developers who are migrating applications from CDPD to GPRS.

1.2 Contact Information

- Liz Makofsky, Program Manager, liz.makofsky@attws.com.
- Peter Rysavy, author, rysavy@rysavy.com, (541) 386-7475.

1.3 Resources

The following resources were utilized in the writing of this document:

- ANSI Standards, can be obtained at the following URL: http://global.ihs.com
- GSM Association URL: http://www.gsmworld.com
- WAP specifications URL: http://www.openmobilealliance.org/
- "*Dealing with the EDGE Evolution*", By Terry Locke, Si Nguyen, and Dominique
- Moreuil, Nortel Networks, CommsDesign.com, Sep 24, 2002 URL: http://www.commsdesign.com/story/OEG20020906S0045
- 3GPP TS 03.60 specification is available at the 3GPP URL: http://www.3gpp.org
- *Guide to WML Coding for Multiple Browsers or Mark-Up Language Tutorial*. URL: http://developer.openwave.com/technotes/hdml2wml/index.html

1.4 Terms and Acronyms

Table 1 defines terms and acronyms used in this document.

Table 1 Glossary of Terms and Acronyms

Term or Acronym	Definition
1X-EV DO	One Carrier Evolution Data Only
1X-EV DV	One Carrier Evolution Data and Voice
1XRTT	One Carrier Radio Transmission Technology
3GPP	Third Generation Partnership Project
ANSI	American National Standards Institute
APN	Access Point Name
AWS	AT&T Wireless Services
BSSGP	Base Station Subsystem GPRS Protocol

Term or Acronym	Definition
CDMA	Code Division Multiple Access
CDMA2000	A 3G code division multiple access (CDMA) standard compatible with cdmaOne.
CDPD	Cellular Digital Packet Data
DNS	Domain Name System
EDGE	Enhanced Data Rates for GSM Evolution
ESME	External Short Message Entity
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
GTP	GPRS Tunneling Protocol
HDML	Handheld Device Markup Language
HTML	Hypertext Markup Language
IP	Internet Protocol
IPSec	Internet Protocol Security
IR	Infra Red
ISP	Internet Service Provider
J2ME	Java 2 Micro Edition
kbps	Kilobits per second
LBS	Location-Based Services
LLC	Logical Link Control
MAC	Media access control
MHz	Megahertz
mMode	An AWS consumer offer, introduced in April 2002, which provides easy access to a variety of communication, information, and entertainment services from a wireless phone.
MMS	Multimedia Message Service
MS	Mobile Station
MS	Mobile station
NAT	Network Address Translation
OEM	Original equipment manufacturer
PCS	Personal Communications Services
PDP	Packet Data Protocol
PVC	Permanent virtual circuit
RLC	Radio link controls
SGSN	Serving GPRS Support Node
SIM	Subscriber Identity Module

Term or Acronym	Definition
SMPP	Short Message Peer to Peer
SMS	Short Message Service
SMTP	Simple Mail Transfer Protocol
SNDCP	Sub-network Dependent Convergence Protocol
SSL	Secure Sockets Layer
TAP	Telocator Alphanumeric Protocol
TCP	Transmission Control Protocol
TDMA	Time Division Multiple Access
UDP	User Datagram Protocol
UMTS	Universal Mobile Telecommunications System
VPN	Virtual Private Network
WAP	Wireless Application Protocol
WCDMA	Wideband CDMA
WCO	Wireless Connectivity Option
WML	Wireless Markup Language
xHTML	Extensible Hypertext Markup Language
XML	Extensible Markup Language

2. Technology Overview

This section compares GPRS to CDPD, discusses the capabilities and architecture of GPRS, compares GPRS to other network technologies such as CDMA2000 1XRTT (one carrier radio transmission technology), and describes the evolution from GPRS to even more powerful technologies, including EDGE and UMTS.

GSM with GPRS is a powerful cellular technology that, with related developments, brings:

- Global roaming
- Higher speeds than CDPD (up to 53.6 kbps raw throughput and 40 kbps effective throughput rate)
- Tight integration between voice and data services (e.g., ability to receive a voice call or short message during a data session)
- A multitude of devices
- Color handsets
- New connectivity options for handsets, including IR and Bluetooth
- Phones with digital cameras
- Java 2 Micro Edition (J2ME) language execution
- Short Message Service (SMS)
- Complementary services, including multimedia messaging service, location based services, and electronic wallets

GSM is considered second-generation technology (Analog cellular is considered the first generation), and GPRS is sometimes referred to as 2.5G. GSM provides an elegant evolution to third generation technologies. For instance, all the cell-site radios that AWS is deploying support a 3G technology called Enhanced Data Rates for GSM Evolution (EDGE). Once EDGE devices are available, the AWS network will support both EDGE and GSM/GPRS. EDGE is backward compatible with GSM/GPRS and GPRS is forward compatible with EDGE, which means that GSM/GPRS and EDGE devices will operate on both GSM/GPRS and EDGE networks.

2.1 GPRS Compared to CDPD

GPRS provides essentially the same service as CDPD, namely the transport of IP packets between mobile devices and fixed networks such as the Internet or private intranets. GPRS, however, is a more sophisticated system, and offers customers greater power, flexibility, and control.

Another similarity between CDPD and GPRS is a packet-based, always-connected capability that provides instant communications once registered with the network. This approach uses only the radio resource while actually communicating data. Both technologies encrypt radio communications, and both carefully authenticate the mobile device before allowing it access to the network. Most IP-based applications that work with CDPD will work readily with GPRS, whether designed for vertical markets, office productivity (e.g., Microsoft Outlook), Web browsing, virtual private networking, or many other applications.

There are a number of differences between GPRS and CDPD. Most of these differences offer customers new capabilities and benefits. For example, GPRS coverage will far exceed CDPD coverage. AWS is deploying GSM/GPRS to match its current digital PCS (based on TDMA technology) footprint. GPRS will be available everywhere that GSM is available. GPRS, with its higher speeds and capacity, also supports a much wider range of applications, including streaming multimedia applications. However, differences exist between CDPD and GPRS that may affect some applications. Table 2 summarizes the differences, and subsequent sections discuss the differences in more detail.

