Notice

This manual is published by SkyTel, L.L.C. for informational purposes only and is without any warranty whatsoever. The manual and software described in it are copyrighted with all rights reserved. Your rights of ownership are subject to the limitations and restrictions imposed by copyright laws. No portion of this document may be copied, photocopied, reproduced, translated or reduced to any electronic medium or machine form without prior consent from SkyTel. Any physical defects, typographical errors, inaccuracies of current information, improvements to programs, and/or equipment in the manual may be made solely by SkyTel at any time without notice. Such changes will, however, be incorporated into future releases of the manual.

Trademark Notice

SkyTel is a service mark of SkyTel. Research In Motion, RIM and the RIM logo are registered, U.S. Patent and Trademark Office. Mobitex is a registered trademark of Swedish Telecom. Windows is a trademark of the Microsoft Corporation. All other trade names used herein are trademarks of their respective companies.

©2005 SkyTel
All Rights Reserved.
10 Woodbridge Center Drive
Woodbridge, New Jersey 07095

Telephone: (732) 602-5500
Fax: (732) 602-5285
http://www.skytel.com
Printed in the United States of America.
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Overview</td>
<td>1</td>
</tr>
<tr>
<td>SkyTel Mobitex Network</td>
<td>1</td>
</tr>
<tr>
<td>2. Introduction to Mobitex</td>
<td>4</td>
</tr>
<tr>
<td>The Origin of Mobitex</td>
<td>4</td>
</tr>
<tr>
<td>Packet Switching</td>
<td>4</td>
</tr>
<tr>
<td>Channel Access Mechanism</td>
<td>4</td>
</tr>
<tr>
<td>Mobitex System Components</td>
<td>5</td>
</tr>
<tr>
<td>Network Control Center</td>
<td>5</td>
</tr>
<tr>
<td>Backbone Network</td>
<td>6</td>
</tr>
<tr>
<td>Base Station</td>
<td>6</td>
</tr>
<tr>
<td>An Open System</td>
<td>7</td>
</tr>
<tr>
<td>3. System Overview</td>
<td>8</td>
</tr>
<tr>
<td>Introduction</td>
<td>8</td>
</tr>
<tr>
<td>System Level Characteristics</td>
<td>8</td>
</tr>
<tr>
<td>RF Link Characteristics</td>
<td>8</td>
</tr>
<tr>
<td>Service Areas</td>
<td>9</td>
</tr>
<tr>
<td>Subscriptions</td>
<td>9</td>
</tr>
<tr>
<td>Network Protocols</td>
<td>9</td>
</tr>
<tr>
<td>Airlink Data Rate</td>
<td>10</td>
</tr>
<tr>
<td>Dynamic Power Control</td>
<td>10</td>
</tr>
<tr>
<td>Power Saving Protocol</td>
<td>10</td>
</tr>
<tr>
<td>4. System Architecture</td>
<td>11</td>
</tr>
<tr>
<td>Overview</td>
<td>11</td>
</tr>
<tr>
<td>System Hierarchy</td>
<td>12</td>
</tr>
<tr>
<td>Network Topology Enhancement</td>
<td>12</td>
</tr>
<tr>
<td>5. SkyTel System Features</td>
<td>13</td>
</tr>
<tr>
<td>Overview</td>
<td>13</td>
</tr>
<tr>
<td>Transparent Roaming</td>
<td>13</td>
</tr>
<tr>
<td>Store-and-Forward</td>
<td>14</td>
</tr>
<tr>
<td>Group Broadcast</td>
<td>15</td>
</tr>
<tr>
<td>Closed User Groups (CUGs)</td>
<td>15</td>
</tr>
<tr>
<td>End-to-End Delivery Verification</td>
<td>15</td>
</tr>
<tr>
<td>POSACKS</td>
<td>15</td>
</tr>
<tr>
<td>NACKS / Non-Acknowledgments to the Host</td>
<td>16</td>
</tr>
<tr>
<td>Positive End-to-End Acknowledgment</td>
<td>17</td>
</tr>
<tr>
<td>Back-in-Coverage Notification</td>
<td>17</td>
</tr>
<tr>
<td>Error Correction</td>
<td>18</td>
</tr>
<tr>
<td>Wireless Subscription Management</td>
<td>19</td>
</tr>
<tr>
<td>Future Enhancements</td>
<td>20</td>
</tr>
<tr>
<td>6. Mobitex Security</td>
<td>22</td>
</tr>
<tr>
<td>Overview</td>
<td>22</td>
</tr>
<tr>
<td>Subscription Security Features</td>
<td>23</td>
</tr>
</tbody>
</table>
Table of Contents, Continued

7. Component Performance Characteristics 26
   Overview 26
   Message Characteristics and Routing 26
   Message Packet Characteristics 26
   Mobile-to-Host Messaging 26
   Host-to-Mobile Messaging 27
   Multiple Devices / Applications 27

8. Connectivity Options 28
   Overview 28
   Network Host Connectivity Options 28
   Frame Relay 29
   Customer Requirements 31
   Customer Premises Equipment Required 31
   Internet Access Service 32
   Direct Lease Line 32
   Capacity of Host Links to the SkyTel Mobitex Network 32

List of Figures

Figure 1-1: SkyTel Mobitex Network Architecture 2
Figure 1-2: Enhanced Backbone 3
Figure 4-1: Network Architecture 11
Figure 5-1: POSACK Flag Format 16
Figure 5-2: Back-in-Coverage Notification 17
Figure 5-3: ROSI Frames With Error Coding 19
Figure 5-4: Error Correction Technique 20
Figure 8-1: X.25 Over Frame Relay Host Connection 29
Figure 8-2: TCP/IP Over Frame Relay Host Connection 30
Figure 8-3: Packet Transmission at Various Line Speed 32

List of Tables

Table 6-1: Security Features 24
Table 8-1: Summary of Frame Relay Host Connection Responsibilities 31
1. Introduction

OVERVIEW
SkyTel provides various types of packet-switched, wireless two-way data communications service in the United States. This document focuses on wireless data technology that is based on Mobitex, a proven, stable, internationally recognized, open protocol standard. Mobitex Technology AB supplies Mobitex systems. Mobitex systems are deployed in the United States, Canada, and over 20 other countries. Active development and deployment of Mobitex-based systems continue in Latin America and the Pacific Rim. The Mobitex Association (MA; more information can be found on its Web site, http://www.mobitex.org) is the standards body that controls and continually updates the Mobitex Interface Specifications (MIS).

In its 21st software release and third hardware generation, the Mobitex digital wireless data system has become a stable, reliable, international standard that will continue to be supported and improved. Mobitex has emerged as the clear leader in wireless data technology worldwide. In Europe, for instance, seven of the ten currently operating or planned national public wireless data networks and both authorized private networks use Mobitex systems.

SkyTel’s data network services provide significant differentiation from competitors’ offerings and a robust set of features including, but not limited to:

- Nationwide coverage
- Transparent Roaming
- Store and Forward
- Group Broadcast
- Closed User Groups
- Positive Acknowledgment
- Host Group Addressing (Multiple Host Connection Points)
- Advanced Battery Power Saving Protocol

The SkyTel Mobitex Network is America’s premier nationwide wireless data service. It combines the power and maturity of Mobitex with the flexibility of its connections to complementary networks, providing the most advanced and robust wireless data communications service available today. The SkyTel Mobitex Network has three major components:

THE SKYTEL MOBITEX NETWORK
1. Core Network – The SkyTel Mobitex Network relies on Mobitex technology—the de facto international standard for two-way wireless data communications.

