Technology White Paper

IP Telephony (IPT):
What Airports Need to Know

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Ross&Baruzzini

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Today's Comfort Zone

A decade ago, the telephone industry and related enterprise telephone systems (Customer Premise Equipment/CPE) faced an unfamiliar challenge: Y2K. Many self-appointed experts received tremendous press predicting that telephone and computer systems would cease operating because of an inability to process the correct date and plummet electronic systems into a world of chaos. Despite widespread uncertainty, Y2K passed as an expensive non-event.

In the process, facilities spent millions of dollars on new and upgraded telephone systems. By the time January 1, 2000 arrived, the United States boasted the most reliable and maintainable telephone infrastructure in its history. As a whole, it was state-of-the-art at that time, equipped with spare capacity and upgradeable via software and firmware. The United States stood in a more robust telephony environment than it could ever have imagined a decade earlier.

Today there are clouds on the telephony horizon. Systems are approaching the end of their supportable service life (generally ten years), and most manufacturers will no longer provide support for them. This forces a new round of telephone system planning and procurement. Traditional telephony is being replaced with Internet Protocol Telephony (IPT) and requires existing telecommunications organizations to step out of their comfort zone. This paper will shed light on what airports need to know about IPT.

Uniqueness of Airport Communication Needs

The communication needs of an airport are unique from other types of facilities. Not only do millions of people with cellular phones and laptops pass through airports each day, airports also house and often provide the infrastructures for data and voice transmission of the airport staff, airlines, federal agencies, check-in counters, boarding gates, concessions, courtesy/emergency phones, and other communication capabilities on the airport campus.

Additionally, airports must respond efficiently and effectively to life safety emergencies. With such a quantity of employees and passengers, the chances of a spontaneous crisis are multiplied. Even manmade disasters that threaten the lives of many people at once (bombs, terrorist attacks) are situations that airports encounter all too often.

The communication system of an airport is the nervous system that connects the campus, enables transportation of information, and keeps the airport body alive. Airports demand reliable voice and data transmission to minimize delays and provide dependable information exchanges. During normal activity, the network must support a fast-paced, time-dependent environment in which operations have cascading effects on airports around the world. During a catastrophe, the survivability, reliability, speed of transport, and traffic-handling capabilities of the network are the difference between life and death, success and failure.

IP Telephony (IPT): Not Voice over IP (VoIP)

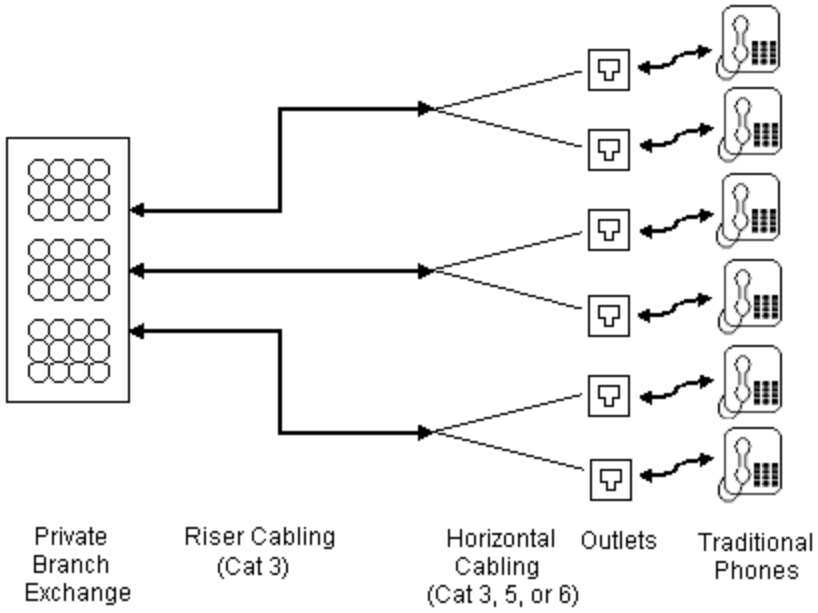
IP Telephony (IPT) represents the convergence of voice and data communications over an IP-based Local Area Network (LAN). The terms IPT and Voice over IP (VoIP) are often used interchangeably in the Information Technology (IT) industry, which is misleading. VoIP is the addition of voice to an existing network, using the data network in place. IPT is the creation of an IP-based communications system from the beginning, taking into consideration the current environment, needed reliability, quality, traffic distribution, security, and on-going support and maintainability. The bottom line: VoIP is a part of the broader IPT system.

