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Enhanced 911 Service in a Private Branch Exchange Using USWest PS/ALI Service

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Colorado State University

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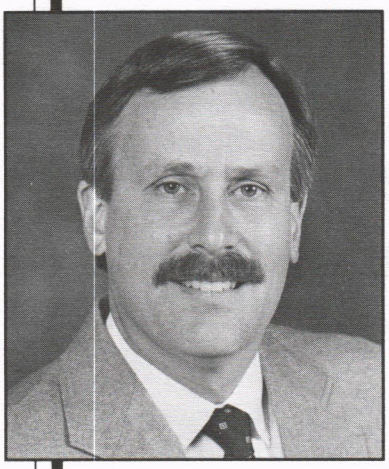

About the Author

Jim Hebbeln

Telecommunications Specialist

Colorado State University

Jim Hebbeln came to Colorado State University after a 24-year career with Mountain States Telephone, a.k.a. Mountain Bell, a.k.a. U S West Communications. There, he initially performed the duties of an Installer-Repairman and Service Representative, and subsequently was promoted to the title of Central Office Technician in 1979.

He is experienced in AT&T 1AESS and 5ESS (Electronic Switching Systems), and Northern Telecom DMS switching products. In recent years, he provided 1AESS and 5ESS complex translations (database) implementation and maintenance in large central offices in Denver. He also provisioned ISDN translations services for a large government system, and implemented Signaling System #7 and CLASS features in U S West central offices. In addition, he provided backup manpower for the technician responsible for implementing and maintaining the E911 Tandem Switch's translations database.

Hebbeln was recruited by the Colorado State University Telecommunications Department in January 1993 and now provides technical services to provision and maintain the large central office-class Northern Telecom SL-100 Private Branch Exchange at CSU.

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Introduction

Enhanced 911 Service, or E911, is a proven telecommunications technology that significantly improves the accuracy and swiftness of police, fire, and ambulance dispatching by routing Emergency 911 calls to the correct Public Safety Answering Point (PSAP) and concurrently providing the emergency services PSAP dispatcher the caller's telephone number and associated name and address.

Despite E911's capabilities to quickly identify calls from individual (POTS) telephones connected directly to the public switched network, calls from Private Branch Exchange (PBX) extensions still do not provide sufficiently detailed location information to adequately dispatch emergency personnel if the caller can't speak. Addressing this problem, U S West Communications recently expanded their E911 Service offering with optional Private Switch / Automatic Location Identification (PS/ALI) to (1) accommodate 911 calls directly from "private switch" PBX customers, (2) route these calls to the correct PSAP, and (3) identify private PBX extension locations (street address, building, floor, room) with the same clarity enjoyed by regular POTS customers.

This paper gives an operational overview of traditional E911 and its component parts, followed by a description of the new U S West Communications E911 Private Switch / Automatic Location Identification (PS/ALI) option, and how Colorado State University implemented this new service within the campus PBXs during November 1993.

I Enhanced 911 Operation Overview

Most telephone customers are connected directly to the Local Exchange Carrier's (LEC - "telephone company") central office which provides local telephone service to many customers in one contiguous geographic area. The served area may be just a

portion of a city and/or suburbs, or an entire town and the surrounding rural area. A central office may serve less than 500 rural customers or more than 100,000 lines in a city depending upon population density.

The geographic area served by the LEC central office does not directly correspond to the existing political boundaries of the city, towns, suburbs, and/or counties being served. This poor correlation between telephone serving areas and governmental boundaries was not a problem in the operation of telephone service until the Universal 911 Emergency Services number was promulgated by the United States Congress in the late 1960s. The intent is to provide a universal, easy-to-remember number to dial when summoning emergency service, and, for most telephone customers, Basic 911 Service performs correctly.

However, if the caller lives within a different governmental jurisdiction than the central office and the majority of served telephone customers, the caller's 911 calls will likely be routed to the wrong emergency services dispatcher. Further exacerbating the difficulties of 911 call routing is the plethora of different police/sheriff, fire, and ambulance jurisdictions—each likely with different service area boundaries.

