MOTOROLA

Network Solutions Sector

iDEN™

Technical Overview

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Document Overview

Scope of Manual

This document is intended to summarize and explain the major principle and functions of the iDEN® system. Technical information is presented at a introductory level.

The iDEN system is designed for specific customer needs. Because of its complexity and size it is not easy define, consequently this document is organized to describe:

- How the iDEN system addresses communication needs
- The hardware and software elements that are the iDEN system
- The technical developments of the latest version of the iDEN system
- How the iDEN system and the various elements work together
- A description of the functional aspcets of the communication methods
- An overview of how iDEN functions to meet communication needs
- What features are associated with these methods of operation.

The scope of this document encompasses the definition of the Motorola iDEN radio communications system and identifies the items required to support inter-working between iDEN systems and land based telecommunications networks such as the Public Switched Telephone Network (PSTN). This description is also intended to provide a general iDEN overview, to assist customers with the development of sales and marketing literature (with written approval from Motorola), and to provide a reference document to Motorola sales and area systems engineering personnel.

Because of the dispatch capability implicit in iDEN, the subscriber is not always the intended user of the equipment and or features. *For example:* If a trucking firm purchases iDEN for its fleet of trucks, the firm is the subscriber purchasing the equipment while the drivers and dispatch personnel are users of the system. This document makes the explicit distinction between user and subscriber but the reader is cautioned that there can be instances where the subscriber and user are one and the same.

The distinction also appliies to mobile equipment. Regardless of the equipment (mobiles, PDA, pagers, or portable radios) or who specifically is using them, the units are generally termed Mobile Stations (MSs).

This manual depicts new system operation and does not imply that all MSs (Legacy Units) are capable of supporting all features listed in this document.

This manual attempts to include features released or baselined up to and including System Release 9.1 and GSM10. Some features are considered optional and may require additional cost. This manual is subject to change without notice.

Version Information

The following table lists the manual version, date of version, and remarks on the version.

Issue	*Date of Issue*	*Remarks*
-O	07/18/95	First Release
-A	08/16/96	Major rewrite to include latest features, functions and technological developments.
-B	10/10/98	Major rewrite to include latest features, functions and technological developments, up to and including GSM09 and SR7.0
-C	11/19/98	Minor corrections added from Formal technical Review (FTR).
-C	4/19/99	Minor corrections added from Legal and Intellectual Property review.
-D	5/1/99	Minor corrections
-D	9/24/99	Reformat and redraw
-E	08/08/00	Re-organize and re-write contents. Update for Software Release 8.0 and 9.1

Manuals On-line

This manual is available on the World Wide Web at *AccessSecure*, the iDEN customer site. This site was created to provide secure access to critical iDEN Infrastructure and Subscriber information. *AccessSecure* features the following categories of information:

- Quick reference to the iDEN organization, answers to frequently asked questions, and definitions to iDEN acronyms.
- Product training information including course descriptions, prerequisites, training planning tools, schedules, pricing and registration information.
- A library of iDEN Infrastructure and Subscriber technical documentation such as bulletins, system release documents and product manuals.
- New product announcements and marketing bulletins.
- System product performance and customer satisfaction.

For information on obtaining an account on this site contact Motorola at (847) 576-9541.

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Chapter 1
Introduction

This chapter provides an introduction to the iDEN® system communications types, a model to iDEN system, and a discussion of changes to the system that have taken place since the last release of this document.

System Overview

The outgrowth of the wireless communications market has produced vast opportunities to enhance and improve the communications between individuals. Because of this growth the need to optimize Radio Frequency (RF) spectral resources and provide ever-increasing services is essential.

To support the increase in wireless services while making best use of available resources, the iDEN system capitalizes on the fact that communications can be:

- Half-duplex — where one user is transmitting (talking) and other users are receiving (listening)
- Full-duplex — where there is an open bi-directional link that allows full two-way communication

Many times communication does not require a full-duplex link. Messaging, paging, some forms of data communication and structured voice communication are, or can effectively operate in, half-duplex mode (Chapter 4, Dispatch Call Processing).

Traditional telephone conversations and more intensive data links require the ability to interrupt; that requires full-duplex operation (Chapter 5, Interconnect Call Processing).

The iDEN system provides both full and half-duplex operations. This melding of communications methods allows much of the voice traffic to be run in half-duplex mode, while providing full-duplex functionality when required.

As part of the ongoing effort to support the outgrowth in wireless communication, the iDEN system is an integration of traditional Push-To-Talk (PTT), half-duplex, analog radio technology and feature-rich, full-duplex digital cellular communications. This integration of mobile communication technologies provides state-of-the-art functions and benefits to mobile users while optimizing the available infrastructure resources.

Reasons for Considering iDEN

Traditional PTT radio communications in corporate and municipal environments was limited by the number of radios and Federal Communication Commission (FCC) licensing. These restrictions limited the coverage area, contact outside the assigned, licensed mobile units, and provided little privacy. The iDEN system:

- Removes end-user FCC licensing requirements
- Opens communication to other subscriber corporations and all telephones[1]
- Increases the coverage area
- Allows private and group calling
- Optimizes RF resources
- Improves quality with higher frequencies and digital technology

Because of the finite availability of the Radio Frequency (RF) spectrum and a need to optimize this resource, iDEN technology increases the efficiency of a single 25 KHz RF carrier by applying up to six times the traffic of an AMPS Cellular carrier.

In addition to the increased channel efficiency, an iDEN system may be deployed to support communications outside the provider’s network (roaming). The telephone-style interconnect capability allows users to roam seamlessly throughout linked service areas. A user may place and receive calls as if the Mobile Station (MS) is on its home system. This also allows the service provider to offer an integrated service that includes:

- Messaging (Short Message Service)
- Private, Two-way & Group Call Cellular Telephony Service
- Voice Mail
- Data Networking (Intranet, Virtual Private Network (VPN), Internet).

Since the iDEN system uses digital technology, it provides clear voice quality, interference is reduced and voice quality is enhanced.

As the wireless industry grows, subscribers are seeking more services and increased functionality from a single service provider. With iDEN systems, these services and system outgrowth can easily and quickly be provisioned and made available to the end user because the radio link reduces installation time and cost when compared to land-based approaches.

Organization

To support the growing need for emerging telecommunications services, iDEN systems are organized into different levels or areas. These areas are based on geographical areas of decreasing size. The areas are:

- Global
- Region
- Domain
- Service Area
- Location Area
- Cell

1. Requires Software Release 8.0 or above.

Global

Global refers to the worldwide, multi-provider, Public Telephone Switched Network (PSTN). The telephone services available worldwide may be accessed from the iDEN system using Interconnect calling. When the iDEN system uses the PSTN (Interconnect) system, the rules and procedures of the PSTN are used. Interconnect calling is the access to land-line systems and the services available and emerging in the public switched environment. Global Two-Way (Dispatch) communications, while currently not available, is emerging technology.

Region

A Region is a large geographic area that is usually associated with more than one market or, more than one urban area. Just as urban areas tend to be adjacent and overlap, so do service provider coverage areas. A single service providers provides services by regions. A service provider may have adjacent or overlapping markets that can be linked to provide contiguous service across the areas. Regions may be covered by either Interconnect and Dispatch calling.

Domain

A Domain is an optional logical division of a region. This is usually defined by marketing and sales strategies as a fleet-based geographical area. The intent is to subdivide the region into smaller areas based on expected usage patterns.

Domain 0 is a system-wide domain. The default for Domain 0 is all service areas. There can be up to 50 domains can be assigned. Each domain may contain up to 254 service areas and represents the area of operation for a fleet or fleets. A Domain:

- Can not split a service area
- Can cross MSO boundaries.
- Should be geographically contiguous and should not intertwine or overlap.
- Should conform to obvious geographic - demographic borders
- Should have borders in areas of zero, or few subscribers
- Should make use natural obstacles that constrain subscriber movement

To minimize movement of subscribers between domains, domain borders should avoid major roads, highways, and thoroughfares. Obstacles like rivers, mountain ranges, and diverse geographic areas separated by a lack of contiguous RF coverage are good boundaries.

Users within a domain tend to stay within its borders. A business' fleet will normally stay within a domain throughout the course of the work day.

Service Area

A Service Area is dispatch only and is defined in provisioning by the subscriber and user databases. A service area is a group of Dispatch Service Areas (DLAs) that define a range of operation. Multiple service areas may be defined. Service Areas may overlap. Users in a service area tend to stay within its borders. A business' users that travel outside the service area will not be able to obtain dispatch service.

Location Area

A Location Area is logical geographical area that is based on the present (most recent) location of a Mobile Station (MS). Each MS on the iDEN system has Location Area Identifiers (LAIs). As the MS moves, different cell sites may service the MS. The equipment that may service the MS defines the Location Area. Interconnect service locations are not the same as Dispatch locations. Interconnect Location Areas are most often larger than Dispatch Location Areas. In both cases, the Location Area defines the general area where the MS is currently located for paging and call setup.

Cell

A cell is the area serviced by the RF propagation pattern of the antennas and a radio of a remote tower (cell site). The area is the effective size of a cell. An EBTS cell site may be either omni-directional or sectored. An omni site will have 1 cell. Sectored sites have 2, to 12 sectors (cells). Sectored sites most commonly have three cells. An MS is located by radio link integrity between 1 or more cells. One cell acts as host serving cell until a better radio link is detected from another cell.

Logical Environments

Most communications can be logically organized and grouped. When a sufficient number of users is reached, call patterns and communication relationships can be organized into a 4-tier functional model. The units of the model are:

- **Global** — all the potential users of voice and data communications
- **Fleet** — the broad logical group of users based on a common bond usually consisting of between 15 and 65,000 users (95,000 for Software Release 8.0)
- **Group** — a subset of a fleet based on the inter-relationship of users in the fleet (managers, sales, transportation, drivers, etc.)
- **User** — an individual or a compatible device that has access to the network

Global

As an increasing marketplace, the global, telecommunications market requires the ability to access and communicate within and across service provider networks. To provide access to these services, the iDEN system utilizes Global System for Mobile Communication (GSM) based technology that is compatible with Public Switched Telephone Network (PSTN) equipment and standards. This method provides direct dial to other network subscribers and networking through internally-direct and dial-up facilities. By linking directly to iDEN system and other-provider equipment, any PSTN equipment in the world is a potential resource for users. Any connection equipment outside the iDEN network is full-duplex and is discussed in greater detail in Interconnect Call Processing.

iDEN also provides dial-up data communications (Chapter 7, Circuit Switched Data Networking).

A single service provider may have markets in more than one geographical area. In these cases, connections within the same provider in different markets or urban centers are referred to as domains. Software Release 8.0 and above supports designated domains (Dispatch Call Processing).

Fleet

A Fleet is a logical organization of people and/or systems (users) that require mobility. In the broadest terms, a fleet is a subscriber. A subscriber can be:

- An individual
- A business
- An agency
- A government or municipal department
- An extended family
- Any functional organization with members that communicate with each other.

The iDEN system provides fleet-based communications with Dispatch call processing (half-duplex mode). Half-duplex mode is also called Push-to-Talk (PTT) because a button is pushed when transmitting (talking) and the same button is released when receiving (listening).

TalkGroup

Each fleet may contain subsets of localized communication. Like lines a multiline telephone each MS may be linked to a talkgroup that includes other fleet members. Individuals or groups may be selected to share in resources to engage in conversation.   Large groups can be defined and users may subscribe to memberships in the group. The number of groups and members is flexible. Groups are tailored to fleets and marketing plans. How fleets and talkgroups in the fleets are organized in provisioned in the Dispatch call processing databases.

Users

Users are individuals with network devices (radios, phones and similar devices). Users must be provisioned before they may use the system.

Advantages

The iDEN network products provide several important advantages in wireless communication. Broad capabilities and adaptive design provides:

- Flexible, multi-national, network scaling
- Efficient RF Channel usage in several spectrum bandwidths
- Circuit-switched (dial-up) and Packet-data (IP) digital data networking
- Dispatch capability for Private, Local and Wide Area Group calling
- Clear GSM cellular subscriber services
- Alphanumeric Messaging (Short Messaging Service)
- Reliable digital communication technology
- Fully Featured, compact portable devices (Mobile Stations)

Network Scalability

By combining industry standards with modular design elements, iDEN technology provides progressive, manageable, implementation, migration and outgrowth.

With consistent design standards and software upgrades, new technologies and enhancements can be implemented on the network that minimize the need for new hardware. The segmentation of tasks and functions to common hardware standards and remotely upgradable software modules allows the implementation of new technologies within the existing infrastructure. By reducing the amount of major changes, the network can be expanded and adapted as demand dictates.

As the demands of the market increase, iDEN technology is continuing to provide expandable hardware enhancements and inventive software upgrades that improve reliability and service quality. The development of new technologies is being based on the same principles and standards so migration is structured and more easily managed. This philosophy allows forecasting and capacity planning to adapt to the latest improvements while utilizing existing technology.

RF Channel Usage

RF spectrum resources are an increasingly valuable resource. The iDEN systems make effective use of these resources. A iDEN system allows multiple users on a single RF carrier. iDEN products provide precisely defined RF carriers with distinct centers and very low noise separations that exceed United States Federal standards and recommendation. This is discussed in greater detail in Radio Link.

Digital Data Networking

iDEN wireless networks support digital data communications for.

- Remote-mobile computing
- Fax
- Messaging
- Wireless internet (Packet Data)

The iDEN system's Circuit-switched (dial-up) and Packet Data technologies provide a communication link for data transfers and internet compatible wireless network elements. Any mobile device on the wireless network must be compatible with the channels in the local coverage area.

Circuit Switched Data Networking

Using traditional dial-up technologies, an iDEN MS can access and use remote computing services based on the access rights and permissions of a Host server or and internet service provider.

Packet Data Networking

Packet data allows an MS to be logically linked to a host system of the internet. Using packet data the MS becomes a remote mobile node on the associated network.

Dispatch Calling

Dispatch calls follows the half-duplex model of communication. Communication is one-way at a time. This applies to most voice communication.

Dispatch calling splits a single 25 MHz carrier into 6 channels. This division increases the carrier load from one (analog cellular) to a maximum of 6 per carrier.

During a dispatch talk, one channel on the carrier is used. For all those in the group listening during a group call at a single cell site use only one channel -- reducing resources. If everyone in the conversation, only one channel at each hosting EBTS is used. A channel is used and allocated for the duration of the conversation (until everybody hangs-up or times-out). This consolidation reduces the network traffic and allows dynamic channel assignment to maximize the network resources.

Interconnect Calling

The iDEN system also provides clear, digital cellular subscriber services if a call is made across a land-line network.

The service provider may chose to provision the system for optimum resource usage or for optimum voice quality. The iDEN system splits a single 25 MHz carrier into 6 channels. The provider may provision one channel per call for optimum resource usage or the provider may provision 2 channels for a call to improve interconnect voice quality but reduce available resources. (page 3-7).

Short Messaging Service

As part of subscriber services, up-to 140 alphanumeric characters can be transmitted to a mobile station. This Short Message Service (SMS) can be applied to voice and data devices the are compatible with the local coverage area network. This service is part of, and controlled by, the Mobile Switching Center (MSC).

Digital Communication Technology

Digital communication has several advantages over analog communications.

- Voice compression maximizes network resources and reduces eavesdropping
- Bad packet rejection reduces echoes and interference to improve voice quality
- Improved security by encoded voice and digital data
- Intranet, Virtual Private Network (VPN) and Internet Access
- Increased potential for subscriber services

Mobile Stations

The type of devices that can be used as Mobile Stations (MSs) include:

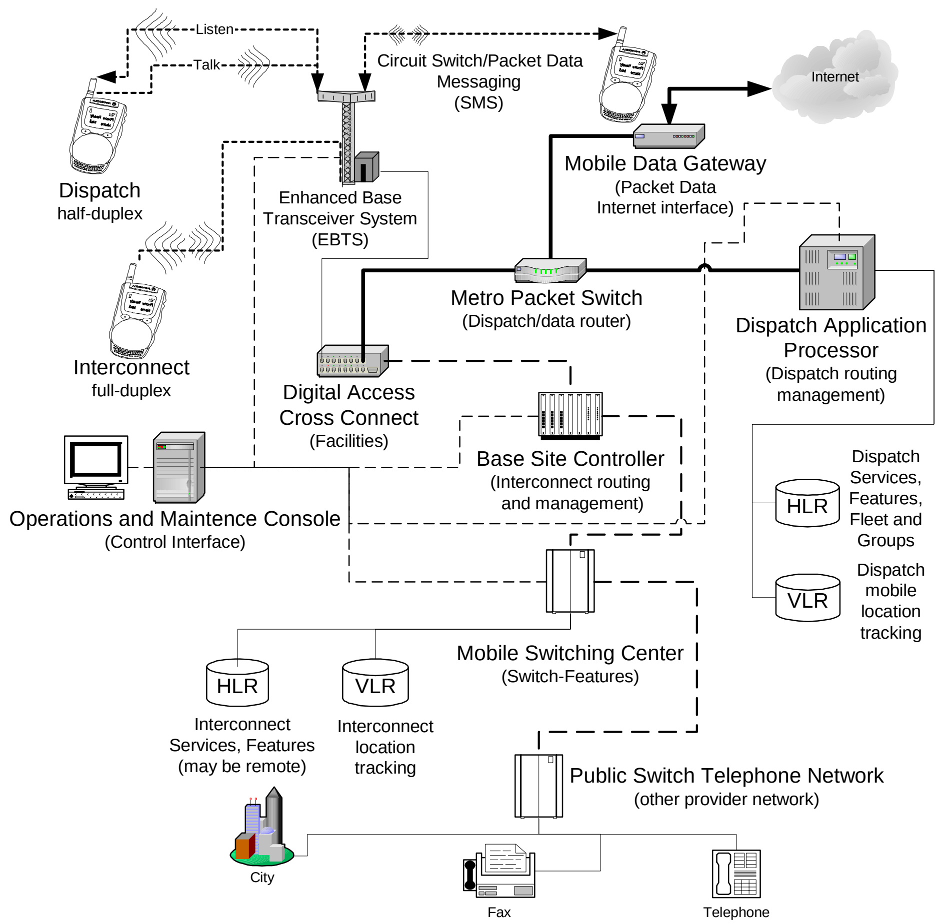
- Dispatch Base Stations
- Radios/Telephones (Lingos 360s, *i*500s, *i*6000s, *i*6000+s.)
- Emerging RF Laptops (terminals) and Personal Data Assistants (PDAs)

To function, the devices must operate in the local network's RF spectrum.

Physical Organization

The iDEN system consists of many components and pieces of physical hardware. The components and hardware are located throughout the local service coverage area. To simplify integration, the equipment uses industry standards for physical size, power requirements, and interface connections wherever possible. Each major component listed has sub-systems that perform more specific tasks. The layout of a simplified iDEN network is shown in Figure 1-1. Each network element is discussed individually.

Figure 1-1 *Simplified iDEN Communications Network*



Technological Advancements

Software Release 8.0

Software Release 8.0 (SR 8.0) introduces several important and major changes in the operation and functionality. The changes are:

- Year 2000 compliance
- Advanced Time-of-day processing
- Improvements to Base Site Controller software
- Enhanced data communications handling
- Significant improvements to Dispatch communications
- Improvements to the Enhanced Base Transceiver System software
- More inclusive network management

Each of these changes is discussed individually and in greater detail as required throughout this document.

Y2K Compliance

The iDEN system software has been extensively and inclusively tested to assure the ability to accept and output proper day/date/year information for 1999, the year 2000, and the change from 1999 to 2000. The software is also tested to assure the ability to recognize and adapt to the fact that the year 2000 is a leap year so the system can correctly recognize and process February 29th, 2000 (02/29/2000).

Time-Of-Day Processing

Time of day processing refers to the dynamics of local time zones. The time in a coverage area may cross time zones. The coverage area may also include more than one state or more than one country. SR 8.0 provides that ability to tailor the time of day processing to each cell site. It also provides the ability to adjust to seasonal changes (daylight savings). Since different states and countries adjust the seasonal time of day differently, SR 8.0 can process the change at the cell level three ways.

- 1st, 2nd, Last — the first second or last day of a given month
- On or Before — on or before a specific time on a specific date
- Literal — at a specific time on a specific date.

Base Site Controller Software

Software Release 8.0 provides five major upgrades to the Base Site Controller (BSC) software. These upgrades improve the event and error reporting. They are:

- BSC Event Reporting — to report a reason during event reporting if the BSC is not busy or locked
- BSC System Activity Reporting — to establish controls and guidelines to report and notify the need to load balance traffic on BSCs
- Voice Processor Recovery — to improve detection, monitoring and recovery of suspect voice processors while keeping the transcoder online
- Transcoder PSTN Noise Reduction — to reduce noises from the public networks with a new compression algorithm
- Autocoded Call Processor Application — to simplify and improve software development with a 4th generation language

Each of these enhancements is discussed in greater detail as required.

Data Communication Improvements

Data communications handling changes simplify MS configuration, increase capacity, reduce data stream volume and improve routing failure recovery. The improvement to data comminations include:

- Packet data bootstrap download — to simplify re-configuration of MS without a PC or direct cable connection
- An increase in Mobile Data Gateway (MDG) — to increase MDG capacity from 5,000 users to 15,000 users with a software change
- Packet Data Header Compression — to reduce the amount of data transmitted on-air with IP header compression. (This requires IP header compression be enabled on mobile during dial-up data networking)
- Mobile Internet Protocol (IP) Home Agent Redundancy — to help maintain a data link if the master home agent fails by copying binding and routing information to an assigned standby router.

Dispatch Communications

Significant changes in Dispatch Call Processing have been introduced to improve capacity, increase fleet size, allow cross fleet dispatch calls, and to reduce audio degradation (dragging).

Cross Fleet Dispatch calling — a new identification scheme increases the number of subscribers in a fleet and allow dispatch calls between different fleets.

New Dispatch Application Processor (DAP) hardware — a new version of the dispatch switch controller and upgrade kits to convert exiting DAPs to the more powerful configuration.

Home Location Register Portability — SR 8.0 improvements allow the HLR to be on any T-DAP not a dedicated DAP.

Private Call Hang Time — a new dispatch call parameter to better define call tear down and re-selection when a mobile travels across cell boundaries.

Enhanced Base Transceiver Station Improvements

The Enhanced Base Transceiver System (EBTS) has been expanded and upgraded to increase frequency range, reduce recovery time and improve alarm and error reporting

- Introduction of 821-825 MHz spectrum capabilities
- Dynamic adjustment of Transmit power on Base Radio Recovery or switchover to redundant control channel Base Radios
- iDEN Monitor Unit (iMU) Alarm Module Control improvements in monitoring and reporting of EBTS activity.

These changes are discussed in greater detail as required throughout this document.

Network Management

Changes to the hardware and software of the Operations and Maintenance Center (OMC) vastly improve Network Management. These changes are driven by the phasing out of production of the S1000 and OMC 3000 workstations by the supplier. These computers are going out of production so new hardware is being introduced to act as OMC. The changes include:

- Introduction of the OMC 3500 platform
- The ability to control multiple frequency bands on one OMC
- The ability to network OMCs

The OMC 3500 is a newer, faster processor that is available in rack-mount and cabinet configurations.

Software Release 8.0 also allows a single OMC to be connected to, and control EBTS sites that cross RF spectra. If a multinational system exists with different frequency ranges, some simple rules apply.

- All radios in a single EBTS must be of the same band
- All neighbor list candidates for an EBTS must be of the same band.

Legacy and new platforms of OMC may now be networked to share configuration and event information. This allows broad services areas, more precise configuration control, and better network management.

Software Release 9.1

Software Release 9.1 (SR 9.1) provides significant improvements in the operations and maintenance of the iDEN system. SR 9.1 is supplied for equipment under warranty and is offered as part of the Software Maintenance Program (SMP) that is available as a subscription. The changes are summarized in Table 1-1.

Table 1-1 Software Release 9.1 Summary

<table>
<tr><th>Sub-System</th><th>Enhancement</th><th>Hardware Impact</th><th>FNE Notes</th><th>Subscriber Impact</th></tr>
<tr><td rowspan="8">EBTS</td><td rowspan="2">ACG Background Download (operations)</td><td></td><td>Requires Redundant Site Controller</td><td>None</td></tr>
<tr><td colspan="3">This allows site controller software to be loaded without taking the cell out of service (in the background). An EBTS must have a redundant controller to allow software is loads to the redundant (standby) controller while the active controller processes traffic. Controllers may then be switched and loaded.</td></tr>
<tr><td rowspan="2">Fast Site Initialization</td><td></td><td>Not fully supported on VME ACG</td><td>None</td></tr>
<tr><td colspan="3">If a EBTS is not moved, but is re-initialized, this enhancement bypasses the GPS synchronization of the initialization process because Latitude and Longitude are remembered. This reduces initialization time where line of site to the GPS satellites may be blocked (buildings, similar obstructions). VME sites may track 6 GPS satellites, iSC sites may track 8 GPS satellites. If a site is relocated, perform the GPS synchronization prior to service.</td></tr>
<tr><td rowspan="2">GPS Fault Reporting (additional stats to OMC)</td><td></td><td>Not fully supported on VME ACG</td><td>None</td></tr>
<tr><td colspan="3">This improves commonality of hardware indicators and software alarms and messages, GPS related reporting, and diagnostics for coordination of information between the OMC and the field technicians. Hardware is not changed.</td></tr>
<tr><td rowspan="2">RF uplink Channel Quality Statistics</td><td>None</td><td></td><td>None</td></tr>
<tr><td colspan="3">New statistics help Radio Link quality reporting:
1) The number of time below optimum SQE (20 dB)
2) The number of SQE per all calls
3) Average interference on idle channels
4) The carrier cabinet position
This identifies radios and sites with substandard radio link performance</td></tr>
<tr><td rowspan="2">EBTS</td><td rowspan="2">ACG Enhanced Redundancy</td><td></td><td>Requires Redundant Site Controller</td><td>None</td></tr>
<tr><td colspan="3">Provides greater recognition and automation of EBTS ACG critical faults and cutover to the standby ACG in sites with redundant ACGs. The EBTS site must be provisioned as; redundant equipped or unequipped. Any background software load is interrupted and superseded (cutover has priority of loads)</td></tr>
</table>

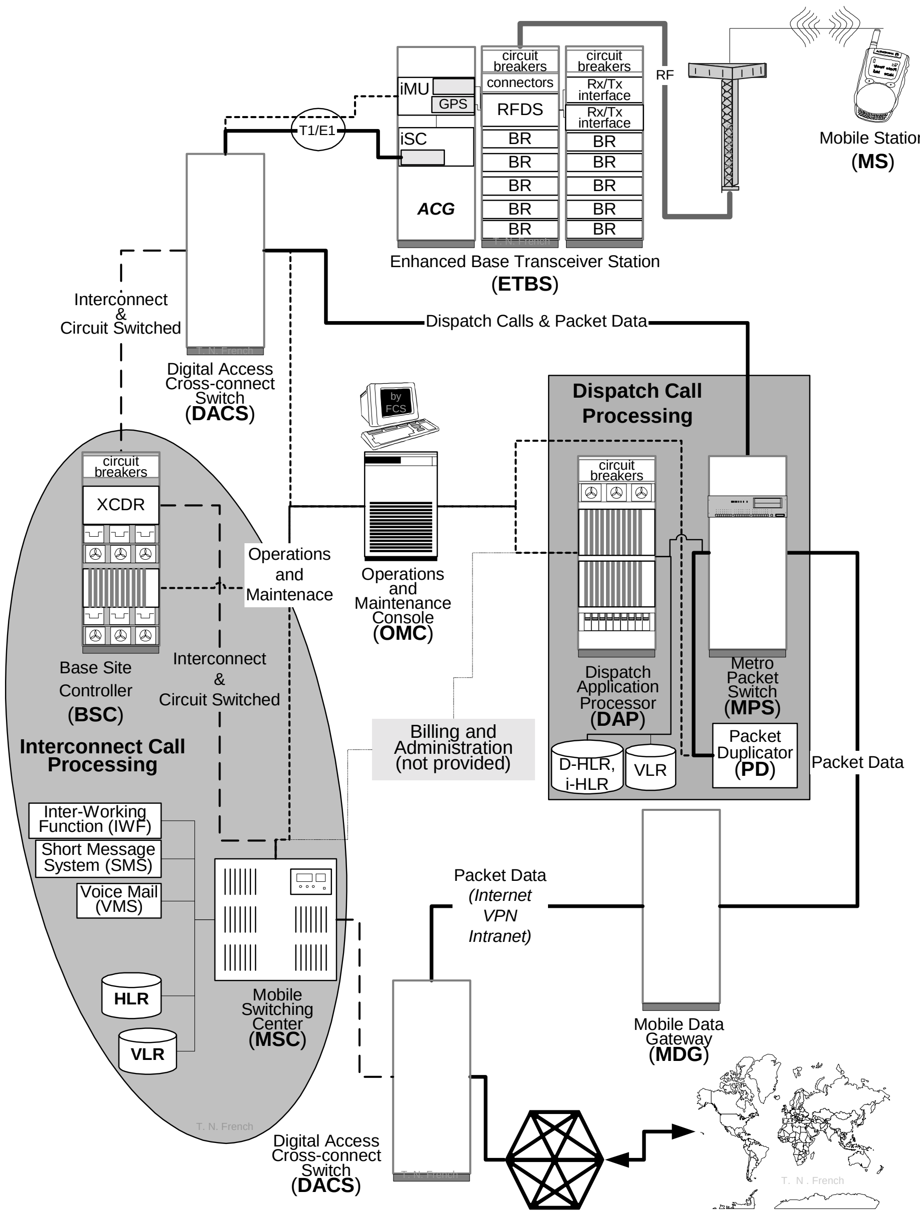
<table>
<tr><th>Sub-System</th><th>Enhancement</th><th>Hardware Impact</th><th>FNE Notes</th><th>Subscriber Impact</th></tr>
<tr><td rowspan="4">OMC</td><td rowspan="2">Performance Management Phase 1 (Operations)</td><td>None</td><td>S1000 OMC is no longer supported</td><td>None</td></tr>
<tr><td colspan="3">This improves reporting and prioritization of alarms and messages for E3000/U2 and E3500/U60 OMC-R platforms. The OMC-R will poll for missing statistics until they are received. Network elements stagger the delivery of statistics to reduce the load on the CPU.</td></tr>
<tr><td rowspan="2">Isolated Site Operation for Multiple OMCs</td><td>None</td><td></td><td>None</td></tr>
<tr><td colspan="3">Isolated Site operation is now available for networked OMCs</td></tr>
<tr><td rowspan="8">BSC</td><td rowspan="2">XCDR Voice Processor Recovery</td><td>None</td><td></td><td>None</td></tr>
<tr><td colspan="3">XCDR processor can be software reloaded if it is in standby, reset, reloaded, and re-initialized status.</td></tr>
<tr><td rowspan="2">Enhanced BSC Event Reporting (OMC/ BSC) Operations</td><td>None</td><td></td><td>None</td></tr>
<tr><td colspan="3">Provides a smart tool to assist in fault isolation. New status information is acquired, and root causes are displayed.
▲ Caution
This is not backwardly compatible with SR 8.0. BSC elements must be upgraded at the same time.</td></tr>
<tr><td rowspan="2">BSC system Audit Trail (OMC & BSC)</td><td>None</td><td></td><td>None</td></tr>
<tr><td colspan="3">Helps identify BSC under-utilization or over-utilization with proactive CPU utilization reporting. This reports average CPU utilization between reporting periods for each control processor. New alarms are available and thresholds are configurable.</td></tr>
<tr><td rowspan="2">BSC Time Synchronization</td><td>None</td><td></td><td>None</td></tr>
<tr><td colspan="3">To reduce BSC - OMC-R timing differences, the BSC will not poll the OMC for timing information. This may be enabled or disabled at the OMC.</td></tr>
<tr><td rowspan="4">Data</td><td rowspan="2">Packet Data Compression Capacity</td><td>Yes</td><td>Requires new MDG</td><td>None</td></tr>
<tr><td colspan="3">SR 9.1 provides Packet Data compression. Packet data may be compressed for transmission. This is provisioned in the iHLR</td></tr>
<tr><td rowspan="2">Enhanced MDG - Phase 1</td><td>New MDG</td><td>15K subscriber MDG not supported</td><td>None</td></tr>
<tr><td colspan="3">A new MDG increases the number of subscribers per MDG from 15,000 to 64,000. The replacement should be 1 to 1 to reduce downtime.</td></tr>
</table>

Chapter 2
iDEN® System

This section describes the iDEN® system Network Elements (Figure 2-1). Network elements are hardware and software that form operational components of the system.

Each of the depicted components is described individually.

Figure 2-1 *Generalized iDEN System Architecture*



Mobile Station

The Mobile Station (MS) is the end-user interface to the network. A Mobile Station is a phone, pager, modem, mobile transceiver, end-user base transceiver, or similar device that is registered in, and compatible with, the iDEN system. Mobile Stations, also called mobiles or subscriber units, are capable of:

- Multi-service (capable of several functions)
- Dispatch calling
- Interconnect calling
- Roaming
- Message Mail
- Data communications

The network supports these services for all mobile stations, however, some mobile stations may not be compatible with all the functions. Product listings are available on the Internet at: *http://www.mot.com/LMPS/iDEN/*.

Enhanced Base Transceiver System

Physical Components

In the iDEN system, the base station radios and associated control equipment are contained in the Enhanced Base Transceiver System (EBTS) or, more commonly, cell sites. The EBTS provides the Radio Frequency link between the land network and the MSs. The Base Radios (BRs) perform the communications with the MSs, sending both the control information and the compressed speech over a radio channel. EBTS components (Figure 2-2) are rack-mounted. A standard configuration is recommended, but an EBTS can be configured with different equipment to tailor the performance.

Figure 2-2 *Enhanced Base Transceiver System (typical).*

The EBTS site consists of:

- an Access Control Gateway (ACG), which is either an integrated Site Controller (iSC) or the aging, VME platform
- one or more Base Radios (BRs)
- an RF Distribution System (RFDS) (hybrid or cavity)
- a site synchronization Global Positioning System (GPS) receiver
- a Local Area Network (LAN) interface

Motorola does not typically supply:

- the site antennas
- the site to infrastructure transport facilities

Access Control Gateway

The Access Control Gateway (ACG) is the site controller and the communications gateway between an EBTS site and the System's central network. The ACG exists in two versions. The legacy VME-bus version and the modular iDEN Site Controller (*i*SC) version. The iSC version of the ACG consists of two units the:

- iDEN Site Controller (*i*SC) that integrates the access gateway, timing reference and facilities termination functions.
- iDEN Monitor Unit (*i*MU) that integrates the Environmental Alarm System (EAS) and the Base Monitor Radio (BMR).

The iSC discriminates between Dispatch, Interconnect and Packet Data calls and routes the traffic accordingly. It also controls base radio timing and terminates transport facilities. Network infrastructure facilities (T1/E1s) are terminated at the iSC.

The iMU integrates the Environmental Alarm System (EAS) and Base Monitor Radio (BMR) functionality in a single unit. Alarm and status information is reported to the Operations and Maintenance Center - Radio (OMC-R) through the EAS/BMR on VME systems and the iMU on shelf-oriented systems.