IPT is quickly replacing traditional telecommunications systems for a number of reasons: (a) potential cost savings and simplicity of a single network, (b) cheaper long-distance communication, (c) business advantages of software-controlled phones, and (d) adaptability for changes. As with any new technology, IPT faces challenges in reliability and ease of implementation. However, with some background research, careful planning, and wise deployment, IPT systems can avoid those hurdles and provide the benefits of a unified communications infrastructure.

Existing Telephone Systems

Most airports today have a traditional telephone system with a copper distribution plant (Category 3, see Cabling section for bandwidths of different cable categories). The distinction of the traditional environment begins with the CPE, which is simply a Private Branch Exchange (PBX) or local switching system for the airport. These are generally Time Division Multiplexed (TDM)/Pulse-Code Modulation (PCM) products.

The traditional telephony environment appears conceptually as the following:

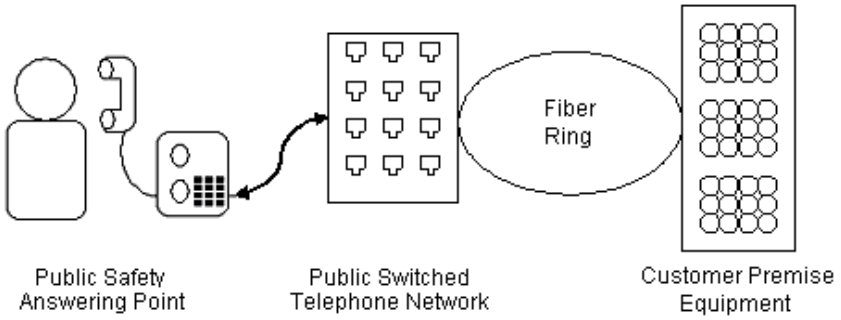


Traditional Telephony Environment

Riser cabling generally runs vertically from the PBX (Equipment Room) to the different building floors or areas (Telecommunications Rooms). These cables are typically Category 3. The horizontal cabling runs from the Telecommunications Rooms directly to the phone jacks in the various rooms on each floor, and may be Category 3, 5, 5e, 6, or 6A in airports. Traditional phones, which are proprietary digital or analog instruments, connect directly to the outlets in a traditional telephony environment. These phones are line powered from the PBX and have proven to be extremely reliable; i.e., they remain operational as long as the PBX has power.

Whether an airport has a traditional, pure IP, or hybrid telephone system, the connection to the national telephone network, known as the Public Switched Telephone Network (PSTN), is the same. The PSTN connects the airport to off-campus locations (throughout the world) and to emergency responders through the Public Safety Answering Point (PSAP).

The following illustration shows how a fiber ring network, often called a Synchronous Optical Network (SONET), connects the PSTN to whichever kind of telephone switch (CPE) the airport has installed. Some airports today still utilize copper lines instead of a fiber ring, but doing so (particularly in Category X, I & II airports) puts airport communications service at risk and raises the question of liability if service is lost due to a cable cut.