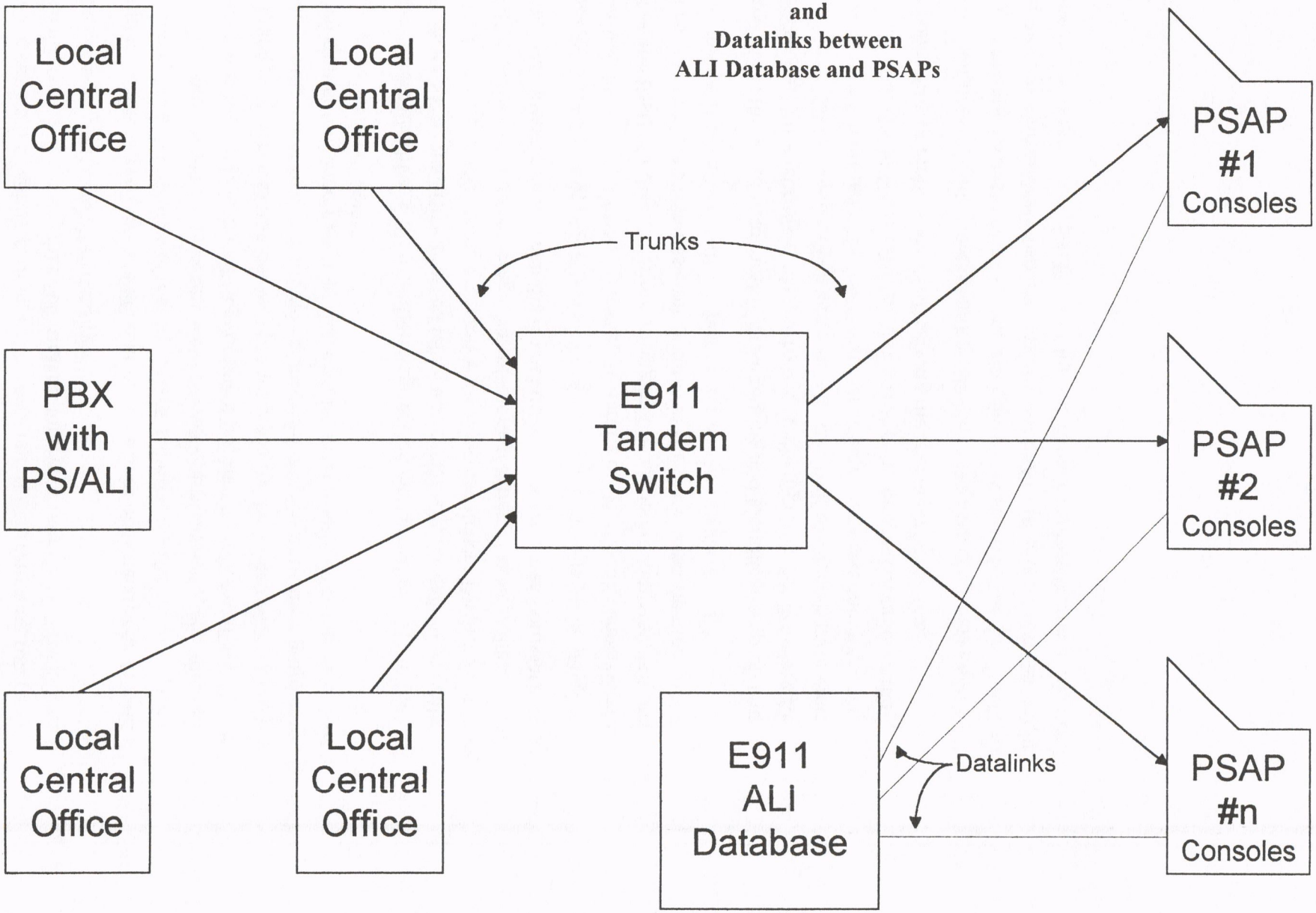
Perhaps worse yet, Basic 911 Service does not provide any identification of the emergency caller or their address. To identify a mute caller, the call connection can be held by the Basic 911 dispatcher for tracing by the telephone company, but this consumes many precious minutes—precluding an adequate response time, for example, to save the life of a cardiac arrest victim who is unable to speak.

Enhanced 911 is the solution to most of these routing and identification problems. The E911 system automatically routes each caller to their proper Public Safety Answering Point (PSAP) where a dispatcher initially determines which type of emergency assistance is required. The PSAP dispatcher may then need only press the appropriate POLICE, FIRE, or AMBULANCE button to transfer the caller to the correct police, fire, or ambulance PSAP serving the specific caller's area.

E911 also identifies the caller's telephone number and the associated name and address within approximately one second after the call is answered at the PSAP. The calling name and address also appears at other PSAPs to which the caller might subsequently be transferred. See Figure 1 for a schematic representation of E911 call routing.

Figure 1

Schematic of E911 Call Routing
Via E911 Tandem Switch
and
Datalinks between
ALI Database and PSAPs



To provide E911 Service, the LEC installs special trunk lines exclusively for 911 calls from each of their central offices to a specially equipped central office called an E911 Tandem Switch that serves all telephone users and PSAPs within a metropolitan area or even large portions of a state. The E911 Tandem Switch includes a disk-resident database that contains the specific PSAP routing information for each telephone in the Enhanced 911 service areas, and can easily contain more than one million telephone numbers. This routing information directs the E911 Tandem to connect the trunk from the caller's central office "in tandem" to one of the trunks to the appropriate PSAP. The Post-Dialing Delay (after the caller finishes dialing 911 and before the first ring is heard as the call arrives at the PSAP) is about five seconds. As all of the area PSAPs are connected to the same E911 Tandem, emergency calls can be transferred between PSAPs. For example, a call answered at a Police PSAP may be transferred to the Ambulance PSAP, and is accomplished by re-switching connections at the E911 Tandem.

The caller's phone number is automatically determined using Automatic Number Identification (ANI, pronounced "annie") and is transmitted ahead as the trunk connections are set up to the PSAP. Special equipment at the PSAP gathers the ANI digits and, through dedicated (non-switched) data circuits, queries the LEC-owned data base to obtain the caller's name and address. This is known as Automatic Location Identification (ALI, pronounced "alley"). Both the ANI and ALI information are displayed to the PSAP dispatcher, and also can be passed to the PSAP's optional Computer Aided Dispatch system. For a more detailed description of trunk operation, see Addendum A.

II U S West Communications E911 Private Switch/ Automatic Location Identification Feature

Although E911 performs admirably for customers who are directly connected to the LEC's central offices, those telephone users connected to Private Branch Exchanges (PBX) still are not identified adequately with specific location identification such as the building, floor number, and room number in which they are located. This problem—which is particularly acute in large PBXs employed by large corporations, government offices, and universities—occurs because the PBX is usually connected by a group of shared trunk lines to the LEC central office. The telephone numbers

that identify these trunk lines to the LEC can only be used to locate the PBX switch, not the individual PBX extension users.

Over the years, however, many PBX administrators have arranged with their LEC for Direct-In-Dial (DID) service whereby a block of usually contiguous telephone numbers (varying from less than one hundred to tens of thousands) are assigned to, and outpulsed (dialed) into the PBX, partially eliminating the need for a PBX switchboard attendant. DID is proving ever more attractive and economical, and gives each extension user a unique telephone number that can be dialed from anywhere at any time without assistance from a PBX attendant.

This unique DID number can also be used to accurately locate a PBX extension that has dialed 911, if the U S West Private Switch / Automatic Location Identification (PS/ALI) feature has been implemented both in the PBX and in the LEC network.