Table 2 Summary of Differences Between GPRS and CDPD

	CDPD	GSM/GPRS
Where deployed	US, Canada, Mexico, South America	Worldwide (except Japan, Korea)
Coverage	Key metropolitan areas	Throughout voice footprint
Major US Operators	Alltel, AT&T Wireless, Cingular, Verizon	AT&T Wireless, Cingular Wireless, T-Mobile
Canadian Operators	Telus Mobility	Microcell, Rogers AT&T Wireless
Raw Throughput	19.2 kbps	53.6 kbps

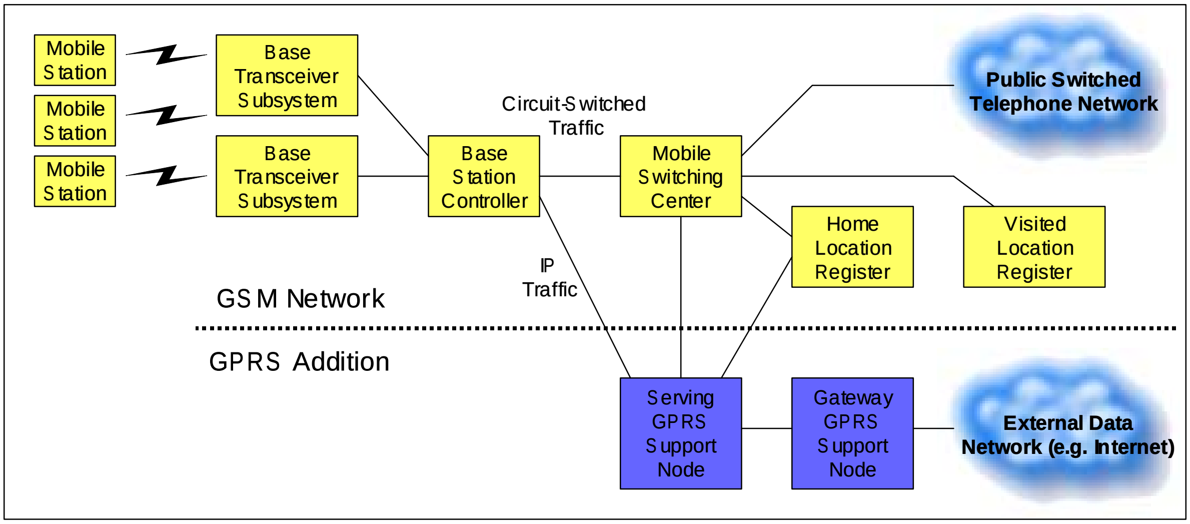
	CDPD	GSM/GPRS
Authentication	Based on device serial number and permanent IP address	Based on Subscriber Identity Module (SIM) card. Actual speeds depend upon the number of time slots a device supports, the radio conditions and network loading.
IP Address	Static	Dynamically assigned
Network Capacity	Limited to one radio channel per sector	Scalable with much higher capacity
Network Redundancy	One national data center	Multiple national data centers with redundant capabilities
Value Added Services	More Limited	Multiple services, e.g., Web optimization or compression, Network Address Translation (NAT), multimedia-messaging service, location-based services, electronic wallets
Voice/Data Integration	Limited	Complete
Short Message Service	Unavailable to applications	Available to applications
Fixed-End Connectivity	Frame Relay (AT&T, AT&T Wireless, Quest, WinStar), native Internet	Frame relay (AWS), native Internet, managed Internet. (Frame-relay service will be available from AWS in the future)
Compatibility with Future Technologies	Partial	Fully forward compatible with EDGE

This document expands on a number of these points in subsequent sections.

2.2 GPRS Capabilities and Architecture

In working with GPRS, it is helpful to understand its architecture. While knowledge of the architecture is not necessary for software development, it is useful for system designers and integrators who are planning items such as fixed-end connections and security requirements. The architecture of GSM and GPRS, as shown in Figure 1, employs traditional digital cellular elements, including base stations (referred to as base transceiver stations), base station controllers, mobile switching center, home location register, and visitor location register. GPRS adds two key network elements: the Serving GPRS Support Node (SGSN) and the Gateway GPRS Support node (GGSN).

Figure 1 GPRS Architecture



The SGSN keeps track of the location of the Mobile Station (MS), forwards user data from the MS to the GGSN, and sends data to the MS that originates from external networks such as the Internet. The AWS network encrypts communications between the MS and the SGSN. The HLR contains user account information. The GGSN is the gateway between the GPRS network and other networks (such as the Internet) and customer networks (including corporate intranets), and is the element responsible for assigning IP addresses to mobile stations.

Note: The Mobile Station (MS) consists of a mobile device (e.g. phone, PC card modem) and any attached computer equipment (e.g., notebook computer).

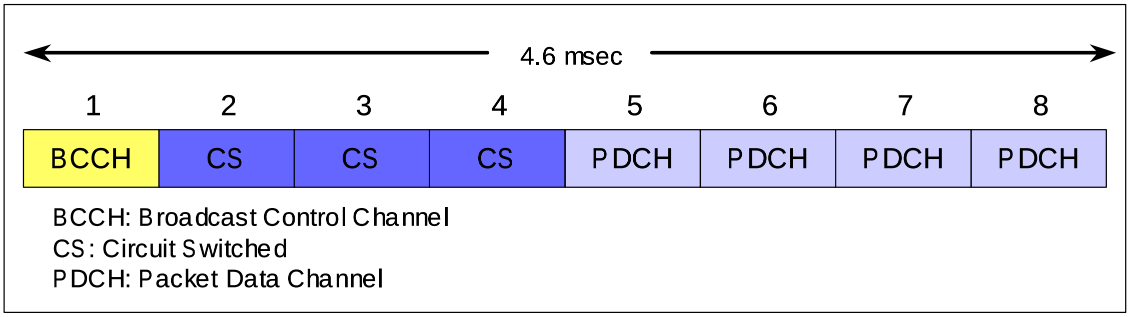
A formal technical description of GPRS is available in the specification 3GPP TS 03.60, available at the 3GPP Web site (http://www.3gpp.org).

An important aspect of GPRS is how the network controls what external networks a mobile station can access. This is done using an Access Point Name (APN), which specifies the external network. APNs, their uses and benefits are discussed in the Section 4.3, *Access Point Names.*

For allocating resources across the radio interface, GSM uses 200 kHz radio channels that are divided into eight time slots, each of which constitutes a physical channel that can either convey control information, a circuit-switched connection (e.g., voice call), or packet data. The effective capacity of each time slot is a raw throughput rate (which includes protocol overhead) of 13.4 kbps, and an effective throughput rate (as experienced by users) of approximately 10 kbps. As of this writing, GPRS devices are capable of communicating on up to four time slots at the same time (in either uplink or downlink directions) resulting in an effective throughput rate of 0 kbps (raw throughput 53.6 kbps). The GPRS specification defines devices that can use up to eight time slots.

