International Considerations in PBX Design

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Private Branch Exchanges (PBXs) designed for the global marketplace must be adaptable to differences among the technical and cultural environments in which they will be sold. In this paper we describe some of the challenges arising from these differences, and illustrate approaches taken to address them.

Introduction

Culturally-based expectations are an important and sometimes underestimated part of what types of technical designs customers view as natural, correct, and easy to use. When considering communications systems, particularly Private Branch Exchanges (PBXs), it is important to recognize the special implementations that people accept as "natural." For one thing, PBXs often are heavily used, and even small problems with perceived ease-of-use—e.g., the PBX not doing the expected—can produce customer dissatisfaction and decreased efficiency. Even for alternatives that *seem* objectively equal in performance, the users' experiences with one method may produce strong subjective preferences.

This paper describes some culture-related differences important to designing PBX equipment for the international market. These differences are related to aspects of the technical environment, but also to non-technical matters of history, culture, and society. Although we will treat these technical, historical, cultural, and experiential factors as though though they were mutually exclusive, in fact these sources interact. For example, characteristics of the technical environment lead to particular ways of doing things, and experience with certain methods leads to subjective preferences for them. Similarly, social conventions often shape characteristics of the technical environment and produce technical differences among international markets. Research[1] shows that these interrelated areas can affect a PBX design.

Recognizing intercultural differences and their importance is only the first step in successful global PBX design. The product must be designed to address those differences, and various methodologies are available for that purpose. These include specialized customer documentation, generalizable product flexibility and specific product modifications (localizations). The most appropriate methodology for the needs of a particular locale must be determined with great care because every cultural difference cannot be reasonably accommodated through lengthy and economically unsound customized design or redesign of the PBX.

Our approach includes four basic practices. Each has costs and benefits that are evaluated in terms of each adaptation issue. That is, their applicability depends the specific problem they are meant to solve.

- Providing features to meet the needs of particular countries. We call such adaptable, multi-country hardware and software designs *World Class*. This is a dominant theme in AT&T's current global PBX development.

- Providing customized features not intended for more general application. This approach is time-consuming and expensive, but may be suitable for critical needs in high-payback markets. Besides the cost of designing and maintaining special features for a potentially limited market, this approach risks breaking existing software and generating unexpected and potentially conflicting interactions between and among features.

- Reusing existing PBX features. This approach sometimes can be used to address special feature needs without changing the PBX's design. But such an approach may require creative insight to overcome our personal experience using existing features.

■ Documentation and training. A fourth approach is to provide a combination of additional documentation and training to ease the transition to an alternate implementation. Unfortunately, though it appears attractively simple, this approach most frequently challenges users because it places the burden of adaptation upon them, and can create customer acceptance problems. Therefore, using it must be carefully justified.

Using these approaches, separately or in combination, will be found in examples of problems presented throughout this paper.

Impact of Differences in the Technical Environment

The technical operating environment has a profound effect on PBX use and design. Given the relative ease of modifying PBXs compared to the public telephone network (PTN), PBXs often are buffers to accommodate PTN cultural effects on end-users. How this buffering is done varies among countries. For example, long PTN call setup delays in some countries often lead to using attendants to place calls. Therefore, many specialized features have to be built in to accommodate attendant needs.

Long Call Setup Delay. In many countries, step-by-step (S×S) switching equipment until recently has been the PTN's foundation.[2] Telecommunications implications include slow call setups and, typically, geographically-dependent numbering systems.

Interpreting call-setup delay. Though the standard objective in advanced telephone networks is return of dial tone within two seconds, in some PTNs a 15-second (or longer) wait for dial tone is common, while in other countries such a long delay reliably indicates trunk problems. Thus PBXs must be adaptable to avoid misinterpretations of long dial tone delay as a trunk fault in some countries, while being able to detect legitimate trunk problems in others. In addition to maintenance, PBXs may use expected return-of-dial tone delay to determine, after seizing a trunk for an outward call, when to transmit addressing to the central office (CO).

A common PBX feature is *senderized outward addressing*, where the PBX collects all manually dialed digits from an extension, optionally converts the signaling to dual tone multifrequency (DTMF) or dial pulse (DP) format, and then sends addressing to the CO at high speed. The PBX must ensure the presence of PTN dial tone before address transmission. To do so, it may provide a wait between trunk seizure and transmission, based on expected return-of-dial tone delay. AT&T PBXs adapt to return-of-dial tone delay variability by providing an administrable "World Class" timer for this purpose. Experience with American PTNs suggests a 5 to 10 second maximum value for this timer. However, based on requirements in environments where the Definity® telecommunications system is being marketed, the upper limit of this timer has been raised to 255 seconds and even may allow disabling the timer entirely.

