ISDN Wide Area Network Design

Dry Creek Joint Elementary School District

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Organization Overview
The Dry Creek Joint Elementary School District is recognized as the fastest growing school district in the state of California. To maintain continuity of service with student increases averaging 47% for the last two years, the district has embarked on an aggressive use of technology. This has included the design and implementation of local area networks for each of its three school sites, all connected to the district office through a wide area network.

Business Need
Historically, the Dry Creek Joint Elementary School District has been a small single-school district. It was established in 1876 and maintained a stable population of between 100 and 200 students for most of its first 100 years of existence. Around 1988, significant residential development occurred within the district, and the student population began to increase by 400 to 600 per year. The current enrollment is almost 2,300 students.

With this rapid increase in student enrollment, the district constructed two new state-of-the-art elementary schools, which include the necessary information infrastructure to provide for computers in the classroom, integrated computer labs, integration of computers in libraries, cable television in each instructional area, telephones in each of the classrooms, and office spaces for teachers. Dry Creek has implemented year-round educational programs in all three schools.

To provide for the exchange of administrative and instructional information, the three school locations require connection with the district office. In partnership with Hewlett-Packard, the district has selected a two-phased strategy using extended local area network (LAN) technology. Phase I implements access to student administrative applications, electronic mail, and other office automation applications for a core of trained administrators and clerical staff.

During the 1993-94 school year, the district will begin phase II by designing and implementing an integrated instructional computer network tying all school instructional areas together in a wide area network with access to external resources such as the Internet.

Applications
Dry Creek's enterprise network must support office automation applications such as electronic mail, word processing, graphics, and electronic spreadsheets, as well as host- and server-based business and student administration applications. The wide area network also must handle the additional load of instructional traffic, such as electronic mail and Internet access, when those services are brought online.

Network Topology
The current network is a star topology with the district office as the center hub. Currently, the entire district is serviced by Roseville Telephone Company from one central office. Roseville Telephone Company can provide either 56 Kbit/s leased digital circuits or basic-rate Integrated Services Digital Network (ISDN) services. The district's criteria for its wide-area service are that it must be
cost-effective, provide high performance, be supportable, and provide maximum uptime.

ISDN and point-to-point circuits are the only carrier options available to the district. The costs of these services are shown in table 1.

The traditional point-to-point extended-LAN topology that was considered is shown in figure 1.

**Figure 1**

![Point-to-Point Network Design Option](image)

**ISDN**

Traditionally, the point-to-point network depicted in figure 1 would be implemented with leased 56-Kbit/s circuits; however, the low cost of ISDN required a thorough investigation of whether this option was appropriate for Dry Creek Schools.

ISDN is a switched technology that is provided as a basic-rate service or a primary-rate service. The basic-rate service, called 2B + D, provides two 64 Kbit/s “B” (“bearer”) channels. The primary-rate service, in North America called 23B + D (or in Europe 31B + D), provides a variety of voice, video, and data connection options. Each service includes one control or messaging “D” channel (16-Kbit/s for basic service). Basic-rate service (2B + D) is all that Dry Creek School District needs. This article discusses the implementation considerations for basic-rate ISDN only.

When comparing cost and speed to digital 56-Kbit/s services, ISDN seems to be the better choice, but ISDN has potential problems. The terminal adapter equipment is currently more costly than DSU/CSU equipment, and ISDN services are not always available in all areas of a particular local exchange carrier or between carriers. In many cases, a digital link may be available between two end points, but the call may start out as ISDN with out-of-band signaling, be converted to Switched 56 with in-band signaling, and be converted back to ISDN. In this example there would be a loss of throughput because of the Switched 56 in-band signaling. Signaling System 7 is a standard network service that will eliminate this problem when it is universally implemented by all carriers.

Another design consideration is that there may be measured charges incurred for an ISDN data call, depending on the geography of the sites. Usage charges are regulated and will depend on carrier network services, depending on how the customer is set up as a business group with a particular carrier. Extended LAN connections regardless of protocol tend to establish their connections for long periods. A good rule of thumb is that if there are toll charges or measured-business-unit charges for voice connections between two end points, there probably will be such charges for ISDN data. Obviously, all ISDN charges must be considered when comparing the costs of ISDN to other digital services.