Two site controllers (*i*SCs) are recommended for redundant/standby operation. These units are software switchable (active-standby). Communication between the master (active) and standby is initiated by the active controller. This redundancy reduces maintenance and downtime. In the event of an EBTS failure, the iSC allows an OMC-R operator to perform tests to isolate faults between the EBTS and the facilities (T1/E1) and, with SR 9.1, load new software. The ACG also allows the operator to remotely switch to a site's standby ACG.

The ACG controls the RF base radios through an Ethernet LAN.

Base Radio

The EBTS requires one Base Radio (BR) for each 25 MHz carrier. The EBTS currently supports up to 20 radios when configured as an omni site and 24 radios as a 3-sector site. A BR can be removed from the EBTS and replaced with a new BR without taking the site off the air (can be hot-swapped). The base radios and the radio link traffic (voice and data) are controlled by the ACG over a LAN.

RF Distribution System

The Radio Frequency Distribution System (RFDS) is the frequency combiner that allows several BRs to share a common antenna system. The EBTS can be configured with either hybrid or cavity combiners. This creates minor changes in maintenance and operation but does not affect the functionality of the radio link.

Site Timing Reference

Each site requires precise timing and location information to synchronize data across the network. To obtain and maintain this information each EBTS uses GPS satellites obtain a precise, timing reference pulse (Refer to Site-to-Site Frame Synchronization).

LAN Interface

Each EBTS component is monitored and communicates with each other directly or over a LAN. The LAN interface is the path for traffic flow. The LAN also supports the Alarm and Messaging monitoring functions (iMU or BMR/EAS). Operations and Maintenance uses the iMU and the LAN to access the cell site.

The LAN is a thinwire, coaxial Ethernet (10base2) that runs Carrier Sense Multiple Access/Collision Detect (CSMA/CD) protocol. This allows the BRs and the iSC to access each other as time and traffic requires with a minimum of control overhead.

BR Antennas

Antennas will vary with each installation. Each EBTS cell requires has a minimum of one antenna for the radiation and reception of the RF energy that is the Radio Link. There is usually more than one antenna or branched antennas (Diversity Antennas).

Functional Characteristics

The EBTS can be configured to support multiple RF frequencies in a omni-directional or sectored configuration. Major functions of the EBTS are:

- Maintenance of the radio link
- Radio link formatting, coding, timing, error control & framing
- Timing control supervision to subscriber units (time advance)
- Radio link quality measurements — Signal Quality Estimate (SQE)
- Recognition and separation of traffic (Interconnect, Dispatch, Circuit Data or Packet Data)
- Site-to-site frame synchronization
- Interface conversion - radio link to DS0
- Switching functions between base transceivers
- Operation, maintenance, and administration of Radio Link equipment

The EBTS also relieves the network from the lower level site control functions. This helps isolate the central network functions and the RF radio link. Because the EBTS performs most control functions, the number of network messages is minimized. This results in a shorter call setup time and decreased link control overhead.

Radio Link Maintenance

The basic wireless radio link is a 64 kbs digital baseband signal subdivided into 6 timeslots. Each timeslot at the cell site is a radio link. The MS constantly analyzes the quality of the radio link. When the MS and the FNE determine that a better signal exists and the MSs radio link is processed accordingly.Some of the radio link functions the EBTS is responsible for include:

- Channel disconnect and failure
- Trolling — contact, position update, and identification of the MS
- Handover — changing to a cell site with a better signal
- Cell selection — choosing a cell to host the MS
- Disconnect and re-connect

Site-to-Site Frame Synchronization

Timing is a critical issue to assure the proper transfer of voice and data calls between cell sites. To assure proper processing, each site must have highly accurate time information to provide a timing offset to adjust for the signal propagation time across the network. By using the common GPS timing pulse as a network clock, circuits and software in the EBTS can assure that input and output data streams within the iDEN system are synchronized.

Interface Conversion

The radio link is a voice and data is a digital signal. This over-the-air data stream is specific to the radio link and must be converted to more a traditional data stream to be transported across the network. The EBTS converts the radio link voice or control data between radio link timeslots and the data packets that can be applied to T1/E1 links between the EBTS and the rest of the network. The EBTS network interface consists of 64 kbps DS0/timeslots that are either T1 (24 DS0s) or E1 (32 DS0s). The allocation of DS0s on a single T1from the EBTS to the central network will depend on the number of BRs, the total traffic loading and the traffic mix at the EBTS. The information the EBTS passes to the iDEN network through T1/E1 facilities includes:

- Network Management (status/control, and statistics)
- Telephone Interconnect Traffic
- Inter-Working Function Traffic
- Dispatch Traffic
- Packet Data Traffic

Compressed voice for Interconnect and circuit switched dial-up networking data is sent in a 16 kilo-bit-per-second (kbs) sub-rated (shared DS0) format. Dispatch and Packet Data packets are sent in Frame-Relay format. T1/E1 Requirements are:

- T1 Speed: 1.544 Mps, framing: ESF, coding: B8ZS, DS0: 64 kbps, Clear channel capability
- E1 Speed: 2.048 Mps, coding: HDB3

This functionality is discussed in greater in separate manuals.

Switching Functions

For calls in the range of a single EBTS, the EBTS handles and controls handover in conjunction with the MS. The EBTS handles intra-site (sector-to-sector) handovers between sectors of the same site. For handovers involving multiple sites, the handover metrics are passed to the BSC-MSC or the DAP-MPS (Appendix D, Handover).

Operation, Maintenance, and Administration

Part of the EBTS is the network management agent. The operation maintenance and administration functions are managed by the OMC-R. The OMC-R is responsible for performing the EBTS network management functions such as:

- Configuration Management (code download)
- Fault Management (alarm processing and re-configuration support)
- Performance Management (statistics gathering).

Configuration Management allows for parallel BR downloads. This allows software downloads to each BR in the EBTS simultaneously and reduces downtime.

Statistics are sent to the OMC-R every 30 minutes. Alarms, state events, and faults are sent as they occur.

Digital Access Cross Connect Switch

Physical Components

The Digital Access Cross Connect Switch (DACS) is the attachment point of T1/E1 span lines (trunks) between the iDEN system equipment and the external transport facilities. The point-to-point connections are discussed in separate manuals and in Interfaces. The DACS is not part of the iDEN network's equipment but is required to connect the remote locations to the Mobile Switching Office (MS)

Functional Characteristics

The DACS is a channel bank/multiplexer that distributes the DS0s (span lines) of the T1s to EBTSs and the Fixed Network Elements that are connected though the external equipment or transport facilities (Figure 2-3). These may include T1, DS3s DS4s Fiber Optics or microwave.

- Dispatch and Packet Data DS0s (frame relay spans) are routed from the EBTS to the Metro Packet Switch
- Interconnect paths and control signalling is wired from the EBTS spans to the Base Site Controllers
- Operations and Maintenance information on a single DS0 between the EBTS and the OMC
- External transport facilities are often connected to the iDEN system through a DACS

Trunking and span line connections are discussed in Networking and in separate manuals.

New or changed hardware may be installed and configured before being activated. The DACS can act as a switch to electronically route (re-route) signalling to place new or changed hardware in-service or remove old hardware from service. The cutover method can significantly reduce downtime. Procedures for this type of maintenance are usually site specific but may be available from Motorola in print and/or online at *AccessSecure.com*.

Figure 2-3 *Digital Access Cross Connect Switch*

Metro Packet Switch

Physical Components

The Metro Packet Switch (MPS) is a subsystem that connects the EBTS frame relay connections to the Dispatch Application Processor and the Packet Duplicators. It consists of the system cabinet and attachment point for frame relay span lines.

Figure 2-4 *Metro Packet Switch*

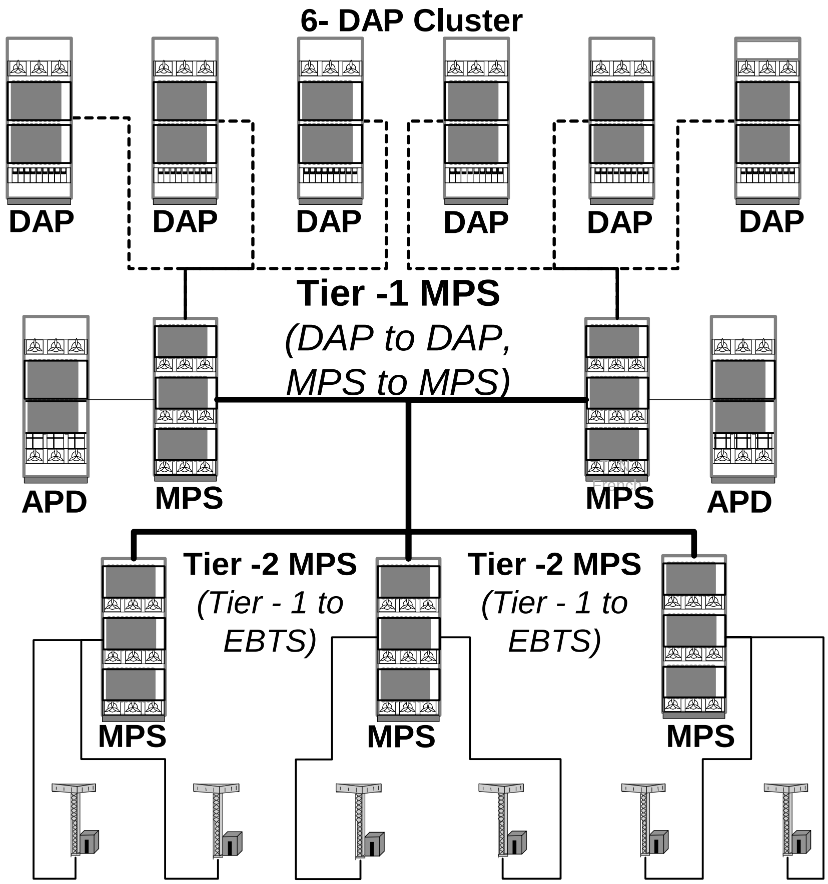
Functional Characteristics

The MPS is a Frame Relay digital data packet switch. The MPS manipulates the paths dispatch voice packets use during a Dispatch call and the data packet paths during a Packet Data networking. For group dispatch calls and data network multicasts, the MPS routes packets to and from the Packet Duplicators (PDs) and Advanced Packet Duplicators (APDs) to the appropriate destination. The MPS also routes control and signalling information between the DAP, MDG and the EBTS sites.

The source and destination definitions for routing and movement of voice and data packets (signalling) is under the control of the Dispatch Application Processor. The MPS controls the overhead and manages the flow of voice and data between the associated dispatch network elements.

The MPSs are usually implemented in a tiered architecture (Figure 2-5). One or more MPSs control the routing of voice and data between the PDs and the Dispatch Application Processor cluster, and a second tier of MPSs that actually route the data the appropriate radio in the correct EBTS.

Figure 2-5 *Two-Tier MPS Implementation*



Dispatch Application Processor

Physical Components

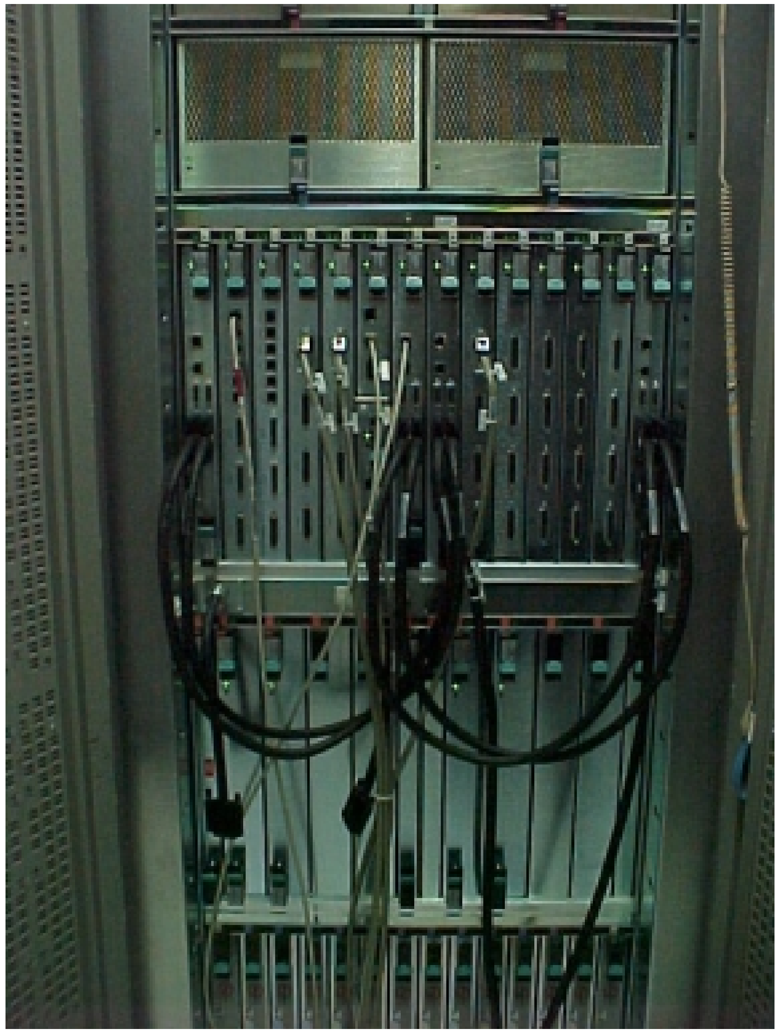
The Dispatch Application Processor (DAP) is usually installed in a standard rack. DAPs are usually deployed in groups (clusters) of up to 6 DAPs. DAPs and DAP-clusters vary with age and capacity. The DAP (Figure 2-6) exists in several configurations:

- IMP-DAP — that supports 300 EBTS sites and 45,000 users
- N-DAP — that may be a 6-DAP cluster with up to 1000 EBTS sites and 90,000 users
- T-DAP — That supports clusters 1000 EBTS sites and 180,000 users

The DAP consists of:

- Standard System Controllers
- Input Output Controllers
- Central Processing Unit
- Router Controller
- Mass Storage Devices

Figure 2-6 Dispatch Application Processor (typical)



Standard System Controller

The Standard System Controller (SSC) cards provide the ServerNet communications routing for the:

- I/O controllers
- Internal control and maintenance system
- Small Computer System Interface (SCSI) disk drives
- Host bus adapters (HBAs)
- Configuration and maintenance
- I/O expansion functions for the system

There are two SSCs in the unit for fault tolerant redundancy.

Input Output Controller

The Input Output Controller (IOC) cards provide for the connection of external equipment. In most cases synchronous V.35 may be used to handle frame relay communications (dispatch call and packet data processing) with the MPS and Operations and Maintenance communications. Some installations may use another card to provide a single port to an Ethernet LAN transceiver for Operations and Maintenance. The Ethernet LAN controller is a single-height IOC Card. The Synchronous controller is a double-height card.

Central Processing Unit

The Central Processing Unit (CPU) provides the central processing engine and memory for the DAP. There are two CPUs in the processor shelf for each hardware fault-tolerant processor. CPUs provide the logic circuits to execute dispatch processing code and access the databases for service and location information.

Router Controller Cards

The Router Controller Cards (ROCs) manage communications routing of control signaling and Operations and Maintenance information between the DAP processor and the rest of the system. There are two cards for redundancy and fault tolerance.

Mass Storage Devices

The DAP mass storage devices are used to store and maintain the operating software and databases. Tape backup and CD-ROM devices are also available. All of these devices are SCSI. The databases contain the identification, location and authentication information for dispatch enabled MSs.

Functional Characteristics

The DAP is the processing entity responsible for the overall coordination and control of Dispatch and Packet Data services. The DAP has been optimized to support rapid response time for services, which include but are not limited to: Group calls, Private calls, Call Alerts, Emergency calls and Packet Data networking. To increase subscriber capacity, the DAP may be expanded to form a six-DAP cluster. The DAP provides:

- Control for all Dispatch and Packet Data functions
- First-time registration for all Interconnect and Dispatch subscribers
- Maintenance and tracking of MS mobility (Dispatch and Packet Data)
- Alarms and performance statistics for the OMC
- Maintenance of all Dispatch subscriber provisioned information

Dispatch and Packet Data Control

The DAP assigns the signalling and routing paths for Dispatch calls and Packet Data. When the MS requests service the DAP verifies the mobile, confirms the services availability to the MS, and processes the request (See Dispatch Call Processing).

First-time User Registration

When an MS is powered-on, the MS sends a service request. If the mobile's identification is not valid in the system, service is denied. (See Over-The-Air Programming).

Dispatch Mobility

The DAP maintains the last known dispatch location area for all active and recently active MSs. This is used by the DAP to route calls (See Dispatch Call Processing).

Alarms and Performance

The DAP collects and maintains performance metrics, usage and call record information. Alarms and status information is collected and reported every half-hour. Performance metrics and usage is also collected for optimization and billing.

Dispatch Provisioning

The DAP maintains databases that are used to control the activity of a mobile MS on the system.

- Dispatch Home Location Register (D-HLR) — for conditional dispatch call users
- iDEN Home Location Register (iHLR) — for conditional packet data users
- Dispatch Visited Location Register (D-VLR) — for mobility and activity of all dispatch and packet data users

These are discussed in On-Air Programming and Dispatch Call Processing.

Packet Duplicator

Physical Components

Each Advanced Packet Duplicator contains:

- MTX Boards
- High Speed Serial Interface

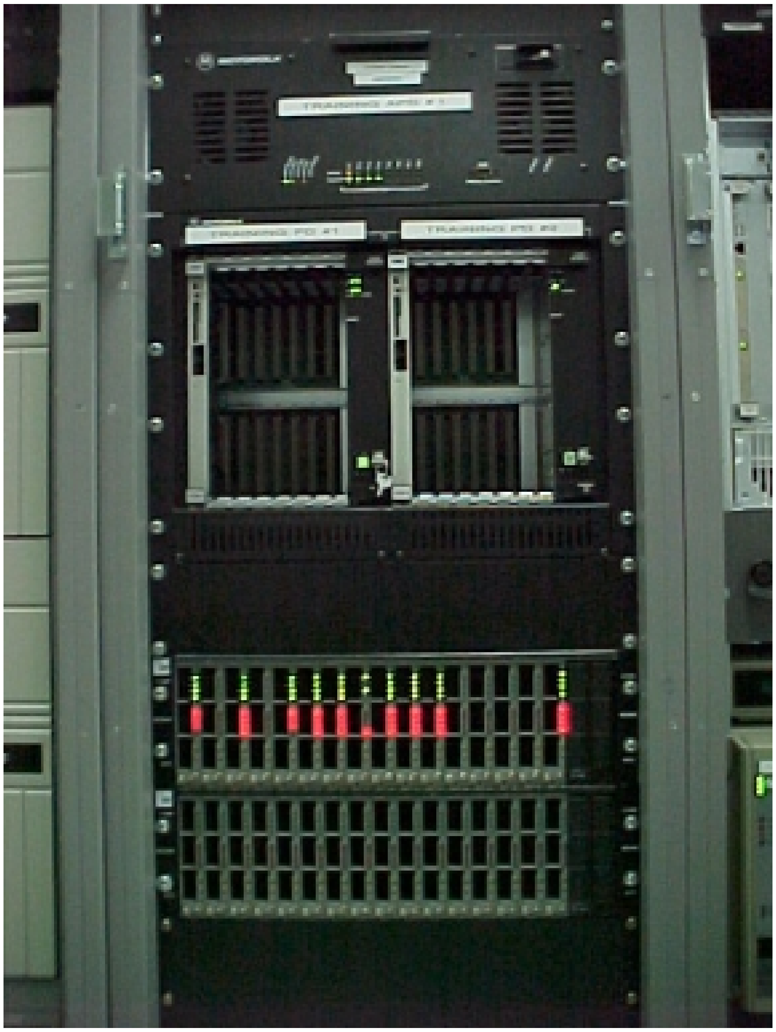
MTX Boards

The processing and control logic for the operation of the APD is on the MTX single board processor. The OMC-R exchanges status and control information with the MTX through a RJ45 twisted pair connector on the board. The MTX board also contains 4 slots that use the 32-bit Peripheral Component Interface (PCI) bus standard for the connection of 4 serial interface boards

High Speed Serial Interface

The High Speed Serial Interface (HSSI) contain ports that are opened and closed under the control of the MTX board. When a port is opened the incoming packet is duplicated to the output ports to the EBTS sites as determined by the mobility management of the DAP.

Figure 2-7 *Advanced Packet Duplicator (typical)*



Functional Characteristics

The Packet Duplicators provide the functionality to allow broadcast, group and multicast operation with dispatch calls. Each packet duplicator has the processing power to make enough duplicate packets for each EBTS in the system. The packet duplicator is used to replicate voice and data packet for output to multiple MSs in Dispatch calling and Packet Data networking. If a dispatch call is to a group, the voice packets from the sender must be duplicated for output to each of sites hosting a receive unit.

The Packet Duplicators are under operations control of the OMC-R. Alarm and status information is set to the OMC-R every half-hour. The OMC-R may download software and control the operation of the PDs using X.25 protocol over V.35 cables to PD and 10BaseT ethernet to the APDs.

Mobile Data Gateway

The Mobile Data Gateway (MDG) is the interface to the Internet and the World Wide Web for the iDEN system during Packet Data operation.

Physical Components

The MDG is a Enterprise level switching router. This device is rack mounted and has direct connections to the Internet. The number of ports available will vary according to the provisioning and growth planning of the individual iDEN system.

Functional Characteristics

The MDG isolates the iDEN system for other devices on the Internet. The MDG is programmed and managed as a discreet unit. The Operations and Maintenance Center has no direct control over this device. The MDG has three major functions during Packet Data operation:

- Gateway
- Home Agent
- Foreign Agent

The MDG supports 15,000 users. Software Release 9.1 includes a new MDG platform that supports 65,000 users. Earlier versions of the MDG are not supported by SR 9.1.

Figure 2-8 *Mobile Data Gateway*

Gateway

The MDG is a logical point-of-presence for the iDEN system on the Internet. This universally addressable device provides secure networking routing, switching and network masking functions. These functions are individually unique and are tailored to specific applications and installations

Home Agent

The MDG stores a provisioned MSs Internet Protocol (IP) address in a database. This IP address is used to identify, permission and route data packets from the internet to the MS during Packet Data operation. The Home Agent identifies an MDG as the point-of-presence on the Internet that accepts data packets addressed to IPs in the Home Agent database.

A home agent MDG can a communicate with remote MDGs and temporarily transfer the logical addressing to the remote MDG (foreign agent) when the MS is roaming in another system. The Home Agent will transfer a roaming MSs IP address to the remote MDG so the remote MDG will accept packets for the MS. The Home Agent then re-routes packet data information to the remote MDG (Foreign Agent) as required.

Foreign Agent

During roaming, an MS will register and attempt to authenticate in a remote system. For Packet Data operation, the remote system will contact the MSs home system MDG (Home Agent) and obtain authentication, identification, services and permissions information. If allowed, the MDG will receive the visiting MSs IP address and allocate resources to service the MS. This enables the remote (visited) MDG to accept packets routed to it by the Home Agent MDG.

Base Site Controller

Physical Components

A Base Site Controller (BSC) may be linked to one or more EBTS sites. The BSC manages Interconnect Call Processing between EBTS sites and other network devices. The BSC (Figure 2-9) is divided by function into to physical shelves in a rack or it may be divided into individual racks. The major BSC shelves are:

- Base Site Controller - Control Processor (BSC-CP)
- Base Site Controller - Transcoder (BSC-XCDR)

Base Site Controller - Control Processor

The Base Site Controller - Control Processor (BSC-CP) contains the memory and logic circuits to administer and monitor the routing of Interconnect Calls. The BSC-CP manages the general call signalling and voice paths of the BSC-XCDR. One side of the BSC-CP connects to the Mobile Switching Center with SS7 signalling and the Operations and Maintenance Center with X.25 protocol. The other side connects to the EBTS through the DACS with modified A-bis interface (Mobis) signalling and alarm and maintenance data with X.25 protocol. The BSC-CP consists of:

- MegaStream Interfaces — to physically connect external paths (T1 spans)
- Cross Connect Switch — to dynamically connect control paths
- Generic Processors — for overall control and monitoring of BSC operation

Base Site Controller - Transcoder

The BSC Transcoder (BSC-XCDR) converts the voice packets used on the radio link to the Pulse Code Modulation (PCM) used by local and interconnected Public Switch Telephone Networks (PSTNs). The BSC-XCDR consists of:

- MegaStream Interfaces — to physically connect external paths (T1 spans)
- Cross Connect Switch — to physically connect traffic paths
- Generic Processors — to route traffic packets internally to the XCDR
- Transcoders — to convert between radio link packets and PCM

Figure 2-9 .Typical Base Site Controller

Functional Characteristics

The BSC provides control and concentration functions for one or more EBTS sites and their associated mobile stations. The functions are segregated into separate circuits to improve the adaptability of the system to the local network requirements. The functions include:

- Link concentration from multiple EBTS sites
- Conversion of the radio link to the land network format
- Handover data collection, preparation, and execution to sites under its control
- Operation, maintenance and administration agent for OMC X.25 network
- Call Processing control of interconnect audio

Link Concentration

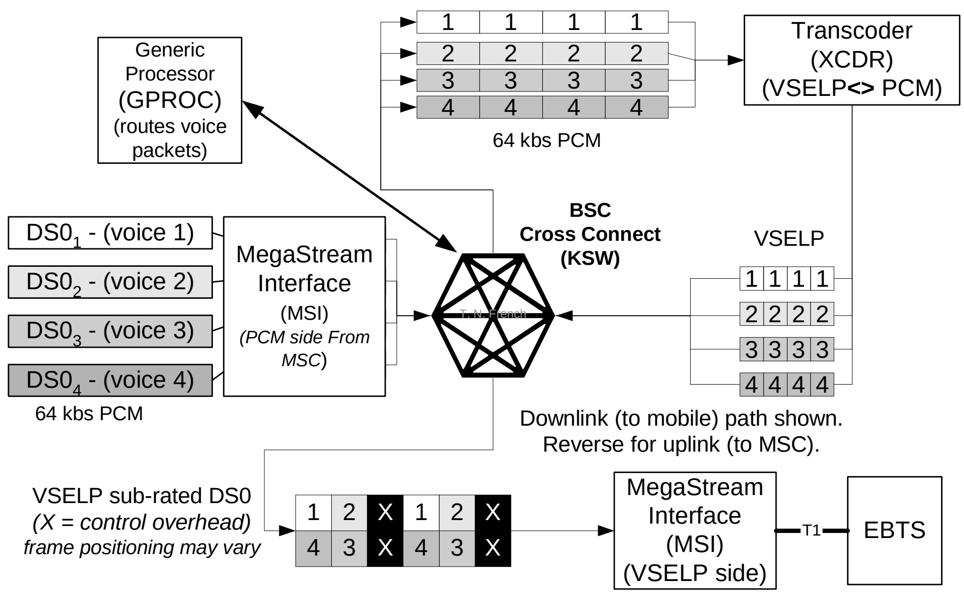
The number of remote cell sites that can be linked to a single BSC will depend on the traffic, location and outgrowth potential of the network. The T1/E1 span lines from the EBTS sites link to a MegaStream Interface (MSI) card in the BSC rack. Since the configuration of the BSC will limit the number of available slots for MSI cards, the number of EBTS sites a BSC can support may vary.

Radio Link Conversion

The conversion of the radio link is handled by the Transcoder (XCDR) or the Enhanced Transcoder (EXCDR). These cards convert between the Vector Sum Excited Linear Predicting (VSELP) compressed signal from the radio link to 64 kbps PCM used on the PSTN.

The PCM voice packets for a call arrive at the XCDR on a single span (DS0). The XCDR converts the packets to radio link packets and applies them to the timeslot scheme used by the EBTSs. Because of the difference in the amount of data between PCM (64 kbs) and the radio link timeslot (VSELP in a 16 kbs timeslot). The timeslots can be shared. Four radio link packets can be applied to a single timeslot with routing and signalling overhead. This sub-rated concentration allows 4 conversations to one DS0 on the T1 line (Figure 2-10).

***Figure 2-10** 4:1 Sub-Rated T1 Concentration*



The number slots available for XCDR cards will vary with configuration.

Data Collection

The BSC also provides limited call processing. The BSC monitors call metrics from the EBTS and uses this data for facilitate the transfer of call routing between EBTS sites during Interconnect calls. The BSC will route calls to the appropriate DACS so it can route the call the appropriate EBTS. This function is handled by the BSC-CP or the BSC - Enhanced Control Processor (BSC-ECP).

Control Information Handling

The BSC also routes data across the X.25 Operations and Maintenance network to the OMC. Alarm and status information for the EBTSs is routed to the OMC for collection and display. Administrative control commands such as cut-overs and loads from the OMC are routed to a EBTS by the BSC. This function is handled by BSC-CP or the BSC-ECP.

Multi-threading

In cases where a a BSC-CP has access to more than one XCDRs, the traffic may be routed two or more XCDRs (XCDR Multi-Threading) to reduce XCDR failure downtime. Multi-threading allows for redundant XCDRs and helps optimize their usage.

BSC Implementation

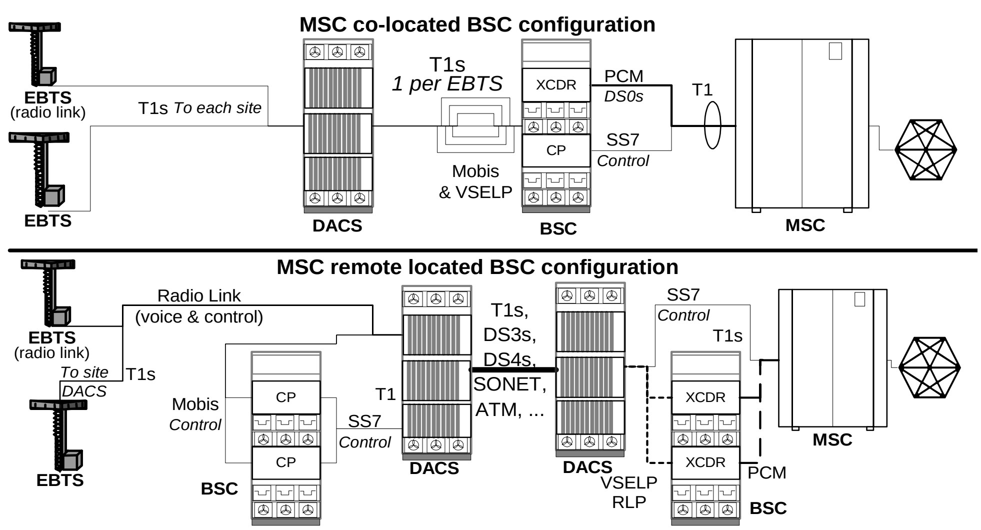
The BSC may be implemented in several ways depending on the network configuration, the mix of legacy systems with new devices, and the location of the hardware that converts the radio link to the network link. The configurations are:

- Non-enhanced
- Enhanced BSC remote located
- Enhanced local located

Non-enhanced BSC Implementation

Slower and more legacy system may use the BSC for both control and transcoding functions in the same cabinet to form an integral BSC/CP/XCDR. This implementation uses one set of hardware to provide all interface, conversion and control functions. In an non-enhanced BSC, all traffic and signalling passes through both the BSC-CP and the BSC-XCDR. The advantage of this method is lower cost and the ability to locate the cabinets remote from the Mobile Switching Office (MSO) and then use larger transport facilities to connect them (Figure 2-11). The disadvantage is limited capacity, redundancy and growth.

Figure 2-11 *BSC Implementations*



Enhanced BSC-XCDR Remote Located

An Enhanced remote located implementation distributes the control, conversion and interface hardware. The BSC-CP may be remotely located amid several EBTSs and handle the processing for those sites. While the BSC-XDCR is located at the central location. This offloads MSO space and allows larger transport facilities in cases were the MSO location is overcrowded. The disadvantages of this implementation are remote maintenance, transport issues and a potential circuit under-utilization.

Enhanced Local Located

An MSO co-located implementation places the BSC-CP/XCDR at the same location as the MSO. XCDRs may still be multi-threaded. Local location centralizes the radio link conversion function at the MSO. This impacts transport facility design because it limits the size of transport facilities to the EBTSs and increases the demand on space at the centralized MSO.

Mobile Switching Center

The Mobile Switching Center (MSC) is a GSM-based Mobile Telephone Switch which provides Interconnect services. The MSC provides the interface between the mobile network and other service provider's PSTNs.

Physical Components

The MSC is a variation of the Nortel DMS switch family. The implementation of this equipment is a coordinated effort between the provider, Motorola and Nortel. The MSC is detailed in the manufacturer's documentation. This equipment may be configured and upgraded according to capacity and outgrowth requirements. The MSC is available in three sizes:

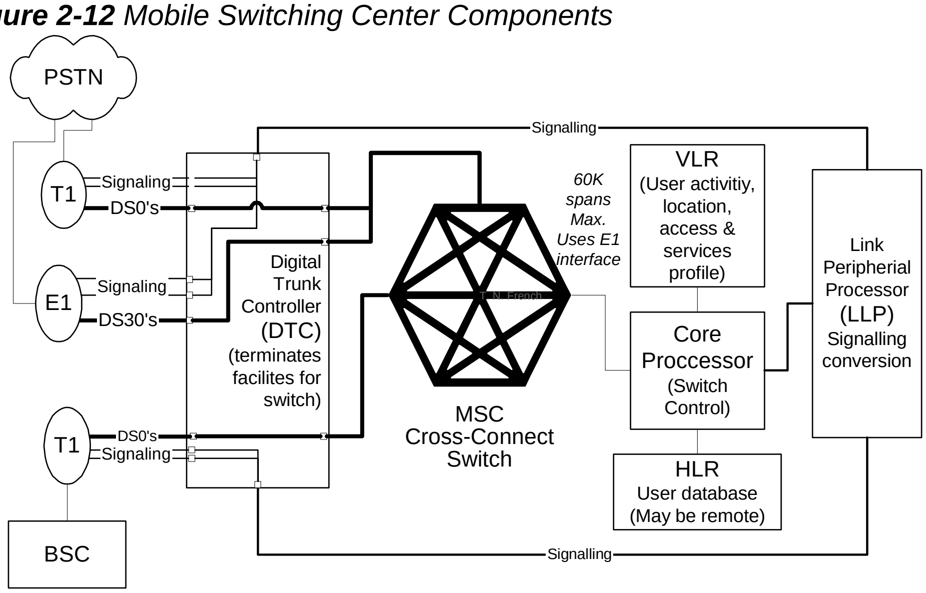
- DMS-MSC Supernode
- SuperNode Size Enhanced (SNSE)
- MicroNode

In general, all versions of the MSC (Figure 2-12) consists of:

- Facilities Interface
- Switch Matrix
- Core Processor
- Signalling Interface
- Home Location Register
- Visited Location Register

Each of these components is discussed individually.

Figure 2-12 *Mobile Switching Center Components*



Facilities Interface

Both iDEN system span line and the PSTN transport facilities (T1 and/or E1) are connected to the MSC through Digital Trunk Controllers (DTCs). The DTC is the interface between the MSC, the iDEN system, and the external world. T1 or E1 telephony connections may be hardwired to the DTC. The Signalling and data span lines of the T1/E1s are split off and connected to the switch matrix for telephony data and the LLP for signal processing. The DTC cards may be one of two types: T1 for North American markets and E1 for International markets.