After E911 PS/ALI service is implemented in a PBX with DID numbers, calls to 911 (or another internally advertised emergency number) are Automatic Number Identified and routed by the PBX directly to the LEC E911 Tandem Switch and onward to the correct PSAP where they are properly identified.

Note that all PBX switches are not capable of E911/Operator Services-type trunking arrangements, or may not have purchased the feature. This may preclude PS/ALI implementation, or trigger the replacement of an older PBX.

Traditionally, E911 service is provided by the LEC who owns and maintains the central office, dedicated trunks, E911 Tandem, and ALI database. LEC Service Orders automatically change the E911 PSAP routing and ALI databases.

PS/ALI, however, requires the PBX switch to provide an Operator Services-type trunking and signaling interface to the E911 Tandem Switch, and PBX administration personnel to update the LEC E911 databases when PBX extensions are added, moved, or disconnected within the privately-owned PBX switch.

The PBX administration communicates changes to the LECs E911 databases through a customer-owned personal computer (IBM-compatible 386 or 486 with MS-DOS) which is loaded with software created and distributed by U S West Public Safety Group. This software provides a local database with forms-based video screens through which the PBX administration adds, modifies, or deletes lines off-line from the LEC database. Each PBX telephone number, customer name, address, and other location remarks (building name, floor, room number) is entered by the PBX administration personnel. After the local PC database entries are completed each day, the PC is commanded to dial the LECs E911 database and upload all the changes via modem.

Changes are not blindly accepted into the LEC's database. Each entry is validated for errors such as a misspelled street name, out-of-range street number, or out-of-range telephone number (a DID number not assigned to the PBX). Wrong entries are not accepted into the working databases, and are returned to the PC in an error file during subsequent upload sessions. Correct entries are loaded into the ALI database and the Telephone Number-to-ESN routing is loaded into the E911 Tandem Switch routing tables. (An ESN [Emergency Services Number] represents the unique combination of Police, Fire, and Ambulance PSAPs that serve an area. Each telephone number in the same area is assigned the same ESN.)

III Implementation of E911 with PS/ALI at Colorado State University

Overview

Colorado State University, located in Fort Collins, Colorado, serves a population of approximately 21,000 students and employs a faculty and staff of about 3,000. The main campus in the center of the city has over 150 buildings distributed across 850 acres. About 3,500 students live on-campus in dormitories or in nearby married student housing. In addition, the Foothills Research Campus of several thousand acres is located three miles west at the base of the Rocky Mountains, and two agronomy farm sites are located on the plains northeast and southeast of Fort Collins.

The CSU Police Department (CSUPD) is responsible for answering emergency calls from CSU lines and providing police services for the campuses. Fire and ambulance emergency calls are logged into the CSUPD Computer Aided Dispatch (CAD) system (shared with and owned by Fort Collins), and are automatically dispatched to Poudre Fire Authority which serves Fort Collins and surrounding rural areas. (Fire personnel are also paramedics who co-respond to ambulance calls, often arriving more quickly than the Poudre Valley Memorial Hospital ambulance.)

The telephone service for the 9,000 working lines on the main campus is provided through an SL-100 PBX manufactured by Northern Telecom and is very similar to the DMS-100 central office. CSU is assigned blocks of 12,200 DID telephone numbers which span portions of two telephone prefixes (491 & 495). In addition, three small AT&T System 75 PBXs are trunked to the SL-100 PBX and serve 500 lines at the Veterinary Teaching Hospital, 200 lines at Facilities Services, and 100 lines at Housing Service, all located upon the main campus. Two SL-100 remote switches, located

at the Foothills Research Campus, provide service to 600 telephones and are hosted by the main campus PBX so that all three SL-100 sites operate as one integrated system. The southeast agronomy farm receives service directly from U S West. The northeast farm receives off-premises extension (OPX) phone service from the main SL-100 PBX via U S West circuits. See Figure 2 for a diagram of the CSU PBX system. Regardless of the CSU caller's location—on or off campus, served by the PBX or directly from U S West—911 calls are routed and identified so as to provide the most expedient emergency service using U S West Public Safety Group's PS/ALI.

