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BUS 54 — WHERE ARE YOU? A SCHOOL BUS INTELLIGENT INFORMATION SYSTEM

Lorena F. Truett
Voice: (423) 574-4225; E-mail: LFT@ornl.gov
Sheila Moore
Voice: (423) 576-8046; E-mail: SZ9@ornl.gov
Bruce Tonn
Voice: (423) 574-4041; E-mail: BET@ornl.gov
Fax: (423) 574-3895
Oak Ridge National Laboratory
P.O. Box 2008, MS-6207
Oak Ridge, TN 37831

Tim Conley
GTE Wireless
3100 West End Ave., Suite 700
Nashville, TN 37203
Voice: (615) 386-5025; E-mail: Tconley@mobilnet.gte.com
Fax: (615) 269-2345

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Oak Ridge, Tennessee 37831
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BUS 54 — WHERE ARE YOU?
A SCHOOL BUS INTELLIGENT INFORMATION SYSTEM

ABSTRACT

Although major accidents involving school buses are rare (only about 0.3% of all fatal crashes since 1986 are classified as school-bus-related), even minor accidents and breakdowns cause a great deal of parental anxiety. Currently, there is no mechanism, except by special announcements on radio or television, for alerting a parent concerning the existence of a delay, the cause of the delay (weather, accident, mechanical breakdown, etc.), the duration of the delay, or the actions that the parent should take. The **proposed** "Bus 54" computer system contains modules for keeping parents as well as school officials informed, in near real time, about the location and condition of school buses.

The objective of this research is to design an efficient, cost-effective, accurate, and secure system that will track individual school buses and communicate appropriate information to the school system's central administration unit, to the school transportation administrator, and to parents of children on the bus. In a rural environment, children may spend a significant part of each day riding to school on a bus. The greatest benefit of the proposed information system is that parents and officials can always know the location and condition (these "conditions" would vary depending on the needs of a particular school system) of the school buses. In case of an accident or mechanical problem, when emergency crews are needed, they can be dispatched almost immediately with a good understanding of the problem and the exact location of the bus. In addition to being able to track the bus while the child is on board, parents will be able to determine the location of their child's bus prior to its arrival in the morning in order to prevent the child from needing to wait outside in inclement weather. The information available to parents can also be expanded to include maps of limited routes (e.g., snow routes).

Basically, the "Bus 54" concept consists of a bus component and a central data processing unit. Each bus will be outfitted with a global positioning satellite (GPS) device, a wireless communication device, and wireless data communication service. The central data processing unit will receive and process information from the buses and provide information access to parents and officials via an Internet link.

INTRODUCTION

The recent spate of violence on school campuses and at school events sparks fear in all parents' hearts that their child could become a victim. At this point in time, school buses have not been targeted as a setting for violence or terrorism. In addition, students, while passengers in the bus, are 90 times safer than when riding in the family car. [In 1995, for example, there were 22,288 fatalities of passengers in automobiles (0.9 fatalities every 100,000,000 passenger miles) while there were only 12 school bus passenger fatalities (0.01 fatalities every 100,000,000 miles).] Although these statistics indicate that a school bus is one of the safest modes of transportation, parents worry when the bus is late. A methodology by which parents could stay in touch with a child's transit between the home and the school would allow parents to address and alleviate their anxieties. The time is now to conduct the research to determine the best means to accomplish this goal and to initiate a program for integration of a school bus intelligent information system for our yellow school buses.

SYSTEM ARCHITECTURE

Each school bus will contain an on-board computer and a Global Positioning Satellite (GPS) receiver mounted on the vehicle. Using Automatic Vehicle Location (AVL) technology based on GPS, the bus's location can be accurately pinpointed. This location information is maintained in the bus's computer and also is automatically transmitted via wireless technology to the central data processing facility. The process of updating the location information is repeated on some pre-determined time interval — for example, once every minute. The occurrence of an accident, a mechanical problem, or other delay will also be transmitted to the central processing unit.