Though time slots are shared among users, an operator can use multiple radio channels to increase capacity whether for voice or data. Figure 2 shows a snapshot of a radio channel with a broadcast control channel, three circuit-switched channels, and four packet data channels. The AWS network dynamically controls the number of channels assigned between circuit-switched and packet-switched functions. To ensure critical data does not compete with voice calls during peak times, AWS dedicates a specific number of time slots for GPRS.

Figure 2 Example of GSM/GPRS Time Slot Structure



For a discussion of how GPRS devices register with the network, and how this differs from CDPD, please refer to Appendix D, *GPRS Attachment and PDP Context Activation.*

For maintaining the highest level of reliability, AWS has deployed its GPRS network with redundant capabilities. This includes two separate data centers in geographically dispersed US locations. These contain GGSN and HLR equipment. If one center fails, traffic is can be re-routed to the other center. This represents greater redundancy than in the

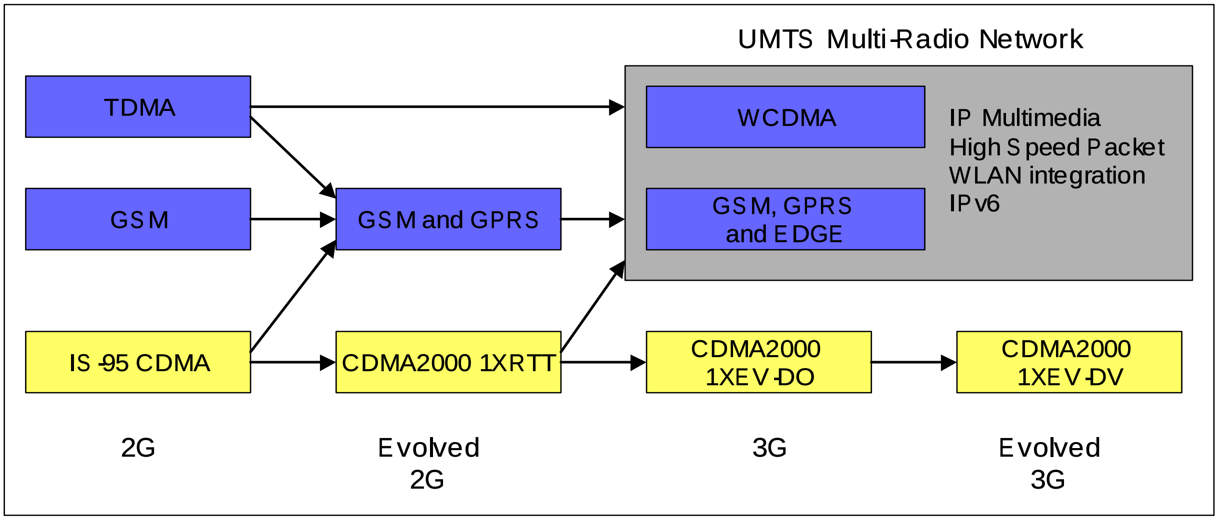
CDPD network. In addition, customers can arrange for redundancy in their fixed-end connections.

2.3 Evolution and Comparison

GPRS is the first step in a significant evolution of capacity and capability. The next step, EDGE, will feature a peak network rate of 473 kbps, while offering practical data rates of up to 120 kbps. EDGE is a highly spectrally efficient technology, that will also double network capacity. Beyond that, the Universal Mobile Telephone System (UMTS), which uses a wideband CDMA (WCDMA) radio network, will initially offer peak rates of up to 2 Mbps and 10 Mbps in future versions. Operators can operate both GSM/GPRS/EDGE and WCDMA radio access networks using a common core network called the UMTS Multi-Radio Network. Developers should appreciate planned service additions, which include full support of IP Multimedia applications (including voice over IP) and integration with wireless local area networks. Figure 3 shows this network evolution.

Meanwhile, Code Division Multiple Access (CDMA) operators are evolving their networks from IS-95 CDMA to CDMA2000. The first phase of this is called 1XRTT (One Carrier Radio Transmission Technology). Future phases will include 1XEV-DO (1X Evolution Data Only) and 1XEV-DV (1X Evolution Data and Voice). While the evolution of CDMA2000 has many of the same capabilities as the evolution from GSM to UMTS, the overwhelming majority of operators worldwide have chosen the GSM-to-UMTS path, which will result in global roaming options and lower equipment and services prices.

Figure 3 The Evolution of Cellular Technologies



During the 2002 and 2003 time frame, the technologies available to customers will be GSM with GPRS/EDGE and CDMA2000 with 1XRTT. GSM is the optimum wireless data technology due to:

- Global availability and compatibility of GPRS service
- Lower network and operating costs, thanks to huge economies of scale and unrestrictive technology licensing. There are over 400 GSM operators worldwide while over 100 operators have committed to UMTS deployment.
- GSM/GPRS terminal equipment being available in greater variety and at lower cost.
- A smooth migration to enhanced capability with EDGE, which outperforms 1XRTT.
- More consistent data performance than alternative technologies.
- A variety of value added services, including Web optimization.

Meanwhile, AWS is the optimum partner because:

- Migrating from CDPD to GPRS with AWS is the fastest and easiest solution for customers and developers with existing CDPD applications.
- As a CDPD pioneer, AWS has some of the most significant experience with wireless data offerings and with building and supporting wireless data.

- AWS offers comprehensive support for data services, including the Developer Program and advanced networking.
- AWS offers enterprises a number of customizable options, including IP address management and fixed-end connectivity solutions.

3. Software Considerations

This section analyzes the software implications of migrating from CDPD to GPRS. The good news is that most IP-based applications that operate over CDPD, including WAP, will operate without any modifications over GPRS. With its faster speeds, GPRS enables a wide variety of applications. This section examines two categories of software:

- Those that involve direct communication between the Mobile Station (MS) and the fixed-end service
- Those based on the Wireless Application Protocol (WAP)

There are some important differences between CDPD and GPRS that can affect software, including IP addressing, session management, server-initiated communications, pricing, throughput, and latency.

For readers interested in the protocols used to convey user data in a GPRS network, please see Appendix A, *GPRS Protocols.*

3.1 IP Addressing

GPRS manages IP addresses in a fashion similar to most Internet Service Providers (ISPs). Most applications, whether WAP-based, e-mail, database access, file transfer, or Web browsing, will function with no difficulty. Some CDPD applications, depending on how they use the IP address, may be affected, as there are some differences between CDPD and GPRS.

