An Evolutionary View of the Critical Functions of Slot Machine Technology

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Abstract

The U.S. gaming industry has grown from its infancy in the early 1930s to a maturing giant in the 1990s. With this growth has come an evolution in management functions associated with one of the major components of casino operations, the slot department. These functions; counting, analysis, security, maintenance, and marketing, have evolved through an iterative process of technology; applying science to enhance functionality. This paper traces the expanding applications of gaming technologies, and provides a framework for understanding the past, present and future uses of technology in casino slot operations. **Keywords:** *Slots, Slot Machine, Slot Department, Gaming Technology, Casino Technology.*

Technology spurs improvements in complex processes. For example, in the slot department, technologies add the capability to track every coin in each machine, which would not otherwise be feasible.

Introduction

Within the framework of two decades (1975 - 1994), this paper traces the managerial needs that drove the increased application of technology in support of the slot department, a major component of casino operations. This examination extends from simpler times when counting wagers was the main slot department function, to today, when the demands of a strategic management approach make increasing demands on managers. Today's gaming managers face even greater

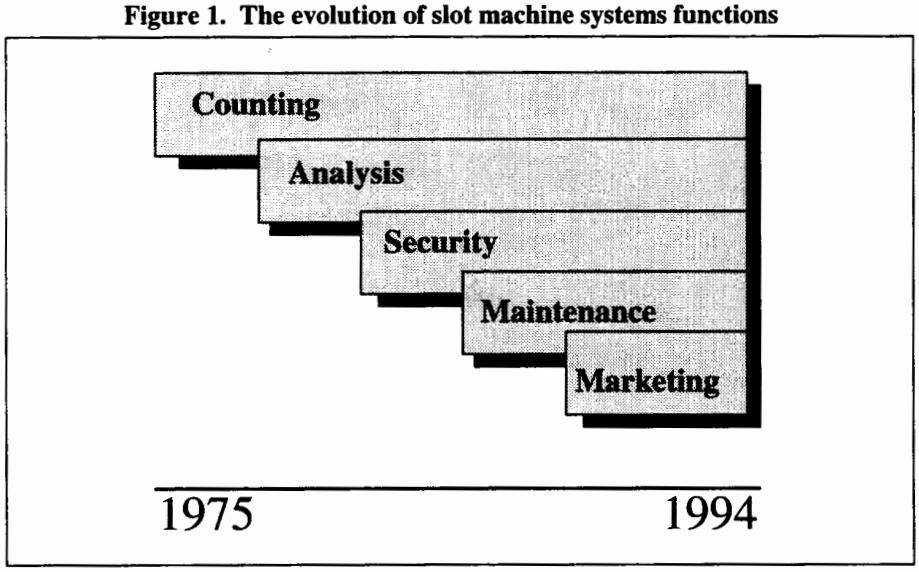
pressure for player responsiveness, productivity, and profitability. In this adaptation, slot machines have evolved from simple mechanized devices to sophisticated, microprocessor based systems that combine the entertainment device with a managerial tool. This paper provides a framework for understanding the past and present uses of technology in casino slot operations, and for anticipating future slot technology directions.

Technology, Tasks, and Time

Modern management techniques are replacing "judgmental and intuitive" operational styles with the emergence of "a new breed" of gaming executive (Eadington, 1992, p. xxv). Especially in the last decade, developers and manufacturers of slot machines and related systems have responded to the needs of these increasingly sophisticated operators by applying and improving upon a variety of technologies.

Positioned along a conceptual time-line, Figure 1 presents basic slot department management functions, each positioned in the relative time interval in which it felt the impact of technology (Legato, 1994b, pp. 44). Accordingly, this progression defines the content and order of this review. Specifically, the paper chronicles technological responses to management needs in five functional areas: (1) counting wagers; (2) analyzing wagers and play; (3) securing wagers and data; (4) maintaining the machines; and (5) marketing the games and the property. Innovations and advances in slot related technologies for these critical management functions have not evolved in an ad hoc manner. Rather, a genesis of each slot technology application typically developed as a response to management's needs, and/or in response to the regulatory environment. Once a function became the focal target for technological applications, its sophistication continued to evolve in an iterative manner.

Figure 1. The evolution of slot machine systems functions



Because a managerial perspective provides the focus of this historical panorama of slot technologies, and because bounds are necessary, not every aspect of slot technology is included. While certainly significant in a general temporal view of slot development, excluded here are such topics, tangential to management concerns, as technological developments in *gameware* (e.g. the programs behind the various slot games such as *Red, White, and Blue 7's)*, and the artistic and physical *design* aspects of slot machines.