Specialty markets are also supported with other tailored DTC cards. The MSC provides enough space for the connection of 60,000 simultaneous phone calls (14,000 for the SNSE). The exact number will depend on the market and system configuration as specified by planning and capacity. The DTC is the interface between the external T1/E1 lines, the Core Processor and the Switch Matrix.

Switch Matrix

The Switch Matrix a set of digital cross connections between input and output lines that represents the path to be followed for a particular call setup. The design of the matrix uses E1 style connections. Up to 60,000 lines may be attached to the switch matrix (14,000 for the SNSE). Traffic flow and routing is controlled by the Core.

Core Processor

The Core Processor is an Motorola 8800 series based CPU that interprets signaling from the external PSTN and the iDEN network equipment to identify, authenticate, service and route call signalling and traffic in the MSC.

Signaling Interface

The Link Peripheral Processor (LLP) is the signaling interface of the MSC. All interconnect signaling from the PSTN and the iDEN system passes through the LLP.

Home Location Register

The Home Location Register (HLR) is a database system that is often implemented as a stand-alone device or an outside service that is shared by one of more MSCs.

Visited Location Register

The Visited Location Register is the location and activity database of the MSC.

Functional Characteristics

The MSC is the telephone switch for mobile originated or terminated traffic. Each MSC provides service within a geographic coverage area, and a single iDEN network may contain more than one MSC. Major functions of the MSC are:

- Control and Interface to the PSTN
- Call Processing for Interconnect calls
- Echo Cancellation for Voice Calls (with associated equipment)
- Provisioning of Subscriber Supplementary Services
- Authentication of Subscriber Units
- Intra-System Roaming and/or Handover between BSCs
- Inter-System Roaming and/or Handover between MSCs
- Billing Record Collection
- Interface to a customer supplied billing system
- Control of Inter-Working Function for data networking
- Interface to the Voice Mail System

The MSC controls the Interconnect call setup and routing procedures like a land network end-office. On the land network side, the MSC performs call signaling functions. Other call control functions include:

- Number translations and routing
- Matrix path control
- Allocation of outgoing trunks.
- Collection of Interconnect call billing data
- Format of the call records
- Transfer of call records to the billing center or to tape
- Collection of traffic statistics for performance management

The MSC also helps to administer interconnect handover procedures. The handover procedure preserves call connections as mobiles move from one coverage area to another during an established interconnect call. Handovers within a cell group that is controlled by a single BSC are controlled entirely by that BSC. When handovers are between cells controlled by different BSCs, the handover procedure is coordinated at the MSC. This is discussed in greater detail in Appendix D, Handover.

Home Location Register

During an Interconnect call MSs are validated by the Home Location Register (HLR) database. This database may exist as, part of the MSC, as separate computing system, or a provided service. The identity, billing information, usage limitations and active services for each MS are stored in the HLR. The HLR is the source of information on the service provider's network for the users' service profile (identity and services) that is used to assure the subscriber's services follow the MS throughout the network. The HLR:

- Contains the master database for all subscribers
- Supports multiple MSCs
- Contains the basic and active supplementary services for each subscriber
- Contains the location of the current VLR for each subscriber
- Contains information used by supplementary services
- Supports roaming by being remotely accessible to all MSCs and VLRs
- Provides a Fault Tolerant computer platform
- Support interfaces to a customer supplied Administrative Data Center (ADC)
- Contains the Authentication Center (AUC) with MSs Authentication Keys
- Supports SS7 connectivity to network's Signal Transfer Point (STP) switches

The Administrative Data Center (ADC) is the service provider's administrative and business control equipment. The ADC may be used to enter/provision user information and accepts system metrics and call records.

Visited Location Register

MS units are tracked via fixed geographic Interconnect Location Areas (ILAs). These areas are defined by the system operator based on the coverage area of the EBTS sites. Location data is stored in the VLR. These records contain current information like most recent location area and the feature provisioning table. The VLR is always integrated with the MSC and the VLR accesses the HLR to download subscriber information as MSs move into the VLRs coverage area. The functions include:

- Subscriber database local to the switch for fast access during call set-up
- Contains most of the HLR information about the active MS units
- Contains the most recent location information within the coverage area
- Adds/deletes MSs as units roam into or out of, the coverage areas

Short Message Service

The Short Message Service -Service Center (SMS-SC) will deliver short messages (up to 140 characters) to a full alpha-numeric display MS. The MS can store up to 16 messages. There is additional storage in the SMS-SC database. These sources of a short message can include:

- Operator entry of alpha-numeric messages
- Messages from an online message site
- Numeric messages entered using DTMF overdial from a telephone
- Optional voice mail indications from a connected voice mail system

The SMS-SC delivers the short message to the MS. Messages are sent to the MS when space is available in the MS memory or when a stored message in the MS is cleared. The MS can receive a message when it is either idle or during an interconnect call. A MS active in an dispatch call cannot receive a message. If the MS is unavailable or unable to accept the message, the SMS-SC stores the message for delivery when it becomes available.

The SMS-SC is optional and requires an MSC. Functions of the SMS-SC include:

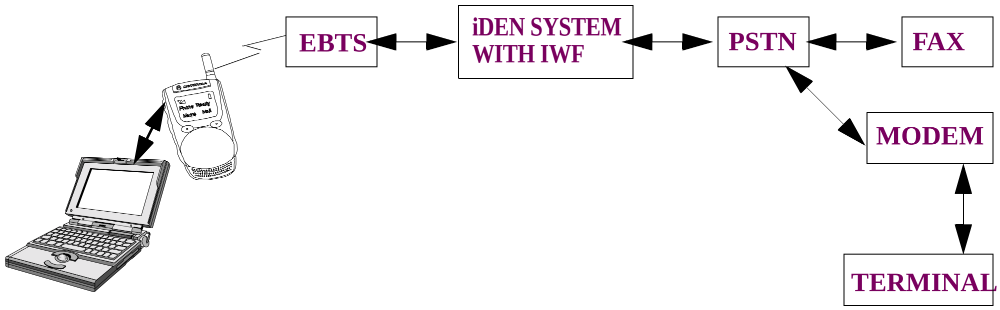
- Short Message Service with message acknowledgment
- Short Message delivery when MS is idle or on a Interconnect Call
- Delivery of messages to subscriber through retries
- Delivery of messages across MSC boundaries for roamers
- Optional link to Voice Mail & E-Mail to send a Message Waiting to an MS
- Entry of messages from operator positions
- Entry of messages from dial up devices utilizing the TAP protocol
- Entry of messages from E-mail systems through an Internet interface

Inter-Working Function

The Inter-Working Function (IWF) performs the data-rate adaptation between the PSTN and the iDEN system. The IWF provides a modem bank that allows data transmitted from data devices on an external the network to access MSs and RF modems. The IWF terminates the PCM digital data format such as Teletype (TTY) facsimile and dial-up networking (Figure 2-13). Functions of the IWF include:

- Circuit switched data services for the MS
- Data connectivity to TTY devices with Bell 103 compatible modem
- Data modem functions to the PSTN
- Group 3 FAX Modem
- Non-transparent Data Services up to 9600 Baud

Figure 2-13 *Interworking Function Non-Transparent Modems Services*



Voice Mail System

The MSC supports Voice mail capabilities. If an incoming call cannot be completed the Voice Mail may be provisioned to allow the caller to leave a brief voice announcement for the called party. Voice Mail allows otherwise interminable calls to be routed to a Voice Mail system.

Voice Mail is a system option. Motorola can act a coordinator to help implement this type of system or, the provider can add this type of system independently.

Operations and Maintenance Center

The Operations and Maintenance Center (OMC) is the network element management subsystem that establishes, maintains, collects information about the network, and presents it to the system operator. This data is used primarily to support the daily operation of the network radio system elements and to provide the system operator with valid information for future planning decisions. As the complexity and control requirements of the iDEN system and its relationship to other systems increases, the need for control and monitoring equipment also increases. The OMC exists in at least one form in every system.

- OMC - Radio (OMC-R) — *required* for radio system management
- OMC - System (OMC-S) — for possible Switching system management
- OMC - Network (OMC-N) — a possible Network Operation Center (NOC)

Others may be implemented as the need arises. Only the OMC-R is discussed.

Physical Components

The OMC-R (Figure 2-14) may exist in different platforms:

- S1000
- OMC 3000
- OMC 3500

S1000

The OMC S1000 is a legacy system used in older and smaller service areas. Advances in technology and aging of the S1000 indicate this system my not have the performance and handling capacity for continued use. The S1000 can support up to 300 EBTS sites and may be networked with other OMCs running a minimum of Software Release 8.0. The S1000 must be a secondary processor in this network configuration. The S1000 is no longer supported with SR 9.1.

OMC 3000

The OMC 3000 is based on the Sun Microsystems E3000[1] processor. This processor has been superseded and support is being phased out. The OMC 3000 can support either 300 or 500 EBTSs. This processor may be upgraded to run Software Release 8.0. The OMC 3000 may be networked with other OMCs with SR 8.0. The OMC 300 may act as a primary OMC in a networked environment with some limitations on performance and long-term support.

OMC 3500

The OMC 3500 is the latest version of the OMC. Based on the Sun Microsystems E3500 processor, it is introduced with Software Release 8.0 because the manufacturer has upgraded system performance and is phasing out support for the OMC 300 platform.The MC 3500 can support:

- up to 500 EBTS sites
- 6 DAPs (6-DAP cluster)
- 8 active MDGs and 1 standby MDG.

The OMC 3500 can effectively act as the primary processor in a OMC network.

Figure 2-14 *OMC 3500 Platform Options*

OMC Networking

OMC-R networking is an enhancement of Software Release 8.0. To reduce the maintenance overhead and improve performance, OMCs may be networked to share configuration, event, and status information. This provides the facility to create and maintain a centralized configuration and mertics set of databases. In a networked environment the primary OMC can maintain configuration, event and status information that can be recovered to secondary OMC should the need arise. The centralized databases make it easier to assure and manage the configuration across a Wide Area Network (WAN). Larger networks may require a primary processor be dedicated to the primary processor function. OMCs of other functions may also be networked as implementation requirements dictate.

The networked environment does not allow remote diagnostic and cutover of network resources that are not directly controlled (MSC and MPS). An OMC in one network does not have control of network equipment associated with another OMC.

1. E3000 and E3500 are registered trademarks of Sun Microsystems

Multiband OMC-R

With Software Release 8.0, an single OMC can mange and control EBTSs in more than one frequency range. If muli-national, a single OMC may be connected to EBTSs that use frequencies in different RF spectrum ranges. Limitations are:

- All EBTS sites must use the same spectrum at one site
- All neighbor list candidates of a site also may the same spectrum.

OMC-R Interconnect

The OMC-R controls and monitors the radio network elements, including the:

- Dispatch Application Processors (DAPs)
- Base Site Controllers (BSCs)
- Enhanced Base Transceiver Systems (EBTS)
- Mobile Data Gateways (MDGs)
- Advanced Packet Duplicators (APDs)

The scope of responsibility for the OMC-R is the Fixed Network Radio Equipment (FNE). The OMC-R does not control:

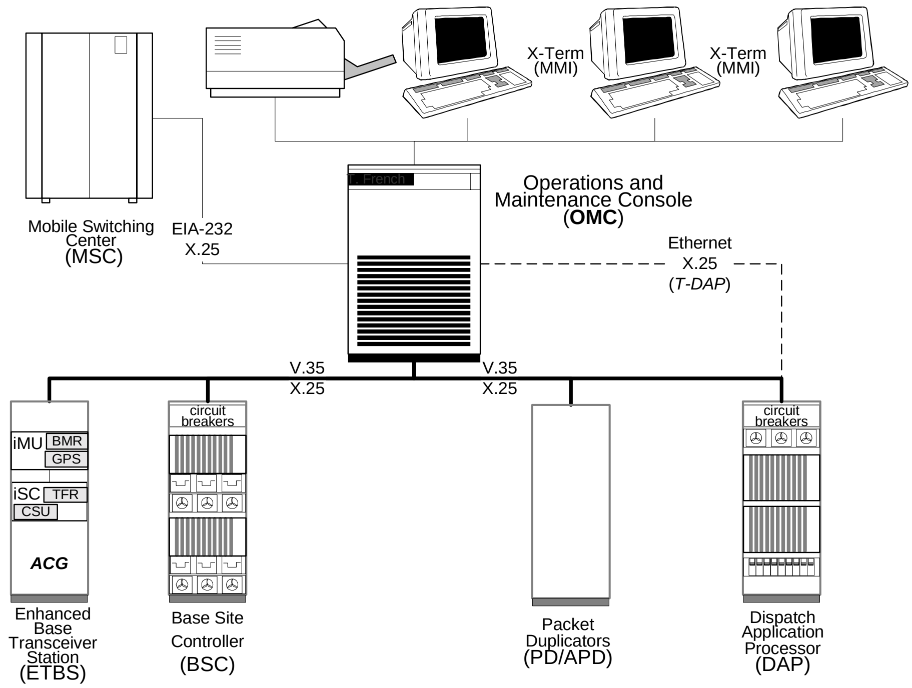
- Mobility Management of the subscriber within the network
- Mobile Switching Center
- Telco Transmission management.
- Inter-region administration and control

Each of the radio network elements can be managed remotely by the OMC. The OMC supports connection to the other network entities through:

- X.25 packet network (BSCs and EBTSs)
- Frame Relay Permanent Virtual Circuits (PVCs) (MDG)
- Ethernet networks (DAP and APD)

The general interconnection of network devices is shown in Figure 2-15

Figure 2-15 *.Operation and Maintenance Console - Radio Interconnections*



Functional Characteristics

Functions the OMC provides include:

- Event/Alarm Management
- Fault Management
- Performance Management
- Configuration Management
- Security Management
- Performance Statistics
- Event Data Repository (event archive)
- View Operations, Administrative & Maintenance (OA&M) of the MSC/HLR
- Limited interaction with the EBTS through SNMP (power level, frequency and software level)

Fault Management

The fault management function of the OMC collects alarms and events from the network. If an alarm or event window is open on the OMC display, these alarms and events are displayed in the order in which they arrive. The OMC provides the required alarm handling functions to report and log alarms generated by the radio network elements. Specific events the agents will report to their managers include:

- Processing
- Equipment and Field Replaceable Unit (FRU) level failure reporting
- Environmental
- Communication
- Quality of service data
- File available
- Test results available
- State change events

Fault management enables the system operator to detect and respond to network element faults within the system. The OMC provides fault management by using Network Management agents that are resident on the various network elements to pass events to the OMC. The events are reported and identified by priority level. The system operators are able to filter the reporting of events based on priority (severity).

For example, if a power amplifier fails on a BR, the BR will send an event message to OMC indicating a failure exists. The system operator can then send a technician.

Alarms and Events are stored on the OMC for future reference. If a higher order management Network Maintenance Computer (NMC), is connected to the OMC through a LAN, the event stream can be directed to the NMC for correlation with other events not reported to the OMC.

Performance Management

The performance management function controls the collection and presentation of metrics to the system operator. These statistics files are stored in a database on the OMC for the creation of reports. There are several generic reports that can be selected for local analysis. The statistics files can be transferred to a higher order manager such as an NMC. Metrics are gathered in four broad categories:

- Call Processing
- System Performance Metrics
- Link Layer Communications Metrics
- Meta-management Metrics.

Call Processing metrics are concerned with the number, duration and quality of calls placed by the end-user for the various types of services available on the network.

System Performance metrics relate to service-oriented status and events such as availability and outage impact.

The Link Layer Communications metrics provide information on the functional operation of the radio links as discussed in Fault Management of this section.

The Meta-management statistics help the system operators control the impact of the management system on the call processing system.

Configuration Management

Configuration Management is monitoring and control of system and subsystem components for state, software release, and components. The system configuration databases of the DAP, EBTS, BSC, MDG and APDs are downloaded from the OMC. These databases change as the physical configuration of the network expands to accommodate growth. This configuration management relates to:

- Software Load Management
- Database Management
- State Management

Software Load Management refers to the distribution and version control of all software objects placed into service in the network. The OMC keeps track of which radio network elements are running which versions of software. Configuration Management provides the command structure to load new software into the various network elements. Software loads can be downloaded from the OMC.

Database Management refers to the creation and distribution of the databases of configurable parameters used to tune performance of the network. There is also a version control requirement for the database objects as well.

The current state of each network element is maintained. The state tells the system operators if the device is, in-service or out-of-service.

Administrative Data Center

Billing and Administration

The Billing and Administration equipment is customer supplied equipment. Business operations are solely the responsibility of the service provider. The iDEN system supplied usage and performance data for business operations and decision support.

Policies, procedures and mechanisms for the exchange of data and administrative and operational control of the information is the responsibility of the service provider.

Dispatch

Usage and call record data for dispatch calls is collected by the DAP. These records are available through tape transfer or through direct network connections.

Packet Data

Time and data bit rates are collected by the Billing Accumulator of the MDG. The usage and performance information may be transferred to the business unit by tape of direct network connections.

Interconnect

The MSC provides all the metrics billing and data collection facilities normally required for production of complete call record data. The MSC also provides industry standard network and interface connections to allow the exchange of data between the MSC and the service provider’s internal data processing infrastructure.

Service Database Provisioning

The ADC may also have the facilities to populate and maintain the iDEN system databases. The databases to be maintained include:

- HLR - for interconnect calling identification and services
- D-HLR - for dispatch calling identification and services
- iHLR - for Packet Data networking identification and services

The Interconnect database, the HLR, may be a centralized system or a provided service from a third party. The provisioning requirements of the HLR is a coordinated effort between the MSC provider, the service provider and any third party that may be involved.

The Dispatch database, D-HLR, and the Packet Data database, the iHLR, are resident on the DAP. The ADC may be also used to provision the subscribers and services for dispatch calling and packet data processing. The Interface between customer supplied equipment and the DAP is discussed in greater detail in *iDEN DAP ADC Manual - SR 7.0/SR 7.1* 68P81130E31.

Chapter 3
Operating Characteristics

This section describes how the individual iDEN® system Network Elements are physically and logically linked together and how the elements interact to perform Dispatch, Interconnect, Circuit Switched and/or Packet Data operations.

Physical Interface

The iDEN system uses several interface types. The transport facilities between the DACS may include microwave, fiber, and/or copper. The iDEN system uses:

- Air Interface
- Coaxial
- V.35
- EIA - 232
- Twisted Pair
- T1/E1

Air Interface

The network link between the mobile (MS) and the Fixed Network Equipment (FNE) is Radio Frequency (RF). This is discussed in greater detail in Radio Link.

Coaxial

Within the system, coaxial cable is the physical interface between the EBTS BRs and the antenna system. Coaxial cable is also used between the BRs and the cell site (EBTS) distribution and control circuitry.

V.35

The OMC-R Operations and Maintenance Link (OML) uses V.35 cabling between the OMC and the DAP. The connection to the BSC may also be V.35 cabling.

EIA-232

The OMC-R, OML also uses EIA-232 cabling to the switched circuits (MSC).

Twisted Pair

Thin-wire (10baseT) Ethernet may be used between the OMC and the T-DAP. A minimum of Category 5 cable and connections is required. Other elements may be optionally networked by Ethernet. With Software Release 8.0 and above OMC-Rs may be networked using an Ethernet link.

T1/E1

The iDEN network has standardized on the T1 as the physical interface. The exchange of information between the various pieces of equipment is over direct link or dedicated facilities using T1 (E1) industry standards. Full or fractional T1s are used. In the MSO, the network devices are interconnected with T1s. Optimization, load balancing and capacity planning will be affected by the physical backbone used.

Network and iDEN equipment is ordered with the appropriate hardware to support either E1 or T1 facility. The equipment may be re-configured between the span types by replacing hardware. Since an E1s have a different configuration than T1s, reconfiguring may impact the capacity of network elements.

Interface Protocols

The iDEN system supports and uses several protocols and interface standards. These include:

- Radio Link Protocol
- Motorola Implementation A-Bis interface
- Signalling System Seven
- X.25
- Ethernet
- Simple Network Management Protocol
- VSLEP
- Frame Relay
- Pulse Code Modulation

Radio Link Protocol

Radio Link Protocol (RLP) is the method of transferring compressed character data between the MS and the MSC-IWF during Circuit Switch data networking.

Motorola Implementation A-bis

Motorola's implementation of GSM A-bis (Mobis) is a modified version of the GSM A-bis interface (GSM 8.08). Mobis provides increased timing and error handling capabilities to provide greater radio link reliability and improved link quality. These modifications include changes in message format and the inclusion of additional parameters for handover messaging. Modifications adapt the A-bis standard to the RF link sideband and help to assure timing and mapping of radio link data packets.

Signalling System Seven

Signalling System Seven (SS7) is the routing and control interface between the other provider networks and the MSC and from the MSC to the BSC-CP. SS7 is used by the MSC-based InterWorking Function, Short Message Service and Voice Mail. Interconnect calls use SS7 at the BSC. SS7 is the Message Transfer Link (MTL) and is implemented in accordance with ANSI SS7-ISUP. CCITT SS7 signaling is used between the MSC and the HLR and; the MSC and the SMS-SC.

X.25

The X.25 protocol is used primarily in the Operation and Maintenance functions of the network. The X.25 link is used by the Operation and Maintenance Link (OML) and its functions between network devices linked to the OMC. The OMC uses X.25 - Link Access Protocol -B-Channel (LAP-B) and Link Access Protocol - Data (LAP-D). The LAP-D protocol is used in signalling as the Message Transport Protocol (MTP) between the EBTS and the BSC. LAP-B is the protocol used between the BSC, the MSC and the OMC. The BSC handles the translation between LAP-D and LAP-B. X.25 functions primarily at 19.2 kbps on V.35 cables (including the DAP). The T-DAP uses an Ethernet link but maintains X.25.

Ethernet

The principle use of Ethernet in the iDEN system is between components in the EBTS. The EBTS uses Ethernet for traffic and control by running Carrier Sense Multiple Access/Collision Detect (CSMA/CD) protocol. Transmission Control Protocol/Internet Protocol (TCP/IP) is supported in the Ethernet environment in accordance with IEEE 802.X. TCP/IP may be used to communicate with the Administration and Data and other service provider equipment. The TDAP - OMC interface is Ethernet running X.25 protocol.

Simple Network Management Protocol

Simple Network Management Protocol (SNMP) is used over the dedicated links between the EBTS and BSC. SNMP is used within the X.25 OML to manage the alarm, messaging, control and performance data routing to the EBTSs.

Vector Sum Excited Linear Predicting

Vector Sum Excited Linear Predicting (VSELP) protocol is a voice compression method used in the mobile station and the XCDR. The MS compresses voice for all transmits and decompresses on voice on all receives. The MPS-DAP cluster controls the movement of VSELP packets between EBTSs during Dispatch calls. The BSC-XCDR converts VSELP to Pulse Code Modulation for interconncet calls.

Frame Relay

The iDEN system supports Frame Relay protocol during Dispatch communications. Depending on how the EBTS is configured for Interconnect and Dispatch, the number of DS0s available will vary. The iDEN system engineering staff provides guidelines to allow service providers to provision the T1/E1s for interconnect and dispatch.

Link Access Protocol-Data (LAP-D) is used between the EBTS and the MPS-DAP-APD cluster.

The Advanced Packet Duplicators (APD) and iSC are linked using Frame Relay - LAP-D on a V.35 link. This is an indirect link through the MPS. The speed is at least 256 kbps from the DAP to the MPS, and is set by the MPS. The T-DAP uses High Speed Serial Interface (HSSI) to interface to the APDs.

Pulse Code Modulation

Pulse Code Modulation is the telephone industry standard for the format and encoding of data packets transmitted across voice networks. PCM is used by iDEN for interconnect calls to land networks. The MSC and the BSC XCDR use PCM for voice and data transmission. The XCDR converts between PCM and VSELP.

Radio Link

Frequency Bands

The iDEN system supports Radio Frequency (RF) communications in International and United States domestic spectrum designations. These bands are regulated by Federal and international agencies. Since the service provider is the licensed point-of-presence on the RF spectrum, the user has the advantages of RF communication without the need for FCC licensing.

Not all frequency ranges for RF communications are supported. Within each supported frequency range, the iDEN system uses the 25 MHz frequency carrier pairs. One carrier is used for transmit, the other for receive. This is summarized in Table 2-1. Some bands cannot be combined.

Table 2-1.IDEN Radio Frequency Bands

Range (in MHz)	***Channel Spacing***	***Carrier pairs (MHz)***	***Link***	***Spacing***	***Offset***
806-821	25 kHz	806-821	Uplink (from MS)	45 MHz	12 KHz
		851-866	Downlink (to MS)		
821-825*	25 kHz	821-825*	Uplink (from MS)	45 MHz	12 KHz
		866-870*	Downlink (to MS)		
896-901	25 kHz	896-901	Uplink (from MS)	39 Mhz	12 KHz
		935-940	Downlink (to MS)		
1453-1465	25 kHz	1453-1465	Uplink (from MS)	48 Mhz	12 KHz
		1501-1513	Downlink (to MS)		
* Requires Software Release 8.0					

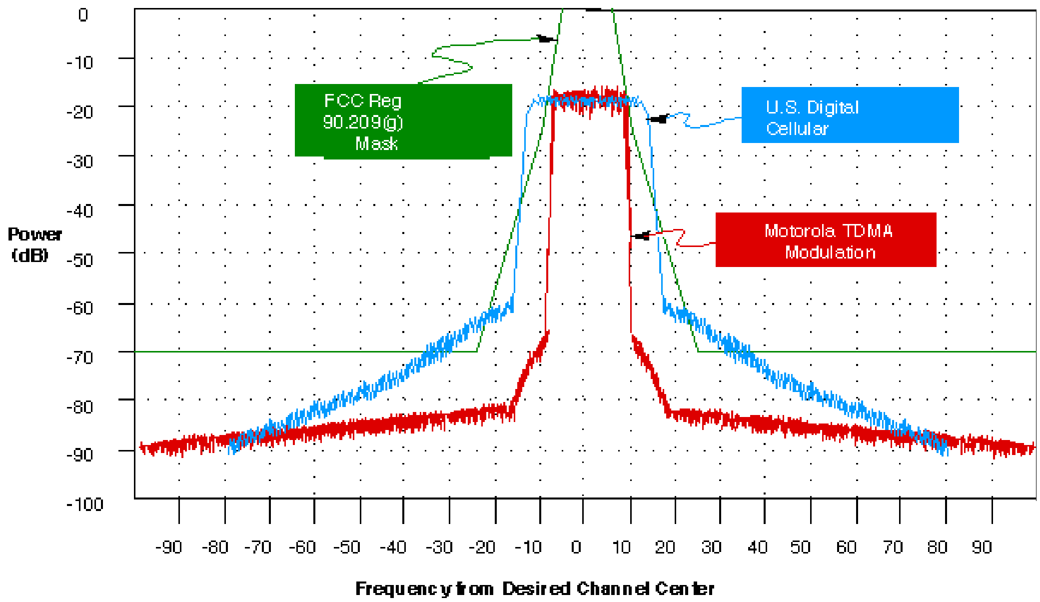
SR 8.0 also allows the use of more than one frequency range in a network. There are specific limitations to multiple range implementation. They are:

- All radios (BRs) in a cell site (EBTS) must have the same frequency range
- All members of neighbor list must have the same frequency range

Radio Carrier Characteristics

Motorola has long been noted for an ability to provide clear and distinct frequency channel definitions. This is accomplished with superior out-of-band rejection and a narrow in-band frequency sensitivity at a precise frequency center. The iDEN system provides high modulation efficiency, carrier sensitivity, optimal Carrier-to-Interference Ratio trade-offs, with low adjacent carrier interference. The carrier fits within the FCC digital emission mask (Figure 3-1). The mean power in either adjacent carrier is greater than 60 dB below the mean output power in the desired carrier. Filtering to prevent cellular interference is also performed.

Figure 3-1 *Radio Carrier Definition showing Motorola Precision*



Signal Processing

The iDEN system uses digital technologies to process and broadcast voice and data communication information. Digital processing provides improved voice and data quality when compared to analog because digital signals provide superior abilities to filter out noise, compress data, and multiplex signals on a single carrier.

Noise filtering improves voice and data quality because the characteristics of non-voice and spurious data signals can be identified and removed with digital filters.

The compression of voice and data streams allows the system to transmit more information in a given timeframe.

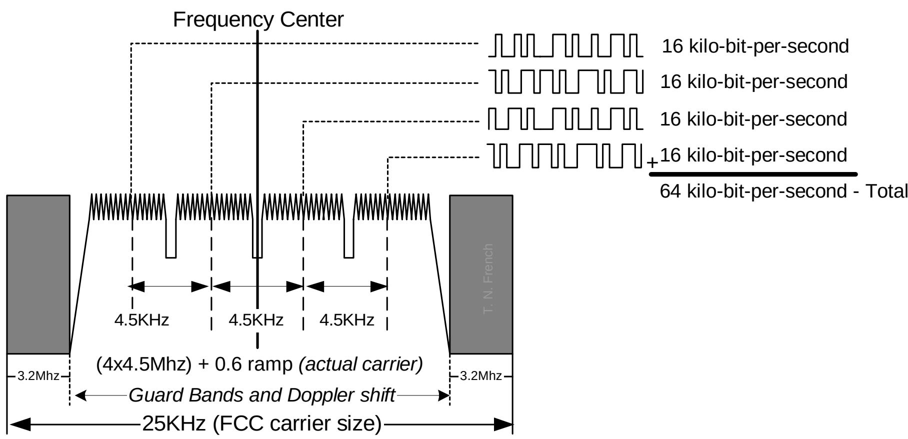
Since data is compressed and digitized, the iDEN system can optimize system resources by sharing the resources.

Carrier Characteristics

The iDEN system does not use the entire 25 Mhz range allocated for each carrier. The iDEN system sub-divides the carrier into four sidebands. This helps reduce interference to the data. Data is transmitted on each of the four sidebands. Using four sidebands allows more data to be transmitted because it increases the data rate.

The iDEN RF signal consists of four independent side bands. The center frequencies of these side bands are 4.5 KHz apart from each other, and they are spaced symmetrically about a suppressed RF carrier frequency (Figure 3-2). Each sideband is a logical 16 kbps data carrier. The resulting signal produces a 64 kilo-bit-per-second (64 kps) gross-radio-channel-bit-rate.

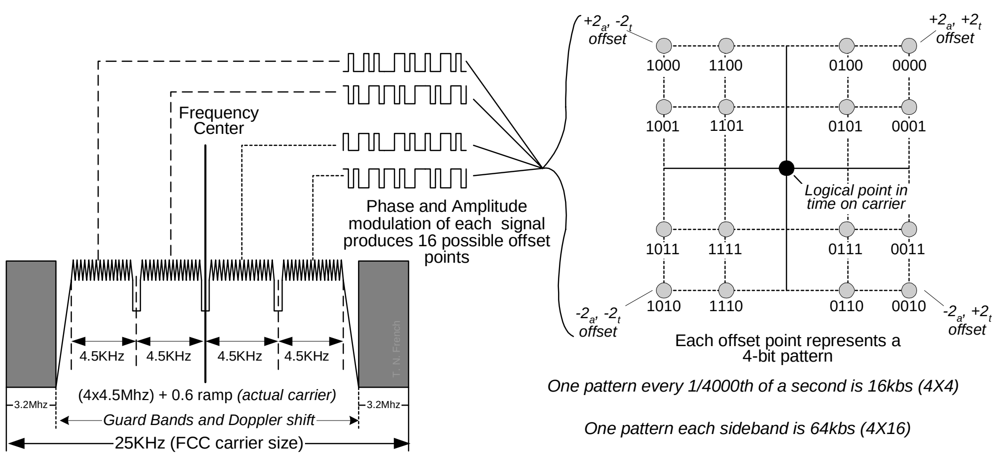
Figure 3-2 *Logical RF Channel Sidebands*



Carrier Modulation

The method used to modulate digital voice and data on the RF carrier is Motorola 16-Quadrature Amplitude Modulation (M16-QAM). This implementation of the data transfer standard uses phase and amplitude modulation to create 16 offset points around the carrier waveform. Each point represents a bit pattern (Figure 3-3).

Figure 3-3 *Quadrature Amplitude Modulation on 4 carrier sidebands*



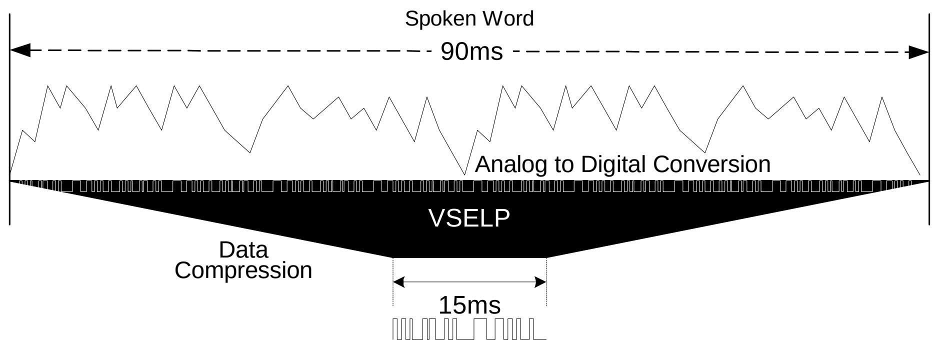
Digital Voice Processing

The iDEN system converts analog voice into digital data for transmission across the radio link of the network. The iDEN system a standard to convert and compress the analog voice into digital data that can be applied to the carrier using M16-QAM.

Voice sounds are converted to digital data by sampling the analog waveform and reducing it to a set of numbers. The analog voice is interpreted by an algorithm that measures and predicts the waveform and converts it to a digital data stream. The 8-bit voice codec (vocoder) used is Vector Sum Excited Linear Predicting (VSELP).

By sampling the voice in small timeslices (milliseconds), summing the vectors (changes in amplitude slope), and predicting changes (gross sum of changes), the voice can be converted to digital with a response time to accurately reproduce speech. The data stream is then compressed before it is applied to the 4 carrier sidebands. This converts and compresses 90 ms of speech into 15 ms of digital data. The resultant data packets are applied to the radio link (Figure 3-4).

Figure 3-4 *iDEN VSELP Voice Compression to 6: 1the Radio Link*



Radio Carrier Access Method

To support and facilitate the use of resources by more than one conversation, the iDEN system divides the radio link data stream by time.