For other dial tone delay variability problems, the cut-through dialing capabilities of the Definity PBX are enhanced to allow the caller, not the PBX, to listen for PTN dial tone. (In *cut-through dialing*, the calling station is connected to the PTN before the addressing digits are sent. As the calling party enters digits, they are immediately sent to the PTN. Cut-through dialing is the opposite of *senderized* dialing.) At the same time, the Definity communications system still is able to restrict outward calling based on the dialed number.

Attendant usage. In PTNs with slow call setups, busy managers often do not make their own calls. Numbers to be called are given to PBX attendants who then make them. In some countries, secretaries may handle this task, but relying on centralized attendants is more common. PBX feature designs need to accommodate special attendant needs for this purpose.

For example, to allow PBX attendants to work more closely with PTN operators, in some countries special PBX-to-CO signals can be sent by having the PBX attendant press a console key to signal his or her PTN counterpart. This feature can provide some task sharing between the PTN operator and PBX attendant in completing one or

more calls. As each connection is established, the PBX attendant returns to the calling party, informs him or her that the call has been made, and then releases from the call.

In environments with difficult call setup, once an outside caller reaches a PBX, its features should help ensure connection maintenance. This sometimes requires disabling the automatic disconnection features that are useful in faster or more reliable PTNs. Many of these protective features are based on ensuring that incoming calls are returned to the attendant if any problem develops (e.g., a call is accidentally left on hold). These features give the attendant additional call maintenance responsibilities not common in the United States market. Examples include:

- The *Serial Calling* feature lets an outside caller reach several different PBX parties with a single call. The caller gives the PBX attendant a series of extension numbers. As each conversation ends, the outside caller is returned to the attendant to continue the call series. This feature is not popular in the U.S. because similar functions are provided by transfer features initiated from the PBX party's phone.

- The *Auto-Hold* feature meets the specific needs of the Italian market. If an active call is in progress, the user might press another line appearance button to place another call. Without Auto-Hold, the active call is dropped. This is unacceptable in Italy because it increases the chance for mistakenly dropping incoming PTN calls. With Auto-Hold, when the PBX user presses another call appearance button, an active call is placed automatically on hold until the PBX user returns to it and deliberately hangs up. This can increase the likelihood of mistakenly leaving a call on hold. Therefore, additional features (such as long hold notification and transfer to attendant) are needed because of this particular cultural difference.

- In the U.S., once a call gets to the PBX, an unanswered call may continue to ring as long as the caller waits. Callers in some countries, however, may find this disorienting. Therefore, it was necessary to add a set of internationally-oriented features to make it almost impossible for an incoming PTN call to remain unanswered. These features ensure that all "orphaned" calls are routed to an attendant rather than dropped.

Availability of DTMF Signaling. In many countries, dual tone multifrequency DTMF signaling is not wide-

spread. In others, DTMF detectors on PTN trunks are ubiquitous. PBX support of DP signaling might even be optional in such countries. Differences in DTMF penetration reflect both technical and economic factors. They also reflect different cultures' attitudes toward convenience-versus-cost tradeoffs. Both differences in DTMF signaling availability and the acceptability of DP telephones significantly affect PBX design. For example, extensive flexibility must be provided to deal with varying requirements on detection and generation of DP addressing make/break ratios and speed [e.g., 10 or 20 pulses per second (pps)].

Auto-attendant and voice mail. Auto-attendant systems are becoming widespread, particularly in the United States. These systems answer calls and ask incoming callers to enter information, via DTMF tones, that allows some level of automated call handling. For example, callers may specify if they are calling to reach a service department or to place an order. The auto-attendant feature then transfers the call appropriately. The usefulness of such features depends on the critical assumption that most callers will use DTMF-capable phones that can interact with the auto-attendant. Though the Definity communications system provides advanced call vectoring and prompting features, these may not be effective in non-DTMF environments. Software for these features must be carefully designed to handle non-DTMF calls.

PBX feature access from analog phones. A common feature access method is to quickly press and release (i.e., "flash") a phone's switchhook. But it is frustrating when the time difference between flash and the longer disconnect signal does not match user expectations. Expected (i.e., learned) switchhook flash duration varies among countries, and the PBX must be adaptable to this norm.