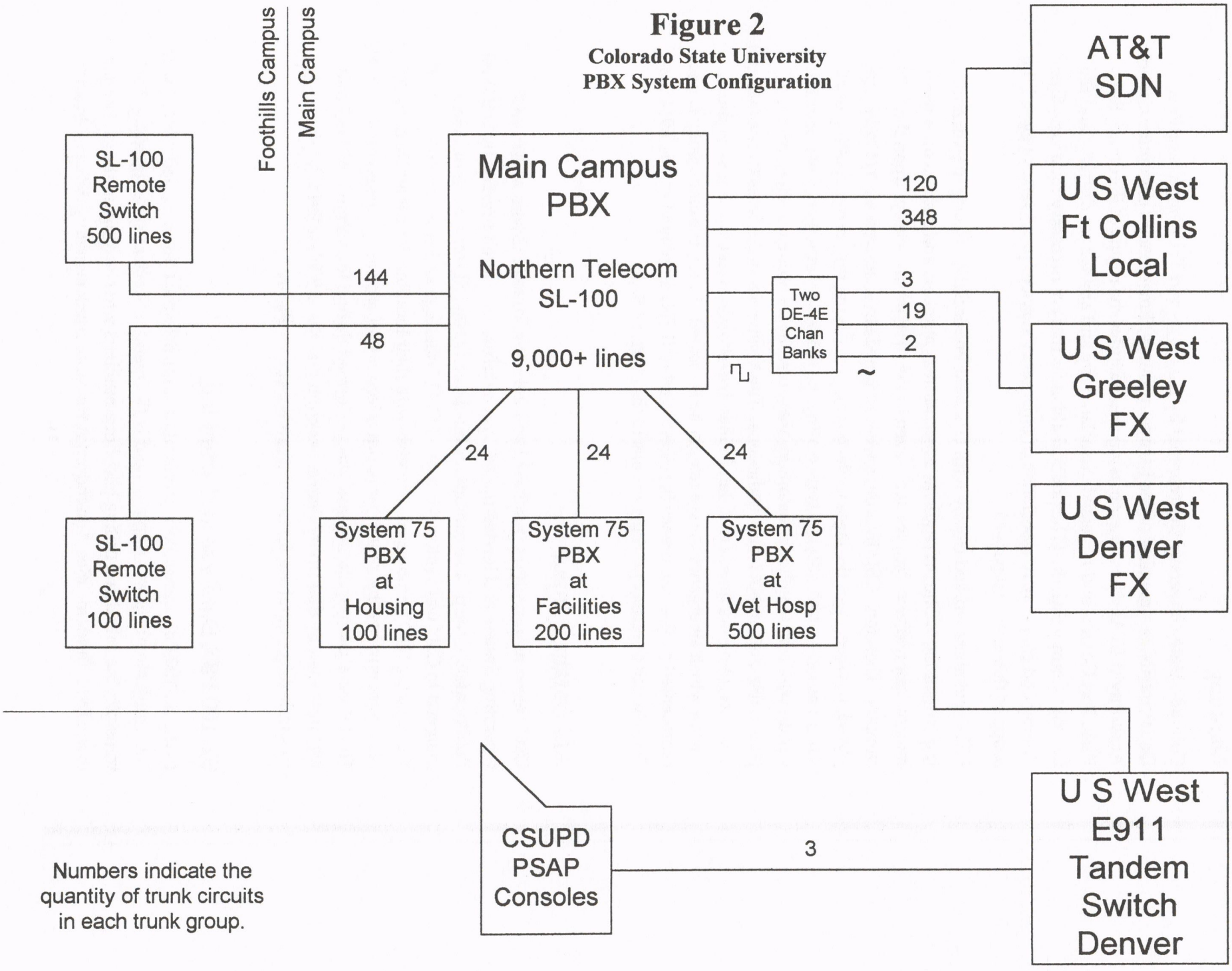
During the summer of 1993, E911 was placed into service in Larimer County with PSAPs located in the towns of Fort Collins, Loveland, Estes Park, and Berthoud, with unincorporated rural areas being served by the Larimer County Sheriff PSAP. The Colorado State University Police Department PSAP was subsequently activated in November 1993. (Previous to E911, CSU emergency calls were taken on a key phone at CSUPD to which on-campus 911 calls were routed.)

CSU is the first PS/ALI customer in Colorado, although PS/ALI was already operational in other U S West states. The E911 Tandem Switch is centrally located in Colorado at the Denver Capitol Hill 1AESS central office sixty miles south of Fort Collins, and serves the Denver metropolitan E911 areas as well as our Larimer County area and several other portions of Colorado. The ALI database is also located in the Denver area. The CSUPD PSAP equipment is owned by the University. U S West installed it and provides ongoing maintenance to all the PSAPs in Larimer County. All trunking is owned by U S West, except for trunk unit circuit packs contained within the PBX and PSAP cabinets. As all PSAPs in Larimer County including CSUPD are connected to the same E911 Tandem, a (technically and politically) prearranged alternate PSAP automatically accepts calls for a primary PSAP if all their circuits are busy or out of service.

Several discrete circuits, when combined, are the building blocks upon which E911 operates: In CSU's case, there are two trunks routed over diverse U S West T-Carrier systems from the SL-100 PBX to the Denver E911 Tandem. Then, from the E911 Tandem to the CSUPD PSAP three trunks are provisioned. (There is one more trunk in this group as some CSU locations (e.g. farm) are not served by the PBX.) Two redundant, non-switched, private-line data circuits route from the PSAP to the ALI database for performing ALI queries. In addition, a trunk group "make busy" circuit is provided between the Denver E911 Tandem and the CSUPD PSAP. When this circuit is enabled (loop closure) by the PSAP, calls normally routed to the CSUPD PSAP are redirected to an alternate PSAP located at the combined Fort Collins Police Department / Poudre Fire Authority dispatch center.

Figure 2

Colorado State University
PBX System Configuration



Planning

Colorado State University (represented by the Police and Telecommunications Departments) is a member of the Larimer (County) Emergency Telecommunications Authority (LETA) whose membership also includes the towns of Berthoud, Estes Park, Fort Collins, and Loveland; associated fire and ambulance districts; and the Larimer County Sheriff. (The political alliances that are necessary for a well-functioning and cooperative association of emergency services providers is beyond the scope of this technical paper.)

LETA members worked closely with U S West Public Safety Group to plan and implement E911. The prerequisite street address numbers and street names were mostly assigned two decades ago—even to the rural areas—except upon the CSU campus. Therefore, CSU buildings were assigned street addresses. Yet to be completed, however, was the large undertaking of verifying the correct spelling of all street names, and identifying and creating the individual emergency services zones within which all telephone customers are served by a unique but identical set of police, fire, and ambulance jurisdictions. The Master Street Address Guide (MSAG) is the resulting document that determines, based upon street and house number, within which emergency zone a telephone is located. Later, the emergency zone is represented by the Emergency Services Number (ESN) employed by the E911 Tandem Switch to route and transfer calls to the correct PSAPs.

ALI Database Input

CSU Telecommunications purchased an Intel 80486-based PC with an MS-DOS Operating System and loaded the PS/ALI database software provided by U S West Public Safety Group. The contiguous blocks of 12,200 DID telephone numbers assigned to CSU were entered into the PC ALI database and subsequently each of the working DID numbers were loaded with their locations (street address, building, and room number) by a member of our telecom staff who also worked on the MSAG. The PC database populating task was performed during the summer of 1993, and was uploaded by dial-up modem connection into the U S West E911 database. A facsimile of the database input form can be seen in Figure 3.