The key differences are:

- In GPRS, addresses are dynamically assigned. In CDPD, addresses are fixed.
- In GPRS, the address stays the same only for the duration of a data session (called a Packet Data Protocol or PDP context). If there is no data activity for a certain length of time (e.g., no data activity for four hours, no location updates for one hour), the network removes the PDP Context. The next PDP context will likely result in a different IP address. For further information, refer to Appendix D, *GPRS Attachment and PDP Context Activation.*

- In GPRS, addresses can be private (non-routable) or public (routable). For private addresses, the network performs Network Address Translation (NAT) to convert the source address from private to public. The use of private addresses allows operators to support a much larger number of customers. Private addressing and NAT is typically used when connecting to the Internet. Public addressing is required when connecting corporate intranets directly to the GPRS network using fixed-end connections (such as frame relay). CDPD uses only public addresses regardless of whether connecting to the Internet or directly to corporate intranets. These differences may affect applications that rely upon the following:

  The IP address of the Mobile Station (MS) for security (i.e., firewall filtering)

  The IP address to identify a specific MS

  The IP address of the MS to originate or dispatch messages to the MS (i.e., push messages)

  The IP address not changing in transmission of packets from mobile to destination host (i.e., certain virtual private networks)

Solutions are as follows:

- For customers that rely on the IP address of the mobile device for security purposes, AWS can provide a fixed range of public IP addresses that are dynamically assigned only to devices that the customer designates. These public IP addresses do not undergo network address translation. See Section 4.3, *Access Point Names*, for further details. This change should not affect the actual application software.
- Applications that rely on the IP address to identify the mobile station may require a software change. The MS will have to use a different form of identification, such as a unique ID manually assigned by an administrator, a user's login name, or the phone number of the device.
- For applications that need to originate or dispatch messages to the MS, see Section 3.2, *Mobile-Terminated Communications.*
- For customers with applications that need the IP address to not change between the MS and destination host (fixed-end server), AWS offers public IP addresses. Note, that any application that

requires a dedicated fixed-end connection will require a custom APN, and currently this arrangement almost always uses public addresses. Most CDPD applications currently use dedicated fixed-end connections, and hence will not be affected. See Section 4.3, Access Point Names (APN), for further details.

Above the IP layer, protocol stacks and applications will normally use transport protocols such as the User Datagram Protocol (UDP) or Transmission Control Protocol (TCP). Like CDPD, GPRS supports both UDP and TCP applications, and whether an application is based on UDP or TCP should not be an issue in migrating from CDPD to GPRS.

3.2 Mobile-Terminated Communications

Some applications, such as dispatch, need the server to be able to send (push) a message to the MS. In the case of telemetry applications, these may be polling messages. There are two considerations with GPRS.

The first consideration is that the IP address of the MS is dynamically assigned, so if a server relies on the IP address of the MS to send a message, it must first obtain the IP address from the MS through communications initiated by the MS. To simplify this process, AWS is researching options that would allow a query against a logical name of a device (e.g., phone_number@gprs.attws.com) that returns the current IP address of that device. This approach is often referred to as dynamic Domain Name System (dynamic DNS).

The second consideration is that the IP address will only remain the same for the duration of the PDP context.

In general, the application software will need to function as follows:

- The MS initiates communications with the server, making its IP address known
- The server can now push messages to the MS using its IP address
- The MS must monitor the PDP context and potentially issue keep-alive messages to maintain the connection. If the IP address of the MS changes, the MS must inform the server accordingly

Customers should note that AWS has configured its firewalls so mobile-terminated communication (IP packets that originate from external networks) is only allowed in conjunction with a custom APN.

There are two other mechanisms that allow applications to push messages. One is short message service, as described in Appendix C, *Short Message Service.* The other is available for WAP applications and is described in Section 3.6, *Wireless Application Protocol.*

Note: New service options in the future may provide alternative approaches.

3.3 Pricing Considerations

Some CDPD pricing plans are flat rate. Most current GPRS pricing plans are volume based, and a large amount of data traffic could result in high usage charges. In migrating to GPRS, applications that are efficient in their communications should not be affected. WAP applications, in particular, tend to be very efficient.

GPRS does offer a significant advantage for managing data volume compared to CDPD through the combination of custom APNs and firewall filters. Customers can restrict traffic to access only certain systems, such as their mobile application server.

Customers should check with AWS for the latest pricing plans to determine which plans best meet their needs.

For further ideas on how to manage the volume of data an application communicates, see Appendix B, *Managing Data Volume.*

3.4 Throughput and Latency

With effective throughput rates up to 40 kbps, GPRS provides higher data throughput rates than CDPD. Therefore, any application that performs reasonably with CDPD should work as well (and probably better) with GPRS. Actual speeds depend on the number of time slots the device supports, signal quality, and the amount of data activity in the cell. Customers should expect some variation in throughput.

GPRS uses sophisticated mechanisms to control access to the radio link and can support a large number of users simultaneously. This resource management does result in GPRS latencies (round trip time) being slightly higher than CDPD: 800 ms versus 600 ms. For efficient wireless applications, this higher latency will have little or no effect. However, applications that engage in excessive back-and-forth traffic (referred to as “chatty”) may be adversely affected. TCP-based applications, such as

Web browsing and file transfer (which are based on a windowing protocol) typically are not affected by the difference in delay.

Note: Windowing protocols transmit successive packets before receiving acknowledgments of previous packets, up to the size of the "window."

For customers using Web-based applications across the Internet, AWS offers an optional compression scheme that significantly boosts performance. This is helpful for applications that have not been optimized for wireless communications. This compression scheme is available with the Mobile Connection Client software from AWS. Other performance-enhancing technologies may be available in the future.

3.5 New GPRS Application Features

GPRS offers a much richer application environment than CDPD, with SMS, Multimedia Messaging Service (MMS), Location-Based Services (LBS), and Java. Most developers will typically not take advantage of these capabilities in their initial migration from CDPD to GPRS, but they may want to consider them as a means of enhancing their applications or for new applications.

This document has already mentioned SMS as an application option, and describes it further in Appendix C, *Short Message Service.* A more advanced messaging option is MMS, which allows the transmission of images, ringtones, voice clips, and eventually video. Meanwhile, Location-Based Services (LBS) provide information about a mobile device's location to external hosts, while carefully addressing privacy concerns. AWS currently has LBS offerings and expects to offer more in the future. With Java an application can operate on the actual mobile device, whether it be a mobile telephone or PDA. Users can download the application over-the-air or transfer it from a computer using a synchronization procedure. While the initial focus of Java is consumer-oriented, this powerful application platform will also prove to be an excellent enterprise solution.