Technology is science applied to achieve a practical purpose. As Radisson Hotel Corporation President John Norlander stated, "Technology is not a magic pill that will fix all our management problems, but is more like a vitamin pill - one that can enhance the quality of ... management" (Norlander, 1994). So it is with gaming management; technology spurs improvements in complex processes. For example, in the slot department, technologies add the capability to track every coin in each machine, which would not otherwise be feasible. These technological improvements may result in enhanced operations by eliminating procedures formerly completed manually or by aging equipment. In addition, technical process enhancements can increase the productivity of existing employees and equipment, making other improvements realizable in conjunction with managerial efforts.

Norlander (1994) cautions, technology "can't be used in lieu of smart management. We want to find technology to help solve our management problems, not find technology looking for a problem to solve." In addition to eliminating barriers to what humans can do, technological advantages increase accuracy in accounting, ease and convenience in accessing data, and both elevate and fortify the productivity and reliability of data and equipment. Finally, technology provides managers unprecedented means for orchestrating resources, due to emerging capabilities in communications, connectivity, and interoperability.

The sciences underlying managerial slot technologies include such engineering studies as mechanical, electrical, as well as computer science. Also contributing are the disciplines of statistics, laser physics, and information resource management. In operations, slot technologies encompass an array of technological tools; some see application in monitoring, maintaining, securing, and conducting analyses for slots. Others compose and control the *game* elements of the machines. Table 1 presents various forms in which users buy and use primary slot technologies, including computer hardware and software, audio and video systems, communications and other interface devices, and scanners, sensors, and measurement systems.

Table 1. Examples of Slot Machine Technologies

Slot Machine Technology Tools
•Hardware
•Software
•Communications devices
•Interface devices
•Audio-video devices
•Scanners
•Sensors/detectors (metal type, door open, etc.)
•Measurement systems (timers, coin comparitors, etc.)

Critical Function I: Counting

In the 1950s, the boom in Las Vegas gaming perpetuated the attitude that all a casino had to do was open its doors and profits were virtually guaranteed. Strategic competitive thinking would have added very little to the profitability. Moreover, the firms did not see one another as competitors; "there was enough business for all" (Brock, Newman, & Thompson, 1992, p. 46). But as competition increased, the need to refine managerial techniques became clear. Logically enough, the first area to be examined was counting and accounting for the cash that flowed through the casino.

Evolution in Meters for Slot Counts

Managing a slot department by counting only the wagers received in the drop bucket can be compared to managing a department store with no records or controls on inventory, sales transactions, or cash handling. In an effort to tighten controls, operators sought counts on coins and tokens, and other information concerning the wager as it entered and exited each machine. Thus, the attention of managers shifted from simply providing the opportunity for the player to gamble, to counting and controlling the wager. Gradually this led to mechanical systems which kept track of internal coin counts; they literally tallied the number of coins passing particular points in the slot machine (Fey, 1991, p. 240). Just beyond the player's view, the counts were recorded by means of incrementing mechanical meters resembling automobile odometers. Because machines were frequently equipped to receive two to five coins per game, two distinct meters became necessary. One tallied the number of times a slot machine game was played by counting the number of times the handle was pulled. Another recorded the coin-in; the number of coins placed into the machine. Counting coin-in provided an important management performance measure - the slot handle, or the dollar value of the total number of coins wagered in the period. Besides the evolution in meters that track the handle, other meters tally coin-out as the number of coins paid to a player for a jackpot or lesser pay-out. Or, of course, the output can go to the house; then the drop meter tallies the number of coins that drop from the slot hopper to the drop bucket. Coin-out and drop meters are incremented simultaneously when the output goes to both the player and the house, as when the player receives a payoff of an amount less than that wagered. Some machines employ additional meters, such as one to record the number of jackpots hit on the machine.

While slot play counts are a foundation, competitive slot managers found that a critical element was missing. Data required meticulous analysis to provide the strategic information needed to address a host of revenue-related systems, performance, and marketing questions.

These mechanical meters evolved into electronic data sensors that counted the coins more accurately and reliably. Later enhancements led to systems which instantaneously transmitted the count data to the central slot accounting system. These counting sensors, together with more than 100 data sensors, comprise the very heart of current slot systems technology. Moreover, the simple electronic transmission of data is not the only change. Today, to derive the handle, meters count more than coins, they also must count currency and various types of vouchers put into the machine, changing the amount of data necessary to track handle, and altering the complexity of the process (Motu, 1994b, p. 30).

