Building Revenue Management Decision Support Platforms with SAS®

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ABSTRACT

The revenue management function in travel and hospitality addresses a well-known economics problem, maximizing revenue. The main facets of the problem are segmenting demand, understanding the price-demand relationship, estimating future demand, and finding the price level that maximizes revenue.

However, with InterContinental Hotels Group's (IHG's) 13 hotel brands spanning more than 5,300 hotels and nearly 800,000 guest rooms in almost 100 countries[1], that analytics challenge is no small task. The problem becomes even more complex when multiple guest segments, macro factors, seasonality, different lengths of stay, and local special events are added to the equation. Further, with decision updates needed daily for every booking date one year ahead, the process speed requirement necessitates an analytics platform.

IHG's Eric Schmidt, Darlene Fenix, and Steven Garrison share how one of the world's leading hotel companies leverages SAS to help meet this revenue management analytics challenge.

INTRODUCTION

The number of revenue decisions facing any given hotel daily can easily exceed human capacity to manage. Revenue managers must estimate demand up to one year out, benchmark rates against publicly available market data over same timeframe, adjust house booking policies, build rate packages, yield inventory, manage distribution channels, and ultimately decide rates for their inventory.

Revenue management, as a practice, began in the commercial airline industry. In the early 1960s, American Airlines developed the first computer automated reservation system, the Semi-Automated Business Research Environment or "Sabre". Just two years following American Airlines launch of Sabre, Holiday Inn (now an IHG brand) launched the first hotel central reservation system, HOLIDEX. These new reservation systems helped centralize and control reservation activity across their systems.

Deregulation of the airline industry came about in 1979, and increased competition in the post-deregulation 1980s era spurred innovation again. With a wealth of booking data collected over the past decade, American Airlines began developing the practice of "yield management" as then CEO Robert Crandall described it. Initially, yield management was a manual exercise where airline employees would control the proportion of full-fare and discount seats daily and by route. Seat inventory was adjusted by comparing actual booked rates to predicted bookings.

By the late 1980s, yield management at American Airlines was mostly automated and run by the Dynamic Inventory and Maintenance Optimizer system (Dinamo). Benefits of the system were estimated to decrease spoilage by 3% and increase yield-management analyst production by 30%[2]. The success of this revenue management system did not go unnoticed and several airlines adopted similar systems, which have realized revenue benefits of several hundred million dollars per year.

The success of the airlines' use of automated revenue management systems did not go unnoticed by hotel companies. Holiday Inn launched the Holiday Inn Reservation Optimization system (HIRO) in the early 1990s. By late 2000s, IHG had a fully developed revenue management system (PERFORM™) and was on the leading edge of innovation in hotel revenue management. In 2008, IHG introduced price optimization to PERFORM™, which showed nearly a 3% revenue lift of about $300 million per year. Bob Cross, Chairman and CEO of Revenue Analytics states, "IHG's Price Optimization capability is the greatest single achievement in revenue management this decade."[3] The achievement, led by Craig Eister (SVP, Global Revenue Management, IHG), Dev Koushik (VP, Global Revenue Management, IHG),

and Jon Higbie (Revenue Analytics) was recognized as a one of the 2011 finalists in the Franz Edelman Award for Achievement in Operations Research.

However, the hospitality industry continues to evolve with new markets dynamics created by online intermediaries, social media, the sharing economy, mobile & wireless technology, big data, and the internet of things. At its core, hospitality is a service industry and the guest is the central focus. As guest needs, preferences, and behaviors adapt, so must the hospitality business (and its supporting systems) adapt.

THE HOTEL REVENUE MANAGEMENT CHALLENGE

The revenue management challenge in the hotel business is matching guests to the right rooms, rates, and conditions of sale for specific stay dates. Revenue managers need a comprehensive view into a hotel's future revenue potential to allow them to set prices and manage inventory appropriately. The typical horizon is up to one year forward-looking with greater focus on the near term, as dictated by booking patterns. If done well, the hotel can maximize its revenue potential for a given set of market conditions[4] (Cross). Given this lens, the two main revenue management processes are 1) estimating guest demand for future stay dates and 2) adjusting business controls to maximize revenue.