Time Division Multiple Access

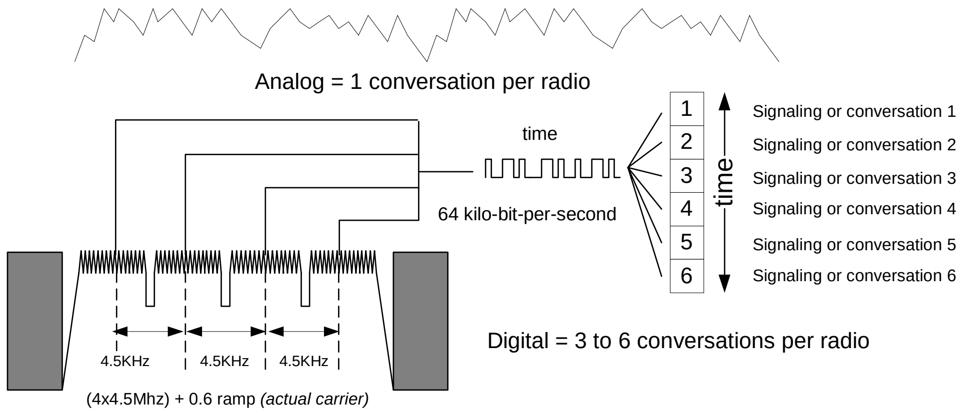
Time Division Multiple Access (TDMA) allows more than one user or device to multiplex on (share) a given carrier. In the iDEN system the radio carrier's digital data stream is divided by time (Figure 3-5). Since the data stream runs much faster than is required during communication, other data or conversations can be placed on a single radio carrier (may be interleaved) without degrading or interfering with each other. This increases the possible conversations per radio from one (analog cellular) to:

- 3 per radio (Interconnect)
- 4 per radio (2-Dispatch and 2-Interconnect)
- 6 per radio (Dispatch only)

This provides several benefits:

- Reduced base station costs as compared to analog transmissions
- Full-duplex support — allowing the MS to switch between transmit and receive.
- No incremental hardware to support dispatch, interconnect, and messages.

Figure 3-5 *TDMA Radio Link timeslots.*



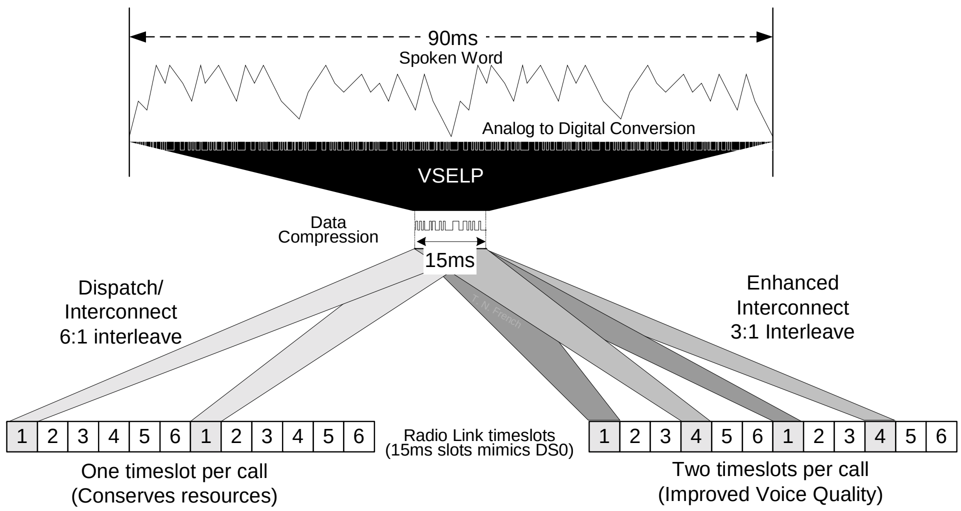
The iDEN TDMA system divides the RF carrier into 6 discrete timeslots of 15 ms in duration. Each of these timeslots is a separate unit that contains; overhead for transmitter turn-on, training & synchronization, propagation delay, or conversation. Auxiliary data imbedded within each slot provides associated signaling. The sharing of the timeslots (interleaving) increases the carriers capacity.

Timeslot 1 on a BR of each sector or cell is designated as a Primary Control Channel. These channels are used for call setup, MS contact and MS location. Secondary Control Channels may be assigned if traffic volume is high enough to saturate the Primary Control Channels.

Timeslot Allocation

A typical iDEN option increases radio link timeslots allocated to a single voice conversation for interconnect calls from 1 to 2 per frame. By doubling the timeslots available, the voice sampling rate can be increased. An increase the voice sample rate results in improved audio quality. The voice bits are transmitted using two timeslots of the 6 timeslot frame. This allows the use of the 8.0 kbs VSELP vocoder, which increases the voice sampling rate to improve tone and richness. The iDEN system also uses forward error correction to reduce corrupted bits in the voice transmissions. This results in improved audio quality even in weak signal and interference areas. This 3:1 interleave is used in interconnect calls.

***Figure 3-6** Voice Packet Interleaving*



Doubling the number of timeslots per call reduces the traffic carrying capacity of the system. The timeslot allocation methods provides flexibility for the operator to balance the requirements for superior audio quality against a reduction in capacity and support for other services. The breakdown on 3:1 interleave voice channels is:

- Embedded signalling = 0.533333 kbps (24 bits per slot)
- FEC = 6.755555 kbps (304 bits per slot)
- Voice = 8 kbps (360 bits per slot)
- Total = 15.28888 kbps

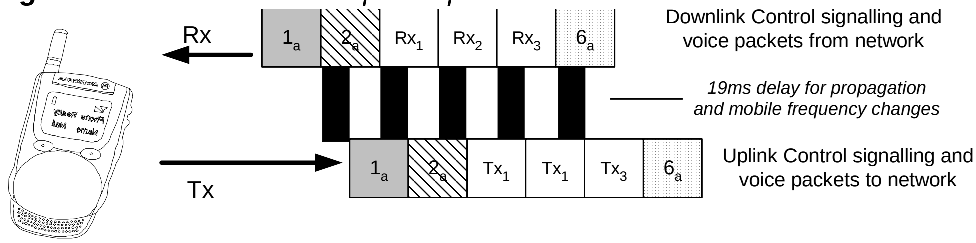
Both 3:1 and 6:1 voice channels use the same transmission unit defined in the Layer 2 RF Interface protocol. The main difference is that 3:1 interleave slots arrive twice as often as 6:1 interleave slots. The method used will affect RF optimization and planning.

Time Division Duplex

To further optimize resources, the discrete timeslots in conversation are divided and offset so transmit (Tx) and receive (Rx) control and voice information can share resources. Both the uplink to the network and the downlink to the mobile can share timelsots during interconnect calls. Interconnect calls use two carriers. The Mobile Transmit and Receive frequencies are separate. With Time Division Duplex the mobile dynamically shifts frequencies to send and receive voice, data and signalling information.

Time Division Duplex (TDD) further reduces network's packet overhead and eliminates the need for RF duplexer on the MS. To reduce errors in propagation delay and allow the mobile to re-tune, the radio link's mobile receive packet is offset ahead of the mobile transmit packet (Figure 3-7).

***Figure 3-7** Time Division Duplex Operation*



Cell Sites

In normal operating conditions, output power of a Base Radio (BR) at a cell site will be limited to the cell's coverage area. The signalling and timing of the system restricts the maximum cell size to approximately 70 miles. The size of a cell coverage area is typically between one and 10 miles. By limiting the range of a radio with its output power, the base radio's frequency may be used in other parts of the network at the distance defined by the re-use pattern. The iDEN system supports both Omi-directional and Sectored cell site configurations in the same system.

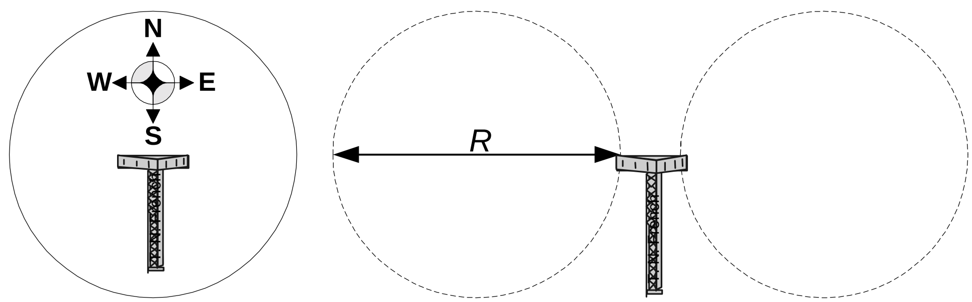
■ **Note**

System design, frequency coordination and planning is primarily a service provider responsibility. Network Element and system capacity may vary based on system design and implementation.

Omni-directional Site

An Omni site uses an antenna system that radiates RF power equally in all directions. In ideal conditions the coverage area would form a circular pattern (Figure 3-8). The Omni cell pattern reduces the number of radio channels (BRs) required but limits the number of calls that the site can handle.

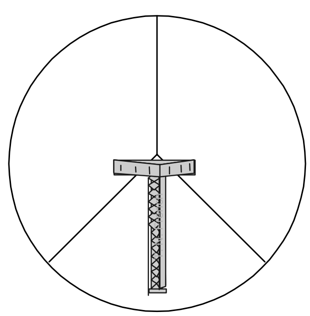
Figure 3-8 *Omni-Directional Site*



Sectored Site

A sectored site uses an antenna system the divides the logical coverage area into areas (usually 3 but maybe 6 or 12). Under ideal conditions a 3-sectored site will produce a circular pattern would be divided into 3 "pie" segments of 120° each (Figure 3-9). This increase the number of channels required to cover a given area but it also increases the traffic capacity and frequency re-use.

Figure 3-9 *3-Sector Site*



Frequency Re-use

The system designer selects the reuse pattern during the design process to address traffic, coverage and frequency requirements.

The iDEN system supports 12-cell/omni re-use pattern or a 7-cell, 3-sector frequency re-use pattern.

System design goals may be specified as a ratio of carrier energy to interference and noise energy. Optimal Dispatch call performance is obtained when the Carrier to Noise plus Interference ratio over 90% of the coverage area is:

$$C/(N+I) \geq 18db$$

For Interconnect calls the ratio over 90% of the coverage area should be:

$$C/(N+I) \geq 20db$$

This ratio is a prime factor in RF design and frequency reuse planning. If there is 1 Base Radio per cell:

- a 12 cell/omni pattern requires 12 channel sets of frequencies
- a 7 cell/3 sector pattern requires 21 channel sets of frequencies.

Frequency distribution maps uses 16 color codes to distinguish between frequency re-use sites. (Refer Appendix A Planning)

The two patterns are graphically depicted in Figure 3-10 and Figure 3-11.

Figure 3-10 *12 Cell Omni Re-use Pattern*

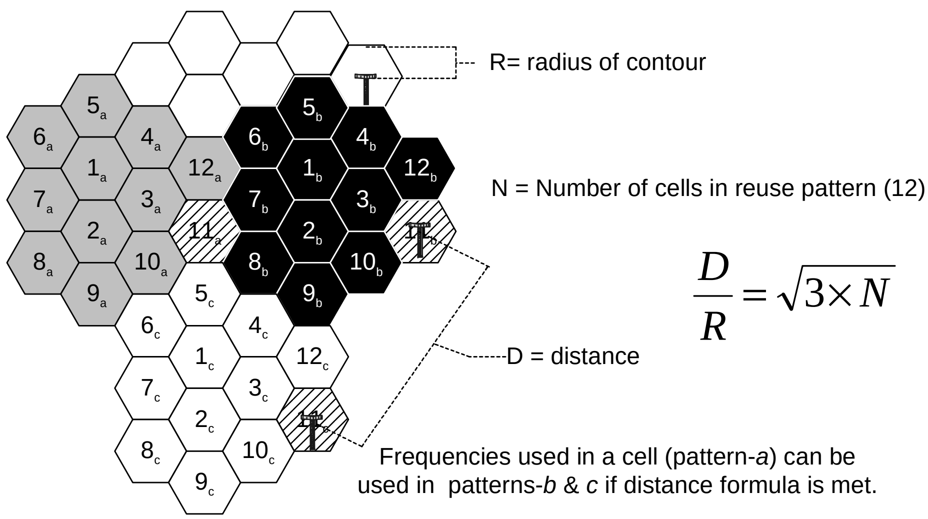
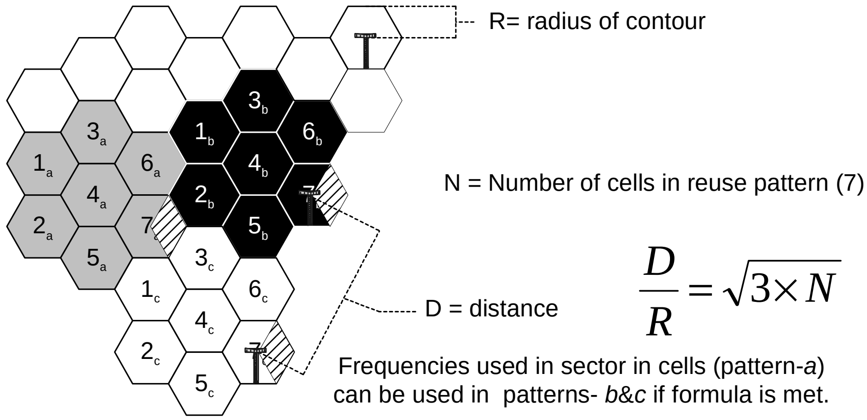


Figure 3-11 *7 Cell 3-Sector Frequency Re-Use Pattern*



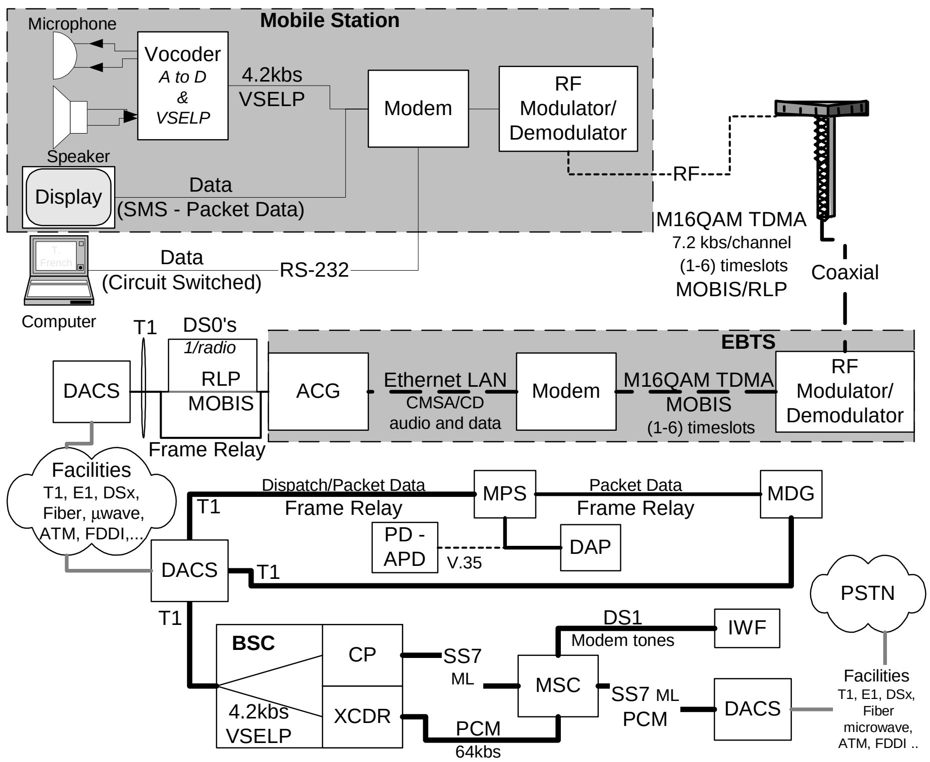
Signaling Scheme

Different protocols are used to complete a call. The process to complete an Interconnect call is more complex than a Dispatch call. The protocols used to complete an Interconnect call are the same as those used for Circuit Switched data networking. Dispatch and Packet Data processing use different paths and protocols.

Figure 3-12 shows the various signaling schemes and protocols encountered when a user places a call or networks from the MS.

Multi-frequency (MF) Inband signaling is used to connect the MSC with other networks. This process requires the MSC seize the PSTN circuits, send dialed information and supervise the call. This process uses ANSI SS7-ISUP if it is supported and available on the other networks (PSTN).

Figure 3-12 *Signal Paths and Protocols*



Over-The-Air Programming

The information needed to define an MSs operating parameters is sent to the MS by the system using the over-the-air, Radio Link Protocol (RLP).

Other optional data (user convenience options) must be programmed by the user or service technician with the MS keypad or with a Radio Service Software (RSS) programmer. The method of programming will depend on the model of the MS. The RSS programmer can also be used to upgrade the MS operating software version or to modify the Control Channel Band Map.

Requirements

The MS units are operational from the factory. An MS does not require programming by the dealer or customer. System access is denied until the service provider can authorize the MS on the system. To identify and authorize the MS, each unit is shipped with:

- a version of code software
- a Control Channel Band Map
- an International Mobile Equipment Identifier (IMEI)
- an Authentication Ki

Each of these are discussed individually.

Software

The mobile operating software is loaded when it is manufactured. Software update and new revision may be loaded to the mobile as they become available with the service providers RSS programmer.

Control Channel Band Map

The Control Channel Band Map is the set of frequencies used as home frequencies. Each provider has a designated set of frequencies that are used to locate and identify the MS within the iDEN system. This Band Map is a lookup table. The mobile scans the frequencies in the band map until an iDEN system is contacted. These frequencies (Primary Control Channels) are used to register, authenticate and track a mobile within the iDEN system. The mobile will always return to this channel set to locate the iDEN system on an error or loss of contact.

International Mobile Equipment Identifier

The International Mobile Equipment Identifier (IMESI) is the mobile’s unique identifier. Analogous to the serial number, each mobile has a unique IMESI.

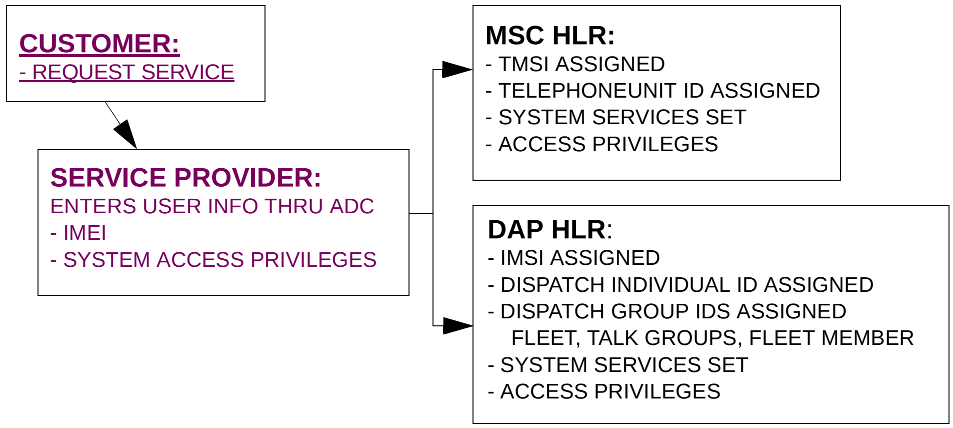
Authentication Key

An authentication Key is a set of algorithms that produce a signature number when provided with a random number. The FNE sends a random number to the mobile. The returned signature is compared with the expected result to confirm the mobile’s identity. This is discussed in greater detail in Authentication in the chapter.

Initial Registration

Before an MS can obtain service, it must be activated and registered in the system. Service activation requires that International Mobile Equipment Identifier (IMEI), basic device parameters and the services definition be entered in the Home Location Register (HLR) on the home MSC and a home DAP. The data entry requirements are shown in Figure 3-13. and discussed in greater detail in Database Subsystems of this section.

Figure 3-13 *Initial MS System Contact*

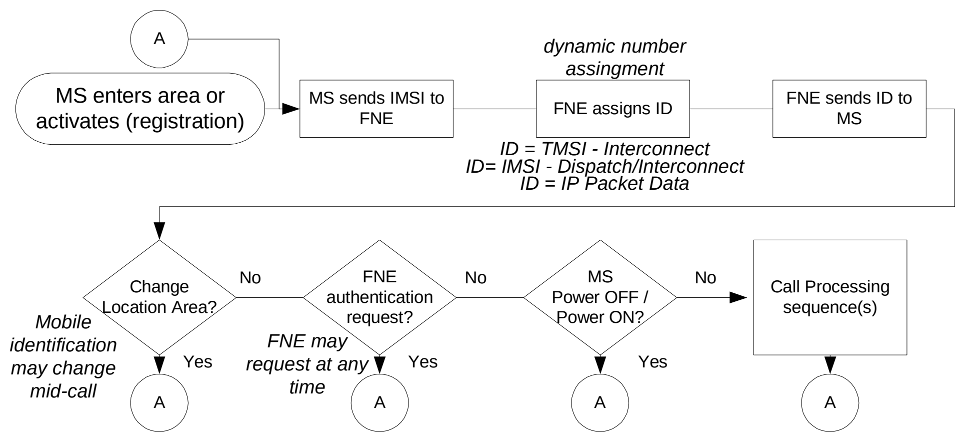


Ongoing Registration

Whenever an MS contacts a system, it will transmit its unique number to the FNE. The ID is sent to the DAP and it searches the D-HLR for the number. If the number is located the services are confirmed (dispatch allowed/conditional allowed). If dispatch calling is allowed, the mobile is dispatch authenticated. If the mobile is OK the D-HLR assigns an internal tracking/billing number (IMSI) and sends it to the MS. The MS will use the IMSI for all further dispatch call requests.

The same process occurs at the HLR for Interconnect permissions. The interconnect HLR is queried for validity and services. The difference is the returned number is a Temporary Mobile System Identifier (TMSI). Packet Data also uses this procedure except a mobile IP address is assigned to the MS by the iHLR (Figure 3-14).

Figure 3-14 *Ongoing Mobile Registration*



Authentication

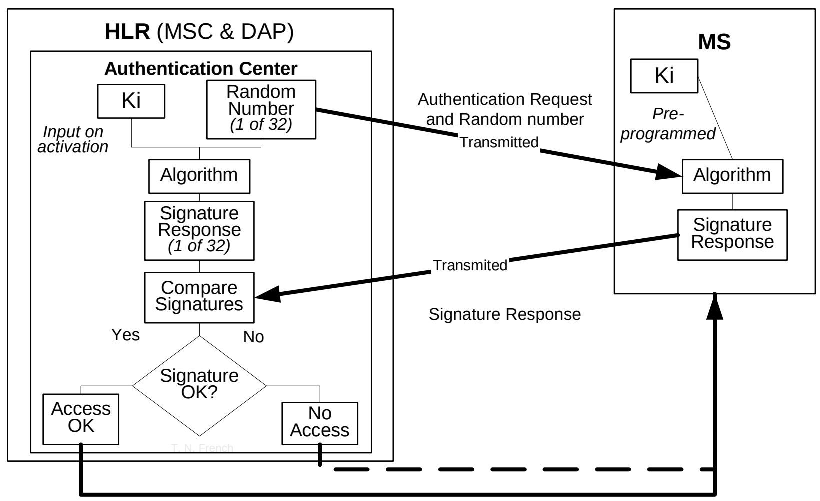
Authentication is the process between the MS and the iDEN system that identifies the MS and permits access to the system and the provisioned services.

MSs are authenticated using a signature number. During initial registration, the MS identifies itself with a IMEI and an authentication algorithm (Ki). The HLRs use the MSs signature algorithm to generate a set of 32 signature numbers from a set of 32 random numbers. Both number sets are transferred to a lookup table in the VLRs. During authentication the mobile sends an ID to the VLRs. The ID is one of:

- International Mobile Equipment Identifier (IMEI) — at initial registration
- International Mobile Subscriber Identifier (IMSI) — ongoing registrations
- Temporary Mobile Subscriber Identifier (TMSI) — for interconnect calls
- Internet Protocol (IP) address — for Packet Data Networking

The VLRs sends one of the random numbers to the mobile. The mobile runs the signature generator and obtains a signature number. The MS returns signature to the VLR where it is compared the expected signature in the lookup table. Services are allowed or denied depending on the results of the comparison (Figure 3-15).

Figure 3-15 *Mobile Station Authentication Process*



When the MS powers up, it attempts to register with the system. During this initial registration, the MS:

1) Sends its IMEI to the iDEN FNE

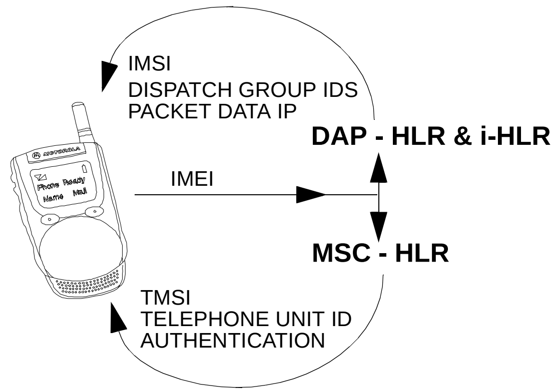
2) Receives an IMSI assigned by the DAP/MSC

3) Receives the essential operating parameters

These parameters are downloaded over-the-air to the MS and allow system access over one of the Primary Control Channels for the provider.

Once the MS has received the system IDs, the IMEI is no longer used as an access ID, until a Master Reset (mobile memory wipe) is performed (Figure 3-16).

Figure 3-16 *Downloading the Operating Parameters*



DataBase Subsystems

Administrative Data Center

The Administrative Data Center (ADC) is customer supplied and may be used to enter user information into the DAP and MSC Home Location Registers (HLRs).

Dispatch Application Processor

Dispatch Call Processing uses data in the DAP to define and control access to the iDEN system and the system services.

DAP Home Location Register

The Dispatch Home Location Register (D-HLR) is a DAP-resident database that stores information about dispatch access rights and features allocated to each MS. The D-HLR performs the Subscriber Access Control. It is queried each time a dispatch call is initiated or call features are requested to manages access to the system and services. The D-HLR database contains Mobile Station ID data and Fixed Network data. Mobile Station ID data includes:

- International Mobile Equipment Identifier (IMEI)
- Billing Number or International Mobile Subscriber Identity (IMSI)
- Dispatch Individual ID
- Dispatch Group IDs
- Dispatch Fleet ID
- Urban ID
- Fleet, Talk Group, Fleet Member

Dispatch Home Location Register Fixed Network data includes:

- Services: Allow/Deny
- Private Call, Group Call, Call Alert, PTT ID
- Optional features (Priority and Emergency)

This data is loaded into the D-HLR database by individual service provider policies and procedures often using the Administrative Data Center (ADC).

DAP Visited Location Register

The DAP - Visited Location Register (D-VLR) is a Random Access Memory (RAM) resident database that contains the most recent location information on each MS. As an MS travels it reports its location to the DAP which updates the D-VLR with the latest data. The D-VLR contains the MS ID, subscriber data and the current status of the MS. The D-VLR is a very fast access database with data about recently active and active MSs. It is a fast look up of authentication and services during Dispatch call processing. The fast lookup helps reduce the call setup delay because the recent list is shorter than the complete list in the D-HLR.

Mobile Switching Center

Interconnect Call Processing uses data in the MSC to define and control access to the iDEN system and the system services.

MSC - Home Location Register

The MSC-Home Location Register (HLR) is where the MSs permanent subscriber Interconnect records are stored. The database may be internal to the MSC (iNode) or it may be a large, remote, shared, system or service. Remote HLR systems are more common because the database processing demands on the MSC may have an adverse affect on call processing.

All MS identities and the various supplementary services are provisioned in the HLR. The HLR performs Subscriber Access Control. It is queried each time an interconnect call is initiated or interconncet call features are requested.

The MSC manages access to the system by verifying requests for service against a database of subscriber privileges. The HLR database also contains Mobile Station Identification data and Fixed Network Data.

The HLR Mobile Station Data includes:

- IMSI
- Temporary Mobile Station Identity (TMSI)
- MS Authentication (Random Number and Signature Number table)
- Telephone Unit ID

The HLR Fixed Network data includes:

- Services: Allow/Deny
- Telephone, Short Message Service, Data
- Telephone Access Privileges
- Local Calls only, Inbound Calls only
    - Supplemental Services: Telephone
    - Call Waiting, Call forwarding, etc.

MSC - Visited Location Register

The MSC - Visited Location Register (VLR) contains the most recent location information on each MS. The MSC VLR is part of the MSC. As an MS travels it reports its location to the MSC which updates the VLR with the latest data. The VLR contains the same MS ID and subscriber specific data that is contained in the HLR. Additionally, the VLR contains the current location and status of the MS.

The VLR is a fast access database storing data about the MS units that are now or have been recently active. It is a fast look up for Interconnect calls permissions and services. The VLR speeds call setup because the entire HLR subscriber database on disk is not searched.

Over the Air Parameters

MS Specific Parameters

The Radio Link contains mobile specific information this link operates according to the RLP and Mobis protocols. Information about the MS that is transmitted includes:

- International Mobile Subscriber Identity (IMSI)
- Authentication Ki
- Temporary Mobile Station Identifier (TMSI)

International Mobile Subscriber Identity

The IMSI is a unique ID downloaded by the home system to the MS at initialization that is specific to the MS The IMSI is commonly used as a billing number.

Authentication Ki

The authentication key (Ki) is an identification of the algorithm the MS uses to create signature numbers from random numbers.

Random Number

The Random Number is part of the table used to authenticate the MS. This is discussed in greater detail in Authentication previously in this chapter.

Signature Number

The Signature Number is part of the table used to authenticate the MS. This is discussed in greater detail in Authentication previously in this chapter.

Temporary Mobile Station Identifier

The TMSI is a dynamic interconnect call processing, temporary ID that is used to identify an MS while it is active. This parameter minimizes broadcasting the more critical IMSI over the air. The IMSI is only transmitted when the MS initially roams onto a system and registers. The system assigns a TMSI for the MS immediately that is used to identify the MS until it roams out of the system. A new TMSI is assigned to the MS each time it changes its location area with the VLR.

Dispatch Identifiers

Several parameters are unique to dispatch call processing. The parameters used to define access and services are:

- Urban ID
- Fleet ID
- Group ID
- Fleet Member ID

Urban ID

The Urban Identifier applies to Software Release 8.0 and above. This ID is used to define the home region (market) of the MS. Motorola assigns Urban ID to markets and regions. Introduction of this ID allows an MS to roam outside the home region and maintain a unique identifier that may be used to control service and permit inter-region and cross-fleet dispatch calling (Horizontal Dispatch).

Fleet ID

A Fleet ID is a number that is assigned by the service provider to distinguish major subscribers (corporate or municipal entities). This defines the largest functional unit of a dispatch call. Individual users are members of fleets. With SR 8.0 the fleet ID may be re-used in different Urban ID areas (regions).

Talk Group ID

A Talk Group ID (Group ID) is a provider defined number that defines a functional subset of a fleet. The type and number of groups in a fleet will vary with the organization and requirements of each fleet. Each group has a dispatcher (user 0) that is assigned as a logical control point for all dispatch communication.

Fleet Member ID

A Fleet Member ID (Member ID) is a number assigned by the provider to uniquely designate an MS. The ID is used to indicate a specific MS during dispatch calls, such as the originator or target MS during a Private Call. It is also used to indicate the specific MS transmitting in the PTT-ID service. Ultimately access and service are designated by Fleet Member ID.

Site Specific Parameters

Each EBTS on the iDEN system has unique identifiers to coordinate the activity and maintain the integrity of the Radio Link. A list of Site specific parameter values is transmitted on the BCCH by each iDEN cell to MSs on that cell. These values are read and used by each MS as it executes its link control procedures (Chapter D, Handover).

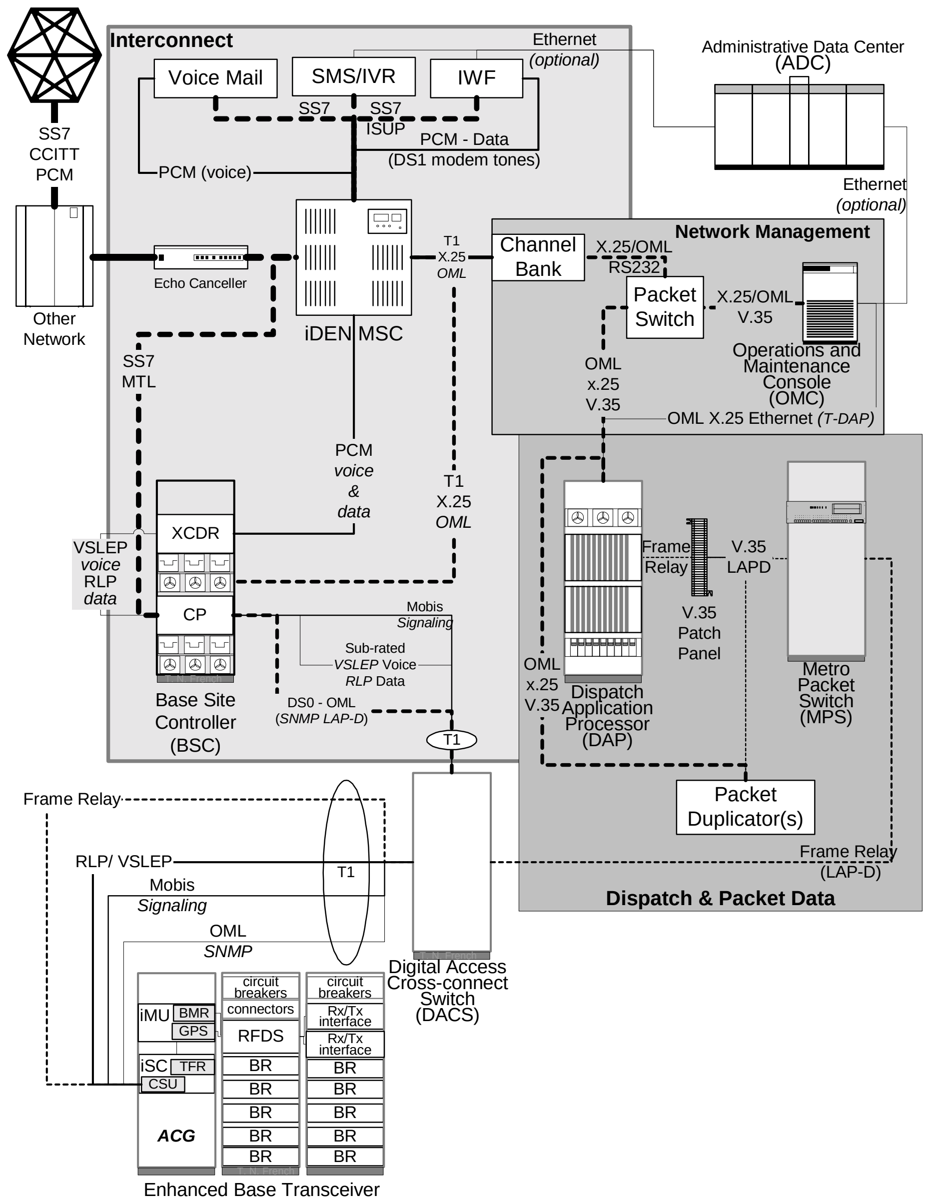
Network Paths

There are four logical subscriber paths.

- Dispatch calls
- Data Packet within and across networks
- Interconnect calls with other provider networks
- Circuit Switched Data using the IWF in the MSC

Figure 3-17 presents a simplified view of the network paths and protocols.