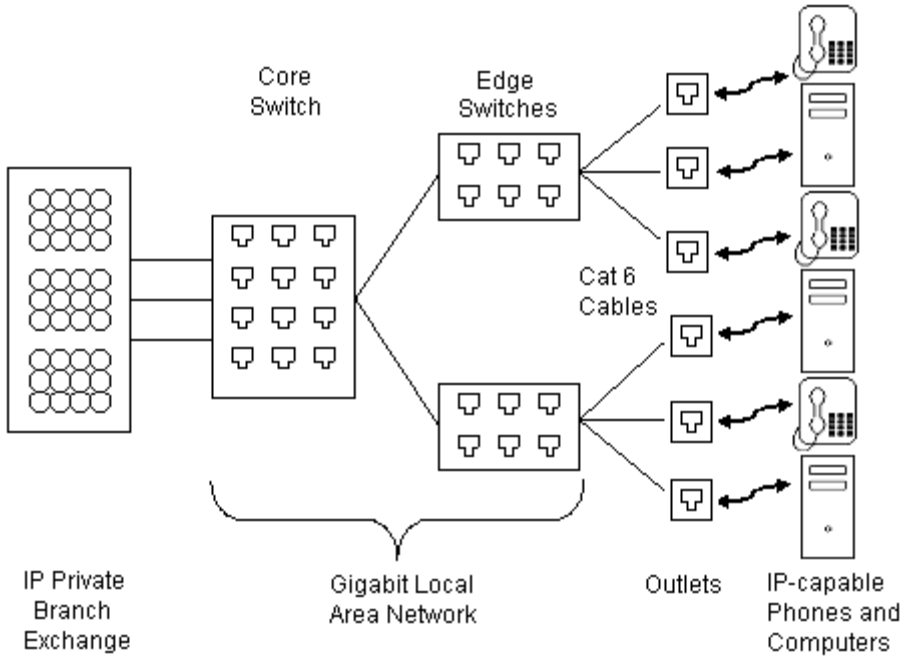


Universal Connection between PSTN and CPE

Although not shown on the diagram, an important capability that should be incorporated into all airport PSTN connectivity is Integrated Services Digital Network (ISDN). Used in conjunction with Primary Rate Interface (PRI, the local access facility for large users), ISDN enables the extension of network intelligence (instantaneous signaling and call information) to the airport telephone system and significantly enhances call-processing capabilities, such as caller identification and increased call volumes.

How IP Telephony (IPT) Works: The Basics

Instead of the traditional PBX environment, IPT requires an IP Platform (Server, Switching Unit, etc., with VoIP application installed) as the CPE. The connection between the IP Platform and the IP-capable phones is a Gigabit LAN, which contains core and edge switches for distribution, reliability and robustness. The following illustration shows an IPT configuration:



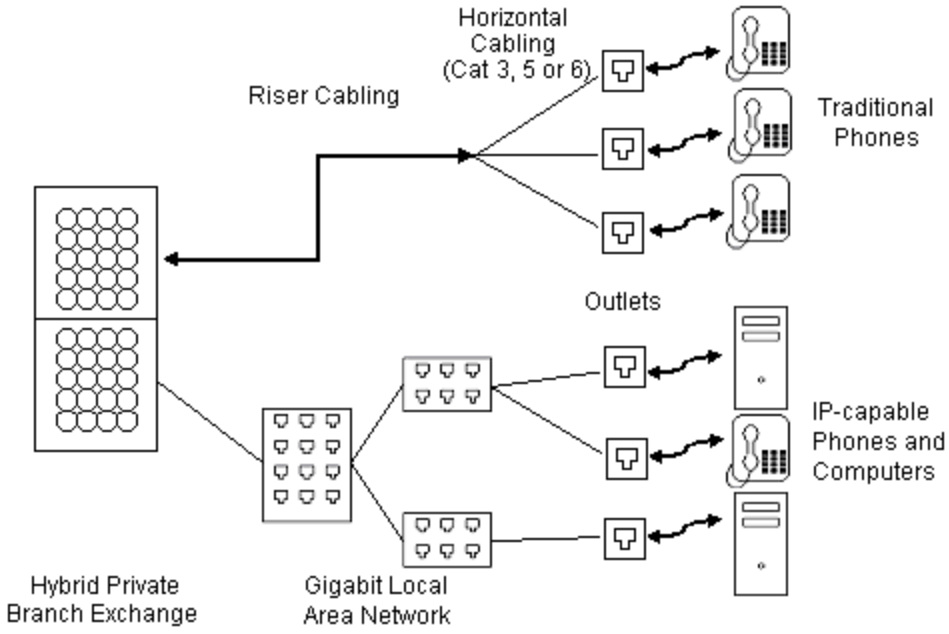
Pure IP Telephony Environment

The differences between the traditional telephony and IPT diagrams are in the switching, premises distribution (copper cable vs. LAN), and user's telephone set. (Cabling is discussed in a later section.)

Hybrid System: The Migratory Approach

A migratory approach to IPT is the recommended solution for environments that cannot be without telephone service. By having both traditional and IPT infrastructures co-existing, the hybrid system allows a flexible service conversion for the airport staff and tenants.