All of Dry Creek Joint Elementary School District is serviced as one business group by Roseville Telephone Company. With no usage charges, ISDN meets all of the district’s design criteria. The network as implemented is shown in figure 2.

**HP Routers**

Initially, the district’s network will be implemented as a bridged network bridging IP. HP routers were selected for use in the Dry Creek design for the following reasons:

1. HP routers can be supported on a standard contract with a guarantee of 4-hour response time for repair.
2. HP routers support ISDN as of release 5.74.
3. The HP Router SR represents a lower-cost design when compared to multiple bridges at the home site.
4. HP routers can support link speeds from 56 Kbit/s to T1, should higher bandwidth be required in the future.

5. HP routers provide more complete troubleshooting capabilities—NCL, statistics screens, and HP Openview Network Management—than do bridges.

With HP router operating system release 5.74 and later, ISDN can be configured for manual or automatic operation. The automatic operation provides for very sophisticated call control using the CCITT V.25 bis call-connect protocol. The Dry Creek implementation uses point-to-point connections that are semi-permanently established, requiring only simple manual operation to be configured on the routers.

**Figure 2**

**ISDN Configurations**

ISDN is a switched/dialed technology and requires that one end point of a point-to-point connection be configured to originate and that the other end point be configured to answer. Each end point is assigned an ISDN telephone number by Roseville Telephone Company. The configurations for the routers and ISDN terminal adapters are shown below.

**District Office Router**

**Basic configuration:** Host only bridging enabled, TFTP enabled, SNMP enabled, and Telnet enabled. The district office router is the originator and causes the terminal adapter to make the call when the router is booted and its DTR goes high.

**HP Router SR  ISDN Circuit Configuration**

<table>
<thead>
<tr>
<th>Circuit Name: WAN2</th>
<th>Auto Enable: YES</th>
<th>Quality of Service: LLC 1 (datagram)</th>
<th>Circuit Type: ISDN Manual Adapter</th>
<th>Min Frame Spacing: 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connect Retry Count: 3</td>
<td>Connect Wait Time (sec): 15</td>
<td>Delay After Connect Failure (min): .5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**District Office Terminal Adapter (TA)**

AT&T 7500B Data Module operating in synchronous DCE mode acting as the originator.

**Configuration**

- Set Autodial = YES
- Set Busy Out = OFF
- Data Rest = OFF
- Set DTR = FOLLOW
- Set Duplex = FULL
- Set Mode = CS
- Set Speed = 64000

The ISDN telephone number for the remote site is configured in the terminal adapter's call table; the autodial feature engages when the router's DTR goes high.

**Remote Router**

**Basic configuration:** Host only bridging enabled, TFTP enabled, SNMP and enabled, and Telnet enabled. The remote-site router is the answerer and causes the terminal adapter to wait to answer the call when the router is booted and its DTR goes high.

**HP Router FR  ISDN Circuit Configuration**

<table>
<thead>
<tr>
<th>Circuit Name: WAN1</th>
<th>Auto Enable: YES</th>
<th>Quality of Service: LLC 1 (datagram)</th>
<th>Circuit Type: ISDN Manual Adapter</th>
<th>Min Frame Spacing: 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connect When: Circuit is Enabled</td>
<td>Connect Retry Count: 3</td>
<td>Connect Wait Time (sec): 0</td>
<td>Delay After Connect Failure (min): .5</td>
<td></td>
</tr>
</tbody>
</table>

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*It was discovered during testing that this parameter should be set to zero to ensure that the "answer" end point is ready to reconnect immediately in the event of a power loss or component failure.*
Remote Office Terminal Adapter (TA)

AT&T 7500B Data Module operating in synchronous DCE mode acting as the answerer.

Configuration

Set Autodial = NO
Set Busy Out = OFF
Data Rest = OFF
Set DTR = FOLLOW
Set Duplex = FULL
Set Mode = CS
Set Speed = 64000

Performance

ISDN provides clear 64-Kbit/s channels for each point-to-point connection. This bandwidth will meet Dry Creek's needs for approximately two to three years. Basic-rate terminal adapters that provide inverse multiplexing are becoming available. The inverse multiplexing feature will allow both B channels to be combined for 128 Kbit/s of bandwidth. This provides a growth path that will be more than adequate for Dry Creek's needs for at least three years.