2. Connection with Other, Complementary Networks – From its Mobitex technology core, the SkyTel Mobitex Network offers access to complementary networks, including satellite, circuit-switched cellular, paging and dial-up through public switched telephone networks (PSTN), depending on the needs of the mobile user.

3. Multiple Host Connectivity Options – The SkyTel Mobitex Network allows customers to take advantage of the Internet, a dedicated IP line, X.25 or Frame Relay for making host connections to SkyTel. SkyTel Mobitex Network users can have connections between the host and any additional external networks through the Mobitex network. This single host connection eliminates the need for customers to manage many different host connections and adapt to different networks and technologies.
1. Introduction, Continued
THE SKYTEL MOBITEX NETWORK, CONTINUED

These components are shown in Figure 1-1: SkyTel Mobitex Network Architecture.

Figure 1-1: SkyTel Mobitex Network Architecture

The SkyTel Mobitex Network makes it possible to offer SkyTel's customers access to 100 percent of their mobile organization. Each multi-network solution can be tailored to the specific needs of an application. The SkyTel Mobitex Network also offers the capability to select the appropriate access network based on availability, cost and speed. Either the application or the network can provide this intelligent selection capability.
1. Introduction, Continued

THE SKYTEL MOBITEX NETWORK, CONTINUED

Finally, with the additional message routing options the SkyTel Mobitex Network provides, the application can use the most cost-effective paths for moving user data. SkyTel recently added an Enhanced Backbone, a high-speed data network that parallels and supports SkyTel’s nationwide Mobitex system, to ensure that the capacity and speed users of the SkyTel Wireless Mobitex Network will require is maintained. Each solution is designed to grow with the expanding needs of each customer. Refer to Figure 1-2: Enhanced Backbone for a pictorial diagram.

Figure 1-2: SkyTel Mobitex Network Architecture
2. Introduction to Mobitex

ORIGIN OF MOBITEX
Mobitex is a trunked, terrestrial, mobile radio system developed by Ericsson for packet-switched data used for a variety of applications.

The original concept for Mobitex was the design of a mobile communications system used by field personnel of Swedish Telecom Radio in Sweden. Because the concept was not economically feasible as a private network, it evolved into a public mobile radio service and became Mobitex.

Early development of Mobitex was begun by Swedish Telecom (now called Telia). Continuing development is done by Mobitex Technology AB, under the guidance of the Mobitex Association (MA). Mobitex Technology AB is the manufacturer of the Mobitex infrastructure equipment. Mobitex was first placed in commercial operation in Sweden in 1986. Networks have since been constructed in 23 countries on six continents (more information can be found on the MA Web site at www.mobitex.org).

PACKET SWITCHING
Packet switching is a very efficient way to transfer data. In a packet-switched network (e.g., X.25, IP, etc.), no end-to-end network connection is established. Instead, a packet of data is transferred between successive nodes until it reaches its final destination. In contrast, an end-to-end network connection must be established in a circuit-switched network before data transfer can start. In circuit switching, an entire circuit, or channel, is tied up and no other data can be sent until the first transmission is completed. In a packet-switched radio network, a single radio channel can handle multiple user transmissions using special “multiple access” methods.

CHANNEL ACCESS MECHANISM
Radio transmissions use radio spectrum (RF), which is a very limited resource. To allow more users to access a radio channel, a special channel access mechanism is needed. There are three basic multiple access methods: CDMA (Code Division Multiple Access), FDMA (Frequency Division Multiple Access) and TDMA (Time Division Multiple Access). These channel access mechanisms are currently used in the existing analog and digital cellular phone systems (1G, 2G, 3G and 4G cell phones). A newer channel access mechanism, OFDM (Orthogonal Frequency Division Multiplexing), has been developed for several new radio/TV broadcast systems (e.g., HDTV and DAB) and 3G digital cellular phone systems.

Mobitex uses the modified, hybrid FDMA/TDMA channel access mechanism. For example, an FCC allocated 5 MHz frequency band is divided into smaller 12.5 KHz radio channels (i.e., FDMA). In large metropolitan areas such as New York and Los Angeles, SkyTel is authorized by the FCC to operate thirty 12.5 KHz channels. Each radio channel further assigns time slots to mobile devices that desire data transmission (i.e., TDMA). In addition, the channel access mechanism in Mobitex is also based on the slotted Aloha system. The original Aloha channel access algorithm was developed by University of Hawaii to improve the data throughput in a radio communication system. The slotted Aloha system further increases the system efficiency and data throughput (e.g., by minimizing data collision on the radio channel).
MOBITEX SYSTEM COMPONENTS

A basic Mobitex system comprises radio base stations (BAS), Mobitex Switching Node (MSN), and a Network Control Center (NCC). In addition, Customer Premise Equipment (CPE) is needed to access the Mobitex network. CPE can be mobile or portable radio devices that communicate with the network over the radio channel. These radio devices are designed to comply with the Mobitex Interface Specification (MIS). SkyTel ensures system compatibility by acceptance testing all radio products for use on its network. CPE can also include “fixed subscription terminals” (FST), such as customer’s host computers, that are connected to the network via the MSN. Customers are responsible for ensuring their fixed terminals and applications conform to the SkyTel Mobitex Network’s operational procedures and rules.

NETWORK CONTROL CENTER

Network operations personnel use the Network Control Center (NCC) to supervise, configure, control, manage, and operate the entire Mobitex network. The NCC is centralized and equipped with:

- Mid-range computers (Alpha) running VMS operating systems
- Unix-based Sun workstations
- Digital storage units (RAIDs)
- System terminals for:
  - Operation and maintenance (O&M)
  - Subscription handling
  - Configuration generation
  - Node dial-up
- Network management systems (SNMP and non-SNMP systems)

The NCC does not take part in the traffic-routing process; however, it is the control point for all network activities. The NCC uses Mobitex software modules to perform the following functions:

- Operation and Maintenance (OM)
- Action Routine Manager (ARM)
- Subscription Authorization Management (SAM)
- Network Register (NETREG)
- Alarm Handling System (ALA)
- Traffic Statistics (TRAFSTAT)
- Traffic Log Management (TLA)

Additionally, the NCC is equipped with the Traffic Analysis System (TRANAL), which resembles dashboard meters in a car. TRANAL provides NCC personnel graphical readings of the network traffic state. With TRANAL, congestion points or traffic bottleneck within the network can be proactively identified and remedied.
2. Introduction to Mobitex, Continued

BACKBONE NETWORK
Between the Mobitex Switching Nodes (MSNs) is a high-speed Frame Relay backbone network as well as dedicated internet pipes. The Frame Relay backbone network provides a high-speed communication path for passing user traffic among different sub-networks. The secure internet path also provides a path for network traffic, customer interconnectivity and alarm routing. Administrative traffic, such as traffic logs, alarms, configuration changes, directory/subscription look-up, etc., is also routed over the backbone network between the NCC and individual MSN’s, and among different MSN’s themselves. Refer to information regarding Network Topology Enhancement described in Section 5.

To ensure the availability and reliability of the backbone network, two separate Frame Relay networks are in place from two different telecommunication service providers. If the primary Frame Relay service becomes unavailable, all the backbone traffic is automatically routed to the secondary Frame Relay network.

The backbone of the network consist of two MSN switching centers. These switching centers are fully redundant within themselves, as well to one another. Switching centers are located in east coast and west coast switching centers.

BASE STATION
Base stations are the lowest-level nodes in the Mobitex hierarchical system, and they are the connecting point for mobile and portable radio devices. An MSN is a base station’s superior node. The base station (BAS) is the turn node for traffic among users communicating through the same base station.