SL-100 PBX Database and Trunking

In the SL-100 PBX translations tables (database), a Trunk Group named "E911" with two trunk members was implemented with Operator Services-type signaling that transmits the called and calling telephone numbers when setting up the connection to the E911 Tandem. (See Addendum A for more trunk signaling details.) In addi-

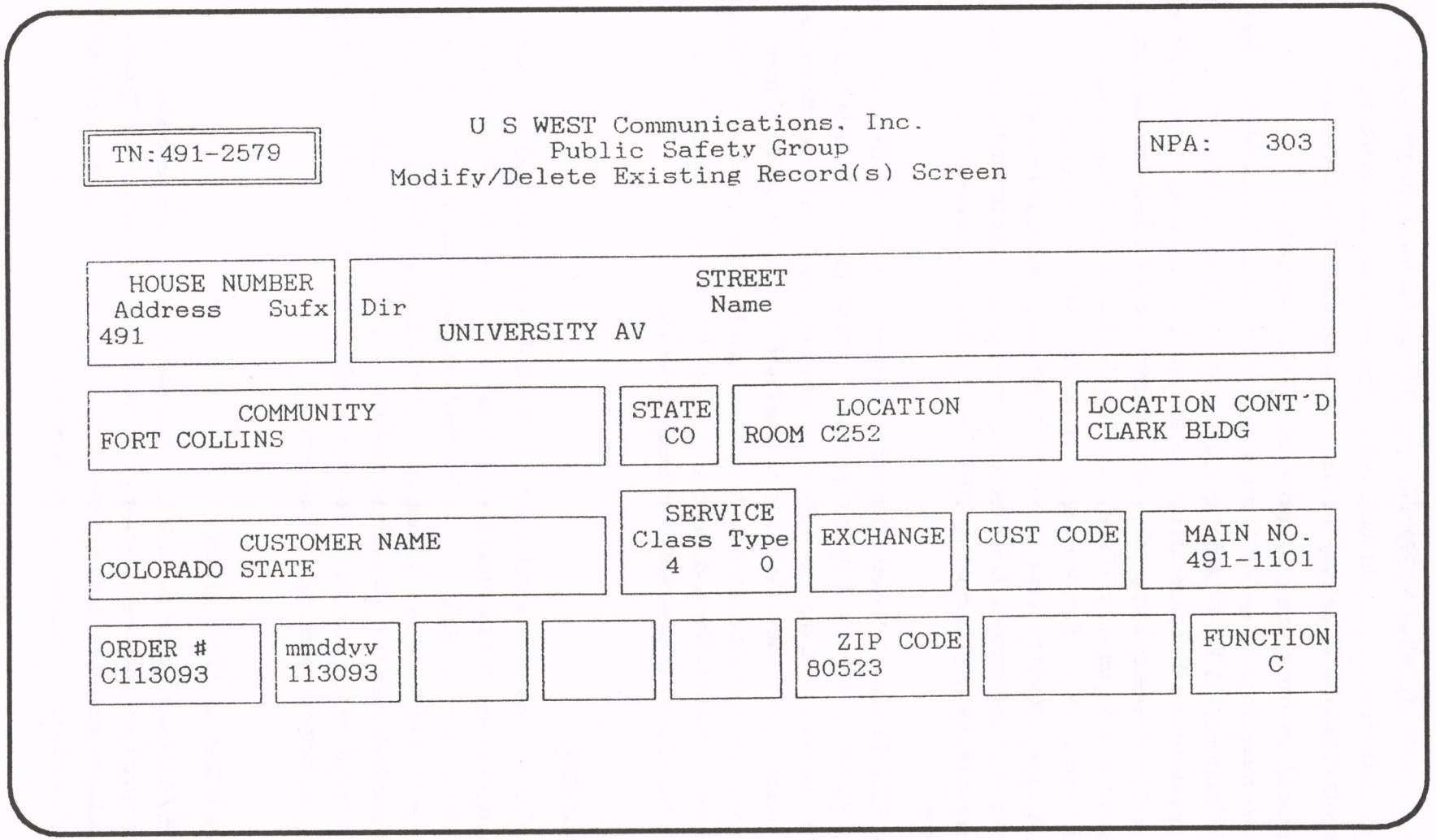


Figure 3

Facsimile of
PC Database Input Form Screen
to
Add, Delete, or Change E911 Database
(uploaded later by modem to E911 database)

tion, we initially datafilled the PBX's routing tables so that the digits 211 (our test code for E911 pretesting) would route through the new Trunk Group like the digits 911 would eventually route (only the digits 11 are transmitted in either case).

All of the SL-100 trunking is provided through T-Carrier interfaces. To provide adequate route diversity, each E911 trunk was assigned to a different SL-100 Digital Trunk Controller's (DTC) T-Carrier span and channel. (The T-Carrier systems already existed and their channels were partially assigned as Foreign Exchange lines for Denver and Greeley bound calls.) The T-Carrier spans are de-multiplexed and converted from digital to individual analog lines in CSU-owned Northern Telecom DE-4E Channel Banks adjacent to the SL-100 switch. The now analog (2-wire, Loop-Start, Reverse Battery) E911 trunks meet U S West at our Demarcation Point of Presence in the switchroom. U S West transports the trunks the remaining 60 mile distance to the Denver Capitol Hill 1AESS E911 Tandem over diverse T-Carrier systems.