Estimating future guest demand is critical for revenue management. However, demand for hotel inventory can be complicated to estimate. One of the unique aspects of hotel inventory is that is perishable. Once a night has passed, it is gone forever, unlike inventory in consumer goods where product can sit on the shelf for weeks or months. And unlike your local grocery store that serves the same neighborhood year-round, demand for a local hotel's rooms can come from virtually any place on the planet at various times of the year. Further, there are many reasons for travel so, like CPG, determining the right demand segments can be challenging. Another dimension is the booking window, where demand for a given room on a specific stay night can come from as far out as one year plus or as near as same day booking. Other factors that need to be accounted for are length of stay, cancellations, and extensions. Once demand has been estimated, the revenue manager has a set of controls that can be applied to help maximize revenue given that expected demand. Key among those controls are yield management and pricing.

In order to manage yield effectively, a revenue manager must know the total demand for any given room product and stay date and when that demand will arrive through the booking window. Availability, or supply, typically decreases as the stay date approaches and bookings accumulate. Rates generally rise in conjunction with that decreasing availability. The revenue manager must estimate the minimum rate at each point in the booking window so that trade-offs at different ends of the booking window are managed. Higher rate demand should be captured later in the window, while not under booking early in the window and leaving revenue on the table.

With minimum rate levels established, the revenue manager must determine rates for each room product that maximize revenue. To do this, the demand function must be known, i.e. the price elasticity. However, estimating the demand function, which can be impacted by seasonality, booking window, and guest segment, can be very difficult without analytic support. The market reference rate is another important factor in determining rates. Market data is provided by various third party data aggregators, but the data must be cleaned and prepared to extract an appropriate reference market rate. This process is also not something that is easy for humans to do without the aid of machine analytics.

All three of these key revenue management processes involve some level of complex analytics, which if done for only a single hotel would be labor intensive without some machine based analytics support. At IHG, these processes are repeated for more than 5,300 hotels every day, so not only strong analytics routines are needed, but also a robust analytics infrastructure are need.

ANATOMY OF THE ANALYTICS PLATFORM

Modern revenue management systems have improved functionality to support revenue management decisions in an ever increasingly complex world. Depending on the system, capabilities could include booking data collection, syndicated and third-party data collection, demand and rate forecasting, market segmentation, yield optimization, overbooking optimization, rate optimization, performance measurement, reporting and advanced data visualization, and work flow management. Exploring all the analytics components of a modern revenue management system is best left for a more comprehensive presentation, so we focus our discussion in this paper on the key analytics routines and infrastructure needed to support the three key revenue management challenges outlined above.

REVENUE MANAGEMENT ANALYTICS ROUTINES

The underpinning analytics need for revenue management is demand forecasting. Whether estimating demand for future stay dates or estimating the sensitivity of demand to price, the analytics objective is to predict demand. Meeting this business challenges requires several fundamental analytics methods. Segmentation techniques, time series analysis, and probability distribution fitting are analytics categories that can be used to solve the demand forecasting problem.

Data collection in the hotel industry is robust, with individual booking transactions and changes stored for operational and analytical purposes. Some of the dimensions captured are check-in date, length of stay, room type, rate product, room rate, loyalty status, booking channel, booking date and guest information. These data, which span multiple years and represent millions of incremental records each day, are a key input into the revenue management platform. Segmenting this data into similarly behaving demand groups is the first step in the demand forecasting process.

By grouping customers that exhibit similar behaviors, we can price the rate products and manage availability to meet customer needs, while maximizing hotel revenue. Segmentation is done using cluster analysis in the SAS/STAT® software package on historical booking data and the optimal number of segments is carefully determined considering impact on forecast accuracy of the segment and users' ability to operationally manage the level of complexity.

With the appropriate demand segments established, the forecast process leverages SAS/ETS® and SAS® High-Performance Forecasting to generate demand forecasts for each demand segment, for all 5,300+ hotels, for up to one year out – every day. Time-series methods are used to generate the forecasts and outliers, special events, seasonality, day-of-week, and level shifts are accounted for in this process. The forecasting and time series software allows each hotel to have its own tailored model specification that best predicts its demand, and that specification is continuously monitored and updated by the system as the demand characteristics for each hotel evolve over time.