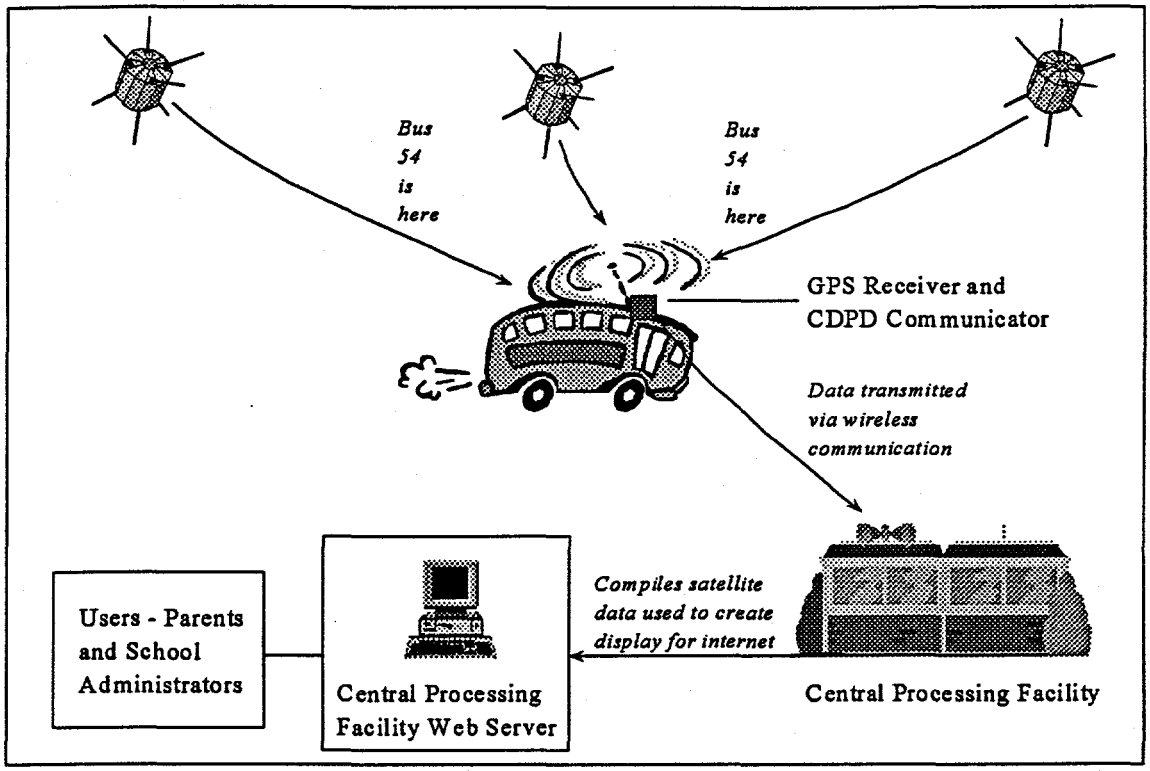
At the central processor, the location data from each bus is placed into a database that contains such elements as time (i.e., the time the bus location was determined), bus number/identifier, location, and other incident-related information. This data will be used to create a graphical display that will then be placed on the central processing facility's web server. The display is refreshed every time new locations are received by the school bus fleet.

Using an Internet connection, school administrators, parents, and the local police will have access to the graphical display.

SYSTEM DESCRIPTION

Interactions among the components of the "Bus 54" system are described below. A drawing showing the data flows among the bus and the central processing facility and the users of the system (parents and school administration officials) is shown in Figure 1.

Figure 1. Data Flow Between the System Components



Collecting Data: the Bus's Role

Each bus in the school system will have a GPS receiver, an on-board computer, and wireless transmission capabilities. Proven to work in rural as well as urban locations, GPS technology pinpoints a vehicle's location. The frequency for accessing the satellites and updating the vehicle's location may vary according to the needs of an individual school system's budget. For this paper, the frequency is assumed to be about once per minute. This location information is stored on board the bus and is transmitted to the central data collector for processing.