This recent inclusion of bill acceptors on slot machines literally has revolutionized slot departments in other ways too (*"Mirage installs,"* 1994). Accepting currency directly into the machine not only reduces the number of change attendants needed by the department, but actually increases the number of games a player can play per minute. Time saved not having to deposit coins into a machine and not waiting or searching for change attendants allows such additional play. Combine this with a technological advance that allows players to play the maximum bet by pushing one button, and the result is a sizable increase in revenue for the time the machine is in play. Further, the impact of bill acceptor technology reduces the number of coins used in the machines, thus decreasing the number of times the drop buckets need to be collected. The secured currency box holds consider-

ably more in terms of revenue before it must be swapped out, and it takes less labor to exchange the currency box, soft count and bank the contents, than to collect drop buckets, conduct the hard count, and perform coin handling activities.

Another coin-out advance being investigated in the U.S. is coin streaming equipment that removes drop coins automatically via conveyors. While not yet accepted by the Nevada Gaming Regulatory Agency, this new application illustrates how technology can shape operations.

Many believe the future to be slot machines that operate without coins, cash, hoppers, or buckets. Some believe the use of debit type cards, purchased for the purpose of gaming will replace cash in the slot department, especially in large operations. Such an innovation would dramatically change the current department operations.

Evolution in Meter Read-outs for Slot Counts

As the information from the slot meters became more important to management, weekly or biweekly readings were necessary. Typically, a clerk read the slot meters, recording their tallies. Others in the slot auditing department set to work calculating the wagering activities and outcomes for the period. In a large property, however, this process could involve reading meters on hundreds of slot machines. To audit, a clerk literally walked from machine to machine, peered down through the machine's glass into the darkness with a penlight to read recessed meters, or when necessary, had the machines opened by security teams to record the necessary data. Next the clerk would hand write lengthy numeric readings from the multiple meters per machine, repeating this for each machine. When completed, the manual audit sheets were delivered to an accounting clerk who, using a mechanical adding machine, ran tapes for the meters on each machine, and for various departmental subtotals (e.g., by machine denomination) and totals. An example of the manual work involved in this endeavor is displayed in Table 2, showing the necessary calculations to determine just one parameter; the machine handle, on a single slot machine.

Table 2. Calculation of meter counts to dollar value for slot machine handle

From Mechanical 10-Key Adding Machine to Electronic Processing		
Current coin-in meter reading	=	853,000 quarters
Previous coin-in meter reading	=	850,000 quarters
Difference	=	3,000 quarters
Slot machine's "handle" for period	=	$750.00

Understandably, this system had some critical problems: delayed results (the process could take days); the labor intensity; multiple opportunities for omissions, transpositions, and other errors; and of course, fraud, in a process requiring thousands of numbers to be copied manually by multiple individuals. As with other bookkeeping and accounting functions that the hospitality industry has migrated over to automation, an evolutionary improvement came with the advent of affordable business computers and appropriate software. Early meter processing enhancements arrived in the form of mainframe-based slot audit programs. These programs did not reduce the labor and vulnerability of slot audit clerk activities, but the accounting clerks now could key the meter readings into a slot audit program, rather than a 10-key adding machine. The next innovation, still used for non-networked systems, was a hand-held system. Machine identification information was scanned, then meter readings were either downloaded electronically, or entered manually via keyboard, only to be uploaded later from the hand-held devices to the property's slot data processing system. As technology progressed, slot systems communications provided the vehicle for centralizing system collecting and distribution. Today, a networked slot

management system can access each machine's meter values, presenting results on remote displays and printers. Modern data capturing systems, linked with slot tracking systems, can communicate their count data in real time, as well as in aggregate modes for reports, queries, and analysis purposes. Table 3 lists selected capabilities of automated data collection and communication systems.