3.6 Wireless Application Protocol (WAP)

The Wireless Application Protocol (WAP) provides a framework for efficient wireless applications that can be hosted on a Web server. The user interacts with a browser on their device, typically a mobile telephone, which communicates with a gateway in the operator's network that then communicates with the origin server that contains the application and content. This origin server can reside in the operator network, public portals or in a customer's enterprise network. WAP architecture is the same between CDPD and GPRS, though there are differences in how various aspects function, particularly with respect to markup languages and push mechanisms.

The CDPD PocketNet phone uses what is called the Handheld Device Markup Language (HDML). Current AWS GPRS phones support the WAP Wireless Markup Language (WML), Version 1.3, mMode-compatible HTML, and xHTML. HDML content cannot be directly rendered on WAP phones; however, the AWS gateway does automatically convert HDML content into WML. Unfortunately, the languages may not have a one-to-one correspondence on the elements they support, and the translation may not result in the expected application behavior.

Most enterprise customers with HDML content today will need to convert their application. The customer has a choice of using WML Version 1.3, xHTML (which is part of the WAP 2.0 standard), or mMode-compatible HTML. Although support varies among phone models, the GPRS phones that AWS sells will generally support all of WML 1.3, xHTML, and mMode-compatible HTML. Of these, xHTML will provide best forward compatibility with future devices.

Developers should verify the mark-up languages and browsers supported by the devices of interest. This information is available as part of the Phone Toolkits on the Developer Program Web site. For more detailed information on markup languages, please refer to the AWS document, *Guide to WML Coding for Multiple Browsers* or *Mark-Up Language Tutorial*, both available in the white paper section of the Developer Program Web site. Information about migrating from CDPD to GPRS is also available on this Openwave Web page, http://developer.openwave.com/technotes/hdml2wml/index.html.

The other change has to do with pushing information to WAP devices. With CDPD, this was done using a mechanism called UP.Notify. With WAP, the mechanism is called WAP Push. Whereas any customer could push messages using UP.Notify, GPRS customers must first register to use WAP Push. Instructions are provided on the AWS Developer Program Web page.

WAP Push operates in a similar fashion to UP.Notify, with the UP.Notify notification (alert) in UP.Notify corresponding to the WAP Service Indication and the UP.Notify pre-fetch corresponding to the WAP Service Load. WAP Push is based on posting two XML documents (one for control, one for content), and operates the same in versions 1 and 2, ensuring forward compatibility. Developers will need to modify applications that use UP.Notify to support WAP Push. Please contact the AWS developer program for additional information about WAP Push.

Another consideration is that the IP address of the GPRS WAP gateway differs from the CDPD PocketNet gateway, and so customers may have to reconfigure their firewalls.

Finally, for customers who have what are called custom home decks (a custom home page) with CDPD, the same capability is available for GPRS. Information regarding this is available through the Developer Program.

3.7 Evolution of GPRS to EDGE and UMTS

GPRS is the first step of data services for GSM-based cellular technology. The next significant step is EDGE, which will boost data rates by up to a factor of three, enabling practical user rates of about 120 kbps (actual throughputs will depend upon radio conditions and network loading). EDGE achieves its high performance through enhanced radio technology. However, all the protocols and core network elements remain the same as GPRS. The result is that any application that operates over GPRS will work over EDGE without requiring any changes, a tremendous benefit for developers. Once AWS begins to deploy its EDGE network, users will have to purchase an EDGE device to take advantage of EDGE's high speeds. However, EDGE will be backwards compatible, supporting current GPRS devices.

Beyond EDGE, the Universal Mobile Telecommunications System (UMTS) brings significant new capabilities, including higher speeds, sophisticated quality-of-service mechanisms, and multimedia support. The UMTS data service is also based on same fundamental GPRS architecture, and migration from GPRS/EDGE to UMTS will be straightforward.

4. Integration and Deployment Considerations

Once customers understand the benefits of GPRS, have decided to migrate their application to GPRS, and have considered potential software implications, they should consider how best to integrate and deploy their application. This section discusses coverage, devices, access point names (with additional information on IP addressing), fixed-end connections, how to support both CDPD and GPRS in a transition period, and roaming.

4.1 Coverage

Of primary concern to customers is that the AWS GPRS network provides coverage in all desired areas. Customers will be pleased to note that the AWS GPRS footprint is extensive and available everywhere that GSM voice service is available. GSM/GPRS is available in most major metropolitan areas and closely maps to the Home TDMA network footprint. Additionally, GSM/GPRS currently enables customers to roam internationally with eighty other carriers. The resulting coverage will be far greater than the CDPD network, and for migrating customers, coverage should generally not be a concern.

Note: Not all TDMA markets will have GSM/GPRS service initially, however, AWS is in the process of adding new markets on a regular basis (e.g., Kansas City and Atlanta).

Customers should note that whereas CDPD operates in the 850 MHz band, the AWS GSM/GPRS currently operates in the 1900 MHz band, and consequently has different radio propagation characteristics than CDPD. If there are highly specific locations where coverage is paramount, customers should test accordingly.

Note: In general, lower frequencies propagate over a longer distance. In-building penetration and coverage may also vary. Future network enhancements may extend range.

4.2 Devices

There are a wide variety of GPRS devices from multiple vendors, including GPRS mobile telephones, PC Card modems, ruggedized external modems, PDAs with GPRS capabilities, and OEM modules.

Mobile telephones with GPRS capabilities can be used stand-alone with their WAP browsers, or can serve as modems to a computer, attached by a cable, IR, or Bluetooth.

Note: AWS only certifies specific products for operation on the AWS GPRS network.

For PC Card operation, migration from CDPD to GPRS is easy, requiring a simple installation of new software on the mobile station. External devices, e.g., ruggedized units, may have different form factors with different mounting hardware. Truly mobile data applications, such as public safety, usually use external antennas and these may have to be modified to support 1900 MHz operation, which differs from CDPD's 850 MHz operation. GSM/GPRS currently operates at 1900 MHz in the US, with 850 MHz operation a forthcoming option for operators. GPRS operates at 900 MHz and 1800 MHz elsewhere in the world.

Please refer to the AWS Developer Program Web page for information about current GPRS devices.