An example involves flash signaling in Japan. In the U.S., PBXs typically interpret on-hooks of less than one second as flashes. In keeping with human factors studies of flash and disconnect movements by U.S. PBX users, pressing for more than 1.5 seconds is interpreted as a disconnect request. But in Japan the standard disconnect interval is only 1 second. Because this operation is so common, the disconnect interval becomes highly learned, and people produce a narrowly distributed range of switchhook press durations, peaking near the minimum acceptable value. When Japanese users attempted call-disconnects with a switch with a slightly longer disconnect criterion (about 0.5 second), many

Figure 1. An illustration of different telephone keypad layouts.

presses between 1 and 1.5 seconds either were ignored by the PBX or—if they were less than 1 second—were interpreted by the PBX as requests to put calls on hold. Because the switchhook press interval was so ingrained, addressing the problem through documentation was insufficient: software and firmware flexibility also was needed. It was provided by administrative setting of upper and lower flash boundaries and well as by disconnecting the lower boundary.

Telephone Keypads. Telephone keypads have been a traditional area of human factors study. Culture-related keypad issues affect not only human performance but also the design and usability of advanced PBX features. Keypad lettering provides one example based on most U.S. touch-tone keypad buttons having alphabetic characters. Definity systems use these to support an integrated directory feature so users can find names by entering them on the keypad.

Unfortunately, the presence of keypad lettering varies among countries. Several examples appear in Figure 1. Also, even when keypad lettering is available, the directory feature may not be matched to particular cultural needs. In the U.S., the accepted name-entry sequences are given-name, family-name (e.g., Johann Schmidt) or family-name, given-name (e.g., Schmidt, Johann). The integrated directory feature is built on this culturally-based characteristic. But in Hungary, for example, where names generally are expressed as family-name given-name (e.g., Schmidt Johann), this can lead to confusion during feature administration because unexpected commas must be inserted to conform to U.S. name entry conventions. Because this problem affects

few people (i.e., primarily system administrators) it is practical in this instance to address it by providing special training and documentation.

PTN Numbering Plans. PTN numbering plan structures in some countries vary widely from a fixed 10-digit dialing plan to a variable plan where 3 to 8 digits may be dialed. From a PBX perspective, differing numbering structures have a particular effect on call restriction and routing features. Such features require the PBX to analyze dialed PTN numbers. Because call permissions can be based on call destination, the PBX may be able to select a call routing alternative such as a private network trunk.

In most countries, the length of the dialed digit string is not fixed. PTN address strings are between five and 12 digits, depending on the endpoint's location. This reflects the operation of PTN equipment that sequentially processes each digit by small steps to move the call closer to the endpoint. Only the minimum digits needed to precisely specify the called location are processed. In the United States, the fixed-length PTN numbering plan format (i.e., every local number is exactly 7 digits) reflects the flexibility associated with table look-ups and stored program control equipment. A PBX must therefore be able to adapt to various digit-string formats.

Because of the complex, variable nature of PTN numbering schemes, the Definity communication system uses a menu and highly adaptable PBX call routing algorithm called the World Class Multinational Call Routing (MNCR) algorithm. It allows administrators to analyze multiple address strings without placing major limitations on selected address strings to be sent to the PTN. Aside from the details of MNCR, this capability is one of

15 features making up a World Class Core feature set that contains the basic set of the Definity PBX's globally-adaptable capabilities.

As the name implies, WCC features are applicable not only in the U.S. but also worldwide. Furthermore, the Definity system's global capabilities rely on an International Core feature set that can address telecommunications needs encountered only *outside* the U.S. These include, for example, special regulations restricting the conferencing of PTN trunks. These two feature sets provide much of the Definity telecommunications system's adaptability to varying global requirements.

Impact of Social and Cultural Factors

Besides special technical characteristics found in the global marketplace, many broader social aspects of PBX markets also must be addressed. These sociocultural characteristics arise from the historical development of each culture. They include the economic system, the demographic structure, and the mores and folkways that develop and evolve in each country.

The economics of PTN trunks and services in each country greatly affects the importance of PBX features. The users-to-phones ratio is often higher than is normally found in the U.S. Expense and unreliable trunks in some countries increase traffic use per trunk compared to typical U.S. values. Higher line-to-trunk ratios than are typical in the U.S. are also found. And economic factors influence line side usage. These differences often invalidate assumptions predicated on U.S. experience that underlie call-handling capacity engineering. Instead, more conservative analyses may be needed.