The base station performs the following functions:

Traffic Routing
A base station serves as a switching point for mobile-to-mobile traffic within its own radio coverage area (see NOTE below). Base stations also communicate with their superior nodes.

Roaming
The system automatically updates the subscriber registers in the base station to keep track of mobile terminals. When a mobile terminal roams to another base station, the mobile sends a roaming message to the base station to update the subscriber register in that base station.

Subscriber Register
The base station subscription register contains information about all mobile terminals operating in its coverage area. Subscription information moves along with the mobile terminals from one base station to another (e.g., transparent roaming).

Protocol Handling
Base station to mobile terminal communications adhere to the Mobitex radio protocol. This protocol contains functions for error detection and correction, selective automatic repeat request (ARQ), channel access control, and roaming.

The base station monitors the functional status of hardware and software modules. Error messages and alarms are sent from the base station, through the backbone, to the NCC. The loading and installing new software or updating of configuration parameters in the base station are done from the NCC.
2. Introduction to Mobitex, Continued

BASE STATION, CONTINUED

ESN Checking
Each time a radio modem registers with the Mobitex system, the base station checks that the radio modem’s built-in ESN matches that stored in the base station’s subscription database. If the ESN check fails, the radio modem is blocked from communicating with the network.

SkyTel can support direct mobile-to-mobile traffic (or peer to-peer).

AN OPEN SYSTEM
Mobitex is an open system, which means that specifications for Mobitex-compatible communications equipment and software are available to all manufacturers and developers. Radio devices designed and manufactured to these specifications are free of license fees. In addition, worldwide standardization of all Mobitex networks and the compatibility of advanced network features and functions developed in the future are ensured by the Mobitex Association (MA). MA is an independent organization of all network operators who offer wireless data services using the Mobitex standard.
3. System Overview

INTRODUCTION
The SkyTel Mobitex Network is a nationwide, digital, packet-data service that comprises land-based radio transceivers arrayed in a cellular-like grid and hierarchical packet switched facilities, all interconnected by digital transmission lines. The system is based on Mobitex technology, which features nonproprietary interfaces on both the radio link and the host access link. SkyTel’s service objective is to provide a one-way packet transit time that averages between three and five seconds for maximum-sized packets, when originator and recipient are in satisfactory contact with the SkyTel Mobitex Network. All maintenance of the Network is performed by SkyTel employees and contractors who are trained and fully equipped with necessary resources to effect rapid restoration of all facility outages. Sophisticated monitoring systems, operating and escalating procedures, and rapid response to trouble alerts allow SkyTel to consistently achieve or exceed our service availability goal of 99.9 percent for its Mobitex Network (excluding third-party telco outages and scheduled maintenance). Details of the Mobitex technology are provided in the following sections. Except as specifically noted, all features, functions, and details described therein reflect actual, current, commercial operating parameters. Planned features and functions are identified as such.

SYSTEM LEVEL CHARACTERISTICS
- Base Transmitter (mobile receiver) Frequency Band - 935 to 940 MHz
- Base Receiver (mobile transmitter) Frequency Band - 896 to 901 MHz
- RF Channel Spacing - 12.5 kHz
- Channel Raw Data Rate - 8,000 bps (bits per second)
- Forward Error Correction - Hamming [12,8] code
- Minimum Packet Length - Eleven bytes for the header, plus one byte of user data. This packet is 96 bits long; transmission duration is 37 ms.
- Maximum Packet Length - 512 bytes of user data. The total length is 7,256 bits, with transmission duration of 0.907 s. If multiple addressing is used, the longest packet is 7,736 bits, with transmission duration of 0.967 s.
- RF Channel Access Protocol - A reservation-based slotted ALOHA algorithm is employed. This access strategy has two important features:
  - High Channel Efficiency – The use of reservations allows base stations to efficiently schedule inbound packets of various lengths without chance of collision.
  - Flexibility – Channel can be tuned for various and changing traffic conditions.

RF LINK CHARACTERISTICS
- Mobile and Portable Radio Modem Transmitter Power - Maximum of 2 Watts Characteristics (under automatic power control).
- Base Transmitter Output Power - Up to 30 Watts (adjustable to change service area and/or to provide link balance).
- Link Balance – SkyTel’s Mobitex base stations are configured with balanced inbound and outbound radio links between the base stations and the 2-Watt radio modems. This characteristic ensures that if a mobile or portable unit can receive a base station’s signal, it is able to communicate to the base station with a high degree of confidence.
- Frequency Reuse – As in the cellular system, Mobitex frequencies are reused within the same service area to support a large customer base.
3. System Overview, Continued

SERVICE AREAS
Service areas in the U.S. are divided into licensed service areas by the FCC. These Major Trading Areas (MTAs) contain one or more Metropolitan Statistical Areas (MSAs) and/or Rural Service Areas (RSAs). SkyTel is authorized to operate the SkyTel Mobitex Network on 10 to 30 frequency pairs (or channels) within the entire continental U.S. and Hawaii, Alaska, and Puerto Rico. Mobitex base stations operating on one or more channels are arranged in a pattern that allows frequency reuse in nonadjoining areas. This cellular layout, as compared to single-channel systems, provides extraordinary capacity and is easily expanded for additional capacity, when required.

SUBSCRIPTIONS
User accessing a Mobitex system must have a subscription. The Mobitex system supports Terminal, Personal and Group subscriptions, as well as a feature called Host Group Addressing (HGA). Terminal subscriptions are required for all physical access points (i.e., both hosts and mobile terminals). Personal subscriptions enable dynamic use of physical access points by allowing applications or individuals to login at any terminals. Group subscriptions permit single messages to be transmitted to all group members. Closed access, which limits communications only to members in the same “Closed User Group”, is also available. HGA allows a mobile/portable user access to a group of host computers as if they were a single host, or allows a single host computer to have multiple network appearances for load sharing and redundancy. Mobitex systems use addresses to identify subscriptions, groups, and external networks. These addresses are called Mobitex Access Numbers (MANs). The PMAN (Personal MAN) and ESN (Electronic Serial Number) provide access security and ensure proper billing. A unique ESN is hard-coded into each radio modem and is validated by the base station automatically as the unit roams from one base station to another. Radio modems attempting to establish network contact with an invalid ESN are rejected by the network. A PMAN, which must be used in conjunction with a password, is associated with an equipment-independent personal subscription.

NETWORK PROTOCOLS
The SkyTel Mobitex Network supports the following transmission protocols at the following levels.

- **MASC (Mobitex Asynchronous Communications)** – The MASC protocol is used to communicate between radio modem and terminal (e.g., laptop, PDA, etc.).
- **MPAK (Mobitex Packet)** – The MPAK network-layer protocol is used to route user data through the system.
- **ROSI (Radio Signaling Interface)** – A link layer protocol on the radio path that controls access to the base station.
- **GMSK (Gaussian Minimum Shift Keying Modulation)** – Technique used to encode data at the physical layer on the radio link.

Detailed information regarding Mobitex network protocols can be obtained from the Mobitex Interface Specification (MIS).
3. System Overview, Continued

AIRLINK DATA RATE
The over-the-air, or “raw,” data rate of the SkyTel Mobitex Network is 8,000 bps (bits per second). The over-the-air user data, or “payload,” throughput depends on the size of a packet and the radio channel condition. The average payload throughput for sending a maximum-size packet (512-byte user data) is about 60% of the raw data rate.

DYNAMIC POWER CONTROL
The Mobitex system employs a sophisticated power control mechanism, as in advanced digital cellular systems. The power control mechanism consists of open loop power control and closed-loop power control.