In the PSAP direction, U S West again transports the trunks from the E911 Tandem to the appropriate PSAP, usually the CSUPD in our case. Please note, as indicated Figure 1, that two distinctly separate groups of trunks exist: (1) from the PBX to the E911 Tandem, and (2) from the Tandem to the PSAP. One trunk is selected from each group and both are connected "in tandem" (end-to-end) to provide one talking path between the 911 caller and the PSAP, via the E911 Tandem. (This is often a source of confusion, during committee meetings no less!)

Pre-Testing

Once all trunk circuits were installed and individually manually tested for proper signaling operation and transmission levels, and the PSAP at CSUPD was in place and functioning with datalinks to the ALI database, pre-testing of the entire system end-to-end could commence. Testing was primarily accomplished by CSU police officers on their rounds and telecom technicians repairing customer sets. They simply dialed the test code 211 and insured that the CSUPD PSAP answered and the calling telephone number and ALI was correct.

Other Issues or Difficulties

E911 PS/ALI users should ask their LEC to double check that each redundant trunk or data circuit is routed over diverse carrier routes. We found both of our PBX-to-E911 Tandem trunks originally assigned in the same T-Carrier system. If this one T-Carrier were to have failed, CSU would have lost all E911 service.

As a fail-safe plan if both trunks to the Denver E911 Tandem should be busy or failing, we have prearranged to alternate route 911 calls directly to a phone at the CSUPD. No E911 ANI/ALI or Call Transfer to Another PSAP features will be available, but the calls will still complete to a 911 dispatcher.

The small AT&T System 75 PBXs do not provide ANI or Operator Services-type signaling. The only call routes in and out of these PBXs are via the SL-100 PBX over two-way Wink Start/DTMF Trunk Groups on T-1 Carrier lines. These Trunk Groups' translations in the SL-100 specify a "Billing Telephone Number" to which incoming calls from the specific System 75 should bill. CSU doesn't use the Billing Number for SMDR (Station Message Detail Recording) billing. However, the Billing Number is outpulsed over the E911 trunk as the ANI number, and displays at the PSAP as the general location (ALI) of the System 75 PBX.

Not only do we route the digits 911 to the PSAP, we also route 9-911 and 8-911 to accommodate those users who mistakenly believe that 911 is an off-campus call.

Coincidentally, the North American Numbering Plan has depleted the pool of unassigned Numbering Plan Area Codes (NPA) where the second digit is either a 1 or 0. The Interchangeable NPA Numbering Plan, that re-uses three digit codes (traditionally and presently assigned as central office "NXX" prefixes) also as NPA codes, was implemented by U S West in Colorado during the Fall and Winter of 1993. (All of the United States and Canada must be converted by January 1995.) The U S West Dialing Plan calls for the prefix 1+ to indicate that a 10-digit long distance call is being dialed, whereas no 1+ prefix indicates a 7-digit local call is being dialed. (Under U S West's Dialing Plan, the Area Code must be dialed on all long distance calls even if the call terminates within the caller's Area Code. To the caller, the 1+ prefix will seem to indicate a toll call.)

CSU telephone users had been dialing 9 + NPA + 7-digits when Dialing Direct. No 1+ prefix was dialed nor required to determine if a call was toll or local as the three digit NPA or NXX code inferred the number of digits expected. This is no longer the case under the Interchangeable NPA Numbering Plan; CSU callers must now dial 1+ to indicate a 10-digit number is following.

However, the dialing sequence would then be 9 + 1 + NPA + 7-digits. This new '91..." sequence concerned us at the Telecommunications and Police Departments as the digit 1 could be dialed twice in error resulting in a misdialed 911 call. (The digit 1 can be dialed two or more times either by errant dialing fingers like mine often are, or defective DTMF (Touch Tone) dials that produce stuttered or garbled tones.) Since CSU callers typically dial several hundred long distance calls per hour, the

probability of 911 being dialed in error several times per hour seemed possible. This was unacceptable to the Police Department.

The solution was to convert to dialing 8 (instead of 9) when calling off-campus locally or long distance. The cutover date (November 1) was well publicized and explicit recorded announcements reminded errant callers to "dial 8 when calling off campus," or "dial 8 + 1 + 303 when calling within your own Area Code." To our pleasant surprise, the Dial 8 conversion went very smoothly with few confused calls to the switchboard operators or complaints from our 25,000 users, although initially 25% of all originated calls were routing to announcements after cutover.

Cost

A cost/benefit analysis of E911 PS/ALI's fast, accurate fire dispatching capability can demonstrate cost savings to be had versus the high cost of replacing facilities more fully destroyed by fire. However, the same "bottom line" analysis is difficult to perform upon human life and welfare. Instead, humanitarian policies to provide high quality police and ambulance services, within the confines of available funding, may become the guidelines for implementing E911 PS/ALI.

Listed below are the telecommunications rates for the component services for E911 PS/ALI as tariffed in Colorado. As public safety policy and telecommunications rates are both highly political, rates for similar services in other states may deviate widely.

Service Description	Installation	Monthly
PS/ALI and Selective PSAP Routing		
• per 1,000 DID station lines	$251.32	$80.90
• per PSAP trunk	431.11	33.52
Trunk, Service Provisioning		
• first trunk	280.42	n/a
• each additional trunk	94.67	
Network Access Channel		
• four wire, per trunk	n/a	38.64
Channel Performance		
• signaling, per trunk	126.01	20.20
Transport Mileage		
• fixed, per trunk	42.00	26.56
• per mile, per trunk	n/a	0.34

Conclusion

Colorado State University is now providing its telephone users with Enhanced 911 Emergency Service, achieving a level of calling number and location identification previously unobtainable by Private Branch Exchange extensions. In the highly transient population of Colorado State University students and summer conferees who may likely be unaware of their specific location, U S West Public Safety Group's E911 Private Switch / Automatic Location Identification service (E911 PS/ALI) provides a good technical solution to a potentially lethal problem.