Dial Pulse Telephones. Rotary and pushbutton dial-pulse (DP) telephones are also used on overseas PBXs more frequently than in the U.S. This reflects the economics of equipment replacement and different expectations about telecommunications technology. Because DP phones are so likely to be encountered in non-U.S. markets, it is particularly important to be able to adapt feature-access methods to these instruments. The most obvious problems are that the "#" and "*" symbols are absent. To adapt to this need, the Definity system allows access to most PBX features (e.g., conference, hold, and transfer) via switchhook flashes from DTMF and DP analog phones.

Social Conventions. Many social conventions have arisen around telephone use and must be addressed. In Japan, it is important that business calls be answered after no more than two rings. To accommodate this convention, features such as pre-ringing are provided so delays introduced between the audible portions of each ring cycle will not delay call answering. (*Pre-ringing* provides a short, immediate "ping" of ringing if a call is presented during the silent period of the ringing cycle.) On the Definity system this issue is addressed primarily with digital phones. Because these phones generate their own alerting signal after getting a control message from the switch, there is no chance the phone will begin the ringing cycle during the silent portion, thus delaying incoming call notification.

Call Coverage Preferences. The question of call coverage requires dealing with many personal and cultural preferences. A particularly important aspect is "manager-secretary" call coverage. Some managers like to answer their own phone and have their secretaries answer only when they are unavailable; others prefer the secretary to screen their calls. Some managers want to know when someone is calling (even when the secretary answers), while others don't. To adapt to these preferences, our approach is to provide a high degree of administrative flexibility. The following scenarios provide examples of the resulting adaptability.

To divert every call to the secretary, a manager's phone may be assigned the coverage criteria "ALL CALLS." For the manager to answer, and the secretary to answer when he or she is unavailable, a Send-All-Calls (SAC) button can be administered. When the manager leaves, the SAC button is pressed to route calls to the secretary. Secretary-to-manager calls may involve the Auto-Intercom feature that provides a distinctive, audible alert. Using the Temporary Bridged Appearance feature, a manager can still pick up a call and, by seeing the terminal display change from "Conference 2" to a trunk group name, the boss can know that the secretary has left the call. If the manager wants an audible alert when incoming calls are redirected a to the secretary, the phone can be administered with Redirect Notification=YES. Redirect Notification=NO eliminates the audible ring while visually indicating an incoming call. If the manager wants to answer calls but wants the secretary to get unanswered calls or those made while he or she is busy, then standard call coverage features are used.

Call Transfer Etiquette. In some cultures, it is impolite to transfer calls to people without first asking if

they want to receive them. The Pull Transfer feature meets this need by allowing the transferred-to party to complete the transfer hand-off (i.e., to "pull" the call) rather than allow the sending party to complete the transfer (i.e., to "push" the call), as in the U.S.

This feature is also related to the perceived impoliteness of transferring a caller to a phone that goes unanswered. The politeness issue is often coupled with the concern that PTN limitations may make obtaining a line difficult. Therefore callers must not be left without any alternative but hanging up and placing another call.

In some countries, expected call transfer procedures involve the attendant. Calls to be transferred are first returned to the attendant, who then completes the process. The Definity communications system Serial Call feature is useful here. If a caller wants the attendant to return after talking with a PBX party, the attendant can enable the Serial Call feature before extending the call. When the PBX party hangs up, the call returns to the same attendant for another transfer.

PBX Tones. Many aspects of a country's telecommunication system can be regarded as almost arbitrary. Perhaps this is illustrated most clearly by PTN and PBX call progress tones. Almost every country has special requirements in this area. Because call progress tones provide important feedback to many untrained users, it is particularly important to be able to adapt to each country's specific tone requirements.

The Definity communications system incorporates several strategies to deal with diverse tone requirements. First, administrable levels of tone-detection precision are available to detect PTN tones. In the least precise mode, the Definity system simply detects broadband acoustic energy above a particular threshold.

Multiple tone sets are provided for tone generation, based on a fundamental repertoire of frequencies and cadences. Enough pre-defined tone sets exist to cover almost all expected international markets. But where no exactly matching tone set is available, provisions have been made to administer customized tones that can be substituted for any tone in a pre-defined set. Each tone definition is based on a simple tone-programming language, and allows independent frequency, level, duration and cadence specifications. With World Class tone-set generation, the needs of all currently expected markets are being addressed.