• Open-Loop Power Control
The radio modem initiates its own output power adjustment by measuring the received signal level (i.e., RSSI) from the base station, without network intervention. When moving away from the base station, the RSSI becomes low and the radio modem increases its output power to ensure the reliability of its transmission. In contrast, when moving close to the base station, the radio modem reduces its output power to conserve its battery power.

• Closed-Loop Power Control
The base station initiates a request to all or specific radio modems under its coverage to adjust their output power levels. For example, the base station makes this request to help prevent any possible harm to its RF front-end (e.g., de-sensing the base station receiver) from a large number of high-power radio modems in the neighborhood. The radio modems respond to the request and adjust output power levels accordingly.

POWER SAVING PROTOCOL
To improve the battery life of portable Mobitex devices, the Mobitex system employs the most sophisticated battery saving protocol (BSP) in the wireless industry. The BSP allows the radio modem to select a specific sleep cycle (10, 20, 40, 80, or 160-second cycle), which is synchronized with the network. The radio modem wakes up from the sleep mode at the end of its sleep cycle and enters the operating mode. The network knows when the device will wake up and will inform the device if it has a message waiting. The device can immediately wake up and enter the operating mode when the user or the application is initiating a message transmission.

The radio modem remains in the operating mode for an additional period after sending or receiving a transmission. This is to ensure that any other packet that is part of this transaction is received.
4. System Architecture

OVERVIEW

Radio base stations in the SkyTel Mobitex Network are geographically distributed over a service area in much the same way as those in a cellular telephone system. Base stations are installed in a pattern that allows frequency reuse in nonadjoining areas. This cellular layout, as compared to a single-channel simulcast system, provides extraordinary capacity and is easily expanded, when required, to provide additional capacity. Unlike cellular telephone systems, however, the SkyTel Wireless Mobitex Network is designed to provide a nationwide service and is optimized for data communications.

The base stations are connected to MSN’s by means of digital circuits that include backup facilities. Refer to Figure 4-1: Network Architecture for a pictorial diagram. Customer-host connectivity is accommodated at the MSN through a variety of standard data communications protocols, including X.25, Frame Relay, TCP/IP, and ISDN (Integrated Services Digital Network).

SkyTel Mobitex Network administration and monitoring functions reside in SkyTel fully redundant Network Control Centers (NCCs) located in Jackson, Mississippi and Plano, Texas. NCC staff is on duty 24 hours a day, seven days a week, 365 days a year.

Figure 4-1: Network Architecture
4. System Architecture, Continued

SYSTEM HIERARCHY

The backbone MSN uses a distributed intelligence approach to increase overall system availability by avoiding single-points-of-failure and allows for faster routing, greater capacity and expandability.

At the first level are base stations, many of which operate on multiple radio channels simultaneously. Simultaneous channel use provides numerous advantages in terms of reliability, availability, traffic capacity, traffic-handling efficiency, and system expandability. Each base station also includes a packet switch that efficiently routes traffic between subscribers. In the event a primary interconnecting link fails, the base station automatically switches to a back-up facility. Back-up battery power is provided at all base stations to ensure extended operation in the event of a power failure.

The Network Control Centers (NCCs) are the focal point of both network administration and performance monitoring, which includes the collection and analysis of maintenance and traffic data from the network. Dual NCCs are in Jackson, Mississippi and Plano, Texas. Each NCC is capable of handling all network management functions if the other NCC fails.

NETWORK TOPOLOGY ENHANCEMENT

By the end of 2007, the SkyTel Mobitex Network had undergone significant architecture changes. The Mobitex backbone MSN network was installed. This new backbone replaced the legacy MOX and MHX switching nodes and replaced them with a new Solaris platform switching node. This backbone eliminated network hops, improved switching time, as well as added switching capacity.

All MSN nodes are connected to the high-speed Frame Relay backbone network, which is also connected to the NCC (refer to Figure 5-1).

New system components built into the MSN architecture:

- **BIU (Backbone Interface Unit):** An interface unit in the MSN that connects the MSN to the Ethernet network.

- **DRR (Dynamic Roaming Register):** A subscriber directory service that contains updated location information of mobile units and assists all subnets in routing traffic to proper destinations.
5. SkyTel System Features

OVERVIEW

In addition to its highly reliable datagram delivery service, the SkyTel Mobitex Network solution offers several system-level features not generally available with competing technologies. Following are summary descriptions of several key system features and associated benefits that enhances the functionality and simplifies the implementation of applications on the SkyTel Mobitex Network.

TRANSPARENT ROAMING

The transparent roaming function is inherent in Mobitex compatible radio modems, which always select the best base station for communicating with the SkyTel Mobitex Network. There are two types of roaming, local and wide-area.

• Local Roaming – As a modem moves within a local area, it periodically monitors the signal strength on adjacent base stations. When it detects a significantly better base station signal, it registers with the new base station for service.

• Wide-Area Roaming – If a modem is switched off and transported (wide-area) to another location, it reestablishes contact with the system by quickly searching through SkyTel’s national list of 200 Mobitex channels until it finds and registers with a suitable base station. Additionally, customers provisioned with cross-border roaming functionality can use the same device when traveling between the U.S. and Canada. Customers in Venezuela, who have cross border roaming services provisioned and enabled, are able to use their devices in the U.S. as well.

Registration performs two important functions:

1. The system is notified of the modem’s current location so that outbound packets are automatically routed to the mobile user.
2. The modem is always operating on the base station most able to ensure reliable communication.

The network registration process is completely transparent to the mobile user and the application. There is no additional charge for roaming, service is of consistent quality, and no user intervention is required, which is not the case with cellular voice systems.

When compared with alternative approaches, SkyTel’s solution to roaming in Mobitex systems has several significant advantages:

• Built Into All Radio Modems – Greater choice of suppliers.

• Available In All Areas – Allows users to roam to any area in the United States, within the SkyTel Mobitex Network coverage area, using the same radio modem.

• Faster – Ensures immediate packet delivery to any Mobitex terminals in coverage.

• More Efficient – Minimizes wasted packets sent to mobiles that have moved since their last transmission to the SkyTel Mobitex Network.

• More Reliable – Each mobile unit makes decisions based on actual performance and not on assumed criteria.
5. SkyTel System Features, Continued

STORE-AND-FORWARD

The SkyTel Mobitex Network’s Store-and-Forward feature allows applications to deal more effectively with radio modems that are temporarily out of coverage (e.g., in a tunnel, or simply turned off). Each registered subscriber (terminal or personal subscription) has storage space allocated within the SkyTel Mobitex Network. If a packet is undeliverable, it may, at the sender’s discretion, be stored in the SkyTel Mobitex Network for up to 72 hours. A customized time limit is planned for a future release of Network software. When the intended recipient’s radio modem reestablishes contact with the system, it automatically registers with a local base station; all packets stored in the system for that radio modem are then forwarded to the base station, and on to the unit. The following example illustrates this procedure:

A device is in operation in Baltimore and is then transported to Pittsburgh. It is powered off and out of coverage during transport, as it would be during travel by air. During transport, several packets are addressed to the unit without the store-and-forward option selected. These packets are immediately returned to the sender with a resultant code of NO TRANSFER.

Also during transport, several other packets with the store-and-forward option selected are addressed to the unit. These packets are stored in the SkyTel Mobitex Network for up to 72 hours.

When the device is turned on in Pittsburgh, it automatically searches the frequency band and locates the SkyTel Mobitex base station with the best signal strength. It registers with the base station, which notifies the MSN of the unit’s new location. The packets waiting in the switch are then forwarded to the appropriate base station for transmission to the unit. This process is accomplished within seconds after the unit has been turned on.