Addendum A
E911 Detailed Operation Description

The following information is provided to aid telecommunications technicians in understanding the details of E911 call processing. The reader is assumed to be knowledgeable of standard telephony trunk signaling protocols such as Wink Start, On/Off-hook Supervision, and Multi-frequency Tone (MF) digit outpulsing. MF signaling uses different tone pairs than DTMF (Touch Tone) signaling.

Please refer to Figure 4.

(1) An emergency caller lifts the telephone receiver, listens for dial tone, and dials the digits 911.

(2) The serving central office (or PBX) collects the digits, analyzes them, and determines that the call should be routed over one of the dedicated trunks to the E911 Tandem Switch. The E911 trunk employs Operator Services type signaling normally used to connect the central office to an AT&T Traffic Service Position System (TSPS), Northern Telecom Traffic Operator Position System (TOPS), or AT&T Operator Services Position System (OSPS). All E911, TSPS, TOPS, and OSPS trunks use the same "Operator Services" digit transmitting and signaling protocol that transmits the called number followed by the calling number (Automatic Number Identification (ANI).

(3) The central office selects an idle trunk and sends an off-hook seizure signal toward the E911 Tandem.

(4) The Tandem responds (usually within 100-300 milliseconds) by attaching a Multi-Frequency (MF) Tone Digit Receiver to the trunk and returning a Wink Start signal back to the originating central office indicating that the Tandem is ready to receive the called digits from the originating central office. (The Wink Start signal is nothing more than a nominal 150-350 millisecond duration "off-hook" signal sent toward the originating end of the trunk. The Wink Start off-hook duration is never longer than 500 milliseconds. On old operator cordboards, the momentary off-hook made the supervision lamp "wink" off and back on, hence the name Wink Start.)

(5) The originating central office deletes the first digit (9) of 911, and transmits the remaining digits using MF outpulsing: "KP,1,1,ST", which is standard E911 signaling protocol. (KP is the Key Pulse digit; ST is the Start digit.)

(6) The E911 Tandem upon receiving the called number then returns a continuous off-hook signal back toward the originating central office prompting it to transmit the calling number (often called "ANI Spill").

(7) The originating central office, again using MF tones, outpulses:

"KP,I,N,N,N,N,N,N,N,ST" where the I is the Identification Digit used to identify various classes of lines:

0 = ANI successful, POTS single or two-party line, or PBX

1 = ONI (Operator or PSAP dispatcher must orally query the multi-party line caller as to his calling number, central office can't perform identification.)

2 = ANI failed to function properly, do ONI

6 = Hotel/Motel Room Guest (Dial 8)

7 = Specially Screened call such as Charge-A-Call public phones, or University lines that prohibit Station Paid calls from being made.

NNNNNNN represents the 7-digit calling telephone number (ANI) being transmitted to the PSAP via the E911 Tandem switch.

(8) After outpulsing both the called and calling numbers, which takes about four seconds, the central office connects the caller's line to the E911 Tandem trunk.

(9) The E911 Tandem, having received the called number of "1,1", recognizes an incoming E911 call and collects the ANI digits, as described in Step 7 above. The calling ANI digits are used to index into the E911 Tandem switch's disk-resident call routing database which outputs an Emergency Services Number (ESN). The ESN represents (1) a unique set of police/sheriff, fire, and ambulance jurisdictions that provide emergency services to the caller (and his neighbors) and, (2) the PSAP the call should be routed to initially. There can easily be hundreds of ESNs in a E911 Tandem, and more than 1,000,000 telephone numbers.

(10) Using the PSAP route specified by the ESN, the E911 Tandem selects an idle trunk to the PSAP and sends an off-hook seizure toward the PSAP's trunk unit. (If no idle trunks are available or the trunk group is "made busy" or otherwise out of service, the E911 Tandem will route the caller to another prearranged PSAP which will provide backup emergency dispatching.)

(11) Upon receiving the off-hook seizure from the E911 Tandem, the PSAP trunk unit returns a Wink Start signal to the Tandem indicating the PSAP is ready to receive the caller's ANI.

(12) The Tandem then MF outpulses: "KP,X,N,N,N,N,N,N,N,ST", where X represents the digits 0 through 3 which are used as short representations for four different Numbering Plan Area Codes that might be served by the PSAP, and N represents the caller's 7-digit ANI number. In most cases, the X digit is 0 (zero). Upon completion of MF outpulsing of the ANI to the PSAP which takes two seconds, the Tandem connects the trunk from the originating central office in tandem with the PSAP trunk.

(13) The PSAP's trunk unit (not the LEC central office, PBX, or Tandem) returns the Audible Ringing signal to the caller to alert them the call is ringing at the PSAP.

(14) The PSAP equipment alerts the dispatch personnel of an arriving call. The ANI information is transferred from the PSAP trunk unit to another PSAP unit that reformats the ANI information into a query message that is transmitted to the LEC Automatic Location Identification (ALI) database over a dedicated (non-switched) data circuit. The database usually responds within one second with the caller's name and address information.

(15) When the PSAP dispatcher answers the call, the PSAP discontinues the Audible Ringing signal and connects the caller and dispatcher together. The ANI/ALI information is simultaneously displayed on a small video screen adjacent (or integral) to the PSAP telecommunications console. This information may also be automatically logged into the PSAP's Computer Aided Dispatch (CAD) system simultaneously.