Table 3. Selected capabilities of automated data collection and communication systems

Slot "Counting" Capabilities
•Slot machine meters automatically "read" by system (coin in, coin out, drop, games played)
•Alternative slot system identification via bar codes or strip readers, scanners, & wands
•On-line, real-time data acquisition from slot floor
•Data editing and reporting
•Integrated slot accounting and reports
•Direct interface to plotter to provide graphical reports
•Integrated internal controls and system audit
•Direct interface to weight scales for hard count
•Soft count processing from bill validators

Critical Function II: Analysis

While slot play counts are a foundation, competitive slot managers found that a critical element was missing. Data required meticulous analysis to provide the strategic information needed to address a host of revenue-related systems, performance, and marketing questions. Table 4 displays typical questions about slots and the slot department to which slot operators require increasingly fast, accurate, and insightful answers via strategic tools to remain viable. Answers to questions such as these begin with counting, but informed management *necessitates analysis*. For example, managers may check to see that each machine's game chip is functioning as expected with such questions as: What is the trend of this machine's daily average? Is the actual hold percent within an acceptable variance of the theoretical hold percent? The hold percent can then be compared to the *theoretical* hold percent; that is, what the slot machine should hold in the long run, over the course of millions of individual plays.

Table 4. Typical slot department performance analysis questions

Slot Performance Analysis
•What is the *actual hold %* of this machine?
•What is the *variance from theoretical hold % to actual hold %*?
•What is the *drop meter* to *hard count* variance?
•During what intervals are the *average* and *rank holds* for this machine above department medians?
•By hour, how do *west* wall machines compare in *productivity* to the *north* wall machines?
•Why is this machine flagged on the *losers report*?
•Progressive link distribution; What did each *machine contribute* to the jackpot?

In response to slot managers' requirements, technologies in the form of business tools now include slot gaming hardware and data collection and distribution software, as well as management programs providing increasingly accurate, targeted, and timely slot and player performance information. Moreover, astride more capable hardware, and within sophisticated accounting statistical software, analysis itself constantly improves. Thus, accounting statistical software can calculate the soundness of a slot machine's performance within a definable level of confidence, using the slot information IN, OUT, WIN, and GAMES PLAYED (For details on these calculations, see Milligan, 1992).

An additional type of analysis has evolved with the advent of player tracking systems. The ability to gather accurate and timely information on type and level of play by an individual has led to improved rating and comp systems that allow slot hosts to more accurately award comps. Additionally, the same data allow casino executives to keep an eye on players who win or lose excessive amounts of money, to check for fraud, and to determine their value to the casino. With such capabilities, technology has guided managers from the relatively noncompetitive environment of the 1950s to the highly competitive 1990s.

Critical Function III: Security

Generally, security systems technologies, to halt or apprehend attempts at slot payout modifications, hone-in on system access and accountability.

As technology evolved, the house's ability to know what the numbers *should* be through accounting analyses indicated variances and performance inconsistencies, interpreted as fraud or theft. As early as 1971, the Nevada Gaming Commission estimated that at least $12 million (a significant sum in those days considering there were only a handful of casinos) was fraudulently taken from slot departments (Friedman, 1974). Understandably, the recognition of the magnitude of this problem intensified efforts to curtail theft, both internal and external. And although several of these efforts focused upon procedural actions (i.e., employee screening), many others revolved around technology based systems. Such slot security technologies emphasized operations and access monitoring to discourage, detect, and thereby deter, fraudulent activities.

Historically, for mechanical and then electro-mechanical machines, slot vulnerabilities generally fell into one of three categories: free play, reel control, and payout alterations (Friedman 1982, pp. 271-282). Among the multiple paths to a payoff via **free play** are, a player might open the play switch on a slot machine by using a slug, by using a similar foreign or filed-down coin, or even by using super glue to attach a coin to a string. In each case, any payoff was either free or of lesser cost to the player than intended by the house.

Today, slot tracking systems "report" individuals who attempt such free plays, notifying the security department of the illegal play. If the thief manages a free pay-out, the system also will flag that a pay-out has occurred with no coins in, or that a pay-out was extended without a game initiation (handle pull or button push). Also, directly at the point of the wager input, free-play is made more difficult. For example, sensors and measurement validation systems check a coin's diameter, weight, and metal content. Column one of Table 5 lists other sensor-based exception reports that could apprehend free players, including coin-in and coin-out switches clocked as open beyond the maximum time that normal play would require.