Demand forecasts are observed at a granular level, where data sparsity may become problematic. For example, a pace forecast is created using a hotel's future on-the-books. This addresses scenarios where a hotel's booking pace differs significantly compared to historical patterns. The final forecast is a combination of the time series forecast and the pace forecast, weighted by the booking curve. Most bookings are made within a 90-day window, so there are not many booking observations to define the booking curve between 91 and 365 days. Fitting a probability distribution helps resolve this challenge. The SAS/ETS® software is again used to fit that booking curve up to one year out. Estimating the length-of-stay for each booking is a similar analytics challenge. Most bookings are 2-3 nights or fewer, however, estimating the number of 4+ night stays can be important when trying to fit reservations into a high occupancy period for a hotel.

These applications are just a few ways IHG uses SAS® to solve for revenue management business needs. By leveraging SAS® capabilities, IHG has been able to accelerate development and implementation time for enhancements and innovation in our revenue management system. The existing procedures allow us to start further down the development path, building on tested and validated analytics code to engineer revenue management solutions from a higher-level process perspective. It shifts the perspective to solving the business needs more so than debugging technical code issues, managing software versions or library updates, or building analytics from the ground up. IHG is using in SAS® in a

production process, so scale and reliability are critical. IHG also leverages SAS® infrastructure to help manage the production requirements for our revenue management system.

REVENUE MANAGEMENT ANALYTICS INFRASTRUCURE

The IHG SAS grid is the world's largest used in the hospitality industry. The grid consists of a clustered metadata tier, a 36 core compute tier, a clustered web tier and a Grid Client Gateway node. It has been designed to meet and exceed the recommended 125 mb/s per core I/O throughput for temporary space which assists in the production hourly job processing.

SAS Grid technology adds value to the environment by:

- Leveraging High Availability of Grid

  o No downtime if single metadata, compute or web hosts fail.

  o No downtime for maintenance, as nodes can be pulled out of the cluster at any point for OS patching, host reboots, routine host maintenance, etc.

- Multiuser Workload Balancing

  o Grid Master Control Server acts as the traffic cop by polling all available compute hosts within the LSF cluster to dispatch to whichever is most receptive.

  o CPU/RAM thresholds are used to determine availability, ensuring that no one host is over-saturated.

- Parallelized Workload Balancing

  o The production forecasting process also utilizes parallelized job runs to efficiently utilize SAS grid technology and efficiently forecast for more than 5,300 hotels daily.

  o Hosts can be easily added/removed to the various queues within the cluster depending on resource demands.

FUTURE INNOVATION

IHG has a long history of leading the industry when it comes to guest reservation and revenue management technology, see Figure 1 below. Introduced in 1965, Holidex was the industry's first reservation system, and in the early nineties we developed one of the first automated solutions for looking at future demand patterns to determine pricing structure. This has evolved into the revenue management systems that we have today.

We have continuously refined our technology over the years, and we are now in the process of rolling out our most recent update; our new Guest Reservation System, which we have developed in conjunction with Amadeus. GRS will sit together with our enhanced proprietary Revenue Management System on our new cloud-based technology platform, IHG Concerto. IHG Concerto will incorporate a comprehensive set of capabilities into a single seamless hotel management tool. Its initial functionality is GRS and revenue management, which in the future, will be joined by an entire suite of hotel solutions, including property management, sales & catering, and point of sale systems.