It should be noted that it is possible for the school system to record other information, for example bus speed or driver safe-driving practices (such as always stopping at railroad crossings), on the bus's computer. Likewise, a video camera could film the behavior of students while boarding, leaving, or riding the bus. The videotaped information could easily be recorded and downloaded at the end of the day to the central processing unit. For the "Bus 54" location system, however, we are assuming that only location information is being collected.

In addition to the fully automated process for locating the bus along its route, emergency events also need to be communicated. Some emergencies can be described and a logic preprogrammed into the computer to send appropriate messages related to these emergencies. If, for example, a bus is stopped for an extended period of time, the system could start sending an alert message to the central processor. For other situations, a pre-programmed set of messages can be prepared for transmission when requested by the bus driver. For example, the driver could send a message about a flat tire by punching a particular button on a control unit. Other events may require the

driver to supply more detailed information (e.g., a child needs medical attention), in which case an on-board cellular phone may be needed.

Transmitting Data from the Bus

The information conveyed from the bus is crucial. The bus's on-board computer communicates with the central controller facility using a Cellular Digital Packet Data (CDPD) modem. CDPD uses TCP/IP, the standard protocol of the Internet, to transmit these packets. At the central controller facility, the information is processed and distributed.

CDPD is a transmission technology which splits messages up into "packets" that are sent on existing analog cellular networks [Advanced Mobile Phone Service (AMPS)] at a rate up to 19,200 bits per second. This allows a fast, flexible method for sending and receiving data to and from the mobile devices.

CDPD is very secure. It uses the Diffee-Hellman encryption key, and also RC4 security (stream ciphering). Therefore, it is virtually impossible for someone to steal or alter the data.

CDPD works best for short bursts of data transmissions. This does not mean that transferring large data files is impossible; however, the pricing is geared for small amounts of data to be transmitted. Examples of current CDPD applications include E-mail, credit card verification, telemetry (meter readings, temperature sensors, alarms), messaging (mobile dispatch, field service), ATM machines, query/response applications, file transfers, and web browsing.

Today, at least fifty major metropolitan areas have access to CDPD. School buses, however, operate primarily in a rural environment. Therefore, the limited range of CDPD must be considered.

Circuit-Switched CDPD (CS-CDPD) addresses the problem of those locations across the U.S. that do not have CDPD coverage but do have analog cellular coverage. CS-CDPD is a technology that seamlessly connects to CDPD. For example, if the school bus leaves the CDPD coverage area, the modem senses it has no coverage and dials an 800 number to connect back into the CDPD network. Thus, if there is analog cellular coverage, there is a possible connection to the CDPD network via circuit switching. Although this technology is very new in its implementation, it is a viable solution for rural areas.

Use of CS-CDPD still applies to short bursts of data in that the modem will connect when packets need to be transmitted and will disconnect after a time-out period. The information to be transmitted will include the time of transmittal, bus number/identifier, and location.

If the bus experiences a delay, this event and the exact location of the bus can be relayed to the central control facility via the wireless on-board communication link. As described in the previous section, this incident communication may be an pre-programmed message which is transmitted based on some time outage (e.g., the bus hasn't moved for *xx* minutes) or based on driver initiation, or there could be some other methodology programmed into the system.

Processing the Data for the User

AVL technology updates the bus's location information on a predetermined frequency and transmits this data to the central data processor. When received by the central processor, the location data is converted to a graphical display for each bus on every route. This display of all buses will be available to school officials. The display available to parents will be limited, through use of approved identifiers and passwords, to only the bus on which their child is riding.

The other piece of information that will be transmitted to the central controller is "bus condition," where "condition" is defined as any incident that needs to be reported, such as a mechanical breakdown, a child needing medical attention, a discipline problem, a collision, etc. To prevent a panic, this information will not immediately be distributed to parents. School administrators will first evaluate the situation, summon emergency aid if appropriate, and manage the information flow to provide maximum protection to children aboard the bus.