Figure 3-17 *Simplified Dispatch and Interconnect Traffic Paths*



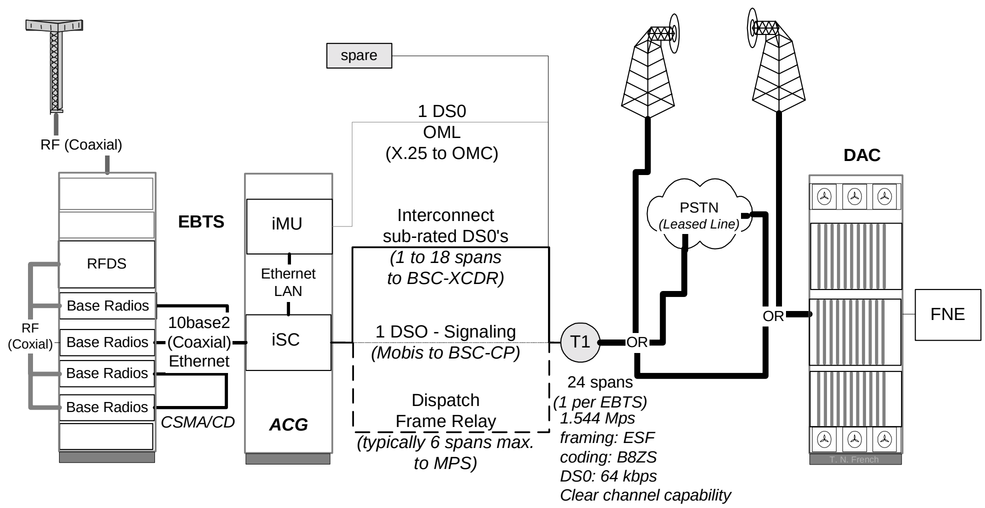
The diagram also illustrates the various protocols used throughout the network. As shown in the diagram, the control and processing of different services is segregated into different network entities. Services are implemented by single operational units or in conjunction with other network elements (DAP and MSC).

- Dispatch calls are routed between EBTSs by the DAP
- Packet Data is routed by the DAP through the MDG to the internet
- Interconnect calls are controlled by the MSC using the VLR and HLR.
- Circuit Data is controlled by the MSC with the aid of the IWF.
- Short Message Service (SMS) is controlled at the MSC using the HLR
- Fixed Network Elements are monitored and administered by the OMC

Enhanced Base Transceiver System

The EBTS functionally converts the Radio Link to land-based protocols depending on the call. Interconnect calls use a T1 DS0 structure. Dispatch calls use Frame Relay. The physical connection is summarized in (Figure 3-18).

Figure 3-18 *EBTS Pathways*



Connection between the Base Radios and the antenna system is coaxial cable sized and rated according to the output power of all the radios attached to the antennas. This carries M16-QAM modulated VSELP/RLP traffic.

Connection between the Base Radios and the ACG is also coaxial but is sized and rated for Carrier Sensing Multiple Access /Collision Detect (CSMA/CD) Ethernet. This link carries VSELP/RLP Traffic, Operation and Maintenance Link (OML-SNMP), Mobis signaling Packet Data and Circuit Data.

The connection between the EBTS and the FNE is over a direct link, microwave or dedicated lines of another carrier. The multiple protocols for different services are applied onto that single T1. A typical T1 setup uses:

- 1 DS0 with iSC/ACG Operations Signaling & Control (Mobis)
- 1 or more DS0s with 16 kbps Subrated Compressed (Circuit Data)
- 1 or more DS0s for Frame Relay (Dispatch and Packet Data)
- 1 DS0 for the Operations and Maintenance Link (OML SNMP)

Dispatch Application Processor

The DAPs are the dispatch call managers/router(s) in the network. Because of the switch functions of the DAP, it has several interface types (Figure 3-19). The DAPs connection to:

- EBTS-iSC using Frame Relay - LAP-D on V.35. This is an indirect link through the MPS. The speed is at least 256 kbps from the DAP to the MPS, and is set by the MPS. The Tandem DAP uses High Speed Serial Interface (HSSI) to interface to the APDs
- OMC using X.25 - LAP-B / V.35. This is a 19.2 kbps direct link. However, the newer Tandem DAP (TDAP) interface to the OMC is Ethernet.
- ADC using asynchronous RS-232. The subscriber information connection is either an Ethernet link or a modem dial-up at 9.6 kbps

Metro Packet Switch

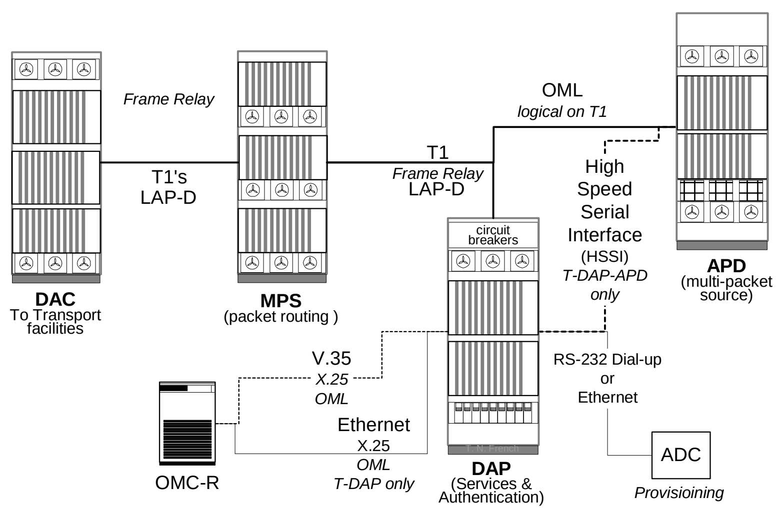
The MPS performs the cross connect functions under DAP control. The MPS connects to the EBTSs over transport facilities. Connections between the DACS and the MPS are T1. The MPS has no OMC-R link. Control and routing from the DAP is exchanged over T1/E1 links using Frame Relay (Figure 3-19).

Packet Duplicators

APDs use a High Speed Serial Interface (HSSI) to communicate with the Tandem version of the DAP.

The Operations and Maintenance Link (OML) for the PDs is by Frame relay on a T1 to the MPS and then using X.25 on V.35 cabling to the DAP. The OML with the Tandem version of the DAP and APD is Ethernet running X.25.

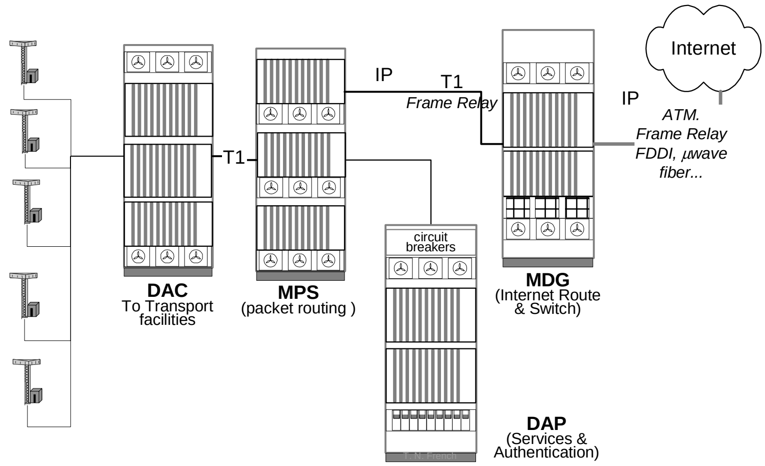
***Figure 3-19** Dispatch Interface Paths*



Mobile Data Gateway

The MDG is an enterprise switching router. Ports are provided allow for T1 attachments to the MPS/DAP and for the attachment of transport facilities of other carriers to the Internet (Figure 3-20).

Figure 3-20 *MDG Pathways*



Base Site Controller

The BSCs have interfaces to the iDEN RF environment and the telephone interconnect environment. This requires different traffic, signaling and maintenance paths. They are:

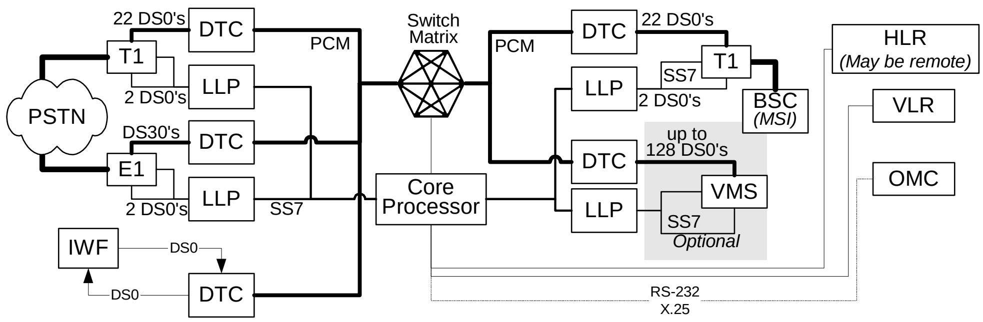
- SS7 signaling between the BSCs and the MSC
- PCM traffic pathways between the BSCs and the MSC
- VSELP/RLP traffic pathways between the BSCs and the EBTSs
- Mobis signaling pathways between the BSC and the EBTSs
- Operations and Maintenance pathways (BSC-OMC-R and EBTS-OMC-R)

Mobile Switching Center

The MSC is a dynamic and flexible device within the network. It will vary greatly between provider requirements and market-based installations. A typical MSC will have several traffic and data pathways:

- SS7 to the global telephone environment, attached hardware and the BSC
- PCM traffic pathways between the MSC and attached hardware and the BSC
- EIA-232, X.25 pathway to the OMC-R

Figure 3-21 *MSC Interconnection Paths*



Operations and Maintenance Center

The OMC-R is the center of a X.25 network. The interface used will vary with the aging of the system and the devices being monitored and controlled.

Chapter 4
Dispatch Call Processing

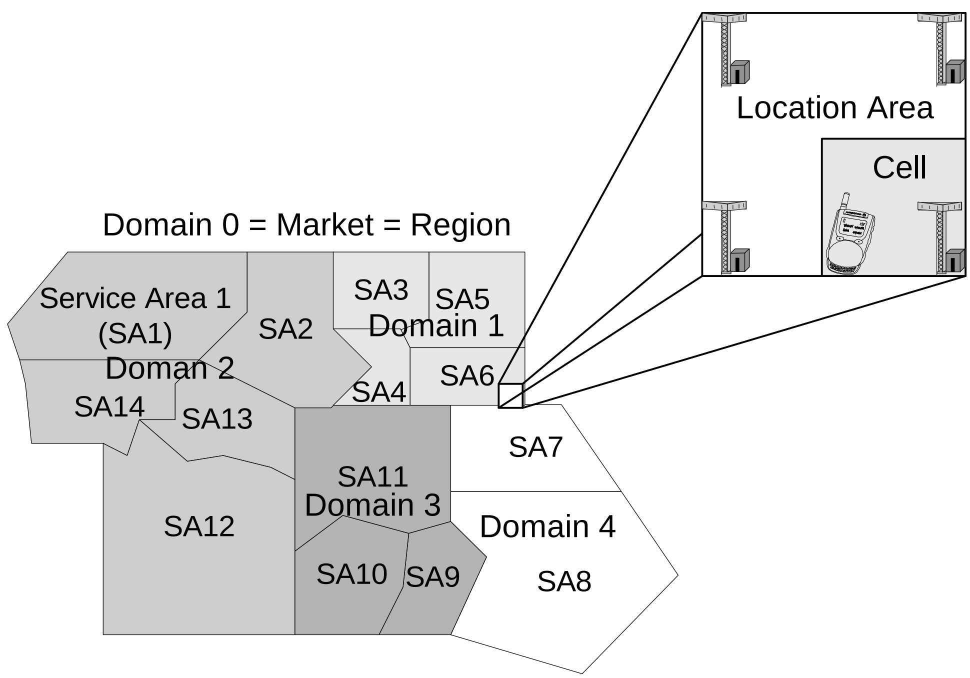
Dispatch calls are voice communications that use the half-duplex Push-To-Talk (PTT) form of communication. This type of call does not use other provider networks except as transport facilities. These calls may cross service areas if the DAPs of both service areas are networked together and have shared processing (provisioning and roaming agreements). Some iDEN systems are implemented as dispatch-only. As dispatch-only, the interconnect portion of the system is not installed and cannot be used. This chapter describes the fundamentals of the Dispatch Call Processing. Further information is available in *MSO Dispatch Sub-System* 68P80800H45 and *MSO Dispatch Planning and Expansion* 68P80800H85.

General Dispatch Calling

To support the logical Global, Fleet, Group and Member calls. Dispatch calling uses most of the levels of the communications model. The model has different levels (Figure 4-1). These areas are based on geographical areas. The areas are:

- Region
- Domain
- Service Area
- Location Area
- Cell

Figure 4-1 *Logical Organization of Dispatch Locators*



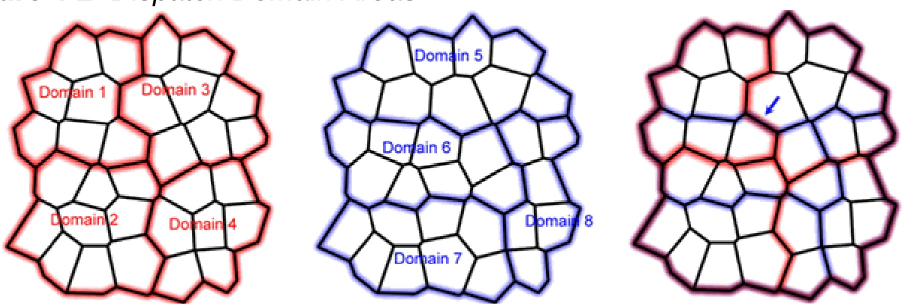
Region

A Dispatch region is a large geographic area that is usually associated with more than one market or, more than one urban area. Just as urban areas tend to be adjacent and overlap, so do service provider coverage areas. A Dispatch region is serviced by a single provider. If a service provider has adjacent or overlapping markets they may be linked to provide contiguous service across urban areas.

Domain

A Dispatch domain is an optional division of a system and/or region (Figure 4-2) and consists of one of more service areas. A domain may be used to divide a region into operating areas. These areas define the dispatch operational area based on a DAP (Fleets). The domain are defined in provisioning. In dispatch calling this generally limits the range and mobility of a fleet's subscriber mobiles. With a 6-DAP cluster, up to 50 domains may be defined. Domain 0 is the entire system. Domains may contain up to 254 service areas but are usually designed using a smaller number of smaller service areas. A fleet may be provisioned to allow coverage in a specific domain.

Figure 4-2 *Dispatch Domain Areas*



Service Areas define Domains

Domains may use different Service Areas

Common boundries (arrow) should be avoided

Service Area

A service area consists of 1 or more location areas. Service areas are service provider defined areas. When placing a group call, an end-user may:

- Call to the same service area only
- Call to a selected service area
- Call to all service areas

Multiple service area provide opportunities of the service provider to structure billing along coverage areas.

A service area is logically defined in the system provisioning and includes location areas that can be accessed during private and group calls as described in Dispatch Call Types. Multiple Service Areas can be defined. Service Areas can overlap. The Fleet's MS can Dispatch call with the defined service area. Outside the defined service area, Interconnect calling must be used.

Dispatch Location Area

A Dispatch Location Area (DLA) is logical area that consists of one or more EBTS sites. Each mobile on the iDEN system has a location area identifier (LAI).

The DLA on a single DAP

The interconnect and dispatch location areas may be different. A Dispatch Location Area is generally more specific (services fewer cells) than an Interconnect Location Area.

Cell

A site has a RF propagation pattern that will define the effective size of a cell. An EBTS may be either omni-directional or sectored. A user MS is located by radio link integrity between 1 or more cells. How the MS is located between sites is discussed in greater detail in Appendix D, Handover.

Functions

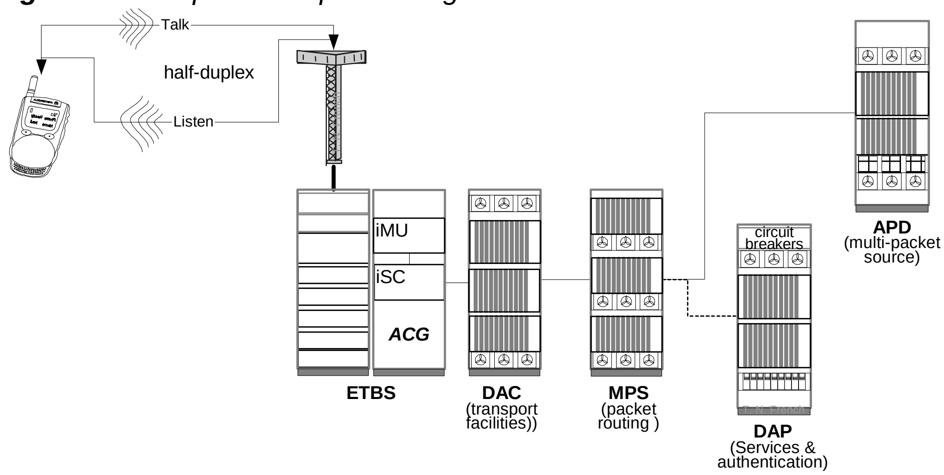
Dispatch Only Service

Because dispatch calls exist entirely within the iDEN system, the services, configuration and administration of individual MSs on the system can be tightly controlled. If desired, a MS on the network may be excluded from using the PSTN networks. Conversely, a MS may be restricted from making dispatch calls. Both of these options are defined by service provisioning in the D-HLR and HLR.

General

Figure 4-3 represents a simplified diagram of the iDEN system elements involved in Dispatch services. The MS sends, receives voice and displays data. The EBTS converts the radio link to the land network link and discriminates between Dispatch, Packet Data and Interconnect calls. The MPS routes dispatch call voice packets and packet data packets. The DAP determines service availability and location information. The APD duplicates voice packet that need to be sent to multiple MSs in group calling.

Figure 4-3 *Simplified Dispatch Diagram*



The control and monitoring steps to complete a dispatch call are internal to the iDEN system. Aside from dialing, sending and receiving, the steps to complete the call are user transparent. There three major steps in a typical dispatch call:

- Establish Radio Link
- Route digital voice packets
- Duplicate packets for group calls

Establish Radio Link

The radio link is the on-air connection. The radio link is a coordinated effort between the MS, the EBTS, MPS and the DAP. The EBTS/DAC/MPS complex routes the call setup information to the DAP. The DAP queries the D-HLR and D-VLR to determine service access, authentication, and service availability. The EBTS establishes and maintains the radio link on the RF control channels. If the MSs location indicates another EBTS has better radio link quality, the mobile re-connects to the EBTSs without handover control overhead. The MS re-selects and connects dynamically as required.

Route Digital Voice Packets

Once the radio link is established, the EBTS discriminates between a Interconnect call and a Dispatch call. The DAC will cross-connect dispatch voice packets to the MPS. The MPS coordinates the movement of packets between the EBTSs and the DAPs. The MPS re-routes calls to another EBTS if the MS reconnects. If more than one called MS is involved (group call) the MPS routes the voice packet to the DAP and Packet Duplicator to be copied. The copied packets are routed to the appropriate EBTS as determined by the call type.

Packet Duplication

For Dispatch group calls the VSELP voice packets are routed to the Packet Duplicator where they are copied and applied to the appropriated link by the MPS. The DAP controls call routing and coordinates the services. The MPS handles the timing and routing of the voice packets.

System Identifiers

The iDEN system allows several dispatch call types. To uniquely identify an MS on the iDEN system several logical IDs are used. This information is maintained in the dispatch provisioning databases on the DAP.

In dispatch calling the identification, call processing, tracking, and selection of services requires logical tags to identify iDEN system users.

Urban Identifier

Software Release 8.0 introduces the concept of urban areas. Motorola assigns Urban IDs to a urban area.

The Urban ID increases the number of fleets available globally and provides a mechanism to establish fleet-to-fleet dispatch calls.

This information is maintained in the Dispatch Home Location Register (D-HLR) and Visited Location Register (D-VLR).

Fleet Identifier

A Fleet ID is a logical designation of a corporate or municipal entity that usually receives the billing. A fleet consists of groups and users (members). As a business-oriented communication service, the iDEN system bases the dispatch calling on the fleet basis. One user in each fleet is designated as a dispatcher (user 0).

Group Identifier

A Group Identifier is used to subdivide fleets into logical units. One fleet member is always the dispatcher (User 0) and is a member of all groups. Other users in the fleet are assigned to groups based on organization, function, task or some other fleet related method. The type and number of groups within a fleet are fleet specific.

The service provider may configure each MS in the fleet with specific operating limits so a user will hear only the conversations and announcements that relate to the members of the same group.

An MS may be part of more the one talk group. An end-user may change the default talk group as required if the service provider allows this in provisioning and the MS can support it. An MS cannot be in more than one group at the same time.

Multiple Simultaneous Talk-group

The Multiple Simultaneous Talk-group (MST) is an optional feature associated with MSs with advanced feature. An Advanced Feature Unit (AFU) MS and the Advanced Feature software are required to support MST.

MST allows an MS to be part of up to four groups in the same fleet. This allows a user to monitor and participate with groups other than the MS' currently registered group. The MS can use a mode switch to change its current (selected) group. One group is Selected and the others (up to 3) groups are Associated. There can only be one Selected group per mode switch setting. Associated talkgroups for all modes can also be toggled On/Off.

Fleet Member Identifier

Each end-user (MS) capable of dispatch calling has a unique Fleet Member ID. This ID is specific to the fleet and may be re-used in different fleets. Dispatch services, limitations and provisioning, are specified by Fleet ID, Group ID and Fleet Member ID. The Fleet member ID is logically the same as the suffix used for in land line communications.

The Fleet Member Identifier is used to indicate the caller and called MSs private dispatch calls and to indicate the transmitter in the PTT-ID service in group dispatch calls. The numbering within a fleet need not be contiguous, so removing a MS will not require the others to be renumbered.

Dispatch Call Procedure

The simplified steps of a typical dispatch call are:

1) A dispatch call is requested via PTT activation.

The call request packet is routed to the DAP.

The DAP recognizes the MSs group and finds the group members by location area (DLA).

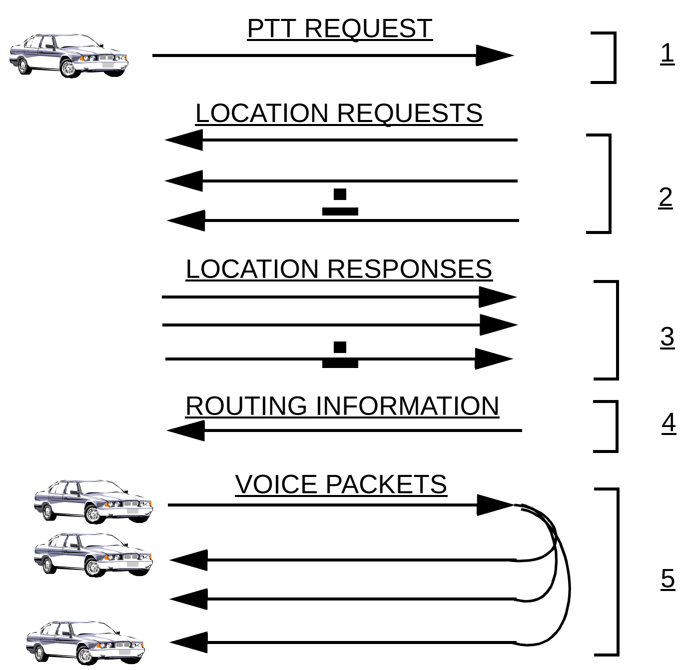
2) The DAP sends location requests to the member's DLA to obtain current sector or cell.

3) The group member MSs respond with each's current sector or cell location.

4) The DAP supplies each member's routing information to the MPS and PD.

5) Call voice packets are sent to the PD, where they are replicated and distributed to the MSs sites.

Figure 4-4 *Typical Dispatch Call Summary*



Capacity Enhancements

One of the limiting factors to the capacity in a large sector/cell is control channel traffic and the ability of the Primary Control Channel (PCCH) to handle system messages. When the capacity of a site is increased, the number of messages per control channel may become high enough to require additional control channels. The use of a Secondary Control Channel solves this problem by allowing one or more RF link timeslots to be assigned as Secondary Control Channels. Secondary Control Channels are configured on a per-cell basis.

Dispatch Call Types

The iDEN system supports the several Dispatch Call types, some of which are optional and require the purchase of additional hardware and software. They are:

- Private Call - Individual dispatch call between 2 users
- Talkgroup Call - Subfleet dispatch call across 1 or more sites and include:
  Local Area
  Wide Area
  Selected Service Area
- Call Alert - Alert message sent from 1 user to another
- Emergency Call - A high priority subfleet dispatch call across 1 or more sites
- MS Status - Alert message with additional field sent from 1 user to another

Dispatch Private Call

A Private Call is similar to a one-to-one call. One user enters another user's designation (Fleet Member ID) and the call connection is one-way and exclusive. Other members of the fleet and group are not involved in the conversation.

A private dispatch call was limited to another member of the same fleet in the same region. There are specific limitations to cross-fleet calling. These limitations are discussed in greater detail in Dispatch Provisioning of this chapter.

The caller enters the called MSs Fleet Member ID and presses the talk button on the MS to hail the iDEN system. The hail sends a request for service over the radio link control channel to the EBTS then to the DAP.

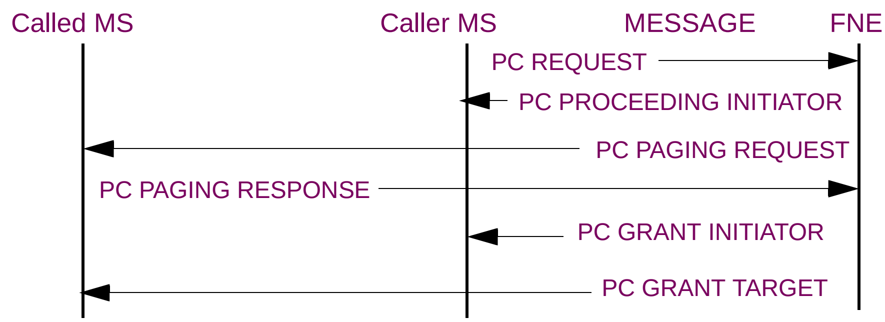
During call setup, the DAP validates the MS (caller), the request, and the target (authentication). After validation, the DAP sends a location request to the called MS unit. If resources are not available to either the caller or called MS, the call is queued.

If resources are available and the called party is available, a call establishment indicates to the originator that the called party has been located and is ready for the call.

The called MS activates the audio. The caller's Fleet Member ID is sent to the called MS during the set-up process for display on the called user's MS or for returning another call. The called MS may display the caller's alias if it has the feature and is programmed to display the alias.

During the conversation, a hang time is provided so that the two parties may exchange transmissions. After each transmission, the Fixed Network Equipment (FNE) maintains the call for the hang time to allow either user time to respond. If at any time during the process, the called or caller MS does not respond in a programmable timeframe, the FNE disconnects all the channels and tears down the call. The call hang timer is reset by each new transmission.

Figure 4-5 *Private Call Functionality*



1. A Private Call (PC) is set up automatically. No other users hears the communication. When a PC is initiated, after the PC proceeding message, a PC Page message is sent.
2. Only the cell returning a PC Page Response to the DAP is included in the PC. If no resources are available, the PC MS will be put into a queue. The DAP PC queue timer is adjustable. If no resources are available after the queue timer expires, the MS will receive an indication that the PC setup is being torn down.

Examples of private Call Scenarios are shown in Table 4-1

Table 4-1Private Call Scenario

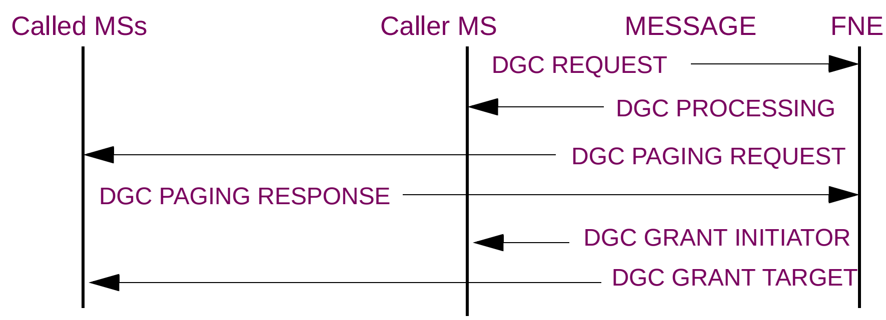
Event/State	***Notification***
Called MS idle	If MS and resources available - Successful Call
Called MS on an Interconnect Call	Caller receives 1 sec Busy Tone / Low and MS displays `TARGET NOT AVAILABLE` along with 1 sec high tone
Called MS on a dispatch Group Call	Caller receives 1 sec Busy Tone / Low and MS displays `TARGET NOT AVAILABLE` along with 1 sec high tone
Called MS on a dispatch Private Call	Caller MS displays `TARGET BUSY IN PRIVATE` along with 1 sec high tone
Called MS is powered down	Caller receives Busy Tone / High and the MS displays `TARGET NOT AVAILABLE`
MS initiates a Private Call to itself	Caller receives 1 sec Busy Tone/High and the MS displays `TARGET BUSY IN PRIVATE`
MS attempts invalid Call Alert (private call)	Caller MS displays `SERVICE RESTRICTED` along with a short tone
MS calls an MS without Private Calling	Caller MS displays `TARGET NOT AUTHORIZED` along with a short tone
MS calls an invalid MS	Caller MS displays `INVALID ENTRY` along with a short high tone
MS initiates a Private Call in other than the home market	Caller MS displays `SERVICE NOT AVAILABLE` along with a short high tone

Dispatch Group Calls

Dispatch Group Calls allow MSs which are members of predefined groups to communicate in half-duplex (one person talking at a time and the others listening) among themselves. Only members of the group can participate in the conversation and any authorized group member can either set-up or participate in the call. The call can be set up without all group members being available and can involve members being served at different sites. Any group member can leave the group at any time. After one MS makes the request, the Fixed Network Equipment (FNE):

- Validates the Dispatch Group Call request
- Determines the Dispatch Location Areas (DLAs) of the group's members
- Pages members (sends a Location Request) in those DLAs
- On Page response, assigns a channel at each site that needs to be added and have resources available.

Figure 4-6 *Dispatch Call Setup*



Three types of Dispatch Group Calls (DGC):

Local Area Call - communications between MS in the "Home" or "Local" service area.

Selected Area Call - communications between a caller and a group in a different service areas.

Wide Area Call - communications between a caller and a group anywhere in the network.

If no servers are available at the caller's site, the call is queued. If a server is available at the caller's site but not at other sites, those sites are included into the call as servers become available. Pages will be sent out only in those Location Areas where active group members are registered (provisioned). Once an MS responds to the page, only those cells with active MSs will have voice channels assigned. After each transmission, the FNE maintains the call for the pre-defined hang time. If the hang time expires, the channels are disconnected and the call is torn down.

The types of Dispatch Group Calls that define the extent of the area of the call are: Wide Area, Local Service Area, and Selected Service Area Dispatch Group Calls.

Local Service Area Dispatch Group Call

A Local Area Group call is a voice multicast to members of the fleet's group in the callers service area, the group dispatcher, and members of the group in the dispatcher's service area (Figure 4-7). Once a group is selected and a Group Call is initiated, all members of the group will be activated on the group call (Table 4-2).

***Figure 4-7** Local Area Group Calling*

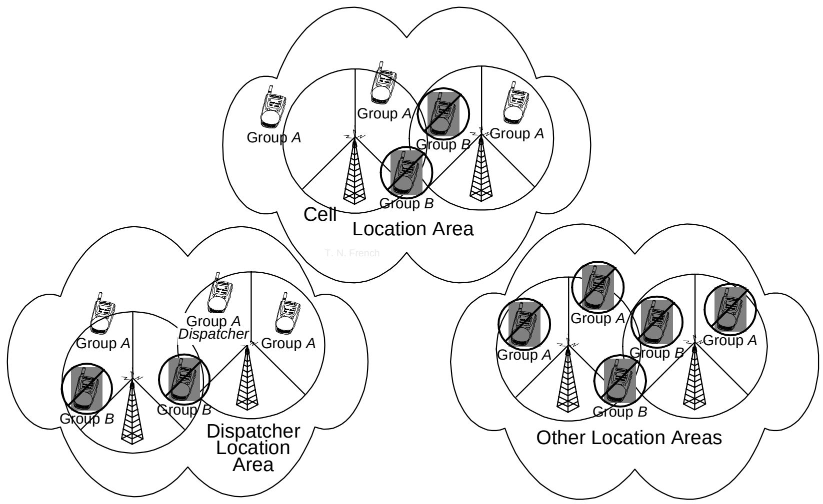


Table 4-2 Local Service Area Group Selection

MS User Selects	*System Locates and Includes*
Local Service Area Group	• Members of group in initiator's service area • Dispatch station (user 0) for the group

Examples Call Scenarios of Local Group Calls are shown in Table 4-3.

Table 4-3Local Group Call Scenario

Event/State	*Notification*
MS in service area	If called MS and resources are available, Successful Call
MS out of service area	Called MS idle. If it attempts a Group Call, it will be brought into the active group call
MS enters the active group call area	MS will be brought into the active call
MS active in call leaves service area	MS remains active in call
MS powers up during call	MS activates. If MS is outside the service area and tries a Group Call, it joins the call
MS ends another service in the service area and is in the active group call area	MS will be brought into the active call
MS ends another service in the service area and is not in the active group call area	MS is idle. If MS tries a Group Call, or other MS enters cell, MSs joins the active call
MS ends another service out of service area	MS remains idle. If MS attempts a Group Call, it joins the active call.
MS ends an service out of service area and enters the active call group area	MS will be brought into the active call

Selected Service Area Dispatch Group Call

A Selected Area Group call is a voice multicast to all members of the fleet's group in the caller's service area and a selected service area (Figure 4-8). Once a group is selected and a Selected Area Group Call is initiated, all members of the group in the callers service area and the selected service area as defined by the fleet's provisioning will be hailed and activated on the group call (Table 4-4)

Figure 4-8 *Selected Area Group Calling*

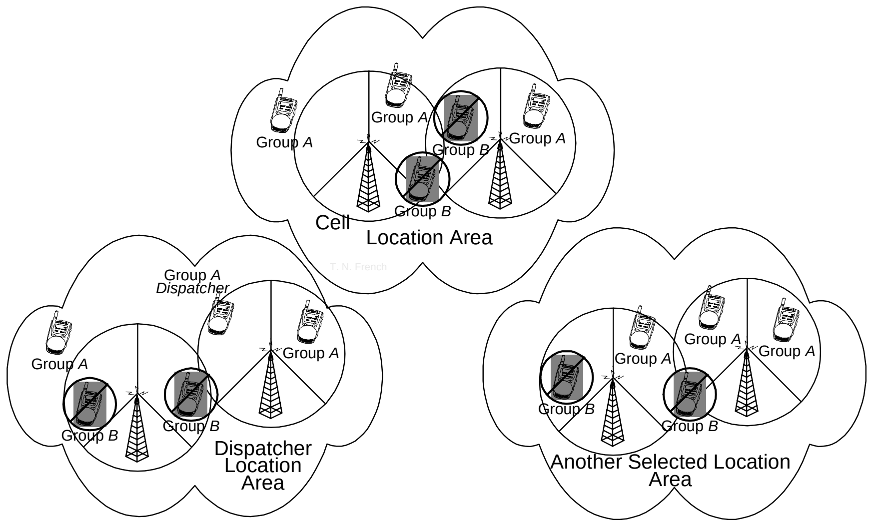


Table 4-4 Selected Service Area Group Selection

MS User Selects	*System Locates and Includes*
Selected Service Area Group	• Members of the group in initiator's service area • Members of the group in selected service area

Example Call Scenarios of Selected Area Group Calls are shown in Table 4-5

Table 4-5 Selected Group Area Call Events

Event/State	*Notification*
MS in Initiator and Target service area	If MS and resources available, Successful Call
MS is out of service area	Remains idle
MS enters service area and is on an active group call area	MS will be brought into the active call
MS leaves service area	MS remains active in call
MS powers up during call	MS becomes active in call through registration if MS is in selected area
MS ends another service within service area and is on group call area	MS will be brought into the active call.
MS ends another service within service area and is not on group call area	MS remains idle. If MS attempts a Group Call, or other active MS enters cell, it joins the active call.
MS ends a service out of service area	Remains idle
MS ends another service and enters active group call area	MS will be brought into the active call

Wide Area Dispatch Group Call

Wide Area Dispatch Group Calls are a broadcast to every MS member in the callers selected (active) group. Once a group is selected and a Wide Area Group Call is initiated, all members of the group within the service area defined by the fleet's provisioning will be hailed and activated on the group call (Table 4-6).