Local Language. Using the local language is an important enhancement. Some features may be useless unless they are presented in the local language. These include most features designed for voice interaction with inexperienced users (such as ring-only and automated attendant). Using the local language also increases ease-of-operation also may make it easier to find qualified employees for positions such as system administrators and attendants. Ease-of-use is critical because of high workloads associated with attendant and system administration jobs. In addition, using the local language reduces the chance for confusion when trying to interpret technical labels and field names during system administration.

Besides usability, local language support meets a competitive need by addressing more subjective, emotional reactions to products with English-only language support. In many countries (including the U.S.) there is a justifiable degree of negative reaction toward products that lack enough local-language support. The Definity PBX addresses local language needs with several capabilities.

First, the PBX has built-in, standardized, alternate-language dictionaries for the most commonly used languages in target markets, including Italian, Spanish, and French. As the market increases, new language sets can be accommodated via language-support algorithms that permit new sets to be added easily. Generally, such sets, rather than replacing existing sets, are added to those already there. Thus, a software base is grown that is suitable for new markets. In addition, the Definity communications system allows non-English-language customers and distributors to program their own custom display languages for system administration terminals, attendant consoles, and display-equipped digital stations. A specialized dictionary-generation feature allows distributors and end-customers to enter a custom set of display messages in their own language. This capability allows the Definity PBX to support any language so long as it is Roman character-based. In addition, this capability addresses the reality that a native speaker, and preferably the system user, is best able to select the most significant and understandable descriptive non-English terminology for messages for the system.

Privacy Issues. Legal and subjective privacy requirements vary greatly among international markets. These issues influence many PBX features including conferencing, bridging, call intrusion, station message detail

recording (SMDR) reporting, and automatic call distributor (ACD) agent monitoring. In terms of privacy restriction, the U.S. is probably near the middle. For example, ACD agent monitoring is allowed, and it is not necessary to provide continuous indication to all conference parties that more than two people are on the call. Countries with stricter privacy requirements disallow the first feature and enforce the continuous conference-tone requirement. Countries with less strict privacy requirements may not require even call-monitoring tones.

Providing a call-monitoring tone during conferences is handled as a special feature activated through system administration. Usually the PBX can be adapted to special privacy requirements with PBX tone plan administration features, though these features were not designed specifically to accommodate these types of differences.

Tenant Services. Many international markets have tenant arrangements that allow user groups in a large building to lease or rent portions of a large, common PBX. The features that support tenant-mode operation vary widely. Tenant-service capabilities may even allow tenants to customize feature access codes and other numbering plan characteristics. Because of the potential complexity of tenant arrangements, tenant-service features often are costly and may involve frequent interactions with call processing functions. To avoid dramatic software architecture changes while providing general purpose tenant capabilities, existing call restriction and SMDR features and numbering plan flexibility are used to satisfy many tenant-feature needs.

One important tenant service feature is that tenants should be able to own trunk groups and prevent other tenants' access to them. It is also useful to provide general-access privileges to high-priority tenants or attendants. In the Definity system, these conditions can be met by assigning Class Of Restriction (COR) codes to each tenant's facilities, and by defining COR connection permissions and permission override authorizations. Analyzing tenant arrangements in key international markets showed that by increasing the CORs supported by the PBX and by using this existing, largely unchanged (i.e., changed only in quantity) COR assignment capability in a new way, almost all tenant facility groupings could be provided.

Another important tenant-service capability

allows each tenant to access its own attendant or trunk groups in a direct, consistent, and convenient way. In the U.S., PBX users typically dial "0" for an attendant and "9" for an outside trunk. Furthermore, tenant service requires that particular attendants or trunk groups are reached depending on the tenant who originated the request. This capability also can be provided through existing features not specifically intended for tenant operation. These include second-digit dialing tables, COR restrictions, and Automatic Route Selection features. For example, members of Tenant A might dial "10" to reach their attendant(s) and "19" for an outside call: Members of Tenant B might dial "20" and "29." Restriction features can prevent Tenant A members from accessing Tenant B's attendant(s).

Conclusions and Summary

Although it is important to accommodate culture-specific needs of international markets, product success also requires identifying and selecting the best approach from numerous alternatives. It is impractical to provide specialized designs for *every* individual characteristic of every market. Local experts with long-term experience using their national PTN often provide the most cost-effective insight in setting this cut-line. The perspective of non-natives is almost sure to be biased by their experiences.

This paper has presented some of the differences among PBX markets arising from both technical and historical, cultural, and social factors. It also has described methods to address them, and has stressed the importance of recognizing these differences and of adapting to them in appropriate ways.

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