In the diagram below, the PBX is a hybrid. Part of the PBX supports traditional telephony, and part of it supports IPT.



Hybrid Telephony Environment

A migratory approach to IPT makes a successful transition more probable. In a large existing airport, not all tenants will be ready to convert to IP at the same time. (Some tenants may never be ready.) Even in a greenfield installation, a hybrid solution is advisable for any large airport environment.

Benefits of IP Telephony (IPT)

Industry Solution

This paper focuses on the basics of IPT and its place in end-user oriented telecommunications technology. Potential benefits of IPT include simplicity of a single voice and data network, innovative functionality, adaptable operations, and financial savings as the most beneficial aspects of IPT; of course, it is also the industry direction. IPT is the next generation of voice communications systems in the rapidly advancing airport industry.

Simplicity: Single Network for Operation, Support, and Management

Integrating or converging telephony and data systems is advantageous from an organizational and operational perspective as one group becomes responsible for operating and maintaining all communication devices, connections, and the network. IPT allows one support group for both the voice and data networks of the airport. This leads to one number to call for questions, problems, and repairs. Moves, adds,

and changes (basic phone relocations and adaptations) also become easier since IPT is more adaptable—through software—than traditional telephony systems, which largely remain cross-connect (i.e. wire) driven. In addition, the administrator can remotely manage IPT network devices and user profiles. Essentially, IPT reduces the staffing requirements for communication networks following implementation and training.

Customize Airport Business Operations

Since IP phones run on software, they have many capabilities that traditional phones lack. Among the many operational improvements, IPT offers the following new or advanced functions: (a) roaming profiles, (b) unified messaging, (c) simplified moves, adds, and changes, and (d) Virtual LANs (VLANs) to keep tenant and airport structures separate. In addition, airports can program IPT to automatically display profiles on screen when calls are received, track and record calls as necessary, and advance their wireless and paging abilities.

Many technology experts and IPT users agree that the software-based functionality of IPT is the supreme benefit. The advanced features enable airports to sharpen how they do business for one main reason: airports gain the ability to customize how they operate. An airport can choose to add features that it finds valuable to operation. By selecting applications that directly enhance the most-used communications, IPT allows an airport to save time, energy, and money. Typical rewards include optimizing customer service, increasing customer-handling capabilities, decreasing the staff required to handle regular tasks, and improving the overall organization. The efficiency that airports can gain by customizing their business yields great advantages.

Opportunity for Cost Recovery: Provide Service Airport-wide

While the initial investment of IPT equipment can be more than that of traditional phone equipment, a conversion to IPT and Shared Tenant Service can usually pay for itself within three years, and over time, it can also generate revenue for an airport. Once the IPT transport infrastructure is in place and the airport utilizes a hybrid IP PBX, the airport can offer all of its tenants the opportunity to convert to a modern, unified system that is adaptable for the future.

Besides the benefits of IPT, Ross & Baruzzini estimates that an airport can provide a 10-20% lower-cost service for campus service than the tenants' existing telephone services. As each tenant migrates to IPT, the airport can quickly recover the money used to implement the centralized system and begin to realize a profit. As most of the airport managers interviewed for this paper agreed, offering telephone service to airport tenants is worthwhile and a factor in converting to IPT.

Potential Cost Savings

A single IPT communications network can save the airport money in another way, by reducing the day-to-day labor costs needed to run the system. In general, maintenance for IPT costs less than that of traditional systems because it often requires software configuration vs. cross-connect labor. Furthermore, IPT is less expensive to upgrade, adapt, and expand than traditional systems.

Lower operational and maintenance expenses are not the only cost-reducing aspects of IPT. IPT can reduce telephone company bills, as well, since voice transmission is over the LAN/WAN instead of typical PSTN phone lines.

An analysis of an airport's communication and infrastructure requirements is necessary to determine the financial and operational benefits of IPT on its campus. Yet, most airports (including the majority of those interviewed for this paper) and corporations that have deployed IPT claim to meet the financial justifications for the conversion.

Complexities of IP Telephony

Cabling: Existing vs. New

Those contemplating IPT often wonder whether their old cabling or new infrastructure is advisable for the new system. The answer to this question inherently depends on the current cables in place.