SYSTEM USERS

There are two types of users of the system: parents and school administrators. Parents will only be able to view the progress of their child's bus. The schematic for this information flow is shown in Figure 2. School officials will monitor the progress of all buses in the school system. The schematic for this information flow is shown in Figure 3.

Figure 2. "Bus 54" Data Flow for Parent

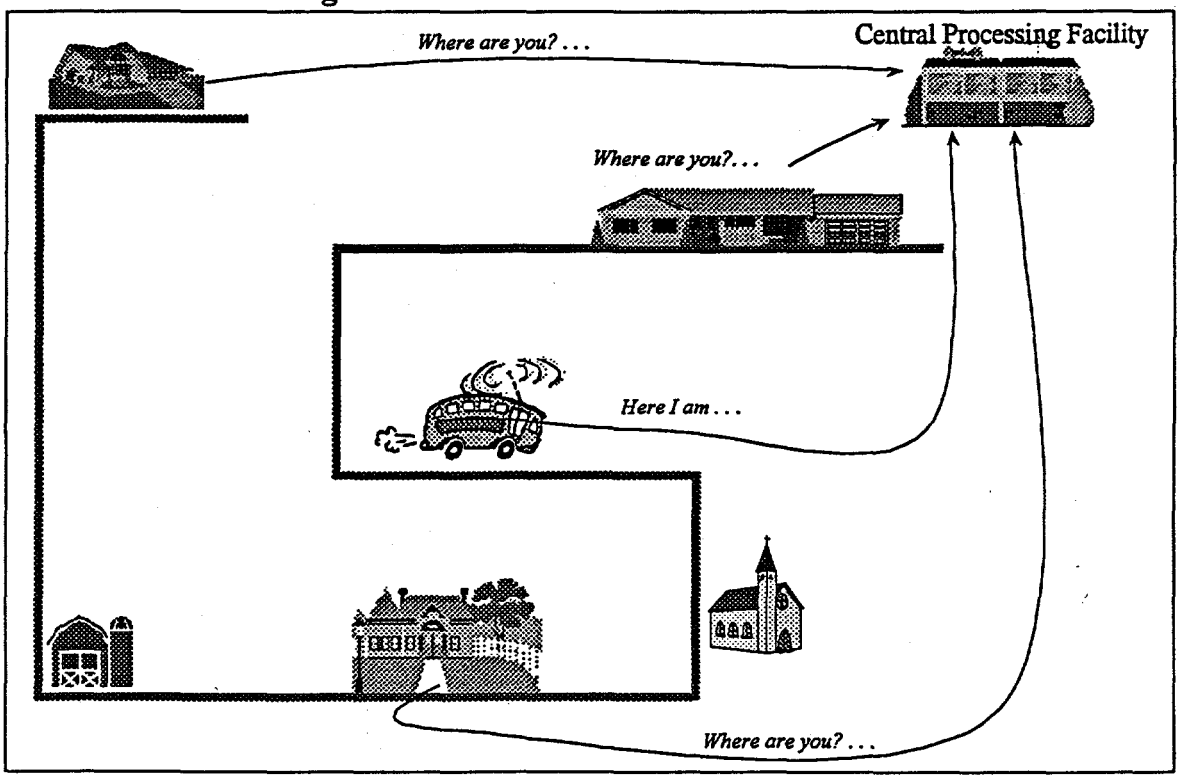
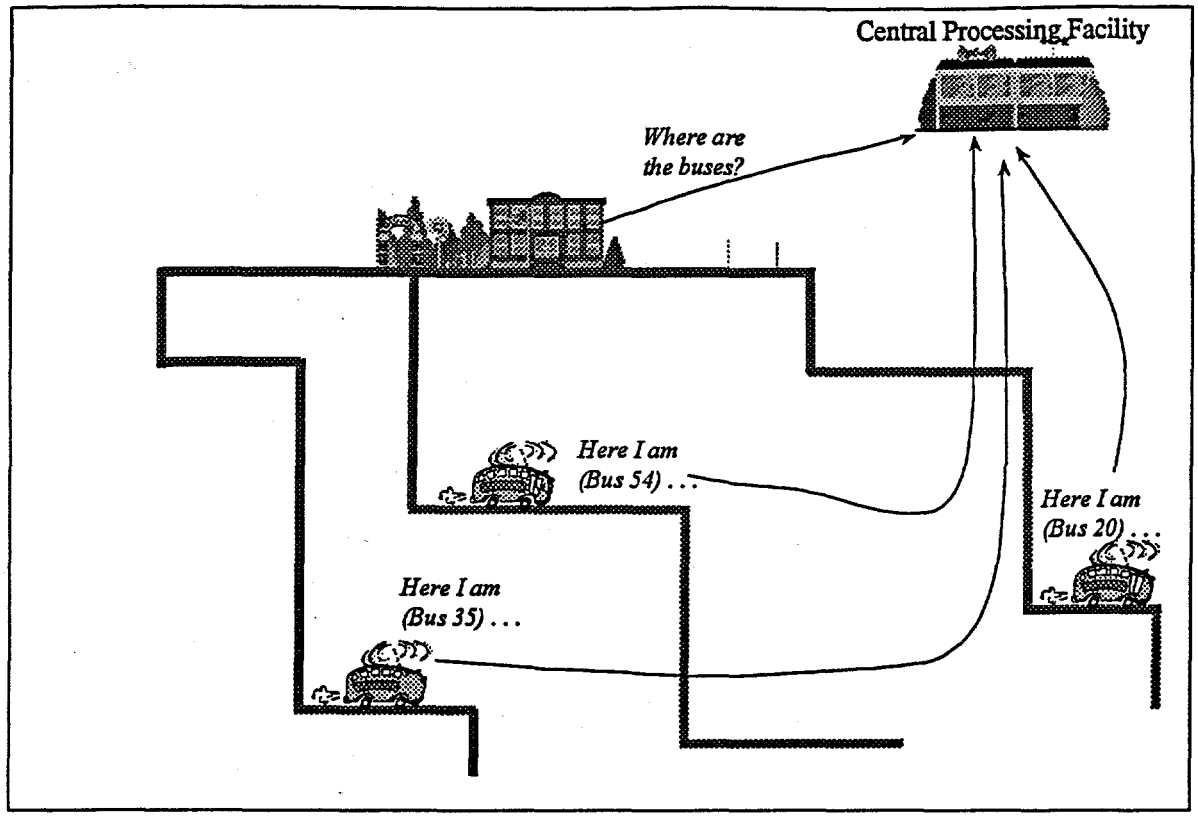