Table 4-6 Wide Area Group Call Selection

MS User Selects	System Locates and Includes
Wide Area Group	• Members of the Group in entire coverage area

With SR 8.0 a wide area group call will include members of the group that are outside the region is the service is supported by both region's provisioning. Prior to SR 8.0 cannot wide area group call outside the region.

Example Call Scenarios of Wide Area Group Calls are shown in Table 4-7

Table 4-7 Wide Area Call Scenario

Event/State	Notification
MS in service area	If target MS and resources available, Successful Call
MS is out of service area	N/A
MS enters service area and is on an active GC cell	N/A
MS that leave service area	N/A
MS powers up during group call while in area	MS will be brought into the active call
MS ends another service within service area and is on group call area	MS will be brought into the active call.
MS ends another service within service area and is not on group call area	MS remains idle. If MS attempts a Group Call, or other active MS enters cell, it will be brought into the active call.
MS ends a service out of service area	N/A
MS ends a service and enters active group call area	N/A

Call Alert

A Call Alert is a dispatch call request. It used to notify the called party that voice communication is desired.

The calling party selects call alert on the MS (Call Alert mode) and then enters the Called MSs Fleet Member ID, or, selects an alias for the pre-programmed list. The calling MS receives an acknowledgment (ACK) if the request is successfully delivered.

An audio tone and a visual indicator on the called MS informs the user of Call Alert. The Call Alert displays and stores the calling MSs Fleet Member ID (or alias) on the called MS. This can be used to simplify call back. The called MS may then select the alert on the MS and initiate a callback. The called MS may also delete the alert. Deleting the call alert does not stop the returned Acknowledgement.

The entire Call Alert procedure takes place on the PCCH or the SCCH so no talk channel resources (TCH) resources are used.

An example of a Call Alert Call Scenarios are shown in Table 4-8.

Table 4-8 Call Alert Scenario

Event/State	*Notification*
Called MS idle	If MS is available -- Successful Call
Called MS on an Interconnect Call	Caller MS receives 2 beeps and displays - `TARGET NOT AVAILABLE` along with 1 sec high tone
Called MS is involved in a Group Call	Caller MS receives 2 beeps and displays - `TARGET NOT AVAILABLE` along with 1 sec high tone
Called MS is involved in a Private Call	Caller MS receives 2 beeps and displays - `TARGET NOT AVAILABLE` along with 1 sec high tone
Called MS is powered down	Caller MS receives 2 beeps and displays - `TARGET NOT AVAILABLE` along with 1 sec high tone
MS Call Alerts itself	Caller MS receives 2 beeps and displays `TARGET BUSY IN PRIVATE` along with 1 sec high tone
MS cannot Call Alert	Caller MS displays `SERVICE RESTRICTED` along with a short tone
MS Call Alerts to an MS without Call Alert	Caller MS displays TARGET NOT AUTHORIZED along with a short tone
MS Call Alerts an invalid Fleet Member	Caller MS receives 2 beeps and displays `INVALID ENTRY` along with a short high tone
MS gets a Call Alert and does not clear that call	MS will not function in any other call till cleared

Emergency Call

An Emergency Call is an option. This is a special situation of a Wide Area Dispatch Group Call that is given the highest priority. The priority allocates resources for the call, as well as preempts existing calls and call requests.

An Emergency Call is used to alert all members of the group of an emergency initiated by a user. An emergency call is handled before any other call and is intended to announce and open a line of communication in a dangerous situation.

For users with an Advanced Feature Unit (AFU) MS, a button on the MS generates an Emergency Call. This option is provisioned in the DAP. The request triggers a new call, or causes an in-progress call to be elevated to Emergency status. Except for the priority, the FNE processes an Emergency call like a Dispatch Group Call. An Emergency Call can also be terminated at any time by the initiator or another user with an MS provisioned override the status. An optional advanced feature package is required for the Infrastructure to process Emergency Calls.

MS Status

MS Status is another Advanced Feature option. MS Status enables one MS to send a Status Code (an 8\+bit number) to another MS in the same fleet.

The meaning of the Status Code is user defined. Some MSs can translate the status code into a character string on the MS display. The Status Code is transparent to the iDEN system. It is not examined, defined or recorded by the iDEN system.

The MS Status is similar to Call Alert and is controlled by the MSs user interface. Like Call Alert, the MS Status returns an acknowledgement when the status is delivered or the MS returns a failure reason. MS Status also saves the calling MS fleet ID so a call back can be selected on the MS display. The difference between MS Status and Call Alert is the definition in provisioning:

- A Call Alert may be activated as send, receive, or neither by MS
- MS Status can be activated for just send, just receive, both, or neither

A Status Code of all zeroes is taken to imply a Call Alert. MS Status is also sent over the PCCH or SCCH and does not use any talk channel resources (TCH).

Limitations

The iDEN system has physical and programmable limitations to service and coverage. The obvious limitations are hardware related. Capacity and traffic planning is required to assure the system can support the call volume generated by the users. (refer to Appendix limits)

Region

Urban IDs allow an MS from one region to be uniquely identified in another region without conflict. The additional of this identifier reduces the potential for registration and authentication conflicts. There can be approximately 11 million Urban IDs

Domain

If a region contains a DAP-cluster or more than one DAP, all DAPs in the cluster service the same region. The service provider can configure the D-HLR and D-VLR databases to permit or restrict mobility across the domains.

Service Area

A Service Area is a logical unit that is used to limit the range of a fleet's group call. Normally a group call will only require resources from a small group of EBTSs. By reducing the amount of MSs in a group call the system resources used is reduced.

Location Area

A Dispatch Location Area can be used to manage and track the mobility of an MS. An MS is located by this group of cells.

Enhanced Base Transceiver System

An EBTS may be either Omni-directional or 3-sector. For 3-sector EBTSs, each cell is a sector.

Physical limitations of EBTS relate primarily to the number of Base Radios and dynamics of the radio link. The more Base Radios, the more control and traffic channels available in a specific area. With more radios available in the EBTS, the more span line facilities, DACs, and DAP resources will be required to support the increase in radio link capacity. Refer to the *iDEN RF Planning Guide* and the *iDEN RF Subsystem/RF Link Optimization Manual*.

Dispatch Application Processor

The DAP may be implemented in two forms. This will depend on the age and the size of the system. The implementation of the DAP and the software release are a major determining factor in the capacity and functionality of the iDEN system.

- R4400 N-DAP — to support 90K Dispatch Equipment Subscribers (DES)
- R10000-DAP — to support 180K DES

Fleet

Each fleet is provisioned in a single DAP. Each DAP can support 10,000 unique fleet IDs. For example, a N-DAP cluster of 6 DAPs can support up to 60,000 fleet IDs.

Group

The maximum number talk groups per fleet is 255.

User

An MS can support up to 3 Number Assignment Modules (NAMs). Each NAM of an MS can only be in 1 fleet. The feature supports Multiple Simultaneous Talkgroups and assumes the MS can support and is configured to support multiple NAMs.

Provisioning

Provisioning is the logical connection between a fleet member MS and the functions and services available on the iDEN system. Each MS is provisioned for unique IDs, areas of service, types of services and fleets, groups. This information not only controls service, it is often directly related to billing and revenues for the system. Provisioning is a data entry function that is usually associated with the service provider's Administrative Data Center (ADC). Provisioning is discussed in greater detail in *DAP ADC and Billing Interface* 68P81130E99, *DAP Operator Manual* 68P81131E03 and *DAP Software Dev Manual* 68P81130E44.

Domain

The optional domain may be used control fleet mobility in the region. The fleet and service areas are defined in the D-HLR. Individual fleets can be included or excluded from the coverage based on the DAP defined domain. By restricting the available service areas and DAPs, the services transferred between the D-VLRs can prevent services in specific areas.

Service Area

Like domains the data entered in the MS' D-HLR records at the DAP can define the coverage of a Fleet, Group, Member (MS) within a specific area. Since MSs may belong to multiple groups in a fleet, this allows greater flexibility to in private and group calling at the MS level.

Fleet

The Fleet is the major logical unit used to define the range and services. As a business unit, the fleet is often considered the major subscriber for logical and billing purposes. Each fleet consists of groups and members. Members may also be considered subscribers associated with the fleet services and groups. How the fleet and user members are defined is controlled by the D-HLR and D-VLR of the DAPs.

Group

Fleet groups are specific to fleet.

Member

Services can be further refined on an individual MS basis. How the fleet users (members) are defined is controlled by the D-HLR and D-VLR of the DAPs.

Chapter 5
Interconnect Call Processing

Interconnect calls are voice communications that utilized other provider networks. The other networks may be either land-based or wireless. To use interconnect calling, the iDEN system must be configured for interface to the telephony network. This chapter will describes the fundamentals of the Interconnect Call Processing

Interconnect Calling

To support the logical Global and other provider calling, Interconnect communications organizes the coordinated systems into different levels. These areas are based on geography. The areas are:

- Global — another provider land-line or wireless system
- Location Area — the set of EBTSs in contact with the mobile
- Cell — the cell of the EBTS hosting the call

Interconnect calls locate the MS to the cell by the Base Radio handling the radio link and control channels. The location area is a logical group of EBTSs maintained as a Interconnect Location Identifier (ILA) in the VLR to track the MS.

Functions

Interconnect Only Service

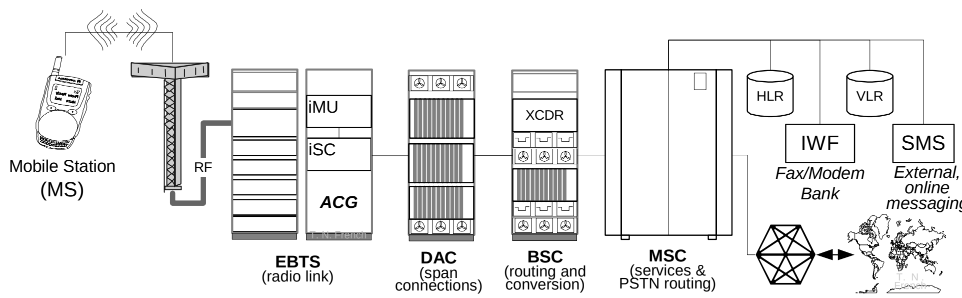
Because Interconnect calls exist outside of the iDEN system, this type of service my be restricted on a per-MS basis. These types of operation are controlled by service provisioning.

General

Interconnect calling allows an MS to travel freely throughout an iDEN system and teamed roaming partners. Within this extended network, a user can originate or receive interconnect calls. The systems track the MS's location and services as well as route the calls. With networked regions the MS can roam into those interconnected regions originating and receiving calls as if the MS is in its home system.

Figure 5-1 shows the major elements involved in Interconnect calling. The MS sends and receives voice data. The EBTS converts the radio link to the land link and discriminates between Interconnect and Dispatch calls. The BSC routes interconnect packets between the EBTS and the MSC. The MSC determines services and location information. The MSC also controls and routes the calls to other providers.

Figure 5-1 *iDEN Interconnect Call Elements*



The control and monitoring steps needed to complete this task are primarily internal to the iDEN system. Aside from dialing sending and receiving, the steps to complete an Interconnect call are user transparent. There four major steps in an Interconnect call:

- Establish Radio Link
- Route digital voice packets
- VSELP/Mobis — PCM/SS7 conversion
- Other network routing

Establish Radio Link

The radio link is the on-air connection. This is a coordinated effort between the MS, EBTS, BSC and the MSC. The RF Subsystem analyzes the MS broadcast and determines the EBTS to host the call. The BSC routes the call setup information to the MSC. The MSC queries the HLR and VLR to determine location access, authentication and service availability. The EBTS establishes and maintains the radio link. This includes coordination of handoff to another EBTS if the MS’s location indicates another EBTS has better radio link quality. Setup, control and monitoring of the radio link uses the Mobis link protocol.

Route Digital Voice Packets

Once the radio link is established, the EBTS discriminates between a Dispatch call and a Interconnect call. The DAC will cross-connect interconnect voice packets to the BSC. The BSC coordinates the movement of packets between the DACs and the MSC. The BSC re-routes calls to another EBTS on handoff. Control of the link between the BSC and the MS use the Mobis protocol. Control of the BSC/XCDR complex and the MSC link uses SS7 routing and messaging.

VSELP -- PCM Conversion

The VSLEP compression at the MS is converted to standardized PCM for use on other networks by the BSC/XCDR The BSC is also the bridge between the Mobis protocol link and the PCM SS7 link.

Other Network Routing

Once the radio link is established, the transmitted connect request (NADP, MSISDN or GSM phone number) is processed by the MSC databases for other provider network routing. The MSC uses SS7 routing, messaging and trunking to cross connect the voice data packets to the appropriate other provider network.

Dual-Tone Multi-Frequency Overdial

Dual-Tone Multi-Frequency (DTMF) overdial is the ability to enter digits on the MS keypad and to transmit the standardized pulse tone across the network to a remote device. This ability to send tone is used to control automated calling system menus and provide enhanced functionality to the MS. Once the interconnect call is established, keypad input from the MS is converted to DTMF by the MSC. The type and number of digits that can be sent is determined by the dialing plan of the implementation of the MSC (International or NADP).

Call Restrictions

Call Restrictions are provisioning attributes that allow the provider to configure an individual MS. These configuration settings include but are not limited to:

- No Interconnect Service
- Answer-only
- No-long distance

Emergency Call

The iDEN system provides facilities to locally defined Emergency Call processing. The U.S.A. Domestic 911 and similar connections to the municipal emergency services is available. The system provides the ability to establish a municipal 911 call by service location area. Local requirements to locate the MS within the municipal area are provided but are limited to the potential serving cells area.

Call Detail Records

The Interconnect call activity will always be collected for capacity and billing purposes. The MSC call record data collection conforms with U.S.A. domestic and international standards. This call record information may be available to the ADC through a direct network link or may be reduced to tape for loading onto the ADC.

Channel Efficiency

The way the internal iDEN network handles interconnect calls is determined by how often a digital voice packet is applied (interleaved) on the radio link. The iDEN system uses two methods

- 6:1 interleaved
- 3:1 interleaved

The method of interleaving used affects the voice quality, throughput and network optimization and the amount of equipment required. Capacity planning and RF optimization are affected by the type of interleaving used. Both types of interleaving may be used on the iDEN system. The type of interleaving is selected by market area during the capacity planning/system engineering phase of the implementation. The impact of interleaving is discussed in the *iDEN RF Planning Guide*.

6:1 Interleaved

The primary method of transmitting digital voice packet is to apply one voice packet slot to a single TDMA frame (1 voice slot per 6 frame packets). The 6:1 interleaving method is the lower-cost, greater-throughput method. Disadvantages are changes to the coverage and optimization to assure audio quality. Refer to the *iDEN RF Planning Guide* for more information.

3:1 Interleaved

The 3:1 interleaving method uses two slots on a single TDMA frame. By effectively doubling the amount of data being sent, the system can use an enhanced vococder that samples voice more and provides better voice quality. Since the load on the radio link is increased the throughput is reduced. This increases the amount of radio equipment required when compared to the 6:1 method. The affects of interleaving on coverage and RF optimization are discussed in the *iDEN RF Planning Guide*.

System Identifiers

Individual users of the iDEN system are uniquely identified on the system. The type of identification will depend on the region. The iDEN system can be configured to support the international and/or North American Dial Plan.

In both cases each MS on the system is assigned a Mobile Station International Subscriber Directory Number (MSISDN). This is the unique identifier the allows global accessibility of the MS. The ability to access the MS depends on the RF sub-system frequency and roaming agreements between service providers.

In the iDEN system the MSISDN aliasing, service access and authorized services are maintained and stored in the HLR. The MS location is in the VLR of the MSC.

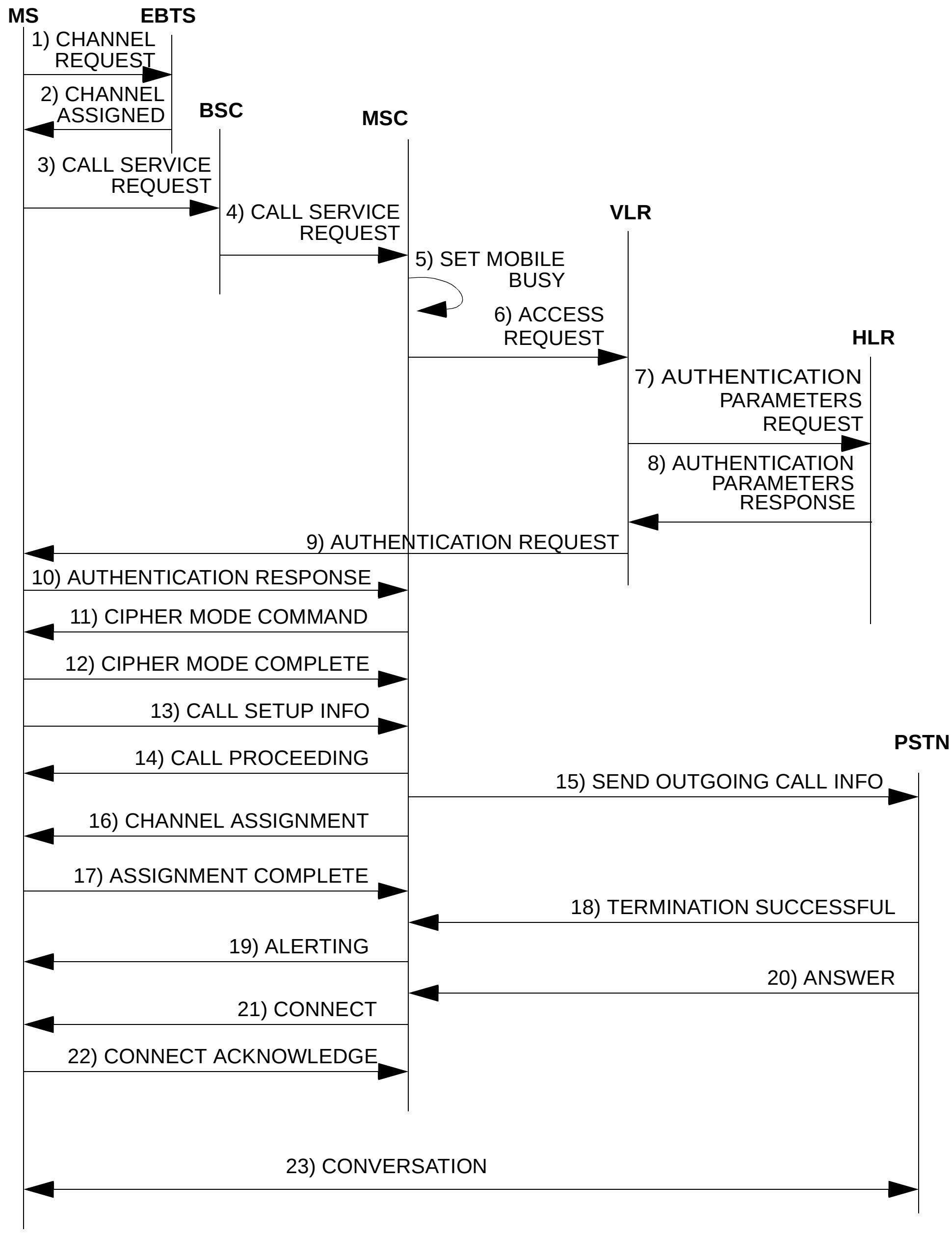
Interconnect Call Procedure

The basic steps involved in a telephone interconnect can be summarized in Table 5-1 an the step diagram of Figure 5-2

Table 5-1 Call Procedures

Make a Call (origination)	
	a) Send Random Access Protocol (RAP) on PCCH
	b) Mobile gets a dedicated control channel assigned
	c) Authentication (optional)
	d) Call setup transaction
	e) Get assigned to a traffic channel
	f) Call termination request on associated control channel
	g) Channel released
Get a Call (receive)	
	a) Locate MS by last known Interconnect Location Area (ILA)
	b) Page MS on primary control channel of all sites in ILA
	c) RAP on primary control channel
	d) Get dedicated control channel assigned
	e) Authentication (optional)
	f) Call setup transaction
	g) Get assigned to a traffic channel
	h) Call termination request on associated control channel
	i) Channel released

Figure 5-2 *Mobile Originated Interconnect Call Setup Step Diagram*



Interconnect Call Types

Mobile Stations on the iDEN system can complete Interconnect Call with other providers networks in three basic ways:

- Mobile to other network (PSTN)
- Other Network (PSTN) to Mobile
- Mobile to Mobile

Mobile to Other Network

On MS power-up, number entry, and call initiation, the MS sends a service request to the EBTS. The EBTS/BSC/HLR identifies an Interconnect call and routes the request to the MSC through the BSC.

When the MSC receives the service request, it queries the HLR and VLR for service access, service availability and MS authentication.

When authentication of the MS is complete, the BSC cross connects the RF channel to the land-based circuit as soon as it is assigned by the MSC. The MSC assigns the trunk according to the provisioning of the networks. The MSC then connects the BSC land circuit to the PSTN trunk.

When the connect to the PSTN is complete, the remote PSTN will request that the local MSC transmit the dialed digits for the call. The remote PSTN will verify service and the called party and send a cut through supervision (the called party answering or a supervisory tone like a busy signal). The MSC will send a connect message to the MS that allows the MS to receive and transmit voice frames - completing the call connection.

Other Network To Mobile

When an incoming call is received at the MSC in SS7 protocol, a channel to the remote PSTN is allocated and the DTMF digits (dialed number) is received by the MSC. The MSC will query the HLR and VLR databases to verify the dialed number exists and to alias the dialed number to the MS (IMSI or TMSI).

The MSC will locate the MS using the Interconnect Location Area (ILA) in the VLR to page the MS. The ILA is used by the BSC to route the call to the most likely set of EBTSs using Radio Link Protocol (RLP).

The MSC will wait for the MS to respond to the page. If the MS or resources are unavailable, the MSC will generate the appropriate status return to the remote PSTN (busy or out-of-service). If the MS and resources are available, the MSC will connect the external trunk to the controlling BSC. The BSC will connect the PCM/SS7 link with the appropriate EBTS span line (T1). The EBTS will establish the radio link, allocate a radio channel and transmit a hail (ring the phone).

When the user responds, the BSC/XCDR converts the PCM voice packets to the VSLEP packets used by the radio link. The DAC and BSC completes the cross connect between the radio link and the other provider land-line to complete connection of the call.

The MSC may also route the call to the Voice Mail system or to Call Forwarding if the service is provisioned for the MS and the MS is eligible for the re-route.

Mobile To Mobile

If an MS calls another mobile using the MSISDN, an Interconnect call is used (Mobile to other network process). Mobile to mobile calls are set up in the same manner as a mobile to land calls.The MSC call routing and translation tables recognize that the call can be completed within the iDEN system and a BSC to BSC connection via the MSC switching matrix is established. This arrangement allows Transcoder by-pass to operate and thus reduce audio delay between the MS involved in the call.

A Mobile to Mobile call that uses a fleet member ID is a dispatch call and is discussed in Dispatch Call Processing.

Chapter 6
Packet Data Networking

Packet Data Networking is non-voice communications interfaces directly with Intranet, Virtual Private Network (VPN), Extranet and Internet. Packet Data Networking allows the service provider to become a point-of-presence for mobile users on the Internet. This chapter will describe the fundamentals of Packet Data.

General

Non-Packet Data Network Service

Because Packet Data Networking uses equipment outside the iDEN® system, this type of service may be restricted on a per-MS basis by provisioning and by restricting radios at the EBTS with iHLR provisioning and OMC-R configurations.

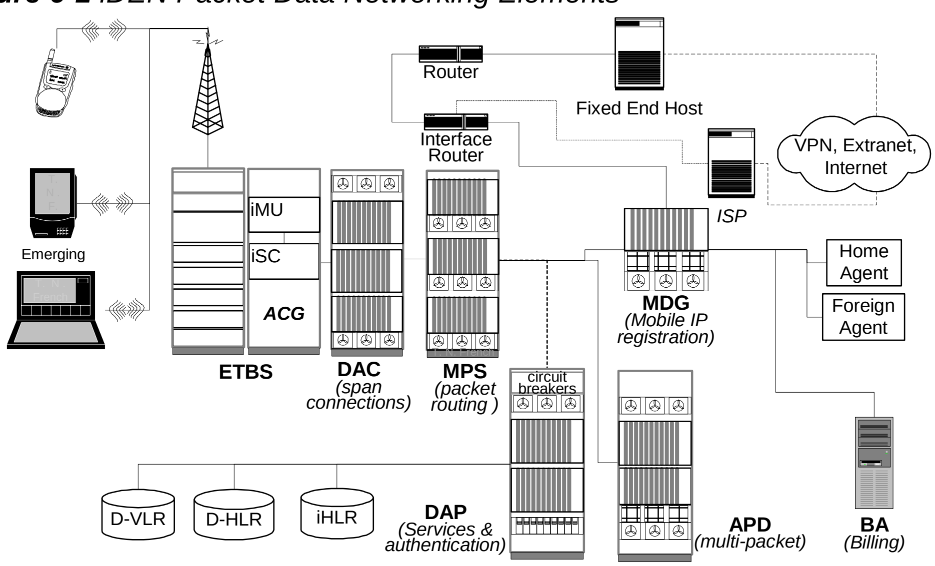
Overview

Packet Data Networking uses the iDEN system dispatch calling functions and infrastructure. An MS may travel freely throughout an iDEN system and teamed roaming partners. If it is supported and provisioned, a user can originate or receive Packet Data. Interconnect facsimile and Dial-up services are not supported.

- The MS sends and receives data directly.
- The EBTS determines the call as Packet Data and converts the radio link to data packets.
- The MPS routes data packets.
- The DAP determines services and location.
- The MDG routes the data to and from the Internet.
- The Billing Accumulator (BA) collects time and bit-transfer information for billing as desired by the service provider.

Packet Data Networking elements are shown in Figure 6-1.

Figure 6-1 *iDEN Packet Data Networking Elements*



Administration

The equipment used to control and monitoring and administer the system are primarily internal to the iDEN system. The Packet Data process follows the same procedures as Dispatch Call Processing. The exception to this procedure is the billing information collection and external routing of the MDG or any servers that may be part of the service provider hosting network.

The MDG uses proprietary billing protocols to gather usage data and forwards this information to the Billing Accumulator (BA). The BA stores and compiles usage and traffic data. Similar to call data records from the MSC this information is used by the service provider to gather usage (time and/or data transferred) and similar account information. This data is available to the ADC for billing and decision support.

Intranet

The Packet Data may be used to extend an internal data processing network to the Fleets, Groups, and Members. A private LAN or WAN outside the iDEN system may use an MDG as a router to connect the a fleet and its member nodes to the private network. The MDG references the fleet and group based subnet and routes data packets to the MSs. This allows mobile users to interact with the central network and the functionality it provides (e-mail, remote sessions, web-browsing and file transfers). This functionality is specific to the rights and permissions of the private network's fixed end host and the capabilities of the mobile stations.

Virtual Private Network

The iDEN system does not explicitly support broad networks. The users' private network may be extended to include MSs and other networks using the fixed end host's secured network, hosts and routes. This allows iDEN to support private VPNs that are part of, and associated with, the fleet's network.

Extranet

An MS can become openly associated with a network. If the user has login rights on a web-addressable, secure server, the MS use can interact with extranet servers or another entity's private network if it is allowed. This is controlled by the fixed end host and the extranet secured hosts.

Internet

Packet Data Network provides access to Internet addressable servers based on the restrictions, rights and permissions of the fixed end host (proxy) and the browsed site.

Internet Service Provider

If Packet Data Networking is used, the end-user cannot directly access online services. However, opportunities exist to allow iDEN service providers to create and support the infrastructure to proxy and host some services. This type of functionality is not provided and is exclusively a consideration of the service provider.

Mobile Computing

An MS may be a phone-type device, an emerging PDA, or Data Terminal Equipment (DTE) that is directly compatible with the iDEN system. Any MS, PDA or RF computing device that provides digital data networking (web browsing) and, that is compatible with iDEN equipment may be used to create truly mobile computing. When a mobile is engaged in Packet Data it exists as a mobile node on the Internet.

The mobile computing devices use Transmission Control Protocol/Internet Protocol (TCP/IP). All devices on the system must be configured for these parameters. Table 6-1 summarizes the parameters.

Table 6-1 Packet Data FNE Parameters

Device	***Parameters***
Mobile	Provider assigned static IP address (over the air programming)
DAP	Valid IMSI for mobile (D-HLR) IP address for mobile (iHLR) Permission for Packet Data (iHLR) Home Agent (serving MDG) Address (iHLR)
MPS	Mobile location (serving EBTS address) (from DAP VLR) Local MDG (Home Agent) Addresses (from DAP VLR)
MDG	Valid mobile IP address (mobile) Internet Presence (Home agent) IP address and clients database Valid remote host IP address (browsed system) Dynamic Foreign Agent and clients database

Intra-System Mobility

Each MS is configured for packet data in its home DAP. The identification (IP address) and permissions for Packet Data are contained in the iHLR. The iHLR operates in the same manner as the D-HLR except it identifies and verifies packet data services instead of dispatch calling services.

When an MS requests packet data service, the MS registers and authenticates for dispatch in the D-HLR. The mobile will then register and authenticate for Packet Data in the iHLR (send an IP address). On approval, the DAP will authorized service to the mobile and notify the MDG of an MS packet data request (activate the MS in the MDG).

As the MS moves within the system the location is maintained by Dispatch Location Area (DLA) in the D-VLR. Paging, selection, connection, re-selection and re-connection all follow the dispatch procedures. The difference is; when a link is established a radio link Packet Channel is used instead of a radio link traffic channel. A packet channel is more dynamically allocated to the TDMA timeslots (See ‘Packet Data Flow’).

The iDEN system's interface to the Internet is the MDG. The MDG is an enterprise level switching router that allows for truly mobile device addressing. The MDG acts as a conduit between the MS and the Internet. Messages across the Internet are addressed to the MDG. The MDG re-addresses the data to the specific MS. Data for MSs that the MDG serves is accepted and the Internet Routing Information Protocol (RIP) is removed and the data is re-assigned to the mobile IP address used by the iDEN system. The D-VLR locates the mobile and transfers the data packet across the MPS to the EBTS and then to the MS.

Inter-System Mobility

For truly mobile computing the iDEN system provides Packet Data remote system usage and roaming. Roaming uses the Home Agent and a Foreign Agent. Each of these is an MDG sub-system that serves an iDEN network. Each agent (MDG) contains a table of the addresses of all the roaming partner/remote MDGs (a virtual network).

Each MDG has a Home Agent that lists the packet data services and remote location of the MS. The remote location is the care-of-address that is also the address of the remote MDG. The local MDG (home agent) forwards data to the remote MDG Foreign Agent) while the MS is away from home. This MS mobility binding has contains the IP address, the foreign agent's address (care-of-address) and time variable. As long as the mobile does not register in another system, the data will be forwarded to the Foreign Agent (remote MDG).

A Foreign Agent is an MDG on the visited network that coordinates the routing of data when an MS roams. The remote system will contact the home system to verify registration, authentication and services. If allowed, the home system will transfer this information to the remote system. The Foreign Agent (MDG) will add the traveling MS to a visitor list and accepts data packets for the local (home) system. Like home system routing, the visited system will locate and route the data packet to the roaming MS.

The home MDG will send all data to the visited MDG that in-turn, will route the packet to the remote iDEN system. All roaming system partners are part of a virtual network defined in both system's MDGs.

Packet Data Flow

The Packet Data network link is dynamic. The actual data rate and flow will depend on the traffic on the system. As the traffic on the system and the integrity of the radio link changes the radio link can adapt to the optimum date flow rate. To optimize performance and resources the iDEN system uses three principles to control the On-Air interface.

- Dynamic Channel Allocation
- Adaptive Rate Modulation
- Queued Continuous Reservation ALOHA

Dynamic Channel Allocation Procedure

Dynamic Channel Allocation Procedure (DCAP) uses the Broadcast Control Channel (BCCH) to control the amount of the TDMA timeslots to be used as a Packet Channel (PCH) for data transmission. In cases of no or low traffic all of the radio link maybe used to carry data only (1:1 interleaving). If 1:1 interleaving is used, DCAP uses all the channels and dynamic changes are not allowed. Packet Data will still require some control and monitoring overhead so not all frames will be data (the link is not truely peer-to-peer).

Allocation of radio link frame slots places highest priority on voice packets. When traffic increases the number of slots is altered to reflect the change in traffic. High voice traffic conditions may pause data transfer (0:1 interleaving) How data packets are allocated is a provider selected channel sizing option. The options are:

- 1:1 interleave - only transmit packet data (except 1 PCH per cell)
- 3:1 interleave - two data packets per frame minimum
- 6:1 interleave - one data packet per frame minimum
- 12:1 interleave - one data packet every other frame minimum
- 0:1 interleave - transmit no data during high voice traffic

Any number of slots from the maximum to the selected minimum can be used. in response to the voice traffic.

Adaptive Rate Modulation

The iDEN system continuously monitors the radio link and will alter the method of modulation of data packets on the RF carrier. As the signal degrades, the amount of data on the carrier is reduced to improve data recognition and reduce the error rates. Three modulation methods are used. The methods and the full (1:1 interleaving) data rates are:

- 64 Quadrature Amplitude Modulation (64-QAM) at 44 kbs with C/N+I greater than 22dB
- 16 Quadrature Amplitude Modulation (16-QAM) at 22 kbs with C/N+I greater than 18dB
- Quadrature phase shift keying-compatible (QPSK) at 11 kps with C/N+I between 18dB toward link failure

The Base Radio must not have a Primary Control Channel allocated and the MS must be high speed compatible to support the 44 kbs data rate. If a Base Radio supports the Primary Control Channel, the data rate is limited to 22 kbs.

As the signal degrades the amount of data on the carrier is reduced to improve data recognition and reduce the error rates.

Queued Continuous Reservation ALOHA

Queued Continuous Reservation ALOHA (QCRA) is a standard protocol used to optimize the buffering and transmission of data across the radio link. If more than one MS on a cell is using Packet Data, the data from each MS is received and radio link timeslots are allocated according to the QCRA protocol. This queuing establishes a method of allocating packet channel resources in response to user and system load.

Call Processing

The manner of dealing with other communication activities when the MS is currently involved in Packet Data Networking is summarized in Table 6-2.