4.3 Access Point Names (APN)

As introduced in Section 2.2, *GPRS Capabilities and Architecture*, an APN specifies the external networks that a mobile station can access. Specifically, an APN is a DNS name that points to a GGSN for the session or PDP Context. It also defines the type of IP address and value-added services to use. Since an APN uses DNS, additional redundancy is available in the network because if a GGSN fails, another one can automatically be engaged. As a result, the APN mechanism is a powerful tool for customers to manage IP addressing, redundancy, security, resources users can access, and fixed-end connections.

APNs are defined as part of a subscriber account and SIM. An MS can have access to more than one APN, though each PDP Context (data session) specifies a specific APN to use. Some APNs are available to multiple customers (e.g., public and proxy), which specify Internet access using either a public or a private IP address. However, if a customer has a fixed-end connection arrangement with AWS (as is the case for most CDPD enterprise customers today), this fixed-end connection must use public IP addresses. This provide greater security as only one the customer's users will have devices authorized to use the custom APN and only their custom APN will have access to their fixed-end connection. Fixed-end connections, including the Wireless

Connectivity Option (WCO), are discussed in the next section, and consist of either frame relay connections or managed Internet connections.

AWS offers the following APNs:

- Proxy - the default configuration, providing Internet access in combination with a private IP address. (The network performs network address translation).
- Public - Internet access in combination with a public IP address. No network address translation is performed on the packets. Additional charges apply for these addresses.
- RIM - for Blackberry devices.
- Custom APNs - Range of public IP addresses only. Assigned on a custom basis to customers to provide connectivity to their networks, typically over private connections.

The format of a custom APN is a Domain Name System (DNS) name (e.g., xyzcorp.com), and it points to a specific GGSN for the duration of a PDP context. Custom APNs support two primary types of IP addressing options:

- Dynamic, public IP addresses within a range. IP blocks include 30, 62, 126, 254, 510 and 1022. These addresses enable mobile access of the customer APN as well as the Internet. There is a one-time setup fee and a monthly charge that depends on the size of the address block.
- Dynamic, customer-provided public IP addresses within a range. These addresses restrict mobile access only to the customer APN. There is a one-time setup fee.

Since custom APNs result in IP addresses being dynamically assigned to MS from a specific range, customers can configure firewalls accordingly. There does not have to be a one-to-one correspondence between the IP address pool and devices, there only needs to be a sufficient number of addresses for all active devices.

Table 3 summarizes the access available to different APNs.

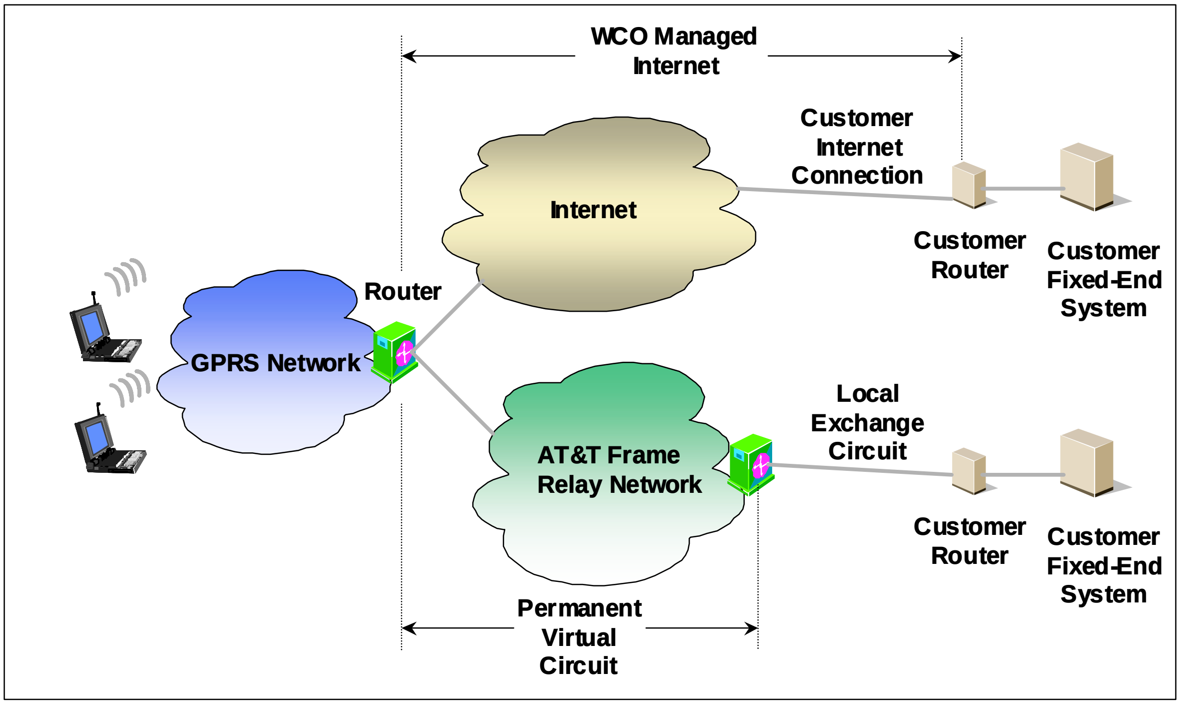
Table 3 Summary of Access for Different APNs

APN	WAP Gateway	Internet Access	Web Optimization	VPN over Internet	Frame Relay or WCO
Proxy	Yes	Yes	Yes	Yes	No
Public	No	Yes	Yes	Yes	No
Custom (AWS IPs)	No	Optional	Optional	Yes	Yes
Custom (Customer IPs)	No	No	No	No	Yes

4.4 Fixed-End Connections

There are two basic ways paths for an MS to access a fixed-end system. One is via the Internet. The other is via a frame relay Permanent Virtual Circuit (PVC). These two paths are shown in Figure 4.

Figure 4 Fixed-End Connectivity Options for GPRS



If using the Internet, the customer has three options. One is to use the Internet in an unsecured fashion (referred to as native Internet), which is generally not feasible given how most customers have configured their

Internet firewalls. Another is to use a customer-provided Virtual Private Network (VPN) that extends from a VPN client installed on the MS to a security server in the customer's network (an alternative approach would be to secure a connection to a Web server using Secure Sockets Layer (SSL). The third option is a service from AWS called the Wireless Connectivity Option (WCO) Managed Internet. This consists of an IPSec VPN tunnel (Using triple DES encryption) between the edge of the GPRS network and a router (or VPN server) at the customer's location.