Unique to SkyTel, this store-and-forward capability operates in SkyTel Mobitex Network’s coverage areas nationwide, regardless of distance or location, at no additional cost. Potential uses for store-and-forward include:

**Coverage Smoothing** – Allows applications to send messages to mobiles that are temporarily out of coverage. The sender never has to retransmit the message periodically until the mobile unit is back in coverage. Coverage need not be continuous to be effective.

**Wake-up Indication** – A host application or dispatcher can post a store-and-forward message (to be acknowledged when received) to a user’s device. The host application or dispatcher can then be notified when the unit goes into service.
GROUP BROADCAST
The SkyTel Mobitex Network supports a unique group broadcast service that functions much like a paging service. This service allows transmission of a message to all units belonging to the subject group and currently registered with one of a predetermined set of base stations defined in the group subscription. Up to eight base stations or host connections may be included in the group subscription (search area). All mobiles belonging to the subject group listen for messages addressed to the group subscription as they do for messages addressed to their individual terminal subscription.

Each base station defined in the group subscription transmits the group message six times at ten-second intervals. Unlike other message types, the receiving mobiles on the radio link do not acknowledge group messages. This feature is a very cost effective way for customers to deliver information quickly to many users.

CLOSED USER GROUPS (CUGS)
The SkyTel Mobitex Network offers great flexibility in addressing traffic among network users. A customer may choose to restrict traffic by Closed User Groups (CUGs) that are administered within the SkyTel Mobitex Network. Users within a CUG have a virtual private network. They may neither send messages to nor receive messages from users outside their group. However, the fact that individual users may belong to multiple CUGs gives customers the flexibility to create groups with partial overlap. For example, field service and field sales personnel within the same organization may each belong to a separate CUG. At the same time, management personnel can intercommunicate by virtue of their own (third) overlapping CUG.

DELIVERY VERIFICATION
End-to-End Delivery Verification has five features.

• Positive Message Acknowledgments (POSACKS)
• Negative Acknowledgments / Non-Acknowledgment to the Host
• Positive End-to-End Acknowledgment
• Error Correction
• Back-in-Coverage Notification

POSACKS
The Positive Message Acknowledgment (POSACK) feature, which is often referred to as return receipt of messages, was implemented with the introduction of Mobitex Release 14. This feature provides delivery confirmation of packets sent over the radio link. When the sending host or mobile enables the POSACK feature, the base station serving the receiving party generates a POSACK packet. Base stations originate and send POSACK packets for packets that originate from a host or another mobile unit.

NOTE: A POSACK shall not be used and generated to verify a host connection.

A return receipt is generated only if the sending party enables the POSACK flag in the MPAK. Setting the POSACK flag in the packet header causes the base station to send a replica of the delivered packet back to the sender when the packet is delivered to the intended radio modem. If the POSACK feature is invoked in conjunction with the network mailbox, a return receipt is sent when the previously stored message is delivered from the mailbox to a radio terminal. One of the benefits of this feature is that it can be used to notify the sending party that a radio terminal has returned to service. Other factors to consider are:

• POSACK packets cannot be placed in the store-and-forward facility.
• Undeliverable return receipts are discarded in the network.
• POSACK packets are billed as status messages.
5. SkyTel System Features, Continued

POSACKS, CONTINUED
To use the POSACK feature, customer applications must be configured to set the POSACK flag in the MPAKs, as well as interpret the POSACK packets received from the network. The POSACK flag format is shown in Figure 6-1: POSACK Flag Format.

![POSACK Flag Format](image)

**Figure 5-1: POSACK Flag Format**

NACKS/NON-ACKNOWLEDGMENTS TO THE HOST
Mobitex uses negative acknowledgments (NACKs) to return undeliverable packets for both outbound and inbound traffic. However, for host-to-mobile traffic, some NACKs take longer to be generated because of the extensive retry algorithm used by the base station, which attempts to deliver the message at pre-defined intervals.

There are different types of Negative Acknowledgments:

- **NO TRANSFER**: Indicating that the packet cannot reach the intended receiving party because the receiving party is either out of coverage or has been switched off.

- **CONGEST**: Indicating that the packet cannot be delivered to the intended receiving party because one or more parts of the network is congested.

- **ERROR**: Indicating that the packet cannot be delivered to its intended receiving party because one or more parts of the network are experiencing technical problems (e.g., circuit disconnect, node failure, etc.).

- **ILLEGAL**: Indicating that the packet cannot be delivered to its intended receiving party because the destination address is incorrect.

SkyTel considers the ERROR and CONGEST conditions as its responsibility due to internal infrastructure failures or temporarily insufficient resources to handle the traffic, whereas the NO TRANSFER and ILLEGAL conditions are responsibilities of end users or network subscribers. The implication of these error conditions could have different impact on the user application or billing process.
5. SkyTel System Features, Continued

POSITIVE END-TO-END ACKNOWLEDGMENT
Positive end-to-end acknowledgment, where required, can be readily provided at the application level. In addition, there are several Mobitex-compatible end-to-end transport protocol options available.

BACK-IN-COVERAGE (BIC) NOTIFICATION
When a customer host receives a returned packet with a NO_TRANSFER traffic state, it should send a BIC packet to ask the network for notification when the intended mobile unit is back in coverage. If the network cannot deliver the BIC packet and has stored it in the network mailbox, the sender will receive a copy of the BIC packet with an IN_MAIL traffic state. When the mobile unit contacts the network, the network will release the stored BIC packet from the mailbox and deliver it to the mobile unit. The BIC packet will not be delivered to the mobile unit; instead, when the serving base station receives this packet, it will send out a radio ping to the mobile unit. Upon receiving the radio ping sent from the serving base station, the mobile unit will process it in the radio modem without sending it to the application layer. The base station will receive an acknowledgment from the mobile unit, and a POSACK copy of the BIC with a FROM_MAIL traffic state will be returned to the sending host. The sending host may receive a POSACK copy of the BIC packet with an OK traffic state in the event that the mobile unit is back in coverage before the BIC packet is placed in the mailbox.

Under normal situations, the addressed mobile unit should not receive the BIC packet; hence, there is no impact to the application. Figure 5-2: Back-in-Coverage Notification illustrates the information flow with the BIC packet.

![Figure 5-2: Back-in-Coverage Notification](image_url)

1. HOST sends a data packet to an out-of-coverage MOBILE.
2. The network returns the packet with traffic state NO_TRANSFER.
3. HOST sends a BIC packet to the out-of-coverage MOBILE. The packet is stored in the network mailbox.
4. When MOBILE comes back in coverage, the network releases the BIC packet to the base station. The base station sends a radio ping to MOBILE.
5. MOBILE receives the radio ping and sends a radio acknowledgment to the base station.
6. The network sends a POSACK copy of the BIC packet to HOST, indicating that MOBILE is in coverage.
5. SkyTel System Features, Continued

ERROR CORRECTION

The harsh radio environment requires error detection and correction schemes in order to ensure extremely low error rates. The Mobitex system employs a robust error detection and correction mechanism, in which a radio packet (maximum 512 bytes of user data) is divided into blocks of 160 bits of data. Each byte of these 160 bits is encoded into 240 bits of error correction Hamming Code that can correct one error in twelve consecutive bits. These encoded bytes are then interleaved across the 30 bytes of encoded data (containing 20 bytes of raw data). This process allows the code to correct up to 30 consecutive bit errors during slow fading conditions that are prevalent in the radio environment.