Table 6-2 Packet Data Processing

Event State	**MS in Packet Data Session**
Data sent to mobile	No conflict
SMS message delivery	SMS retries
Incoming Interconnect or Circuit Data	No Response to page
Dispatch Group Call	Involved mobile is bypassed
Dispatch Private Call	Target Not Available sent
Call Alert	Target Not Available sent

Chapter 7
Circuit Switched Data Networking

Circuit Data Networking is non-voice communications that utilize other provider networks. The other networks may be either land-based (PSTN) or wireless (PLMN). This world-wide interconnected data network provides Fax, modem, Intranet, Virtual Private Network, Extranet and Internet access. To use Circuit Data Networking, the iDEN system must be configured for interface to the worldwide network. This chapter will describe the fundamentals of Circuit Switched Networking.

General Circuit Switched Networking

To support the logical global dial-up data networking, the iDEN system uses the interconnect calling infrastructure and general operation to identify and locate the MS in the iDEN network.

Non-Circuit Switch Network Service

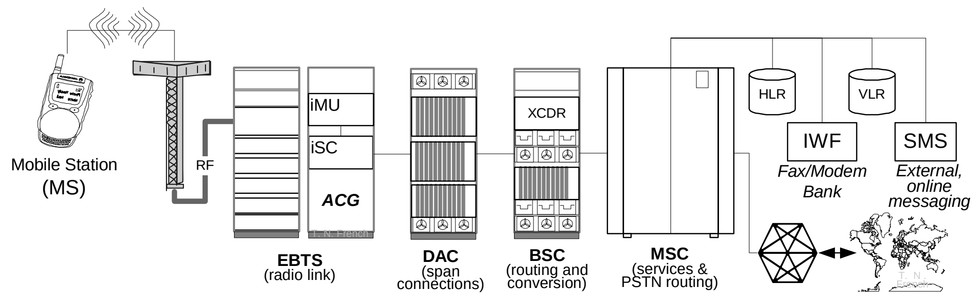
Because Circuit Switched Networking uses equipment outside the iDEN system, this type of service may be restricted to users on a per-MS basis. This is controlled by service provisioning.

General

Circuit Switched Networking uses the Interconnect calling functions and infrastructure with the exception of the Interworking Function (IWF) and the Short Message Service (SMS) of the MSC. An MS may travel freely throughout an iDEN system and teamed roaming partners. If Circuit Switched networking is supported and provisioned, within a extended network, a MS can originate or receive Circuit Switched Data calls. The systems track the MS's location and services as well as route the data appropriately.

The major system elements involved in Circuit Switched Networking are shown in Figure 7-1. The MS sends and receives data directly or to a computing device. The EBTS converts the radio link to the land network link and determines the call is a circuit switched interconnect calls. The BSC controls the signaling, and routing of data packets between the MSC and the EBTS. The MSC determines service availability and location information with the HLR and VLR. The MSC also controls and routes the data to and from other provider networks. The IWF is a modem/FAX bank for PCM compatible data transfers.

Figure 7-1 *iDEN Circuit Switched Networking Elements*



The control and monitoring steps needed to complete this task are primarily internal to the iDEN system. This process follows the same procedures as an Interconnect call (Refer to Interconnect Call Processing).

Specifications

During Circuit Switch (dial-up) data networking, the iDEN system uses:

- Radio Link Protocol (RLP)
- Full-Duplex
- Single rate: 4,800 bits-per-second (4.8 kbs) with 6 users per RF carrier
- 9900 bits-per-second (9600 baud) with 3 users per RF carrier
- Flow Control: X-ON / X-OFF or DTS / CTS
- Error Control:
- Forward Error Correction Coding (FEC)
- Selective Retransmission of uncorrectable blocks (selective ARQ)

Mobile Computing

Circuit Switched Data is a dial-up networking function of the iDEN system. An MS acts as a transport carrier with a compatible modem and a laptop computer or compatible Data Terminal Equipment (DTE). Any mobile connected computing device that is compatible with iDEN equipment may be used to create mobile computing. When a mobile/laptop is engaged in Circuit Switched networking it exists as a dial-up networked device.

The mobile computing devices use Transmission Control Protocol/Internet Protocol (TCP/IP), Point-to-Point Protocol (PPP), and Serial Line Interface Protocol (SLIP). The devices on the system must be configured for these parameters. With the introduction of Software Release 8.0, the routing information (IP Header) is compressed to reduce traffic overhead. The computing devices must be configured to de-compress the header for proper processing.

An MS may establish a dial-up network connection between itself and fixed end hosts using Interconnect Call Processing procedures.

InterWorking Function

The InterWorking Function (IWF) is a MSC-based optional processor that converts data between PCM standards to the radio link standards used by the iDEN system. The Radio link is converted to PCM and applied to the IWF links (trunks) on outbound links. The IWF also has a modem pool that allows other networks to access the iDEN system for inbound circuit switch data like:

- Dial-up access to the iDEN system
- Facsimile (FAX) service (Class 2, Group 3)
- Teletype (TTY) using Bell 103 compatible modems
- Non-transparent data services at 9600 bits-per-second (baud).

On the inbound link, the IWF translates PCM to the radio link.

Dual-Tone Multi-Frequency Overdial

Dual-Tone Multi-Frequency (DTMF) overdial may be used in scripting and remote login procedures. Once the circuit switch network is established DTMF overdial tones may be used to control functions on the host system. The type and number of digits that can be sent is determined by the dialing plan of the implementation of the MSC (International or NADP).

NOTES

Appendix A
Network Planning

Nominal limitations for iDEN systems are based on the available hardware and the localized traffic. Motorola iDEN provides documentation and tools to assist in the planning of a network. The logical planning of network traffic is discussed in greater detail in *iDEN S.E.T.S Group Formulas for Traffic Analysis*, *MSO Timing System* (sysiu020 r12) and the *MSC Subsystem General Planning and Expansion manual*. These documents are available on-line at the iDEN support website, AccessSecure.

The website also contains the DAP Tools capacity planning spreadsheet macros to assist in the planning of dispatch calling.

Timing

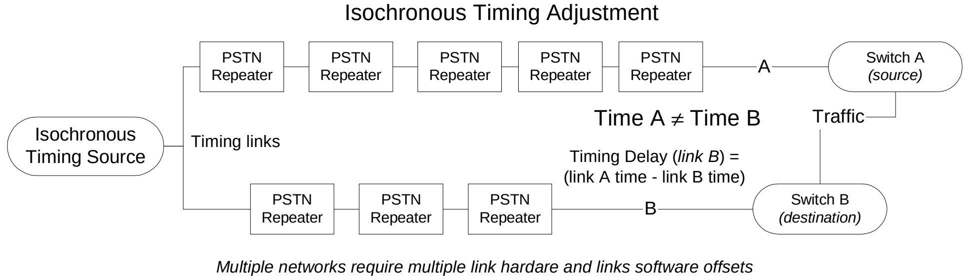
The distributed nature of the iDEN system requires precise timing to assure the proper processing of voice and data across the network. Two time models are possible. (Please refer to *MSO Timing System* - sysiu020 r12).

Isochronous Timing

The synchronization of telecommunications systems is based on digital PCM transport. In North America the standard is based on the T1s, operating at 1.544 Mbs, while most of the rest of world uses the ITU E1 format operating at 2.048 Mbs.

Since voice and data information could use different paths to travel across the networks the data would have to be adjusted for time-delay based on the route the data traveled. If control information takes a longer path than the data or voice information, there would be a mismatch of information at the destination. This requires adjusting the time for distance traveled. Historilcally, each network had a single (isochronous) timing source with hardware and software to manage the time differences. This requires a hierarchical, distributed method (Figure A-1).

Figure A-1 *Isochronous Hierarchical Timing Distribution*



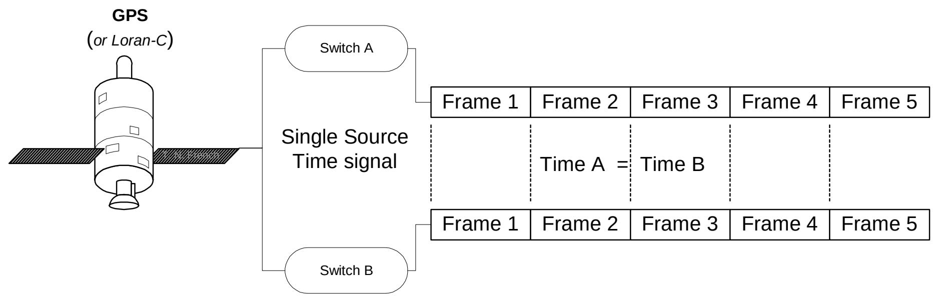
The difficulty with isochronous hierarchical timing is that each element in the path introduces a delay. There is also a delay introduced by the propagation time between the elements. With digital switches, this creates a timing problem that requires more hardware and software.

The different delay times causes the payload synchronization to be out of step between source and destination elements. The result is that the payload (T1 or E1 frames) become unusable.

Pleisiochronous Timing

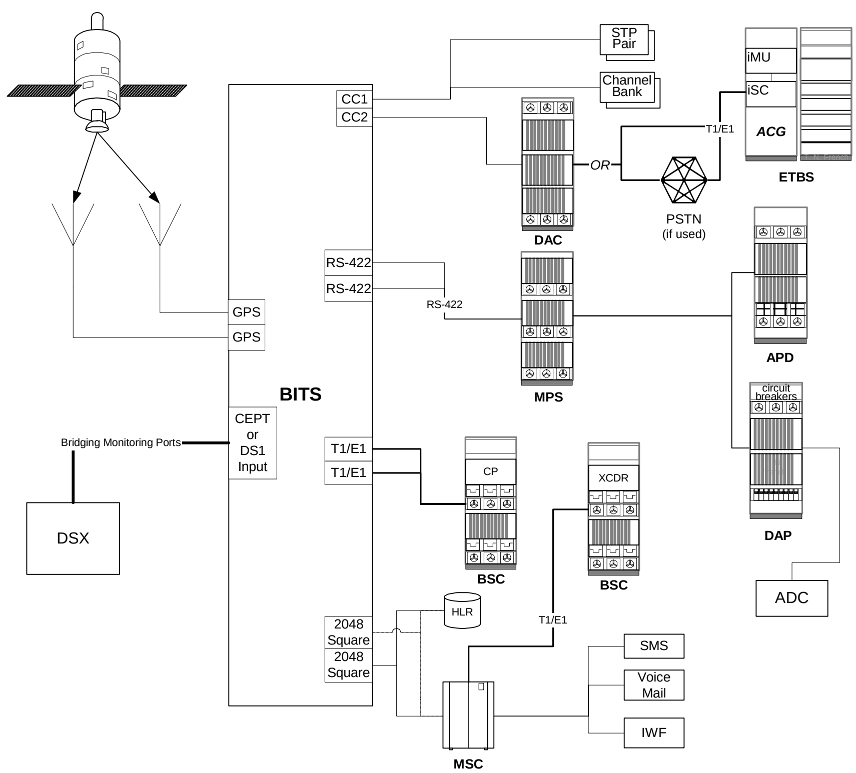
To reduce the cost and complexity network timing the iDEN system uses locally recovered timing. Locally recovered timing uses clock signals from the Global Positioning System (GPS). GPS receivers (Stratum 1 clocks) at major network elements receive a highly accurate clock pulse from the GPS system. This single source (plesiochronous) timing is used for bit-rate and frame synchronization throughout the network. The Building Integrated Timing System (BITS) performs the recovery and distribution timing across the network. This provides highly accurate timing to each network element and highly accurate synchronization. The synchronized payloads improve throughput (Figure A-2).

***Figure A-2** GPS Derived Plesiochronous Clock*



The accuracy of these sources is not less than $1x10^{-11}$ and is defined as Stratum 1, a highly accurate clock. Figure A-3 shows the recommended configuration and implementation of BITS for an installation.

***Figure A-3** Typical BITS Configuration*



Dispatch Call Model

Dispatch calls are half-duplex and tend to be brief. Some sample information used to determine a dispatch call capacity on a iDEN system is summarized in Table A-1 .

Note

Call Models vary. Call Models depend on markets and marketing strategies. The information provided is for example only.

Table A-1 Sample Dispatch Call Model

Characteristic	***Value***
Percent Dispatch Traffic (Erlang)	50%
Call Arrival Rate (per Subscriber or Dispatcher per Busy Hour)	1.2
Mean Call Hold Time	21 sec.
Mean Transmission per Call	4
Channel Hang Time	6 sec.
Server Usage per Subscriber (per Busy Hour)	0.009E
Mean Number of Servers Illuminated per Dispatch Call	3
Traffic Intensity per Subscriber (Busy Hour) (3 servers x 0.007)	0.027 E
Group Size	5 Users
Voice Activity Factor	0.35
Traffic Model Erlang	C
GOS (Grade of Service) RF Blocking	5%

Interconnect Call Model

In most cases an interconnect call will place a greater load on the system. Exchanges tend to be longer and require more resources. A typical Interconnect call models is summarized in Table A-2 .

Table A-2 Sample Interconnect Call Model

Characteristic	***Value***
Percent Interconnect Traffic (Erlang)	50%
Call Arrival Rate (per Subscriber or Dispatcher per Busy Hour)	0.6
Mean Call Hold Time	132 sec.
Mean Call Handover Rate	4/minute
Traffic Intensity per Subscriber (Busy Hour)	0.022E
Mean Number of Servers Illuminated per Interconnect Call	1
Voice Activity Factor	0.35
Traffic Model Erlang	B
GOS (Grade of Service) RF Blocking	1%

Note

Call Models vary. Call Models depend on markets and marketing strategies. The information provided is for example only.

Capacity Tables

These tables are provided as a guideline for network element capacities. Hardware and software revisions may alter these capacities. Current published capacities are available from system engineering.

■Note

Always review the latest capcities and engineering tools available on the iDEN Core Engineering website.

Table A-3 Mobile Switching Center Limitation Guidelines

Subsystem	*Users*	*Sites*	*Limiters*	*BRs*	*Comment*
MSC (U10) (XA Core) SR 7.0	220K	N/A	80% CPU usage	N/A	CPU Utilization varies with call profile. SNSE - Max of 120 LIU7s and 27 DTCs CPU is based on Traffic Profile. 106K is at 0.88 BCHA and at 10% CPU due to mobility 1 in 20 authentications at 0.12ms CA Core is 40% gain over SR7.0 Engineering Limit
MSC (10) SR 7.0	160K		86% CPU usage		
HLR (10) SR 7.0	940K	N/A	86% CPU usage	N/A	Signalling capacity should not exceed maximum capacity on the trunks (40% @ 64kbs). Subscriber limitations are based on 1 in 20 authentication a traffic profile of: 0.12 sms
HLR (09) SR 7.0			85% CPU usage		

Table A-4 Short Message Service Limitation Guidelines

Subsystem	*Users*	*Sites*	*Limiters*	*BR*	*Comment*
SMS	N/A	N/A	16 linksets 70% CPU Usage	N/A	40 messages/second with a 200 Mhz processor @ 0.2 Busy Hour Short Messages (BHSM) 16Mb of RAM for each 60K provisioned subscribers 1 SS7 trunk /40K BHSM attempts Maximum of 38.4K short messages per hour

Table A-5 Base Site Controller - Control Processor Limitation Guidelines

Subsystem	Users	Sites	Limiters	BRs	Comment
BSC-CP	N/A	33	N/A	792 (Typically < 400)	Max Erlangs - 1200 (Typically < 400) Max. No. of BRs = Maxsites*MaxBRs/site (33*24) Max of 7 loads per LCF GPROC 1 MTL = 7 Loads 1 Site = 1 load consisting of 2 RSLs (Mobis and SNMP) 1 XBL = 1 load
BSC-ECP	N/A	80	N/A	1600 (Typically < 1100)	Max of 1240 Erlangs / BSC-ECP (Typically < 800) Max of 12 loads per LCF GPROC 1 MTL = 12 Loads 1 Site = 1 load consisting of 2 RSLs (Mobis and SNMP) 1 XBL = 1 load

Table A-6 Base Site Controller - Transcoder Limitation Guidelines

Subsystem	Users	Sites	Limiters	BRs	Comment
BSC-XCDR	N/A	N/A	1008 TDMA Timeslots Number of cirucits	N/A	Max. No. of Base Radios per XCDR is not applicable Max. Erlangs - 1240 (Typically < 300) Max of 1 active KSW
EXCDR	N/A	N/A	4032 TDMA Timeslots Number of Circuits		Max of 4 active KSW (Max of 4032 TDM timeslots) Max of 1320 CICS (Typically < 900) Max of 1240 Erlangs (Typically < 800)

Table A-7 Dispatch Application Processor Limitation Guidelines

Subsystem	Users	Sites	Limiters	BRs	Comment
T-DAP - 90	90,000	1,000	65% CPU Usage*	N/A	125 Sites/SBE. Maximum No. of SBEs = 12 83 Sites/SBE Maximum No. of SBEs = 16 50 Sites/SBE Maximum No. of SBEs = 24 SBE limits are based on 4 SM configuration
T-DAP - 180	180,000	1,000			
*CPU Limits based on profile and growth rate					

Table A-8 Packet Duplicator Limitation Guidelines

Subsystem	Users	Sites	Limiters	BRs	Comment
APD	N/A	1000 (250/port)	2000 simultaneous calls		500 call/port
*Erlangs/subscriber (user) can not exceed Calls/Port limitation					

Table A-9 Metro Packet Switch Limitation Guidelines

Subsystem	Users	Sites	Limiters	BRs	Comment
MPS (lgx 32)	45	75	N/A	6 /EBTS site	75 sites @ 4DS0s/site (up to 6BRs) Icons=1000 Max./PVCs=16000 w npm64B cards SwitchModules = PD port Max No. of Cards - 32 Max. of 256mbps bandwidth
MPS (bpx)	N/A	200/SM	PD Port capacity		250 sites @ 6DS0s/site 16 MSX per BPX shelf Max. BPX b/w = 9.6Gb

Table A-10 Mobile Data Gateway Limitation Guidelines

Subsystem	Users	Sites	Limiters	BRs	Comment
MDG (SR 8.0)	15,000	500	10 call /PCH	N/A	10 Packet Data calls Maximum of 4 Frame Relay V.34 connections 1 Ethernet 10BaseT
MDG (SR 9.1)	65,000	500	411 kbps I/B 311 kbps O/B	N/A	Minimum of 2 Frame Relay V.35 connections Maximum of 4 Frame Relay V.35 connections 1 Ethernet 10BaseT I/B and O/B Call Model is based on 5 sessions/user in Busy Hr.

Table A-11 EBTS Access Control Gateway Limitation Guidelines

Subsystem	Users	Sites	Limiters	BRs	Comment
ACG (sr7.0) ACG (sr 9.1)	N/A	1	Logical 12:1 DCCH holdbacks	20 - omni 24 - 3-sector 12 with VME EBTS	$12 \times BRs - (PCCH + SCCH) \leq 127$ (sr7.0) $((BRs \times 6) - 3) + BusyQueue = 176$ (sr 9.1) Busy Queue = 35

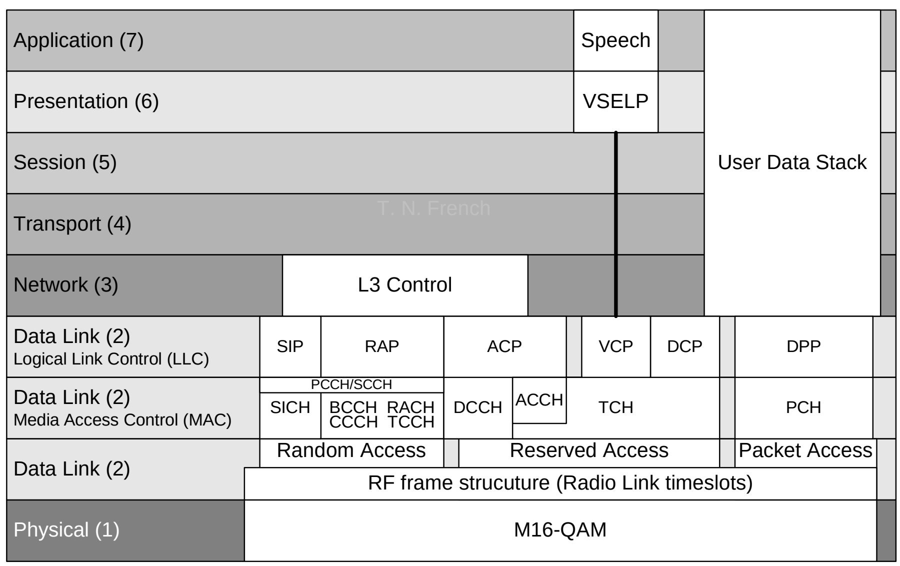
Appendix B
Radio Frequency Channel Types

This chapter describes the communications model the iDEN® system uses on the Radio Frequency portion of the system. The individual carrier uses several logical channels in relation to established international standards. The constituent parts of the model are also discussed in general terms.

Radio Link Communications Model

Various RF channel interface types are required to connect the Fixed Network Equipment o the MSs. Each channel type is utilized to perform a specific task in a specific manner of operation. This architecture is more readily visualized if it is presented as it appears in an Open Systems Interconnection (OSI) 7-layer model. Implementation of the OSI model is shown in Figure B-1.

Figure B-1 *Implementation of OSI model on the iDEN Radio Link*



Physical Layer

The physical layer of OSI refers to hardware-based encoding. The physical layer is concerned with transmitting raw bits over a communication channel. The design considerations are:

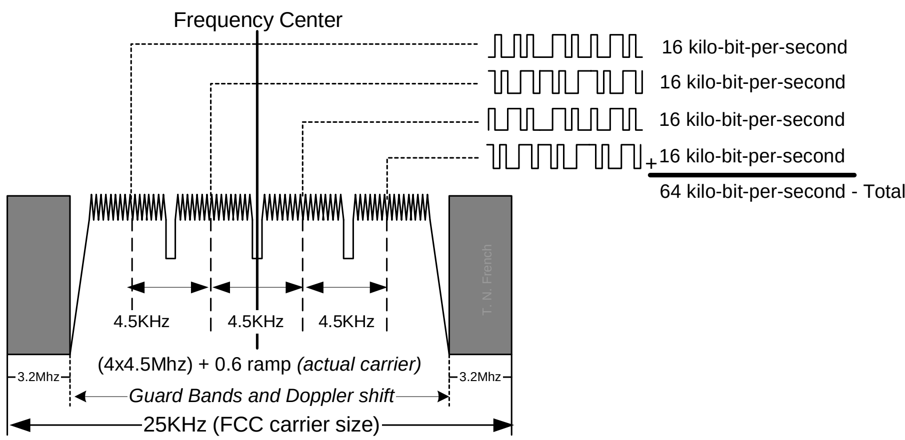
- to assure the data sent is the data received
- the amplitude frequency, time and modulation
- whether transmission is half-duplex or full-duplex
- how the initial connection is established
- how the link is torn down

The design issues here deal largely with electrical characteristics and procedures.

The over-the-air link is a combination of amplitude and phase modulation and digital encoding on a 4-sideband analog suppressed carrier wave.

The RF signal consists of four independent side bands. The center frequencies of these side bands are 4.5 KHz apart from each other (Figure B-2), and they are spaced symmetrically about a suppressed RF carrier frequency.

Figure B-2 *Logical RF Channel Sidebands*

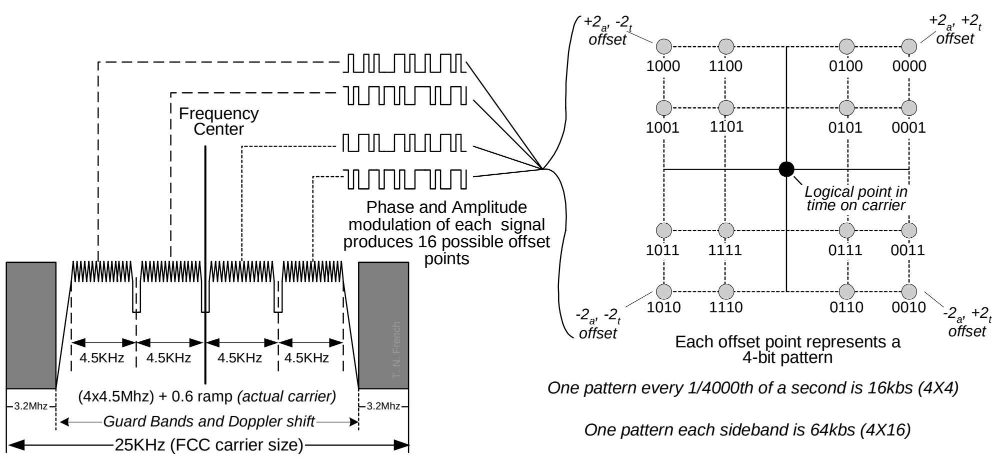


The iDEN system uses a combination of amplitude and phase modulation to identify 16 points in the radiated energy field. The Motorola 16-Quadrature Amplitude Modulation (M16-QAM) method used is a standard that:

- reduces dependency on received signal strength
- increases the number of data bits transmitted in a given time

A digitally encoded signal is applied to each sideband sub-carriers. When the signal is synchronously demodulated, a 16-point data symbol constellation is produced. Each point in the constellation represents a 4 data-bits-per-symbol. These points represent logical states (bit patterns) as shown in Figure B-3.

Figure B-3 *Quadrature Amplitude Modulation Logic Points*



The result is a digital signal that has a 64 kilo-bit-per-second (64 kps) gross radio channel bit rate. This effectively forms a 64 kbs baseband signal that is the bitstream.

Data Link Layer

The data link layer is used to create and recognize frame boundaries. The sender breaks the input data up into data frames, transmit the frames sequentially, and process the acknowledgment frames sent back by the receiver.

This layer incorporates a subset of the Motorola Implementation of A-bis (Mobis). Mobis provides the control and interactive capabilities to support the GSM A-bis radio link standards. To accomplish this, the layer is subdivided into

- Logical Link Control
- Media Access Control

Logical Link Control

Logical Link Control procedures are algorithms that operate on logical channels in the Radio Link. The procedures are summarized in Table B-1

Table B-1 Logical Link Control Contents

Logical Link Control	*Function*
Slot Information Procedure (SIP)	Runs on the Slot Information Channel (SICH) and allocates outbound point-to-multipoint timeslots without regard to confirmation or connection
Random Access Procedure (RAP)	Operates on the Primary Control Channels (PCH) and Temporary Control Channels (TCCH). Transfers short fixed-length control message units on multiple-access channels to the L3 Control of the network layer. This is used to control initial access to the Cell's Traffic Channels and Dedicated Control Channels. RAP is a multiple-access, unconfirmed, connectionless packet data protocol.
Associated Control Procedure (ACP)	Operates in the Dedicated Control Channels (DCCH) and Associated Control Channels (ACCH). It provides the point-to-point data protocol with connection-oriented and unconfirmed, connectionless radio link controls to the L3 Control of the network layer
Voice Channel Procedure (VCP)	An unconfirmed data protocol used to transport fixed-size voice VSELP-coded frames on the Traffic Channels (TCHs).
Data Channel Procedure (DCP)	Operates on the TCHs and is used to provide point-to-point, circuit-switched, unconfirmed transmission of data frames.
Data Packet Procedure (DPP)	The DPP is a packet data protocol that provides reliable connection-oriented and unconfirmed connectionless service on a multiple-access channel to the User Data stack.

Media Access Control

Media Access Control entities are logical paths in the radio link that support the control and transmission of voice and data from the 16-QAM carrier to Radio Link Protocol. These pathways are applied to one or more of the sidebands in the on-air carrier frequency. The major channel paths are described in Table B-2.

Table B-2 Medial Access Control Contents

Media Access Control	*Description*
Secondary Control Channel (SCCH)	The SCCH is an extended control path. This path is similar to the PCCH except it does not contain a BCCH. There may be up to 4 SCCHs per cell.
Primary Control Channel (PCCH)	The logical grouping of radio link channels used to control and monitor the integrity of the radio link. There is one PCCH per cell. (Assigned to radio one frequency one for each cell/sector in the system). The frequencies are provider specific and are loaded in a table on the mobile. The mobile scans this table when not in active communication to determine signal quality and receive control and short messages (SMS).
Primary Control Channel Components	
Slot Information Channel (SICH)	The SICH sends outbound Slot Descriptor Blocks (SDBs) to the SIP for allocation to Radio Link timeslots.
Broadcast Control Channel (BCCH)	The BCCH is an outbound-only path used to send MS system parameters.
Common Control Channel (CCCH)	The CCCH is an outbound-only broadcast channel used for transmission of pages, channel assignments, and similar controls.
Random Access Channel (RACH)	The RACH is the inbound-only multiple-access channel used to gain system access.
Non-Primary Control Channel components	
Temporary Control Channel (TCCH)	The TCCH provides temporary random access signaling on a channel which is normally used for reserved access.
Dedicated Control Channel (DCCH)	The DCCH is allocated to an individual MS for extended network layer control signaling procedures.
Associated Control Channel (ACCH)	The ACCH provides for supervision and control of the associated traffic channel. The added bandwidth dynamically uses the TCH.
Traffic Channel (TCH)	Provides for circuit-mode transmission of user speech and data. TCHs are reserved by individual MSs or groups of MSs.
Packet Channel (PCH)	The PCH provides for multiple-access packet-mode transmission of user data. PCHs are accessed via a Reservation-ALOHA protocol.

Network Layer

The network layer is controls how packets are routed from source to destination. Routing functions are controlled by the DAC, BSC and the DAP within the network and are not part of the Radio Link. The L3 Control portion of the link is a subset of the GSM A-bis complaint Mobis protocol. These aspects are responsible for tasks like Call Control and Mobility Management. Call Control Functions are controlled by the interaction of the MS and the EBTS.

Transport Layer

The basic function of the transport layer is to accept data from the session layer and split it up into smaller units if needed. This function is controlled by the DAC, BSC and the DAP within the network and is not part of the Radio Link.

Session Layer

The session layer allows users on different machines to login and initiate multiple applications. Since the radio link is peer-to-peer, The ability to multiplex on-air is not a requirement so the session layer does not apply to the radio link.

Presentation Layer

In the Radio Link environment, the application layer is the voice compression and decompression algorithm on the MS and the XCDR that creates the required data packets for on-air transmission. The compression algorithm used is VSELP.

Application Layer

In the iDEN system model the application layer is the Mobile transducers (speaker and microphone) and the resultant sounds that are produced or encoded.

Control Channels

Primary Control Channel

The Primary Control Channel (PCCH) is used to transfer most important call control and mobility management information between the MS and the EBTS. Each provider specifies a set of leased frequencies as primary control channels. These channels are assigned to radio-one, frequency-one of each sector. These frequencies are loaded into a table on each MS for the subscriber and are used to locate and contact the MS while it is active in the system. The MS scans the PCCH frequencies to measure signal quality and maintain contact with the system. Both Dispatch and Interconnect call processing use the PCCH to contact the MS. The MS uses the PCCH to contact the network. Registration, Mobility Management, Hails, Requests-for-Service, and Service Permissions are conducted on the PCCH. The information handled by the PCCH is summarized in Table B-3.

Table B-3 Primary Control Channel Contents

Channel	***Contents***
Inbound to MS (downlink)	
Random Access Control Channel (RACH)	Service requests from MSs
Outbound to EBTS (uplink)	
Broadcast Control Channel (BCCH)	Cell information
	Cell parameters
	Neighbor cell list and parameters
	Location area information
Common Control Channel	Paging sub-channel
	Service grants

Secondary Control Channel

Limiting factors to the capacity in a large sector or cell is control channel traffic and the ability of the Primary Control Channel (PCCH) to handle system messages. During Dispatch calling only, when the capacity of a site is increased, the number of messages per control channel may become high enough to require additional control channels. The Secondary Control Channel (SCCH) is allocated one or more timeslots on any Base Radio. Secondary Control Channels are configured on a per cell basis. There may be 0-4 SCCHs per cell. A SCCH is similar to the PCCH, but it does not contain the mobility management information of the BCCH (Table B-4).

Table B-4 Secondary Control Channel Contents

Channel	***Contents***
Inbound to MS (downlink)	
Random Access Control Channel (RACH)	Service requests from MSs
Outbound to EBTS (uplink)	
Common Control Channel	Paging sub-channel
	Service grants

Temporary Control Channel

The Temporary Control Channel is used in mobility management and the interconnect handover process. This channel is used as required to transfer information concerning dynamic frequency allocation and EBTS service parameters. This information is summarized in Table B-5.

Table B-5 Temporary Control Channel Contents

Channel	*Contents*
Inbound (downlink)	Channel reassignment requests
	handover and assignment confirmation
Outbound (uplink)	Handover identification
	Handover confirmation

Dedicated Control Channel

The Dedicated Control Channel is used to maintain constant control contact with the mobile. Parameters passed on this channel are summarized in Table B-6.

Table B-6 Dedicated Control Channel Contents

Channel	*Contents*
Inbound (downlink)	Extended call control
	Location updates
	Authentication
	MS acknowledge
Outbound (uplink)	Extended call control
	Authentication
	SMS data

Traffic Channels

Traffic Channel

The Traffic Channel is used to transfer voice and data between the MS and the EBTS. The Traffic Channel (TCH) is used in both dispatch and interconnect call processing. Voice is carried on the TCH in VSELP compressed. VSELP data and error correction do not require the entire timeslot (Figure B-4). This allows control data to be sent on the TCH as required (Associated Control Channel). The contents of the TCH are summarized in Table B-7.

Table B-7 Traffic Channel Contents

Channel	*Contents*
Inbound (downlink)	Compressed voice packets
	Data packets
Outbound (uplink)	Compressed voice packets
	Data packets

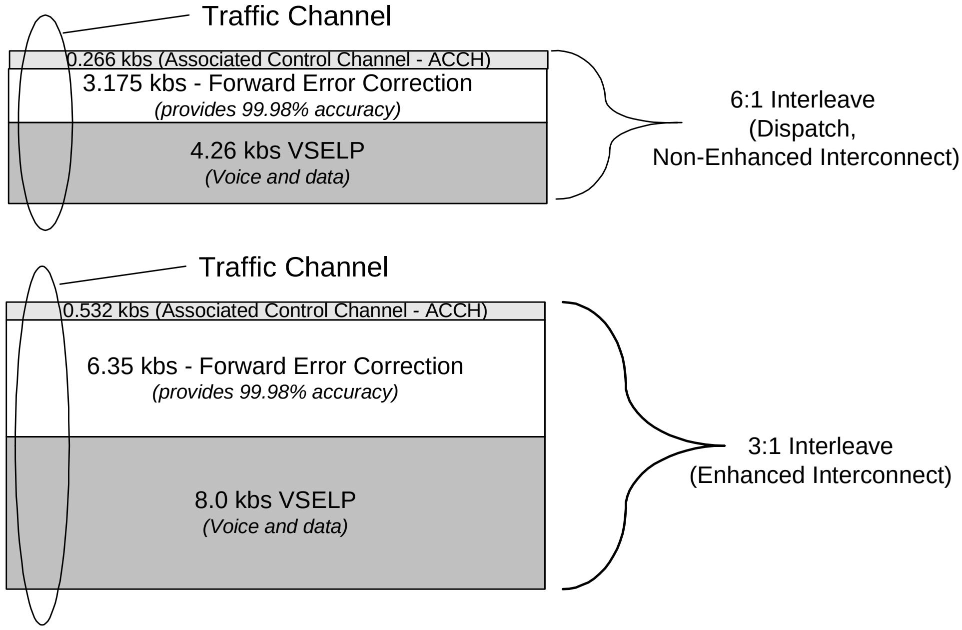
Associated Control Channel

The Associated Control Channel is for Interconnect Calls only and is sub-set of the Traffic Channel and is used to pass radio link status, handover, and control information. Short Message Service Data is also sent on the ACH when an MS is busy (DCCH when idle). Since the TCH does not require the full data stream of the TDMA timeslots, a small portion of the timeslot may contain bits of data that are used to manage the communications during a call (Figure B-4). The passed parameters are summarized in Table B-8.