At this time, most airports have widespread Category 3 cabling (16 MHz bandwidth), constituting the majority of their telecommunication cables. IPT cannot be carried over Category 3 cabling because it lacks the essential bandwidth, so other alternatives must be explored. (Bandwidth is the capability to transmit data over a given period of time.) IPT in airports necessitates Category 5e (100 MHz), 6, or 6A (250 MHz) cables for the required bandwidth.

Another possible solution for this problem is to utilize the existing data cables—assuming they are Category 5e, 6, or 6A—and transmitting voice signals along with the data signals. Again, this arrangement risks not having enough bandwidth, opening the window for latency, jitter, packet loss, or call drops, all of which can impact call quality.

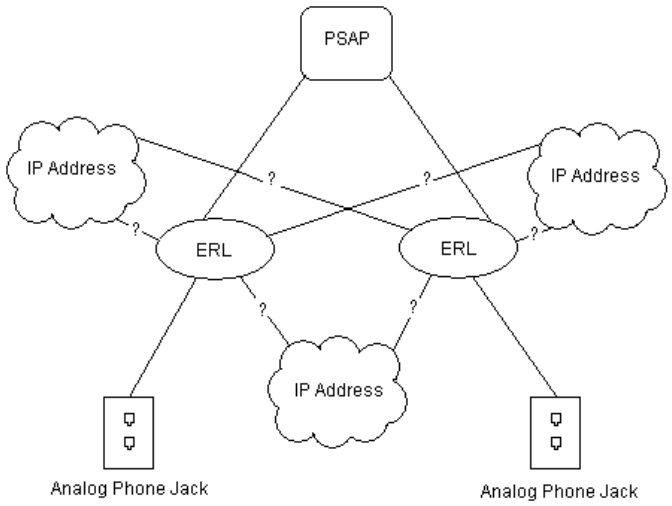
Why is cabling such an important consideration in implementing IPT? For two reasons: the choice of cable types and the structured cabling system directly impact the quality of voice transmission, and the actual materials and labor for cable installation can account for up to half the total cost of IPT implementation. Therefore, successful IPT networks require careful evaluation of the current cabling, present and future bandwidth needs, and the budgetary impacts of cabling.

Life Safety: 911 Location Identification

A crucial topic in IPT deployment is life safety. When implementing a new telecommunications system, the new system must at least match (or exceed) the previous system's reliability and functionality, particularly in the area of 911 access.

Without appropriate understanding and precautions, IPT produces problems that endanger life safety. With traditional phone systems, each phone jack has a particular identity (Emergency Location Identification Number, or ELIN) tied to its location. When a phone is plugged into the phone jack, it automatically takes on the associated Emergency Response Location (ERL), so that any emergency calls made from that phone will signal the correct location to the emergency responders.

However, IP phones and other IP user-end devices (laptops, Personal Digital Assistants/PDAs, which are consolidating communications and will soon have 911 features) each have their own IP address for identification. This address changes each time they log onto the network and therefore does not correspond to a specific physical location. Even if IP addresses are initially logged to nearby ERLs, every time the IP address changes, the new location is not updated in the system. In an emergency, knowing only the building or terminal—which is all that the IP address provides—is not sufficient.



Analog Phone Jack vs. IP Address

This diagram illustrates the specific locations of traditional connections versus the indefinite ERLs that correspond to each IP address, with the undetermined associations denoted by the question marks.

Fortunately, solutions to this problem are available. One alternative is to reenter the nearest ERL for each IP device every time the device changes to a different network area. For many airport phones, location changes may not occur often. Yet, for devices that are more mobile this method is impractical, because relocations happen frequently.

A second option is purchasing software to update the call server, designating the ERLs automatically. Enhanced 911 (E911) software, though relatively expensive, can save many programming hours and headaches by searching the network to determine a device's new location and ERL each time the device logs into the network. Until the Federal Communications Commission (FCC) required manufacturers to include E911 in their products in June of 2005, most IPT manufacturers offered E911 software as an extra feature, not in standard packages.

Despite the serious risk that the ambiguous locations of IP devices can pose in emergencies, the FCC has not yet made the implementation of E911 mandatory for IP Telephony users. Ethically, airports must evaluate their responsibilities to their employees, tenants, and passengers pertaining to life safety, and take care to avoid unnecessary or possibly deadly delays in response.