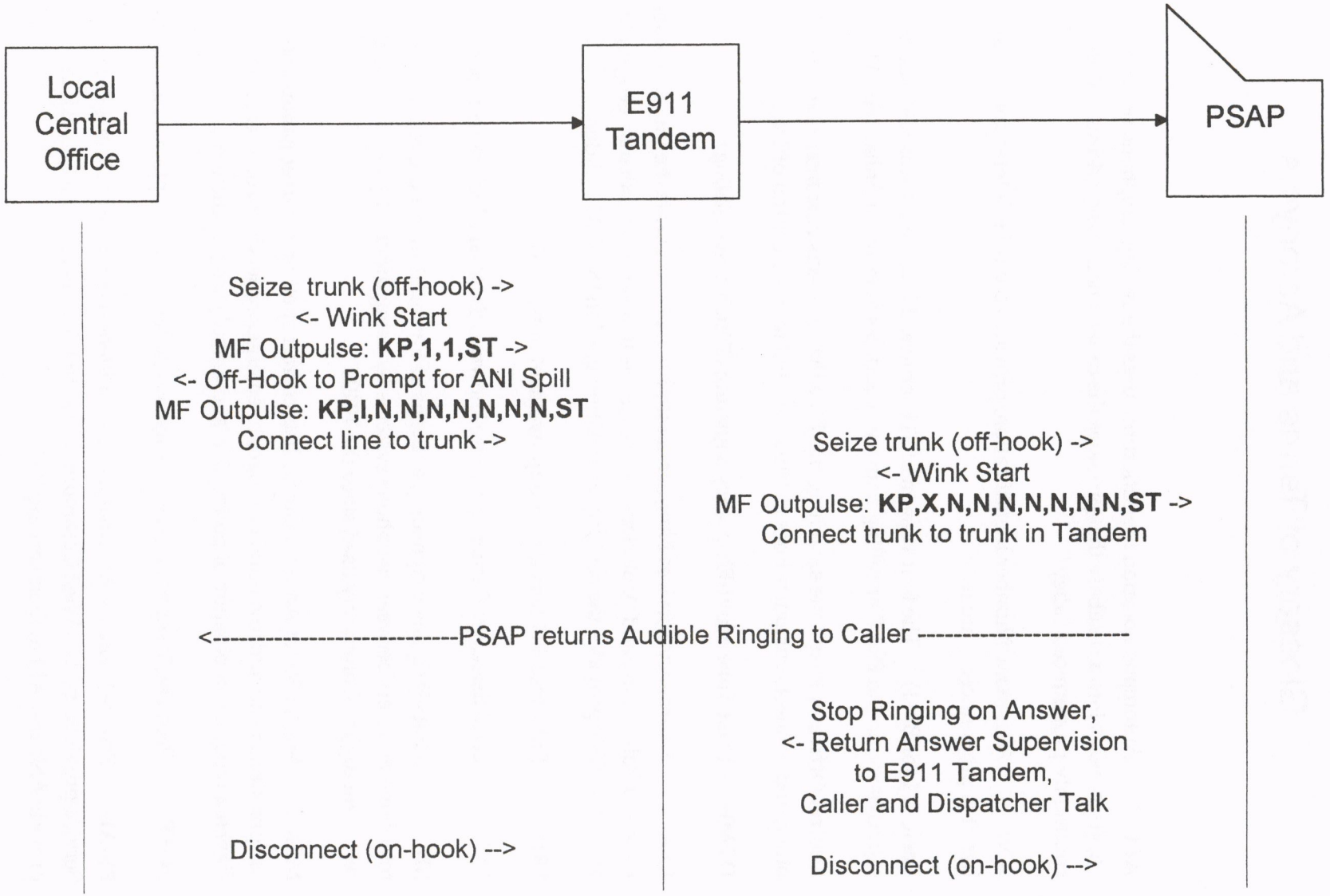


Figure 4
E911 Trunk Signaling Protocol
between
Central Office, E911 Tandem, and PSAP

Addendum B
Glossary of Terms and Acronyms

ALI Automatic Location Identification, uses the calling telephone number (ANI) to index into a database that provides the caller's name and address. It is commonly pronounced "alley."

ANI Automatic Number Identification, provides the caller's telephone number. It is pronounced "annie."

Basic 911 (or B911) The first version of 911 service. However, it was without the selective routing to PSAP or calling name and address features of Enhanced 911.

Central Office A telephone switching machine that connects customer lines to each other, and connects customer lines to trunks routed to other central offices.

DTMF Dual-Tone Multi-Frequency signaling (Touch Tone Dialing)

ESN Emergency Services Number, a number that represents the unique combination of Police, Fire, and Ambulance jurisdictions that serve a particular geographic area. The ESN provides the routing information used in the E911 Tandem switch.

E911 Enhanced 911 Service, an improvement of Basic 911.

LEC Local Exchange Carrier, otherwise known as the local telephone company.

MF Multi-Frequency signaling, a means of transmitting calling and called telephone numbers between telephone systems by using different pairs of tones to represent digits. Commonly used since the 1940s.

MSAG Master Street Address Guide, lists correct spelling of street names and assigns streets and address number ranges to emergency services zones each assigned a unique combination of police, fire, and ambulance jurisdictions.

POTS Plain Old Telephone Service, such as residence and simple business lines.

PS/ALI Private Switch / Automatic Location Identification, an optional E911 Service provided by U S West Communications to PBX customers who wish to provide ANI and ALI to their serving PSAP.

PSAP Public Safety Answering Point, where 911 calls are answered and dispatched or transferred.

Tandem A telephone switching machine used to interconnect two inter-central office trunks "in tandem" (one trunk to another). The E911 Tandem connects E911 trunks from central offices to various PSAPs based upon routing data contained in the E911 processor's database.

T-Carrier A modern, very prevalent type of digital telephone transmission system that uses Time Division Multiplex and Pulse Code Modulation to accomplish its function. One T-Carrier system carries 24 simultaneous, but separate, calls over one circuit.

Trunk A circuit that connects a telephone call between two central offices (or a central office and a Private Branch Exchange). It is a shared resource that serves one call at a time, but is accessible by all lines in each central office.

Trunk Group A group of individual trunks that connect the same pair of central offices to each other, and share common signaling and routing characteristics.

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