In addition, if errors exist after the coding and scrambling, CRC error check (Cyclic Redundancy Check) catches the error and the radio link employs the Automatic Repeat Request (ARQ) algorithm to request the radio blocks received in error to be transmitted. If the ARQ algorithm fails, the radio modem and the base station radio links automatically repeat the transmissions of the whole radio packet up to a specified number of times before the packet is returned as a failure to the application. The application software can further improve reliability by using the recommended message back-off and retransmission algorithms, along with a Mobitex-compatible transport layer protocol to ensure end-to-end data integrity and reliability.

In summary, there are three methods incorporated into the ROSI protocol to ensure that the probability of successful transmission through the radio link is 99.999999%. The three error detection/correction methods used in the ROSI protocol are:

1. **Forward Error Correction (Block Coding)** – Minimizes unnecessary retransmissions of messages caused by normal radio link error conditions.

2. **Data Interleaving** – Makes forward error correction more effective in recovering from fading conditions induced by normal mobile and portable activities.

3. **Automatic Repeat Request** – Specific radio blocks in error are requested for retransmission to minimize unnecessary consumption of radio resources of retransmitting the entire packet.

Block coding is a sophisticated error detection method required for high data rate systems. Blocks of data (primary and following blocks as defined by the ROSI protocol) are followed by a block check character (BCC) that is defined by an algorithm. The same algorithm is used by the receiver to generate another BCC based on the data received. If the two BCCs are identical, the data is correct. The block check character used in the ROSI protocol is the Cyclic Redundancy Check (CRC). In the data link layer, the primary and following blocks are CRC coded, while the frame header, introduced at the physical layer, is not. The CRC code detects all one and two-bit errors, and all bursts errors up to 16 bits in length. Figure 5-3: ROSI Frames With Error Coding shows the CRC attached to primary and following blocks of an M-frame in the data link layer.
In the physical layer, the primary and following blocks are further coded by adding four parity bits to each byte. This brings the total size of a block to 240 bits. These added bits are referred to as a shortened (12,8) Hamming Code and provide a means for the receiver to perform forward error correcting. Figure 5-3: ROSI Frames with Error Coding illustrates the error-detection coding (shortened Hamming Code) attached to primary and following blocks of a radio frame.

Also in the physical layer, a parity byte (2*4) is added to the radio frame header to provide single-bit error correction. The first four bits correct the base ID and part of the area ID. The second four bits correct the rest of the area ID and the control flags. Figure 5-3: ROSI Frames with Error Coding illustrates the parity coding attached to the header of a radio frame.

Radio frame blocks (including the CRC and Hamming Codes) are interleaved before they are transmitted. Interleaving provides protection against burst errors (errors longer than one bit). Without interleaving, the Hamming Code can correct only singlebit errors. After interleaving, a burst of up to 20 errors can be corrected. Interleaving is performed by sending all the bit 0s of each byte in the block followed by all the bit 1s, and so on.
5. SkyTel System Features, Continued

**ERROR CORRECTION, CONTINUED**

Finally, a scrambling sequence is used to generate a pseudo-random pattern of 1s and 0s. Scrambling is not a form of error correction but is used to ensure that the radio receiver remains locked to the center of the carrier frequency band (long bursts of continuous 1s or 0s may cause the radio to drift, or shift in frequency). The scrambling sequence is also known by the receiver’s radio modem to enable the message to be descrambled. Figure 5-4: Error Correction Techniques illustrates all the error correction techniques incorporated in the ROSI protocol.

![Figure 5-4: Error Correction Techniques](image)

**FUTURE ENHANCEMENTS**

All Mobitex enhancements are fully backward compatible and thus result in greater functionality and features availability for all users. Mobitex AB, SkyTel, and the 30 other Mobitex operators around the world continue to invest heavily in the wireless data technology.

The Mobitex Operators’ Association, of which SkyTel is a significant contributing member, controls the Mobitex Interface Specification (MIS) and meets periodically to manage the specification and coordinate planning for future enhancements.

With 20 software releases and years of continuous refinement, Mobitex is a proven technology. Mobitex System Software releases 15 to 20, collectively called NTE (Network Topology Enhancement), supports substantial network growth and associated enhancements. Release 20 (or NTE Release 6), which incorporate many enhancements, is currently being deployed. In the meantime, SkyTel is concurrently working on other network enhancements for Release 21 (NTE Release 7), which will improve network performance and quality of service to customers (e.g., improved network recovery process).

A few of the enhancements considered for future releases (beyond NTE Release 7) include:

- **Improved Group Broadcast** - Will allow the network to broadcast group messages to a large number of subscriber units from selective base stations during specific time frames (i.e., non-peak hours).
5. SkyTel System Features, Continued

FUTURE ENHANCEMENTS, CONTINUED

• **International Networking** - Will allow direct interconnection of Mobitex networks in many countries for the exchange of subscriber information.

• **Variable Data Rate (VDR) Mobitex System** - In which both lower (for coverage extension) and higher (for increased radio channel capacity) data rates (i.e., 4, 8, 16, and 32 kbps) will be available.
6. Mobitex Security

OVERVIEW

Many mobile data customers assume that all radio transmissions employ the same narrow-band FM broadcasting technology. Although this technology is used in existing wireless, voice-based communication systems (e.g., analog, cellular networks, and specialized mobile radio [SMR]), Mobitex is quite different.

The SkyTel Mobitex Network uses advanced digital packet radio technology that distinguishes it from ordinary communications systems. The combination of digital technology and packet data switching yields a high degree of inherent security that safeguards the privacy of user data. In addition, use of sophisticated protocols and radio modems significantly restricts unauthorized access to the Core Mobitex Network.

Although it is the only publicly accessible segment of the data path in a Mobitex system, the airlink is usually not the most vulnerable segment of the communications network. Receiving and transmitting data over the airlink in the Mobitex Network is a complicated process. In fact, because of the technical expertise required, the use of various radio channels at various times by mobiles, and the sophisticated scrambling and interleaving techniques employed in the over-the-air protocol, it might be easier to break into the user's computer system rather than into the network itself. However, SkyTel recommends and supports the use of end-to-end encryption for all sensitive information.

The Mobitex Network uses a hybrid Frequency Division Multiple Access (FDMA)/Time Division Multiple Access (TDMA) method with a modified Slotted Aloha channel access algorithm. This unique channel access algorithm provides efficient channel utilization. Data is sent over the airlink in short bursts at 8,000 bps using Gaussian Minimum Shift Keying (GMSK) modulation, encoded and interleaved for error correction, and then scrambled.

Messages in a Mobitex system are made up of packets (called MPAKs) at the network layer (OSI layer 3). In the radio modem, MPAKs are encapsulated for transmission over the radio link by protocols at the data link (OSI 2) and physical (OSI 1) layers. The data link layer of the radio modem performs the entire required base band signal processing operations. The MPAKs are broken up into radio frames by the radio modem. A frame header of 56 bits is generated and placed in front of each radio frame. Data blocks consist of 20 bytes, each containing eight bits of data followed by four bits generated with a (12,8) Hamming Code. A radio frame has up to 20 data blocks. In order to protect against burst error, interleaving is performed. The interleaving process can be viewed by imagining the data arranged as rows in a 12 bits wide by 20 bits long matrix. The data is then sent column wise. Up to this point, the Hamming Code corrects single bit errors per byte and the interleaved code allows a burst of 20 errors to be corrected. The data following the frame header is then scrambled.