Figure 3. "Bus 54" Route Display for School Administrators



In the morning, parents will be able to determine the location of their child's bus prior to its arrival by either logging in to the Internet on the home computer or by tuning to WebTV™. Parents can use the location of the bus to help decide when is the correct time for the child to go outside and meet the bus. This practice prevents the child from needing to wait outside in inclement weather. The information available to parents can also be expanded to include maps of limited routes (e.g., snow routes). In addition, in the afternoon, the parents can also track the bus while the child is on board and will know when the child will arrive home. A proposed design for the screen that a parent would view on a typical morning is shown in Figure 4.

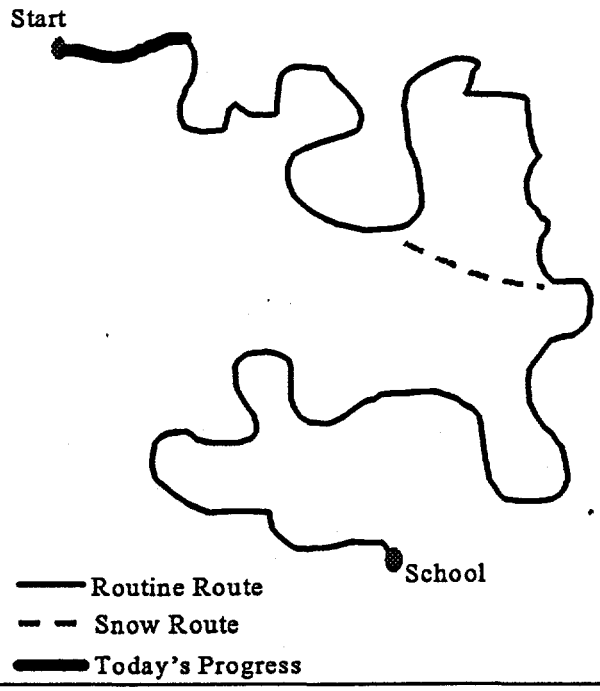
The map part of the display would be updated fairly frequently (e.g., every minute) to show the relative progress of the bus along its route. The tabular portion would be updated as the bus arrived at each designated landmark. Based on the graphical display (see Figure 4) and the bus's progress on the map, the parents would know precisely when the child should go outside to meet the bus.