Table 5. Slot machine malfunctions effecting security and maintenance

Coin-Slot Pathway	Currency Acceptor	Player Cards & Readers
Coin-in jam; coin-in switch opened beyond parameter	Bill jammed	Card inserted or removed
Coin-out jam; coin-out switch on too long	Number of bills rejected exceeds parameter	Abandoned card
Too many coins in; lockout broken	Number of bills changed exceeds parameter	Bad card read, no data
Diverter malfunction	Incorrect amount changed	Cannot read card; ours?
Slot runaway hopper	Acceptor runaway hopper	Bad card reader
Ramp switch closed too long	Acceptor hopper jam	Card box malfunction

Free play losses from slot token counterfeiting also pose a security problem. But in some modern operations, players using counterfeit tokens face laser-like detection technology. Slot tokens may be imprinted with an identification bar code or micro-dot. Slot machine coin-acceptors frequently are equipped with an electronic circuit containing a microprocessor that rejects all non-imprinted tokens. More impressively, the manufacturers insist that these token identifications cannot be duplicated, and that the systems "make counterfeiting virtually impossible" (Motu, 1994a, p. 13).

Reel control results from any unintended influence a player gains over where and on what symbol a slot machine's reels stop. For example, on earlier systems, some players could become so familiar with a machine's behavior that they could adjust their handle-pull timing and pressure and cut the house advantage by 80% or more. Others used very strong magnets, and still others built elaborate miniature drills they used to pierce tiny holes in the face of a machine through which they pushed a wire (called a shim) to hold or slow a reel (Friedman, 1982, pp. 273-275).

Technology has provided numerous reel control remedies. First, reel control has become increasingly difficult with the decline of slot machines with long, easily-leveraged handles. If present at all, they are nothing more than a tribute to their evolution; the increasingly popular push button. Still they remain a frequent alternative to machines with play buttons as a player option.

In the past, brash former or current employees took a direct route to slot machine **payoff modification**; they retained machine keys. In under six seconds, a proficient thief could get inside a slot machine, set the reels to a jackpot, lock the system, and posture innocently nearby to collect the win. For "key jobs," outsiders often worked in collusion with employees. Some even set up covert key shops in their vehicles in the casino lot.

Generally, security systems technologies, to halt or apprehend attempts at slot payout modifications, hone-in on system access and accountability. Advanced technology systems provide three levels of security: the operation-wide system, the machine itself, and the employee. For system-wide protection, security systems can log changes or additions to any information contained in the system. An interface to a surveillance camera system provides an additional important operation-wide safeguard.

On the machine level, the security system involves monitoring machine locks. With every opening and each closure of these locked slot doors tracked, logged, and subject to reporting, fraud has become more difficult. Slot doors with locks include the machine door, the drop door, the currency validator door, the currency stacker door, and the currency acceptor cassette door.

Today, security at the employee level often requires each authorized person to use a special electronically coded card or remote unlocking device to open any part of a slot machine. The cards or remote door opening devices replace or accompany keys for accessing machines. Integrated into many slot security systems are special procedures for employee sign-in and sign-out, as well as multi-level passwords. These systems parallel computer-based housekeeping systems that track and provide a log and audit trail of individual employee activity per shift. If desired, the information also can be reported per machine; e.g., who entered what machine, when, why, for how long, etc. For example, modern systems can isolate the time of coin variances, so variances can be pinpointed as occurring before or *after* employee access.

Critical Function IV: Maintenance

Continuing the slot technology evolution, slot managers soon realized that though security controls were improving, an important element of stability was missing from operations. Too much time was occupied battling not just those who would perpetrate fraud against the machines, but also maintenance breaches with the slot machines themselves. Together, managers and vendors turned their technological attention to slot system maintenance priorities.

Slot maintenance technologies primary roles are keeping games operating legally, productively, and profitably. In tandem with accounting, security and maintenance takes both reactive and proactive steps to assure that games comply with regulatory hold limits, that they are programmed for the posted pay-out, and that they operate as programmed.

Not surprisingly, a focus on slot maintenance highlights the close relationship between performance monitoring, security, and maintenance. Table 6 lists monitored events that illustrate this interplay. Warnings of occurrences of events such as "payout exceeds system's parameters" could indicate foul play or unintended play; or the cause may be a bad game memory, PROM tampering, or simply needed repair. The important thing is the vigilance, sensitivity, and transmission speed of the monitoring technologies which allow management to rapidly identify and correct situations.