If using a frame relay, customers can use a PVC obtained directly from AWS using a service called WCO Frame Relay. The advantage of using WCO Frame Relay is that AWS proactively monitors the connection and can quickly resolve circuit problems. Additional redundancy options may also be available with WCO Frame Relay.

For customers migrating from CDPD, there are a number of considerations.

- The preferred frame relay provider for GPRS is AWS. CDPD customers who used AT&T Wireless or AT&T can continue to use the same frame relay circuit provider but will need to obtain a new PVC from AWS.
- CDPD customers who used WinStar or Quest will need to convert to AWS.
- Customers should increase their frame relay port speed to at least 128 kbps because more data can be sent with GPRS. This arrangement also allows two PVCs to be configured: one for CDPD and one for GPRS. This permits customers to run both CDPD and GPRS applications simultaneously and allow for a more seamless migration. Customers with a DS0 (56 kbps) local circuit should upgrade to a fractional T1 circuit.

Table 4 summarizes the fixed-end connectivity options or CDPD and GPRS.

Table 4 Fixed-End Connectivity Options for CDPD and GPRS

	CDPD	GPRS
Internet	Customer provided VPN (or SSL)	Customer provided VPN (or SSL)
Wireless Connectivity Option (Managed Internet)	Not available	Available
Frame Relay from Third	AT&T, Quest, WinStar	Currently not available

	CDPD	GPRS
Parties		
Wireless Connectivity Option (Frame Relay)	Preferred frame relay solution	Preferred frame relay solution

Customers can arrange for redundant fixed-end connections as they did with CDPD, but with GPRS they have more options. For instance, a customer can designate a WCO - Managed Internet connection as a backup connection to a frame relay connection. Additionally, a customer can arrange for even greater redundancy by having separate IP address blocks allocated to different GGSNs in the AWS network. If there is a network failure involving a GGSN, another one can automatically take its place without disrupting the customer's application.

There are additional fixed-end connectivity considerations for customers needing to support both CDPD and GPRS in a transition period, as discussed in Section 4.5.

4.5 Supporting Both CDPD and GPRS During the Transition

As customers migrate from CDPD to GPRS, there will likely be a period when a customer will have both CDPD and GPRS units operating in the field. This can affect both application software and fixed-end connections.

If the same application software can be used with CDPD and GPRS, then having both CDPD and GPRS mobile stations operating in the field should not be difficult. If however the application software is different, then customers may need to have the CDPD solution operate separately and in parallel with the GPRS solution.

If a customer is using frame relay for the fixed-end connection to the CDPD network, the customer will need to obtain a second PVC for GPRS. This second connection can be over the same local exchange circuit (see Figure 4) if using AT&T or AWS WCO Frame Relay, though the port speed may need to be increased. If the customer's CDPD PVC is with Quest or WinStar, the customer will need to obtain a separate local circuit that connects to AWS WCO Frame Relay.

Note: Increasing port speed requires that the customer be using a fractional T1 line in their local circuit.

4.6 Roaming

Roaming partnerships are different between CDPD and GPRS. For example, both AWS and Verizon Wireless offer CDPD, however, Verizon Wireless does not offer GPRS. For coverage outside of the AWS GPRS footprint, customers should consult with AWS about roaming options.

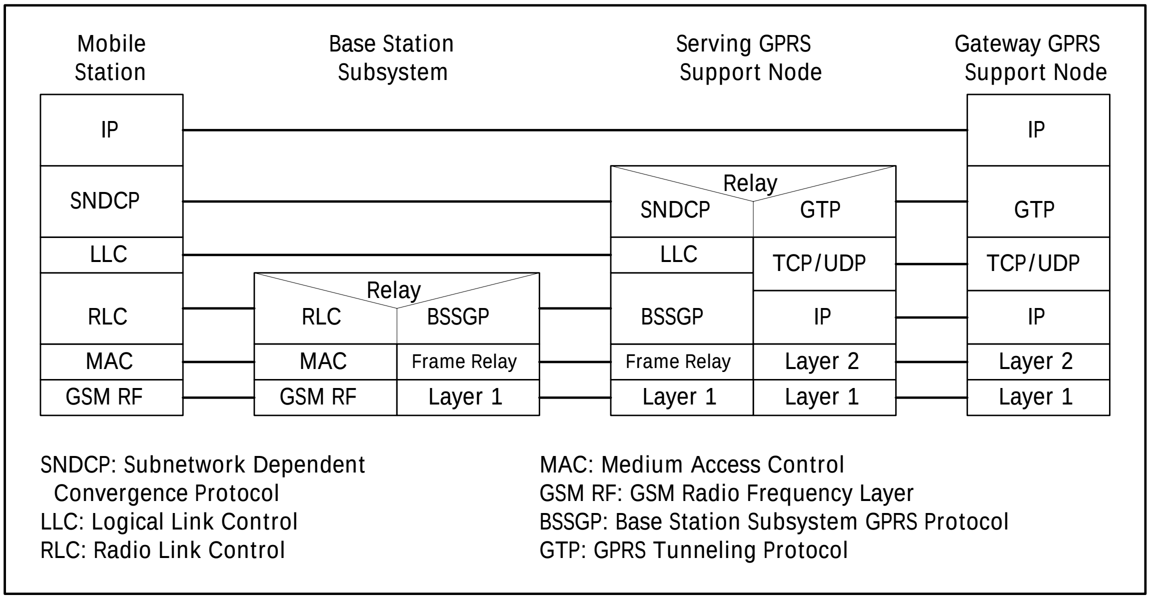
GPRS improves on CDPD in how it handles roaming situations. With CDPD, IP datagrams from an external host addressed to an MS route via the home CDPD network and are forwarded to the serving CDPD network. In the reverse direction (mobile to host), packets may be routed directly to the external host without going via the home CDPD network. This is called triangular routing.

In the case of GPRS, all traffic flows to the MS via the home GPRS network. The MS uses the same APNs as it normally does and has access to all the same resources, including Web optimization and fixed-end connections, as it does in the same network. This is an overall improvement and should not adversely affect customers migrating from CDPD to GPRS.

Appendix A. GPRS Protocols

The GPRS network implements a number of protocols to transport user data and to handle functions such as user authentication, data encryption, mobility management (tracking users as they move across a coverage area), quality of service, and session management. Figure 5 shows the protocols involved.