Reliability

Local Area Network

Airports depend on the reliability of their LANs for data transmission, and with the addition of voice transmission (VoIP) onto the network, the reliability of the LAN becomes ever more critical. What gives absolute and lasting strength to an IPT infrastructure, and how can an airport ensure that outages will not shut down their communications systems?

Similar to traditional telephony systems, IPT infrastructure requires quality equipment and redundancy/diversity in the network. IPT designs should include a redundant and diverse network based on the concept that alternative components are more logical than protecting the system from all potential disasters. With these precautions in place, airports need not sacrifice LAN reliability.

Power Over Ethernet (IEEE 802.3af)

A major issue in an IPT conversion pertains to powering the system end-points or telephone instruments. Traditional telephone systems power their end-points from the central PBX system using the same pair of wires used for talking and signaling. Similarly, IP Telephony requires power at the end-point or end-user locations, provided locally by a power cord or from the telecommunications rooms using Power Over Ethernet (POE). As a result, IPT is subject to power and service outages. This potential point of failure of the telephone system can create havoc for an airport.

What can an airport do to prevent such a crisis? Two things: 1. Deploy POE power from the edge switches located in serving Telecommunications Rooms; and 2. ensure that the main Equipment Room and all Telecommunications Rooms are powered by protected power (a system of UPSs and a building generator).

The cost and complexity of these alternatives often result in these vital system design elements being ignored. However, when compared to the financial and life-safety impact of immobilizing airport operations, especially during an emergency, the costs of installing POE, UPSs and generator(s) are a wise decision and should never be over-looked. Guaranteeing airport business continuity must be a priority, and precautions must be taken to avoid IPT system power disruptions.

Ensuring Voice Quality

Most people have experienced poor reception on a cellular phone call or difficulty hearing someone during a long-distance telephone call. In the world of voice communications, quality is an important acceptance factor.

IPT, operating on converged voice and data networks, walks a fine line between providing quality communications and frustrating communications. The oft-heard statement "We're saving the company money" will not satisfy users who consistently experience poor quality communications.

Sharing network with data can potentially decrease the sound quality because the voice signals become subject to the same latency, jitter, and packet loss associated with IP connections. When network delay is encountered in an email transmission, the sender and receiver are unlikely to notice any difference. However, such a delay in a phone conversation can create disruption, confusion, and frustration.

As previously mentioned, IPT samples the voice signal and converts it (codes it) to digital data, sending it across the network to the correct location in small "packets," from which the system devices convert it back (decode it) to its original form. In this process of coding/decoding, traffic problems occur if the system lacks the required bandwidth, or ability to transmit data over a given period.

The first sound quality problem, latency, is simply delay, or the amount of time the voice signal takes to travel from the sender to the receiver. Obviously, the coding/decoding process adds to the latency. Also, in situations of heavy network traffic or a lack of network bandwidth, queuing increases latency.

Jitter describes the time deviation when a sent package should arrive and when it does arrive, usually caused by queuing. When the coder/decoder system attempts to reconstruct the signal at the receiver location, jitter can create audible breaks.

Packet loss means lost or discarded packets of information. An example of this on the Internet occurs when an email mysteriously does not reach its destination or a web page shows up with a picture missing. With telephony, packet loss can result in a break in the conversation (noticeable or unnoticeable), or on a larger scale, a dropped call.

Signal compression adds another obstacle to voice quality. The coder can digitally compress the data in the packets by removing repetitive data and representing it in a

condensed way. Obviously, compression increases the amount of network traffic that can flow using the same bandwidth. However, compression is imperfect and can decrease the quality of the transmission. One way to avoid this is by simply choosing not to compress the voice signals.

Viable solutions for these dilemmas are available to IPT users. Undoubtedly, adding bandwidth to the network helps improve voice quality. Other options include Quality of Service (QoS), which prioritizes the packets in the network, ensuring that voice packets have precedence over data packets, thus reducing latency and jitter. In addition, redundant links can offer alternate routes for packets and prevent excessive queuing. Certain computer programs can even assist the switches and routers in choosing and sending packets in the direction that optimizes traffic flow. Moreover, IPT administrators may decide to create a VLAN to keep voice signals separate from data signals.