For parents who do not have a home computer, we are suggesting the use of WebTV™. This technology is an affordable alternative and is available now in most areas. The WebTV™ Internet system consists of a unit that connects to the television. The unit contains the necessary browser software and modem that connects to the home's telephone line. This unit costs about $100, and the monthly access charge is about $20. These costs are minimal when compared to purchasing a computer and when evaluating the usefulness of having the bus information.

Figure 4. "Bus 54" Example Screen, As Viewed By Parent Observing Morning School Bus Progress

BUS ID: Bus 37, Early Route
Today's Date: August 31, 1998 Last Updated: 6:29 a.m.

Location	Scheduled	Actual
Start	5:59 a.m.	5:59 a.m.
Cloyd's Creek	6:10 a.m.	6:09 a.m.
Baker Road	6:20 a.m.	6:20 a.m.
Andy's Feed&Seed	6:26 a.m.	6:28 a.m.
Sample's Crossroad	6:35 a.m.	
Disco Loop	6:42 a.m.	
Old Sunbright School	6:52 a.m.	
The Y	7:00 a.m.	
Pilot Station #6	7:12 a.m.	
Fellowship Church	7:16 a.m.	
Etc.	*Etc.*	
.	.	



School administrators will use the system to monitor multiple bus routes. In addition to the individual bus maps seen by parents, an overview of all routes and schedules and the progress of every bus on its route will be available to administrators. The system can be programmed to alert the administration if there is an exceptional delay or if the system receives a transmission of an incident code from a bus.

Because administrators are able to monitor each bus for incidents that might prevent children's safe arrival, they are able to respond more quickly to emergencies.

BENEFITS OF THE PROPOSED SYSTEM

Since 1980, about 60% of all pupils have used the school bus to get to and from school each day. In school year 1995-96, this amounted to 24,500,000 pupils being transported daily!

We want our children to be safe. The proposed design of the Bus 54 system includes several safety features. First of all, access to the system is limited to parents and administrators with an approved identifier and password. In addition, if on-board video surveillance cameras are included

in the design, studies have indicated that the possibility of being "caught" on tape is a deterrent to misbehavior. A school bus driver is primarily responsible for driving safely, and any tool that school administrators can use to assist the driver is valuable.

In a rural environment, children may spend a significant part of each day riding to school on a bus. The Bus 54 design uses state-of-the-art *feasible* technology to provide an efficient monitoring tool for the transit time between home and school. The greatest benefit of the proposed system as currently defined is that parents and officials can always know the location and condition of the school buses. In addition, when emergency crews are needed, they can be dispatched almost immediately with a good understanding of the problem and the exact location of the bus.

ACRONYMS

AMPS	Advanced Mobile Phone Service
AVL	Automatic Vehicle Location
CDPD	Cellular Digital Packet Data
CS-CDPD	Circuit-Switched Cellular Digital Packet Data
GPS	Global Positioning Satellite
TCP/IP	Transmission Control Protocol/Internet Protocol

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Web sites with information on technologies described in this paper include the following: http://www2.wirelessdata.org/public/whatis/index.html, http://www.trimble.com, http://www.miras.com, http://www.webtv.com, http://nces.ed.gov/pubs/digest97/d97t051.html.