Figure 5 GPRS Protocols (User Plane)



The following describes the functions of the different protocols:

- **IP:** These are IP packets generated by the user application (as delivered by the IP protocol stack). Layers above IP belong to the user domain. Typically, customers will use UDP or TCP above the IP layer, both of which are supported by GPRS networks.
- **GPRS Tunneling Protocol (GTP)**: Operating between the SGSN and the GGSN nodes, this important protocol is used to establish the parameters of a mobile station's connection to external networks and then to transfer user data. Packets addressed for MS that originate from external networks (such as the Internet) reach the GGSN by using conventional IP routing methods. The GGSN encapsulates these packets inside other packets and sends them to the SGSN for delivery to the MS. This type of communication

between the GGSN and SGSN is called tunneling. The new packets include headers that contain information such as an identifier for the tunnel endpoint, the type of data type being sent, and quality-of-service parameters. A similar process occurs in the reverse direction for packets that originate from the MS.

GTP itself operates over standard Transmission Control Protocol/Internet Protocol (TCP/IP) protocols using whatever underlying links are the most convenient for carriers, whether frame relay, Asynchronous Transfer Mode (ATM), or Ethernet.

- **Subnetwork Dependent Convergence Protocol (SNDCP)**: The primary functions of this layer are segmentation, where the IP packets are divided into segments better handled by lower layers, and compression. The SNDCP layer also multiplexes user data packets with signaling information that controls functions such as mobility management.
- **Base Station Subsystem GPRS Protocol (BSSGP)**. Located beneath the LLC layer within the SGSN, the BSSGP sends routing and quality-of-service information between base station and SGSN.
- **Logical Link Control (LLC)**: Located beneath the SNDCP layer, this protocol provides a logical link between the mobile station and the SGSN. It is defined in a way that hides the details of the radio network from upper layers, making it easier in the future to enhance the operation of the radio link. This is analogous to the LLC layer within IEEE 802 standards that resides above different mediums such as Ethernet, Token Ring, and IEEE 802.11 wireless LANs. The LLC also ciphers (encrypts) data.
- **Radio Interface**. The layers beneath the LLC operating between the mobile station and the base station constitute the radio interface, sometimes referred to as the air link. The RLC ensures reliable delivery of data while the medium-access control layer controls how user devices send and receive packets of information.

Despite the details listed, from an application development and deployment perspective, these protocols are largely invisible. The GPRS network essentially transports the user's IP data grams between the mobile station and the GGSN, which then routes them to and from external networks.

Appendix B. Managing Data Volume

To monitor how much traffic an application generates, customers can monitor the modem icon in Microsoft Windows, which indicates the amount of bytes communicated during a dial-up networking connection. There are also third party tools (e.g., DU meter at http://www.hageltech.com/) that provide such information. In addition, most GPRS phones indicate the amount of data transferred in a data session.

With GPRS and a custom APN, a customer can carefully control to which sites a user has access. Since all traffic is directed to the customer network, the customer can restrict access to desired application services, and can block access to other locations such as the Internet.

If it is necessary to reduce the amount of data that an application actually communicates, there are various techniques available, including:

- Compressing data. Note that the AT&T Mobile Connection software offers effective compression of Web-based communications for applications that are not already optimized for wireless networking.
- Using tokens to represent larger data elements. A token acts as a name of a previously defined data element, and can be sent in lieu of the data element itself.
- Using local caches to avoid resending of data.
- Restarting operations from the point of failure.
- Minimizing the number of separate messages to complete transactions.
- Using more efficient transport protocols than the Internet Transmission Control Protocol (TCP). While UDP has less overhead than TCP, it does not provide the reliability and congestion-control management that TCP does, and so the application must handle these functions. One approach is to use wireless middleware, which generally uses non-TCP approaches.

Appendix C. Short Message Service (SMS)

A host can send an SMS message either via e-mail (by directing SMTP-based e-mail messages to username@mobile.att.net), or by using the SMPP protocol. An approach based on Short Message Peer-To-Peer (SMPP) may be a more viable solution for many business needs.

SMPP is an open industry standard messaging protocol designed to simplify integration of data applications with wireless mobile networks, including GSM and TDMA.

The SMPP protocol provides multiple advantages over the common SMS messaging platform, Simple Mail Transfer Protocol (SMTP). One primary difference is that SMTP uses the public Internet for message delivery and is therefore subject to message volume limitations. With a direct, private connection to the SMPP gateway, customers avoid the Internet and its limitations.

SMPP was created by the messaging industry with two-way SMS in mind. Other protocols, such as SMTP and Telocator Alphanumeric Protocol (TAP), were created for e-mail and paging, and without the advanced SMS capabilities developed and updated for SMPP.

AWS now offers text messaging for large accounts, which enables External Short Message Entities (ESMEs) the ability to connect directly to the AWS Short Message Peer-to-Peer (SMPP) gateway via frame relay for the purpose of sending messages to AWS text messaging subscribers. ESMEs have the option of one-way or two-way text messaging and delivery receipt confirmation.

Note: To be able to use SMPP, customers must first undergo a registration process. More details are available through the AWS Developer Program.

Appendix D. GPRS Attachment and PDP Context Activation

Devices gain access to the GPRS network through the following two-step process:

1. **Attachment.** Attachment generally occurs when the device is turned on. The device (e.g., modem or mobile telephone) issues an attachment request. The attachment request consists of identity information, routing-area location information and the desired type of attachment, which can be GSM (for circuit-switched services that include voice and SMS), GPRS (for packet-data service) or both. The network then authenticates the mobile device by sending it a large random number, called a "challenge." The device performs a complex calculation of this number in combination with secret subscriber information contained on the SIM card, and returns a "response" that the network confirms. If successful, the device is now attached to the network. For GSM, this allows the device to now make and receive phone calls or to send and receive SMS messages. For GPRS service, the device must undergo an additional step called PDP Context.
2. **Packet Data Protocol (PDP) Context.** Upon user request, or automatically, the device issues a PDP Context activation request. The request consists of the type of IP address desired and APN to use. The network checks the request against the services allowed for that subscriber based on information stored in the Home Location Register. If successful, the network assigns an IP address to the device and creates an association between the SGSN supporting the user, and the GGSN associated with the specified APN. Now the device can send and receive IP packets.

Note: As new services are supported in the future, the request may consist of additional parameters.

CDPD registration differs in that it consists of a single step where the device is authenticated against its hardware serial number and IP address that has been permanently assigned to the device. However, this difference should not have any affect on applications, and should not be a factor in how customers migrate their applications from CDPD to GPRS.