Table B-8 Associated Control Channel Contents

Channel	***Contents***
Inbound (downlink)	Handover requests
	metrics (measurement reports)
	call control (handover commands)
	SMS acknowledge
Outbound (uplink)	Handover target cell
	call control (handover commands)
	SMS data

Figure B-4 *Elements of the Traffic Channel*



Unassigned Channel

When a timeslot on a carrier becomes available, or is reassigned as unused by the system, it is designated as an Unassigned Channel (UCH). The UCH is a data stream from the system that the MS recognizes as something to avoid. When the UCH data stream is detected, the MS will re-synchronize or re-tune to reestablish contact. By avoiding the UCH, the MS can more easily attach to the correct carrier and timeslot and does not attempt to communicate on channels that may be re-assigned.

Appendix C
Services and Features

Calling Features

Operational Controls

Item	Description
North American Dial Plan	The North American Dialing Plan is a 10-digit number format that consists of three elements, The NPA element (Area Code), the NXX element (prefix) and the XXXX element. It is often written as NPA-NXX+XXXX. • The NPA, defines a geographic area within a operating company's service area. • The NXX defines a CO or MSO. • The last four digits (XXXX) defines a specific user. Within an Area Code only seven digits (NXX+XXXX) are needed to complete the call. If the first digit in the sequence is not a 1, the local Area Code is assumed. Though not mandated by law conflicts are avoided by not assigning the local NPA as an NXX to an exchange or service within that NPA. **International Dialing Arrangements** The MSC and HLR support all dialing plans currently in use throughout the world. A system routing table is used to translate between the different dialing arrangements. **Maximum Outpulsing Digits on MF Trunk** The iDEN system supports both the ANSI Multi-Frequency and ISUP outpulse standards to support international calling. For an ANSI MF trunk the maximum outpulsed digits is 24. In ISUP and ESTI MF trunks the maximum number is 15.
Alternate Routing	Alternate Routing allows the system to sequentially scan multiple trunk groups for an idle trunk to be used to complete the call. Alternate routing allows dialed digits to be modified to comply with the requirements imposed by the point-of-penetration into the PSTN networks. When no idle trunk is found, the system terminates the call as determined by the MSCs Call Treatment.
Roaming Restrictions	Roaming restrictions enable the service provider to impose roaming constraints. Three classes of roaming restrictions can be implemented. • No restrictions — permits roaming to all linked iDEN® networks. • National roaming — prevents the subscriber from roaming outside the home PLMN country. • Local roaming — prevents the subscriber from roaming outside the home PLMN. All these functions assume that unique PLMNs exist.

Item	Description
MF Support for PSTN	Provides MF trunk interworking with PSTNs for MS originated and MS terminated calls.
SS7 Signalling	The iDEN system supports Standard ANSI SS7 ISUP signaling, as described in the TR-NWT-000317 specification. ANSI SS7 ISUP signalling to the PSTN can only be provided if the PSTN switch can support SS7. Separate integration of SS7 connectivity to PSTN may be required.
Overdial (DTMF)	The iDEN system supports Dual-Tone-Multi-Frequency (DTMF) to allow dialed digits to be sent between Customer Provided (CP) equipment and Central Office (CO) equipment. DTMF is an unidirectional two-of-seven, in-band, tone-signaling transport protocol.
Intra-System Mobility	The MSC tracks the location of all active MSs and uses this information to locate and deliver calls. The MS is located by an Interconnect Location Area (ILA). A Location Area is a logical a group of cells that may interact with the MS. ILA updates occur when an MS moves from one ILA to another. This triggers an LAI request (Location Area Identity) update. The location update is stored in the MSC-VLR.
Intra-System Roaming (Between Two MSCs on the Same Network)	The ability to travel freely throughout the single service area and originate or receive calls without regard to its current location can be extended to allow MSs to travel from one service area to another. The MS identifies itself to the network on power up. When the MS roams, the power up sequence causes the visited MSC to accesses the MS' home HLR. Authentication and service information is sent to the VLR of the visited MSC. Once the MS is authenticated the MS can originate calls on the visited MSC. When a landline call is received at the home MSC, the home HLR identifies the visited VLR as the last known location of the MS. The home MSC routes the call to the visited MSC to complete the call. If the MS de-registers in the visited MSC the call will not be deliverable and terminates. For the first call to, or from, a visiting MS, the visited VLR assigns a Temporary Mobile Subscriber Identification (TMSI) to the MS and assigns the TMSI to ILA changes. The MS uses a TMSI for subsequent calls. The home HLR assumes the MS to be in the visited area until another VLR updates the HLR.
Inter-MSC Handover	Inter-MSC Handover occurs when a user moves from one MSC service area to the service area of another MSC. A land-line connection is established between the MSCs and the radio resource is switched to the BSC on the visited MSC. The original MSC maintains the PSTN to MSC connection and only the RF is handed to the visited MSC. The anchor MSCs will always stay in the call, even if the MS both handover to other MSCs or the same MSC.
Service Screening	Subscriber services information can be blocked from another service provider's VLR. Service Screening prevents an MS from using selected services when roaming. Service screening prevents forwarding incompatible services or restricts services

System Services

Item	Description
Short Message Service (SMS)	SMS delivers short messages of up to 140 characters to an MS. This requires the Short Message Service Center (SMS-SC) and software to the MSC to interface and interwork with the SMS-SC. The SMS stores and forwards messages to MSs. If the messages cannot be delivered, the SMS-SC stores them for future delivery.
Voice Mail Interface	Voice Mail allows otherwise interminable calls to be routed to a Voice Mail system. Voice Mail Messages are recoverable from either an MS or a Landline telephone. Two interfaces provide connectivity between the MSC and the Voice Mail system. Regular voice trunks provide the audio connection. Selection and setup of the voice trunk route that the redirected call will use is performed by the SS7. This interface conforms with ANSI SS7 ISUP in accordance with the Bellcore TR-NWT-000317 specification.
Data Services	System Data Services uses IWF to support: • Group 3 FAX • asynchronous data The MSC contains call control and routing functions for data and FAX services Non-Transparent Async Data and Non-Transparent FAX are not supported IWF requires the purchase of IWF hardware and software. The MSC software to support IWF functionality must be purchased as part of the IWF Hardware package.
Information Services	Mobile originated, 10-digit, 900 number calls (900+NXX+XXXX) will be translated and routed to the PSTN like any other 10-digit number. No special translation handling is needed. Also, no special treatment is needed. Air time and 900 Service Charges are applied like any other call.
Routing to PSTN Operator	The iDEN system will route various type calls to a trunk terminating to a PSTN operator (0+ and 0- calls) through standard translations. The MSC does not support operators (Does not have Mobile Operator Position System (MOPS) capability.)
Emergency Call Enhancements	The iDEN system assures that the Location Area Code (LAC) and cell identification are used to properly route an emergency call to the nearest service center
MSID for Emergency Calls	Allows the operator to trace prank Emergency Callers by providing the capability for the GCDR records to identify the caller using the mobile station ID. This applies to an MS making Type I Emergency calls. It allows billing records generated by Emergency Calls may be routed to the HOT Billing Stream (if available) or the GSM Call Detail Record (GCDR) stream.
E-911 Phase One Enhancements	The iDEN system provides compliance with Phase I of the FCC's requirement for E911 calls by introducing support for transmission of an emergency callers callback number and location (by cell site) to a Public Safety Assistance Provider (PSAP).

User Control Services

Item	Description
Class-of-Service	The MSC/HLR allows users to be grouped based on the Class-of-Service (COS) groups. Network Class-of-Service (NCOS) allows additional differentiation within each customer group. There are a maximum of 256 NCOS per subscriber group that can define the originating and terminating restrictions on a MS. The combination of COS and NCOS allows the service provider to manage the type of customer services such as barring of 900 calls and abbreviated dialing.
Closed User Group	This feature allows service providers to customize calling privileges among user groups. If a business owner desires to restrict telephone usage the providers can customize calling privileges by: • Call Origination/Termination • to/from the PSTN • to/from other CUG members • to/from the PSTN / PLMN
Call Restrictions	The most common call restrictions requested by service provider are Barring Incoming Calls, Barring Outgoing Calls, Barring Of Outgoing International Calls, Local Calls Only and Class Of Service.
Incoming Calls Only	Barring All Outgoing Calls (BAOC) denies outgoing calls by subscriber. Emergency calls (911) are not barred.
Local Calls Only	A user may be restricted to calls within a defined local area using allowed and or denied NXXs tables. This feature does not interact with Call Forwarding.
Call Barring Outgoing International Calls	Barring All Outgoing International Calls (BAOIC) denies outgoing calls to international numbers.
Source Directed Routing	Source Directed Routing will direct mobile originated calls from one or more cells to predetermined destinations based on Translation Table in the MSC.
Least Cost (Time of Day) Routing	Time of Day (TOD) Routing enables or disables trunks, trunk groups, and trunk routes based on a time of day scheduling. Schedules may be day of week, day of year, weekends and statuary holiday requirements. This provides 16 time rages for changeovers. Results can be defined for any day, or set of days on a weekly basis, or for any specific day of the year.
Connecting Comfort Tone and Call Forwarding Announcement	A comfort tone is sent to the calling party while the MS is being paged. The tone is a recorded announcement. Typically a pip tone is used.
Comfort Tone on Hold	Comfort Tone on Hold allows service providers to record a custom announcement that is sent when the calling party is on hold. When an MS places a call on hold, the announcement is played, reassuring the calling party that their call is still in process.

User Services

Item	Description
Account Codes	An Account Codes is dialed after a phone number by the end user. The code associates that particular call with an activity or account. For example, a user could dial a number followed by a 1111 to code a business call. Account Codes create a new field in the Call Detail Record and must be coordinated with any downstream billing processor. This allows the subscribers to use the phones for business and personal reasons.
Forwarding Number COS Validation	The PNP (Private Number Plan) enables an MS to use a form of abbreviated or extended dialing when making calls to another MS in the same PNP. This allows an MS to input forwarded-to-numbers in the same format as their PNP. The forwarded-to-numbers received by the HLR are translated to a common format and stored.
Call Waiting	Call Waiting transmits an interrupt tone to a MS involved in a active call to notify the user of another incoming call.
Call Forwarding (Unconditional)	Call Forwarding - Unconditional, overrides other versions of call forwarding without regard for other termination activated for the MS. This allows the subscriber to have the network divert all incoming calls to another number. Call Forwarding can be activated by the service provider or the subscriber from the MS.
No Answer Transfer (Not Available)	Call forwarding - Not Available, also called “No Reach”, will forward calls when the MS does not answer the page. The call is forwarded to the specified number. All incoming calls that meet the Call Forwarding condition are forwarded. The user can still originate calls
No Answer Transfer (no Reply)	Call Forwarding - No Reply occurs when the MS is available but the user chooses not to answer the call. All incoming calls that meet the Call Forwarding condition are forwarded. The user can still originate calls
Busy Transfer	Busy transfer forwards an incoming call to another directory number when the user is engaged in an active call. The user call still originate calls.
Call Hold	Call Hold allows the user to place an active call on hold and originate another call, retrieve a currently holding call or answer a call being held in the Call Waiting mode.
Three Party Calling	Three Party Calling provides an MS the ability to have simultaneous communication with two parties. The user can create a three way conference or alternate between the two connections. However, once a conference connection is established it cannot revert to a split connection. A precondition is that the MS must remain in the call. If the MS attempts to drop out of the conference connection, all connections drop.

Switch-based Data Collection

Item	Description
Traffic Data (Operational Measurements)	The MSC provides the ability to collect and maintain metrics on the traffic on the system. These metrics are defined in the appropriate software release documentation. The appropriate documentation is provided by the MSC manufacturer.
GSM Call Detail Records (GCDR)	The MSC collects a full set of call record information. Call Detail Records (CDRs) can be handled in two ways: • 9-track tape with all Call Detail Records for a given period to the customer provided Billing Vendor. • File Transfer Access Method (FTAM) protocol directly to the Billing System in a real time format. Direct transfer requires activation of the Near Real Time Billing software on the MSC and the inclusion of the optional Billing Server platform.
Call Handling Measurements	This feature introduces the following operational enhancements to assist network operations: Average Call Setup time for voice and data calls, Average Holding time for voice and data calls, attempted and successful Authentication Procedures in the MSC-VLR, and attempted and successful Mobile Terminated Short Messages.
Handover Operational Measurements (OMs)	This feature introduces several new operational measurements to better track MS handover statistics, including: Handoff Causes Uplink / Downlink strength Uplink / Downlink Quality Distance OMC intervention Better Cell MSC Invocation Unsuccessful Handovers (dropped call or old cell reconnect)

Network Administrative Features

Item	Description
Near Real Time Billing	Near Real Time data transfer allows billing records to be sent to the billing center as soon as the records are format and written to disk. Take care when setting the download interval. If the interval is too short the MSC call processing is adversely impacted. This allows quicker billing generation than batch processing of tapes. Optional Billing Server Platform equipment and software is required.
Trunk Information in MO and MT Records	The incoming and outgoing trunks to the PSTN are provided in the main structure of the billing record.
Gateway Billing Records	Two records are produced by this feature. The incoming Gateway call attempt record is generated for each incoming call received by a gateway MSC based on route group number. These records, produced in the gateway MSC, are used to settle accounts with other networks. The outgoing Gateway call attempt record is generated for each outgoing call from a Gateway MSC to another network. These records, also produced in the Gateway MSC, are used to settle accounts with other networks.
Intra PLMN Billing Records	Two records are produced. An incoming intra-PLMN record is produced when an MSC receives an incoming trunk call request within the PLMN. This record lets a service provider know when the MSC was involved in a mobile terminated call regardless of how it was involved. Since it is intra-PLMN, all calls within the network will produce this record. An outgoing intra-PLMN billing record is produced when an MSC routes a trunk call within the same network. This record lets service provider know trunk usage information when a call is routed to an MSC within the same PLMN.
Transit Billing Record	This record is produced when an outgoing call attempt received by an MSC is to be routed to a service center such as voice mail system or service provider services.
Roaming Billing Record	This record is produced when a mobile terminated call is going to a subscriber that is not in its home MSC. The record is generated in the Gateway MSC associated with the subscriber. Records for mobile originations under this scenario are not supported

NOTES

Appendix D
Handover

With a mobile system the ability to locate track and re-route voice and data packets between host cell sites is essential. This section describes the geographic terms and the logistics when an MS unit moves from one area to another. Specifics of the nature of the radio link are discussed in greater detail in *iDEN® RF Planning Guide*.

General

To support voice and data communications the iDEN system is organized into different geographical areas:

- Region
- Domain
- Service Area
- Location Area
- Cell

Movement between regions is determined by the provider and roaming agreements. Software Release 8.0 allows dispatch calling between regions. The ability to call outside the region is in the HLR of the MSC and the DAP for transmission to the remote VLR. The ability to place calls is contained in the HLR and VLR databases. Roaming agreements allow exchange of this information between service providers.

Movement between domains and service areas is also set in the HLR and VLR databases. The ability to make calls is restricted by the data in the HLR database.

The process of determining a handover between regions. domains, and service areas is the same for that of a location area.

Mobility Management

Mobility Management is a set of coordinated, automatic procedures between MS and the FNE equipment that allows the MS to move between sites and to roam from one iDEN system to another or to another provider's system. Each Mobile Station, the home service area and the subscriber services are assigned in and on a Home Location Register (HLR).

Dispatch call takes place within and between linked iDEN systems. Linked systems require Software Release 8.0 to fully coordinate dispatch calling between linked iDEN systems. The mobility management allows a service provider to be identified on multiple iDEN systems. If provided as a subscription service it allows the user's MS to automatically identify and obtain service with a roaming partner.

To provide automatic roaming with validation across multiple service providers' networks, one iDEN system may be connected to other iDEN systems using CCITT SS7 MAP interfaces. These connected systems can be owned and operated by the same or different service providers. When connected, the HLR will also co-ordinate the tracking of the MS when it roams to another connected system.

Mobility Management Procedures

To control and manage the movement and communication there are five basic principles. The principles are:

- MS Tracking
- MS Trolling
- MS Authentication
- Location Request Control
- Home Neighbor Network Search

MS Tracking

To contact a mobile (MS) the system must know the general location of the mobile. MS tracking relates to the location and following of a mobile (MS) within the system. The iDEN system MSs report any significant change in their location to the FNE. As the mobile moves within the system the FNE broadcasts:

- Location Area information from each site
- The identifying number of the iDEN System
- The identifying number of the service provider
- The neighbor cell site list

The Location Areas define the geographical area that is considered a significant change in location. By monitoring the broadcast information, the MS can determine:

- When it needs to report its location
- The frequencies (radio channels) used in the neighboring sites
- If the mobile is in the Home system or roaming
- The service provider

MS Trolling

Trolling refers to the ability of the MS to determine the correct control channel to monitor and maintain contact with the system. When the mobile is powered-ON, it scans a pre-programmed list of potential control frequencies. The best signal is determined, then the mobile registers on the system using that control channel of the hosting cell. Once registered, the mobile receives the neighbor cell list and neighbor cell control channel frequencies on the hosting cell's broadcast control channel. When operating on its Home system, the mobile monitors only the control channels assigned by the current neighbor cell list.

MS Authentication

At any time while active, the MS may be authenticated (challenged to provide proof of identity). This is done in association with other activities for convenience and the process is designed so that monitoring the transaction over the air does not allow another mobile to subsequently mimic the authenticated MS. This is discussed in greater detail in call processing.

Location Request Control

The Location Request Control procedure is used to avoid the unnecessary use of channel resources and unnecessary control messages. reporting location changes is primarily the responsibility of the MS. While in range and active, the MS will update the location area in the FNE VLRs.

If the MS exists on the system and is not found in the last know location it may be in partnered systems, the FNE monitors activity of the MS to detect when this has likely to have occurred. When the FNE has determined that the MS may no longer be in its last reported location, the FNE precedes further calls with a Location Request. A channel is only allocated when at least one target MS present on the site.

The FNE will stop sending Location Requests (control message traffic) after a long period of inactivity. This timer is matched to an MS timer which requires the MS to report its location periodically (i.e. at least once a day).

Home Neighbor Network Search

In cases where a user's operating area(s) are covered by more than one iDEN networks or roaming partner network, the preferred system is the home system. Home Neighbor Network Search (HNNS) is used to define and prioritized the home system as the primary serving system

Currently, an iDEN system will only support dispatch services while outside their own network when both networks are using Software Release 8.0 and roaming agreements exists.

When networks overlap, users prefer to re-attach to their home network for dispatch services as quickly as possible. HNNS allows movement between networks with a return to the home network for dispatch services as soon as coverage is available.

This is only available on i600 Galaxy (or newer) Mobile Stations with HNNS compatible subscriber code(s). This is accomplished by a reselect in Radio Link control.

Each cell in an overlap area may contain one or more cells of another dispatch network in the neighbor cell list (home network neighbors). If the candidate cell's Regional Network Code (RNC) matches the home RNC on the user's mobile, the mobile will reselect to the cell in the "home system" and dispatch service will be restored.

Location Handover

All functional operations of the iDEN system locate the mobile station (MS) by analyzing the radio link integrity. When a mobile is powered-ON it receives signals from all EBTSs in range. It also transmits a Request for Service. The MS and the EBTSs in range monitor and analyze the radio link. All EBTSs in range form a location identifier that is sent to VLRs in the MSC and the DAP.

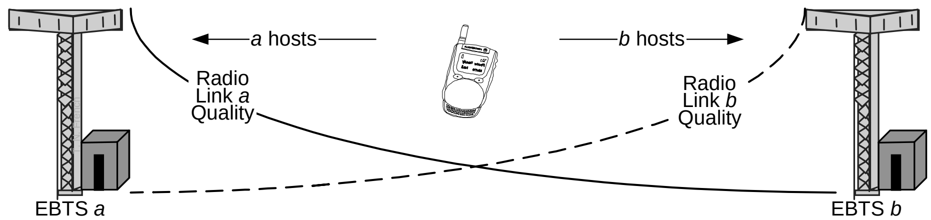
Hosting Cell

During the request for service, the radio link is analyzed using the Received Signal Strength Indication (RSSI) and a Signal Quality Estimate (SQE) The SQE is a ratio of the energy of the carrier to the energy level of both the interference and the noise.

$$SQE = C \div (I + N)$$

These factors are used define the EBTS with the best radio link is designated as the host and is used to handle all control and traffic.data between FNE and the MS. The signal strength relationship is diagrammed in Figure D-1

Figure D-1 *Simplified Radio Link Characteristics*



General Guidelines for SQE and signal strength are summarized in Table

Table D-1 Signal Quality Guidelines

6:1 interleave dispatch and 3:1 interleave interconnect		
C/(I+N)	Dispatch	Interconnect
18dB	Good	Fair
20dB	Good	Good
22dB	Very Good	Very Good
Minimum recommendation: 18dB over 90% of cell coverage area 20dB preferred		
6:1 interleave dispatch and 6:1 interleave interconnect		
C/(I+N)	Dispatch	Interconnect
18dB	Good	Marginal
21dB	Good	Fair
25dB	Very Good	Good
Minimum 20db in cell coverage area		

Reliability

The reliability of the radio link in the iDEN system considers three broad categories.

- Contour
- Area
- System

Contour Reliability

Contour reliability relates to the ability to maintain and control the radio link within the propagation pattern of a cell. Anywhere in the pattern if 100 calls are made with 10 failures the contour has a 90% reliability. Within limits, the radio link quality is to be better closer to the cell site.

Area Reliably

An Area reliability uses the location concept. Since more than one cell may have a sound link, the ability to maintain a call is improved when more that one radio path is available. Generally, area reliabilities are higher than contour reliabilities. If the average of reliabilities in a total coverage are 90% (contour reliablities). The area reliability will typically be about 97%.

System

The system reliability can be calculated by finding the average or the mean of all the area and/or contour reliabilities

Fading

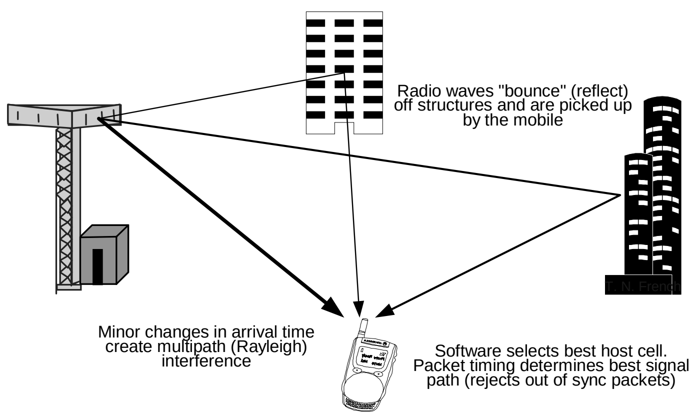
Fading is the reduction of radio link quality based on distance for the source (antenna). This may involve multiple sources, bounced signals, and normal dissipation over distance. The types are:

- Small Scale
- Medium Scale
- Large Scale

Small Scale

Small Scale fading and interference relates to the distribution of the radio link by other signals carrying similar information. The units of measure used in small scale are in orders of magnitude of the wavelength in the signal envelope. The arrival of a multipath signal that is exactly ½ a wavelength out of sync cancel the reception of that signal data bit. This typically involves bounced signals or multipath interference (Rayleigh distribution). This is diagrammed in Figure D-2

***Figure D-2** Multipath Interference*



Typically an signal must be 2dB stronger than normal analog RF.

For a non-moving mobile this requires 10dB difference (9db for enhanced systems) at 10% Bit Error Ratio **(**BER) (Error bits/total bits.)

With a moving mobile the difference is to 19db (18db enhanced) at 4% BER.

The difference in the arrival time of received packets determine the MSs ability to use the packet. The packets are synchronized with the GPS timing reference and requires the packets arrive within a 10-12 microseconds (10-12 µs) time window. Other packets are rejected. There is a maximum round trip delay of 0.75 microseconds (one-way about 69.75 miles) if other parameters can be maintained

Medium Scale

Medium scale fading relates to cross-frequency rejection. Signals of other frequencies (noise) may have arrival times the increase or cancel the amplitude of the signal. The unit of measure of this type is generally on the order of tens of wavelengths. This type of interference is typically 8 dB (nominal for GSM). The average power typically follows lognormal distribution.

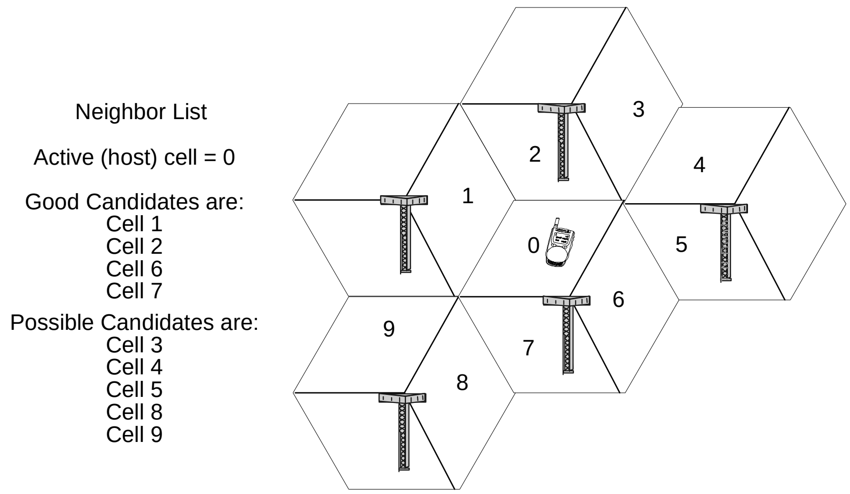
Large Scale

Large scale fading relates to general energy dissipation of distance. The units of measure or in the order of miles. The median average power typically varies in Power-law fashion with path length (the further away the less powerful the signal).

Neighbor Cell List

The Neighbor Cell List is specific to each cell (sector or omni). The neighbor list is a set of logical numbers assigned to other cells that indicate potential handover candidates. The list identifies cells that are adjacent or close enough to take over control of the voice and data communication between the MS and the EBTS as the mobile moves around the network (Figure D-3). The MS uses the broadcast channel to scan the Neighbor Cell List and uses the radio link quality to select a “new” host cell. This is based on radio link quality (SQE and RSSI), and operator (software) set parameters. This assures the best possible radio link quality on a real-time basis.

Figure D-3 *Logical Neighbor Cell Listings*



Handover Measurements

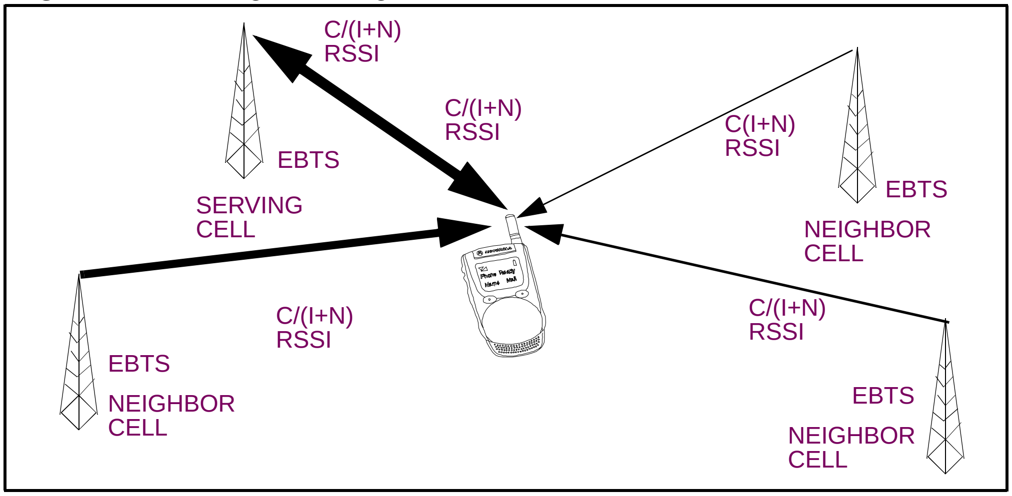
The measurements use to determine radio link quality are listed in Table D-2 and Figure D-4

Table D-2 Handover Measurements

	Host Cells	***Neighbor Cells***	***Idle Servers***
Mobile Station	Signal Quality Estimate (SQE) [C/(I + N)] Color Code Received Signal Strength Indication (RSSI)	SQE [C/(I + N)] Color Code RSSI	
Base Transceiver	SQE [C/(I + N)] Color Code RSSI		Interference + Noise (I + N)

Measurement inquiries may be either mobile or FNE initiated. When the Bit-Error-Rate approaches or exceeds preset limits, the radio link is re-evaluated to assure optimum performance. These inquiries are very fast and are transparent to the user.

Figure D-4 *Serving and Neighbor Cell Measurements*



Handover Operation

Dispatch Calls

During dispatch calling, the reconnect and hosting cell procedures are used to determine the EBTS the should host (serve) the call. The Host (serving) cell selection process is used to re-select and re-connect between serving cell. The short authentication setup time allows the FNE to redirect calls between cells dynamically. The FNE involved in dispatch is the MPS and the DAP. The basic procedure is:

1) MS determines need and identifies potential neighbors

2) MS sends signal measurements to the FNE

3) DAP/D-VLR finds new host (EBTS) and re-assigns traffic to the EBTS

4) MS re-tunes to the new host (EBTS) channel

5) Channel changed to Traffic channel (TCH) and talk continues

Because Dispatch Calling does not have a lot of signalling and call setup communication needs, dispatch does not technically handover. The process is a constant process of selection, authentication, and re-selection.

Interconnect Calls

The Interconnect handover process from Host to candidate is based on an exchange of information about the radio link quality across the radio link control channel(s). The FNE involved are the MSC/BSC. The basic procedure (Figure D-5) is:

1) MS determines need and identifies potential neighbors

1) MS signals on associated control channel with measurements

2) FNE - EBTS finds new host and allocates it as Temporary Control Channel

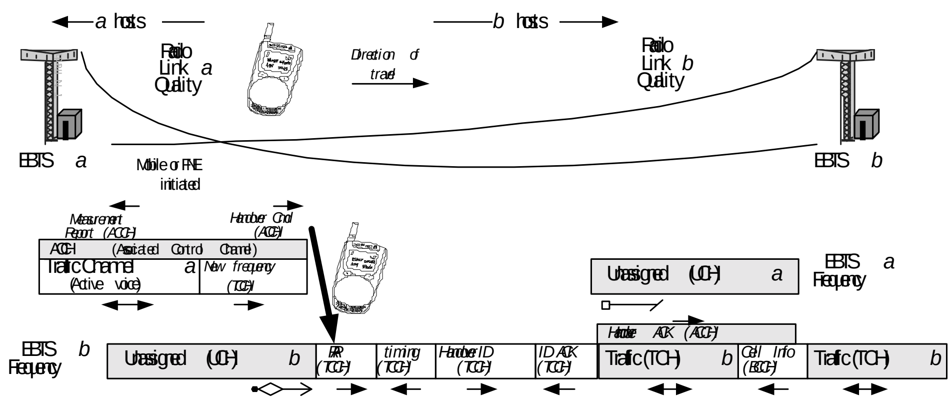
3) FNE - EBTS sends handover and power setting on associated control channel

4) MS changes to assigned channel

5) MS uses the Random Access Procedure (RAP) to get timing information

6) Channel changed to Traffic channel (TCH) and talk continues

Figure D-5 *Handover*



Handover System Defaults

Handover is a coordinated effort between the FNE and the mobile. System and mobile software continuously monitors Cell-information on Broadcast Control Channel (BCCH). This process is driven by over-the-air (radio link) parameters. The MS continuously measures parameters during call. The parameters are:

- SQE = C/(I+N)
- RSSI
- Primary host channel (every 90 ms)
- One non-host channel (every 90 ms)

The process samples neighbor list candidates (Ideally, 7 samples on 3 channels). Less ideal could use 3 samples on 5 channels. When MS detects trouble on the host, or a better neighbor cell:

- The MS sends signal measurement samples to the FNE
- The FNE evaluates potential servers
- The FNE assigns new host
- The MS switches to new host

■Note

Interference in handover activity is not part of normal handover calculations. If interference affects another mobile after handover, the affected mobile will in turn, undergo handover. Load Balancing is not part of the handover algorithm.

High Site / Low Site

The iDEN system selects hosts according to the type of call being made. Interconnect calls require more system resources and must maintain a better RF link (operates better on low sites). Dispatch call do not require as many system resources and can operate in less restrictive RF environments (operates on high sites).

Each cell broadcasts a neighbor cell list that specifies the host candidates the MS should measure for cell re-selection, handover and re-connection. Each entry in the neighbor cell list contains three class values:

- Reselection class
- Handover class
- Reconnection class

Each of these classes has a hierarchy (preference) of each neighbor cell. Each of these class values is software configurable at the OMC. By properly setting up these parameters, MS will operate on either a high site or a low site to provide best performance and optimize system resources (RF channels), for example:

1) The MS tends to stay with (camp-on) and conduct calls with the high site cells (for more efficient operation of dispatch calls).

2) The MS tends to use the low site cells on interconnect calls (for better utilization of RF hosts). (The MS will use a high site cell if that was the only way to keep the call alive.)

■**Note**

An important limitation of this approach is the size of the high site cells. A high site cell must list all low site cells in its neighbor cell list. If the high site cell's coverage area includes many low site cells, the neighbor cell list might become too lengthy. A long neighbor cell list will increase the time required to read the BCCH information and increase the chance of a dropped or lost call.

Coverage

The prediction of coverage and comparison of coverage to other RF systems is beyond the scope of this document. However, the current offering of Base and Subscriber equipment is designed to allow for operations similar to that provided by common digital cellular systems. The iDEN system utilizes:

- Base receive antenna diversity (multiple /branched antennas)
- Low noise receiver multi-couplers to merge base radio output to the antennas
- Optional state-of-the-art tower mounted pre-amplifiers

This helps maximize the base receive performance and balance the radio link power.

Base transmitters are available providing an average power output of:

- 5-70 Watts (800 MHz)
- 2-40 Watts (800 MHz and 1.5 GHz)
- 5-60 Watts (900 MHz)

Either cavity or hybrid transmitter combiners are then used appropriately to combine multiple transmit signals on common antennas. The Mobile Stations also use low noise receiver components and state-of-the-art linear amplifiers.

Dropped Calls

There are many factors and reasons why a call my be lost (dropped) prematurely. The principle reasons for dropped calls are: inadequate and/or inaccurate handover parameter measurement

- Inadequate coverage and/or uncontrolled interference
- No adequate server available in time (blocking)
- Signalling failure
- Processing failure

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