By evaluating an airport's traffic needs and determining the quality-improving option(s) to serve them best, it is possible to ensure the voice quality of IPT.

Network Security Precautions

Because IPT integrates voice and data transmission into a single network, the telephone system faces a completely new set of security threats: those associated with a typical IP network. Hacking, spyware, viruses and worms are now concerns for the new phone connections, which can influence the QoS and privacy of conversations.

Again, these problems can be prevented on a well-designed converged voice and data network. Anti-virus and extra security software adds necessary protection for IPT. In addition, VLANs can provide separation of voice and data traffic to prevent trouble from the data network spilling over into the telephony system. Most organizations already have firewalls in place for their data networks, and these should be added to IPT systems, as well. (Firewalls act as filters to protect LANs and individual devices from outside threats, and they can assist in intrusion detection.) Other options include encrypting the voice packets or implementing Virtual Private Networks (VPNs), which are expensive but provide added protection. Bottom line, the airport must evaluate their IPT security needs and monitor the security of their IPT networks as closely as other areas with security threats.

Pushing Updates and Upgrades

Since IPT runs on software, which needs to be updated more often than hardware, IPT users find a Trivial File Transport Protocol (TFTP) server to be a necessary network component. As new virus protection and updated software become available, IPT offers a convenient way to upgrade the system.

TFTP simplifies these upgrades by efficiently transferring & tracking updates simultaneously. Therefore, operational hassles or worse (neglected updates) can be eliminated. At this point, many IPT planners overlook this subject. Properly

designed, TFTP servers should be included in the financial and network arrangements.

Checklist for Decision Process: Is IP Telephony right for your Airport?

Deciding whether the implementation of IPT is optimal for an airport requires careful examination of the technological needs of the campus as well as the organizational and financial changes IPT initiates. This paper has already discussed how IPT works, the benefits of IPT, and the hurdles of IPT along with alternatives to overcome them. Although this paper cannot give a direct answer on if IPT is right for a particular airport, the following checklist addresses important considerations for the decision process, beginning with an examination of its existing system:

☑ Document the Airport's Current Communications Environment:

- Local PSTN Access:
  - Digital vs. Analog Trunking
    - ISDN/PRI vs. T1 vs. Analog trunks
  - Transport: SONET Ring vs. Copper Cable
  - Single or Multiple Points of Service Entry to Airport
- CPE:
  - Existing PBXs
  - Existing Key Systems
- Cabling:
  - Horizontal Cabling
    - Category 3, 5, 5e, 6 or 6A
  - Riser/Vertical Cabling
    - Category 3
    - Fiber Multi-mode (50 or 62.5 micron) or Single-mode
- User Instruments:
  - Proprietary digital
  - Analog
- Data Network / LAN:
  - Bandwidth: Gigabit or 100 MBps
  - Core
    - Redundant/Diverse
    - IPT Capable
    - IPT Configured
    - UPS/Generator Back-up
  - Edge
    - 100 MBps
    - Redundant Connections to Core
    - POE Equipped
    - UPS/Generator Back-up
    - IPT Capable
    - IPT Configured

- Miscellaneous:
  - E-911
  - Caller ID
  - Shared Tenant Provider

☑ What are the airport's current communication needs, quantified during ordinary times and its busiest seasons/times?
☑ What are the projected future communication needs (for the entire airport)?
☑ How would the implementation of IPT be funded?
☑ How could IPT be financially beneficial/detrimental to the airport and its tenants?
☑ Which existing cables could be utilized for IPT and which ones need replacement? (To be incorporated in cost analysis.)
☑ What sort of equipment would the airport need in order to implement IPT?
☑ How will the airport handle the E911 obstacles of IPT?
☑ How will the airport power the IP phones to ensure their stability during a power failure?
☑ What measures will the airport take to make certain it has sufficient voice quality?
☑ Will the airport offer phone service to airport tenants?
☑ During implementation, how can the airport minimize inconvenience/downtime of normal operations?
☑ Would a migratory approach simplify the conversion to IPT?
☑ Organizationally, how would the airport integrate the IT and telecommunications departments, if they are not one department already?
☑ Who will be responsible for managing the new IPT system?
☑ How can the airport allow sufficient time for training and transitioning?
☑ What functions of IPT would be most useful to the airport, in terms of improving business operations?