Scrambling provides a mechanism to achieve DC voltage balance by eliminating long sequences of ones and zeros in the data stream. The modem then performs the GMSK modulation before applying the signal to the radio transceiver and onto the appropriate radio channel. The receive operation is the exact reverse of the transmit operation.

Hence, eavesdropping on user data is a difficult task. One would require a great deal of experience, as well as sophisticated equipment to be able to break into each packet generation/transmission process.
6. Mobitex Security, Continued

OVERVIEW, CONTINUED

A testimony to the inherent reliability and security of the SkyTel Mobitex Network is the fact that SkyTel provides service to several major credit card processing organizations. While the credit card processors rely on their own application-level data-encryption mechanisms, they depend on the SkyTel Mobitex Network to transmit credit card authorization data for their client banks and merchants. These services are typically used in areas where telephone network access is unavailable, too slow, or too expensive. Credit card authorization transactions can be processed more quickly using SkyTel than dial-up telephone lines and with no compromise to security.

SUBSCRIPTION SECURITY FEATURES

Several different subscription services can be linked to enhance data security. Refer to Table 6-1: Security Features for descriptions of these services and their role in the SkyTel Mobitex Network.
## 6. Mobitex Security, Continued

### SUBSCRIPTION SECURITY FEATURES, CONTINUED

<table>
<thead>
<tr>
<th>SECURITY FEATURES</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MAN CHECKING</strong></td>
<td>Every mobile and fixed terminal in the Core Mobitex Network is assigned a unique eight-digit, 24-bit Mobitex Access Number (MAN). The MAN is stored in electronically erasable, programmable, read-only memory (EEPROM) in the radio modem, and can be changed only by authorized SkyTel.</td>
</tr>
<tr>
<td><strong>ELECTRONIC SERIAL NUMBER CHECKING</strong></td>
<td>A unique, 32-bit electronic serial number (ESN) is hard-coded into each radio modem and is validated by the base station when the device registers with the network. The ESN prevents use of unauthorized radio modems and can facilitate the location and identification of stolen mobile equipment. If the MAN of a radio modem is altered, the Core Mobitex Network will detect such an alteration. For additional security, an encoded form of ESN is transmitted over the air by the radio modem. The Core Mobitex Network verifies that each MAN matches its ESN when a mobile radio tries to access the Core Mobitex Network. Any mismatch in numbers triggers an alert to the Network Control Center (NCC), which sends a DIE command to the modem, rendering it inactive. The NCC uses DIE and LIVE commands to control Core Mobitex Network access by mobile terminals. A Mobitex radio modem can be permanently disabled by sending it a special command called a “lethal injection.” A modem so disabled must be returned for service before it will operate again.</td>
</tr>
<tr>
<td><strong>PMAN</strong></td>
<td>In addition to the standard MAN, a personal Mobitex Access Number (PMAN) subscription provides additional data security. Users with PMAN subscriptions have the additional benefit of a personal password, which must be sent to the Core Mobitex Network before access is granted.</td>
</tr>
<tr>
<td><strong>CUG SERVICE</strong></td>
<td>Users who do not want entities or individuals outside their own group to communicate with them may subscribe to the CUG service. Within a CUG, subscribers can only receive messages from, or send messages to, subscribers of the same CUG. This service keeps users from accidentally or intentionally transferring messages to other network users. The CUG feature, in conjunction with the ESN feature, makes it difficult for unauthorized users to gain access to customer terminals and host computers.</td>
</tr>
<tr>
<td><strong>END-TO-END DATA ENCRYPTION</strong></td>
<td>Data encryption at the user’s application level provides the best protection of user data. The application uses the same encryption algorithm at both ends of the communication path, thus securing the entire path. Because the customer at the application level implements end-to-end encryption, data security is administered and controlled solely by the customer. SkyTel suggests that customers assess their individual security needs and select the most suitable encryption algorithm for their purposes.</td>
</tr>
</tbody>
</table>

*Table 6-1: Security Features*
6. Mobitex Security, Continued

SUBSCRIPTION SECURITY, CONTINUED

Table 6-1: Security Features lists many of the security measures inherent in the Mobitex Network and the wide selection of features available to enhance data security. Each customer must determine the level of data security needed. SkyTel Wireless’ security goal is twofold:

- To protect customer proprietary information.
- To prevent unauthorized access to a customer’s computer systems.

Any landline, which supports the use of the SkyTel Mobitex Network, has the same protection and safeguards as any other network provided by telecommunications common carriers. Although it may be possible to monitor the radio portion of a transmission on the SkyTel Mobitex Network, interleaving, scrambling, coding, roaming, and the sheer volume of packets on a given radio channel make detection and reconstruction of a particular message difficult.
7. Component Performance Characteristics

OVERVIEW
The following sections describe some of the messaging characteristics of the SkyTel Mobitex Network.

MESSAGE CHARACTERISTICS AND ROUTING
The SkyTel Mobitex Network employs a simple, elegant, addressing scheme for packet delivery. Each endpoint (mobile, portable, or fixed) is assigned a unique, 24-bit terminal address called the MAN. Additionally, up to 15 group broadcast addresses and up to seven personal addresses may be registered with a given terminal MAN. The sender of a message need not know what type of device is to receive the message, its location, or how it is connected to the network.

MESSAGE PACKET CHARACTERISTICS
A Mobitex message datagram (packet) consists of from 1 to 512 bytes of user data, which may be either 7-bit ASCII text or 8-bit binary data. In addition, the datagram may use the Higher-Protocol Data (HPDATA) packet type, which provides an extra byte in the packet header for protocol identification.

MOBILE-TO-HOST MESSAGING
To send a message to a host address, a wireless data terminal formats and transmits packets, using the non-proprietary Mobitex Asynchronous (MASC) protocol (specified in the MIS) to an attached radio modem that has been certified for use on the SkyTel Wireless Mobitex Network. The radio modem then transmits the packet to the base station on which it is currently registered. The base station checks and verifies the subscription information and device ESN. The packet is then forwarded to the local switch; time stamped, checked for valid format and CUG (Closed User Group) restrictions, and routed to the appropriate host connection. If the radio modem is unsuccessful in transmitting the packet to the base station after making the maximum number of attempts (pre-configured in the system), the packet is returned to the data terminal with the appropriate result code. If the system is unsuccessful in transmitting the packet to the intended host, it returns the packet to the radio modem with the appropriate NACK (negative acknowledgment).
HOST-TO-MESSAGING
To send a message to one of these mobile addresses, the host application or an intermediary, such as an application gateway, need only to format the packets and transmit them over one of the communication protocols (such as X.25) supported by the SkyTel Mobitex Network. The Mobitex Network will then time stamp the packets, check them for valid format and CUG (Closed User Group) restrictions, and route the packets to the base station currently serving the destined mobile. The base station then transmits the packet to the mobile.

If a radio link acknowledgment (ACK) is received from the mobile, the transmission is complete and logged as such. If the base station fails to get an ACK after four attempts, the packet is returned to the sender with the appropriate NACK. The sender also has the option of placing undelivered messages in the recipient’s store-and-forward facility.

MULTIPLE DEVICES/APPLICATIONS
The Mobitex Interface Specification (MIS) defines requirements for radio modems to address multiple input/output (I/O) devices such as printers, barcode readers, and telemetry sensors operating on a single terminal subscription. A single radio modem can also support up to seven simultaneous personal subscriptions, each of which can be used to map a particular wireless application to a particular host application. In addition, transport and session protocols in the mobile data terminal can establish and maintain sessions with any number of hosts and host applications, all of which can use a common, network-level driver to communicate with the radio modem. Such message routing is transparent to the multiple applications in the device.