Table 6. Technological monitoring: Examples of events monitored for both security and maintenance

Technology Monitoring for Security and Maintenance	
Wrong pay - amount of coins paid incorrect	Illegal play - handle pulled, no coins-in
Overpaid win - coin out hopper motor off	Illegal payout - pay with no coins-in
Payout exceeds system's parameter	Illegal payout - pay with no handle pull
Improper reel spin	Clock accuracy alert
Meter reset during reel spin	Computer hardware errors/warnings

When to summon technical support may be based on technologies that sense, measure, count, calculate, and/or compare some inconsistency on an internal parameter of performance. Additionally, maintenance technologies can focus monitoring on especially vulnerable machine maintenance areas such as coins, currency, and player cards. For ex-

ample, a slot machine may incur subtle malfunctions; a coin sticks for a moment, or a connection is loose (Tables 5 & 6 list several of these warning signs). In this way, maintenance personnel can intervene and either repair slot problems or block machines from play before players become annoyed, inconvenienced, or angered, when they recognize that "their" machines are not, and have not been, operating properly.

In a casino, a down slot machine represents money lost. Numerous technologies support maintenance personnel in keeping systems at their peak, from maintenance logs and redundant backup, to improved power conditioners and fail safe systems. Electronics also have sparked a major advance, replacing the mechanical parts of slot systems. Relative to mechanical slots, such electronic systems have proven more durable, reliable, and trackable, all of which is welcome news for the maintenance department. Some systems even contain their own maintenance tickler schedules for routine tune-ups and self-diagnostics. After executing a self-check routine, the system can deliver reports for any or all of dozens of separate functions. Collectively, maintenance technologies support legal play while they minimize machine downtime and maximize machine productivity.

Another advance arrived with the use of modems and other communications technologies that enable technicians to dial-in for vendor-assisted software diagnostics and troubleshooting. Maintenance technologies can notify technicians when a machine, while not overtly broken, is suspected to be malfunctioning. Table 6 lists several examples. These systems sense or calculate possible trouble, signal the appropriate technician, then print or send an electronic exception report, or otherwise alert management for a proactive inspection of the machine.

With the advent of electronic card readers, data bases technologies, and player clubs, the casinos can gather accurate and timely data from and about their players.

When communications technologies enhance security and maintenance, the result can be seen clearly in improved operations, and particularly in improved responsiveness for players. For communication of slot data, a wireless messaging system integrated into a slot tracking system automatically sends appropriate information instantaneously. The system passes alarm information reported by the slot tracking software directly to predetermined pagers worn by casino maintenance, security, or VIP host personnel. In addition to the improved timeliness of notification, such a system eliminates manual dispatch of messages, and ends the necessity of persons monitoring display terminals and messaging printers (*"IGT, Motorola,"* 1994, p.1).

Critical Function V: Marketing

We began this discussion by describing a management attitude of "open the doors and the players will come." Sophisticated slot marketing departments of the nineties cannot count on players just wandering in the door. The ability strategically to identify markets, develop player profiles, and track specific player information have become critical management tools.

With the advent of electronic card readers, data bases technologies, and player clubs, casinos can gather accurate and timely data from and about their players (Legato, 1994, p. 44). This application of technology uses plastic cards containing a magnetic strip or bar code, that when placed into a card reader in or connected to the slot machine, captures data concerning the player's play. This data may include game preferences, wins, losses, num-

ber of coins played per game, number of games played per minute, number of minutes or hours of play, and number of visits to the casino. When combined with the demographic and profile data that the player provides at the time of "joining" the player club, and data that can be derived by observation and records from each visit, management has a very powerful targeting tool for marketing to specific player types.

In addition to keeping an eye on good and problem players, the casino can more accurately differentiate their product, dispense comps, and offer the incentives that their specific player market values. The data base can be queried to identify individuals for special promotions, tournaments, and other mailings. Further utilizing this data, the casino can match current player demographics against consumer profiles of individuals who have never visited the casino, but fit the profile. These potential customers can now be contacted and attempts made to attract them to the casino.

Another marketing innovation, advanced guest services systems, provides customer preference data anywhere in the casino, personalizing the service to the guest. Such systems give the front desk, food and beverage, and other employees with access to the system, the ability to recognize and appropriately interact with and serve guests, using the information gathered on their preferences. But, while marketing efforts currently focus on gathering and analyzing player data, the future will certainly contain some method of two way communications with players and guests, adding to the ability to interact with the player, and creating new dimensions in casino/player relations.

Continuing Evolution

Technology has certainly taken the casino industry from its less sophisticated childhood to the maturing industry that exists today. In much the same way, advances in technology will assist the gaming industry with the complex management issues of the next century. In casinos new technologies can be expected especially to impact table games, enhance data base analysis, and allow us to better focus on the needs of the customer. Feasibly, technology will extend into other areas, such as customer service, facilitating instantaneous communication of player status and information to both the player and the operation. One thing though is certain, this evolution will continue.

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