Only after reviewing, analyzing and assessing these subjects and any other concerns specific to an airport, it is possible to make a sound decision concerning the implementation of IPT.

Key Players: Who provides this service?

The following list names a few vendors who can provide the devices for implementing IPT.

- Alcatel
- Avaya
- Cisco Systems, Inc.
- NEC Unified Solutions, Inc.
- Nortel Networks
- Siemens

Future of IP Telephony (IPT): Adaptation and Expansion

In conclusion, IP Telephony is the future for telephony systems. It is the industry direction because it can enhance system functionality, adaptability, expandability, cost effectiveness, and simplicity by leveraging a single voice and data network. However…

Through technology, people will continuously find ways to improve the ease of implementation, quality, and reliability of IPT, yet many problems with this demanding and volatile solution will continue to originate from deficient planning and implementations of IPT. Airports must consider the presented issues because they require communication systems that function constantly and provide excellent service; any downtime halts normal airport operations and poses serious risks to emergency response and security operations.

The crucial question is, "Does an airport need to risk the reliability, quality and security of its telephony and network infrastructure to undergo a dramatic communications transformation?" Emphatically, the answer is "No!"

Airports should not let fear of the unknown scare them away from IPT. A migratory approach to IPT, which supports existing users and systems and allows for the transition to IPT over time, is a sensible approach in this environment. By transitioning to IPT with a hybrid system, an airport can simultaneously maintain the dependability of its current approach yet reap the benefits of a new IPT system. As the airport tenants become willing and ready to update their systems, the airport can offer them a simple conversion.

The migratory alternative allows careful contemplation of a large airport's communication needs, which are incomparable in how they require the connection of all airport campus areas and organizations. By considering the change to IPT as an evolution rather than an instantaneous replacement, airports can successfully move into the future of telecommunications technology.

Nomenclature

CPE	Customer Premise Equipment
E911	Enhanced 911
ELIN	Emergency Location Identification Number
ERL	Emergency Response Location
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
IPT	Internet Protocol Telephony
ISDN	Integrated Services Digital Network
IT	Information Technology
LAN	Local Area Network
PBX	Private Branch Exchange
PCM	Pulse-Code Modulation
PDA	Personal Digital Assistant
POE	Power over Ethernet
PRI	Primary Rate Interface
PSAP	Public Safety Answering Point
PSTN	Public Switched Telephone Network
QoS	Quality of Service
SONET	Synchronous Optical Network
TDM	Time Division Multiplexer
TFTP	Trivial File Transport Protocol
UPS	Uninterruptible Power Sources
VLAN	Virtual Local Area Network
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
WAN	Wide Area Network

Contributors

Ross & Baruzzini extends a special thank you to the airport IT specialists who contributed their perspectives for the White Paper:

- Mr. Howard Kourik, Director, Information Technology, San Diego International Airport
- Mr. John Newsome, Director of Information Technology, Orlando International Airport
- Ms. Sandy Schiller, Information Systems Manager, Raleigh / Durham International Airport

About Ross & Baruzzini, Inc.

Founded in 1953, Ross & Baruzzini, Inc. provides professional consulting and engineering services to clients in the aviation, education, government, healthcare, and maritime industries. Ross & Baruzzini provides IT consulting, planning and design of security systems, systems engineering, wireless communications, mechanical engineering, electrical engineering, plumbing / fire protection, and architecture. Located in Missouri, Texas, Florida and Indiana, Ross & Baruzzini employs a staff of systems integration personnel, security specialists, mechanical engineers, electrical engineers, plumbing engineers, architects, and support personnel.

400 N. Sam Houston
Parkway East, Suite 110
Houston, Texas 77060
T: 832.327.8888
F: 832.327.8889

10200 N.W. 25th St.
Suite 111
Doral, Florida 33172
T: 305.513.9000
F: 305.513.9100

6 South Old Orchard
St. Louis, Missouri 63119
T: 314.918.8383
F: 314.918.1766

www.rossbar.com

421 Massachusetts Avenue
Indianapolis, Indiana 46204
T: 317-638-8383
F: 317-638-8384