These options offer SkyTel’s customers great flexibility in the design of cost effective solutions. For example, a vehicle may have some or all of the following devices each attached to a single Mobitex radio modem:

• Status terminal with keypad
• Printer for customer pickup receipts
• Barcode reader for cargo tracking
• Telemetry sensors for refrigerated cargo
• Telemetry sensors for vehicle operation and performance
• Global Positioning Satellite (GPS) receiver
8. Connectivity Options

OVERVIEW
SkyTel has many options available to customers to connect their host, server, or gateway to the SkyTel Mobitex Network.

NETWORK HOST CONNECTIVITY OPTIONS
SkyTel supports a wide range of wireline protocols for use in connecting a host or server to its high-speed, nationwide Mobitex network backbone. The available connectivity methods support both Mobitex native connectivity and gateway services, which map Mobitex datagrams (packets) to standard protocols. The quantity, bandwidth, and location of these interconnections will depend on traffic requirements over time and will have to be jointly engineered and mutually agreed upon by both a customer’s and SkyTel’s technical staffs.

A customer host may be connected to the SkyTel Mobitex Network at the MSN locations. The host or server is normally connected to the SkyTel Mobitex Network by a digital circuit, MPLS circuit or an internet VPN connection provided by the customer. The network’s native connectivity mode MPAXS are encapsulated in the X.25 protocol for delivery to the MSN. SkyTel also supports direct IP host connections (MIS compatible). SkyTel Data Networks (PDNs) are also supported for host connectivity using both Frame Relay and X.25 protocols.
8. Connectivity Options, Continued

FRAME RELAY

Frame Relay Access can provide customers with the option of accessing the SkyTel Mobitex Network at a cost saving over dedicated leased lines, especially if the customer is already connected to or intends to connect to a frame relay network.

SkyTel has determined that a cost effective Frame Relay Access solution is one that does not require modification to customer’s existing platforms, middleware, or software applications. In other words, all that needs to be changed is the media by which the customer accesses the SkyTel Mobitex Network. Frame Relay will replace leased lines as an access into the SkyTel Mobitex Network. All the customer needs to utilize this service is a router and a DSU (Digital Service Unit).

There are two types of customer’s host protocol configurations that can utilize Frame Relay Access Service to connect to the SkyTel Mobitex Network.

1. MPAK Over X.25 – Host uses an X.25 card or device to send and receive MPAK data, as shown in Figure 8-1: X.25 Over Frame Relay Host Connection.

2. XOT – Host uses TCP/IP protocols to send and receive MPAK data, as shown in Figure 9-2: TCP/IP Over Frame Relay Host Connection.

Figure 8-1: X.25 Over Frame Relay Host Connection
As depicted in the pictorial diagrams of the host connections, each host is connected to the Frame Relay Network via a frame relay access router. An X.25 host connects to the router via the router’s synchronous port and an IP host connects to the router via the router’s Ethernet port.

Both SkyTel and customer’s host/server will continue to send and receive data packets as they did using leased lines. Packets transmitted from either side are encapsulated in a frame relay header by the router and sent over the frame relay network to a destination router. The destination router in turn strips off the frame relay header and passes the packets to the end device. Packets between the two routers are passed over an assigned Frame Relay Permanent Virtual Connection (PVC). The following requirements need to be met to establish the host connection.
8. Connectivity Options, Continued

CUSTOMER REQUIREMENTS
- Customer needs to obtain a private line connection to the Frame Relay Network. This line should be a minimum 56 kbps digital access circuit.
- Customer must request a minimum 56 kbps Access port speed.
- Customer should order one Permanent Virtual Connection (PVC) into the SkyTel Frame Relay cloud. Network Engineering will work with the customer for recommended CIR. The CIR is the steady data rate between the host and the SkyTel Wireless POP (Point of Presence).

CUSTOMER PREMISES EQUIPMENT REQUIRED
- **Router** - To support frame relay interface protocol.
- **DSU** - To format data onto the access circuit for connectivity to the Frame Relay Network.

BACKUP
ISDN (Integrated Services Digital Network) Dial lines will be used as a backup to the frame relay connections. Whenever the router detects on the customer side that the frame relay link is down, it will automatically establish a dial backup ISDN connection with the destination router on the SkyTel side. As soon as the PVC is restored it will switch back to using the frame relay connection. Refer to Table 8-1: Summary of Frame Relay Host Connection Responsibilities.

<table>
<thead>
<tr>
<th>SUMMARY OF RESPONSIBILITIES</th>
<th>PROVIDED BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Access Circuit – Customer End</td>
<td>CUSTOMER</td>
</tr>
<tr>
<td>Frame Relay Access Router – Customer End</td>
<td>CUSTOMER</td>
</tr>
<tr>
<td>PVC Ordering</td>
<td>CUSTOMER</td>
</tr>
<tr>
<td>CSU/DSU – Customer End</td>
<td>CUSTOMER</td>
</tr>
<tr>
<td>ISDN BRI Dial Backup Line – Customer End</td>
<td>CUSTOMER</td>
</tr>
<tr>
<td>Bringing up of ISDN Connection</td>
<td>CUSTOMER</td>
</tr>
<tr>
<td>Digital Access Circuit – SkyTel End</td>
<td>SKYTEL</td>
</tr>
<tr>
<td>Frame Relay Access Router – SkyTel End</td>
<td>SKYTEL</td>
</tr>
<tr>
<td>CSU/DSU – SkyTel End</td>
<td>SKYTEL</td>
</tr>
<tr>
<td>ISDN Dial Backup Line – SkyTel End</td>
<td>SKYTEL</td>
</tr>
</tbody>
</table>

*Table 8-1: Summary of Frame Relay Host Connection Responsibilities*
8. Connectivity Options, Continued

INTERNET ACCESS SERVICE
Internet Access Service (IAS) is a host connectivity option designed to allow a customer’s host application to connect to the SkyTel Mobitex Network via the Internet, or through a closed Enterprise Intranet, replacing the leased lines, dialup lines, and PDNs in other host connectivity options. Customers desiring to enable their business for wireless operation via Internet Protocol (IP) links gain access to the Internet through an Internet Service Provider (ISP) of their choice, or through a dedicated link to a corporate Intranet architecture. IAS is easy to implement because it only requires that the customer have a connection to the Internet with a fixed IP address on their host system. No leased lines or special hardware is required. It is also less expensive than X.25 leased line connections. Virtual Private Network (VPN) security is supported using PPTP (Point-to-Point Tunneling Protocol) or L2P security options.

The IAS is fully interoperable with other SkyTel Mobitex services. IAS is representative of SkyTel’s continued commitment to providing customers with flexible wireless solutions over the SkyTel Mobitex Network.

DIRECT LEASE LINE SERVICE
SkyTel can also support host wireline connectivity, using switched X.25, TCP/IP, and UDP/IP.

CAPACITY OF HOST LINKS TO THE SKYTEL MOBITEX NETWORK
Figure 8-3: Packet Transmission at Various Line Speeds shows the maximum number of various sized packets that can be transmitted at different line speeds between the customer’s host and SkyTel’s Mobitex facilities.

![Figure 8-3: Packet Transmission at Various Line Speeds](image-url)
8. Connectivity Options, Continued

CAPACITY OF HOST LINKS TO THE SKYTEL MOBITEX NETWORK CONTINUED

When choosing the link speed, it is important to consider the size of MPAKs to send, traffic patterns, and peak load/hour. Table 9-3: Line Speed vs. Packet Size shows the maximum number of various sized packets that various speed links can handle at a peak load. The greater the speed of the line the more packets per seconds can be sent, for any size file.