As the market continues to evolve, IHG will continue to innovate in the revenue management space. Guests and consumers expect more personally relevant offers, more trip relevant and real-time information, more seamless booking and purchase experiences, and a more integrated ecosystem of products and services across a variety of providers. This marketplace evolution will require ongoing revenue management innovation to meet these new demands. New analytics solutions will be needed to help manage the increasing complexity and deliver optimized value and experiences at every point along the hospitality value chain.
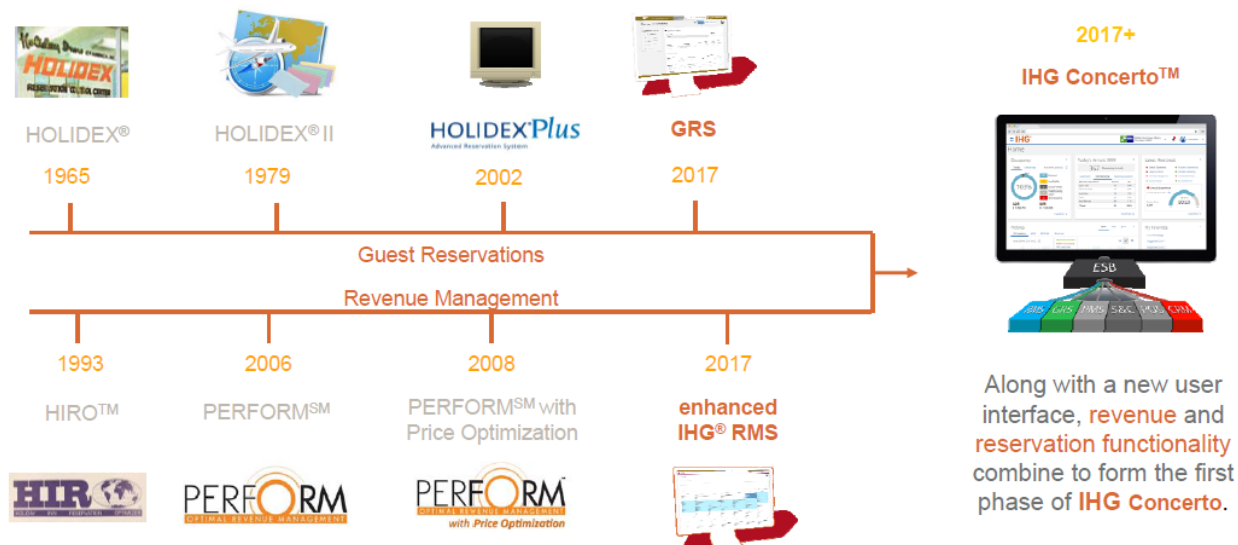
Figure 1. IHG innovation in revenue management and guest reservation systems[5].

From an analytics infrastructure perspective, IHG is exploring complimentary products to the current world's largest SAS hospitality grid. Newer products that work in unison with SAS® grid technology, such as SAS® Viya™, are actively being researched to complement IHG's SAS and 'Big Data' environments. The high-performance processing power of the SAS® Viya™ platform is a SAS® Cloud Analytic Services (CAS). CAS is a server that provides the run-time environment for data management and analytics with SAS®. For reference, run-time environment refers to the combination of hardware and software where data management and analytics take place.

The CAS server has the following characteristics:

- The server can run on a single machine or as a distributed server on multiple machines. For both modes, the server is multi-threaded for high-performance analytics.

  o The distributed server consists of one controller and one or more workers. This architecture is often referred to as a massively parallel processing (MPP) architecture.

  o Using single-server symmetric multi-processing (SMP), the threaded processing of the CAS server is shared by multiple CPUs or is shared between multiple cores of a single CPU.

  o The distributed server has a communication layer that supports fault tolerance. A distributed server can continue processing requests even after losing connectivity to some nodes. The communication layer also enables the ability to remove or add worker nodes from a server while it is running.

- The CAS server can manage all RM data and easily share data with multiple users.

- Code that runs on the CAS server runs in a distributed, multi-threaded environment. Users can take advantage of new high-performance SAS® procedures or CAS actions.

- SAS Studio provides a SAS® programming environment for developing and submitting programs to the server. Languages such as Python, Lua, and Java can submit code to the CAS server by using the open-source code interface.

CONCLUSION

Revenue management is a complex problem, that if solved can help drive improved revenue for operators. The value decision support platforms in the practice of revenue management has been clearly demonstrated across multiple industries, including the hospitality industry. In fact, IHG has led the industry in developing and using revenue management decision platforms (PERFORM™ with Price Optimization) to drive measured revenue uplift.

As the pace of technological progression continues to accelerate and the hospitality industry continues to evolve, IHG is leveraging analytics and technology platforms such as those from SAS® to help us keep pace. By providing proven analytics components and procedures into our development process, SAS® enables IHG to focus more on solving business questions than reinventing analytics processes. Combining these analytics processes in the SAS grid environment also provides the scale and reliability needed to productionize our analytics solutions.

Looking to the future, IHG will keep innovating in the revenue management space, driving value and meaningful brand experiences for our investors, owners, and guests. As IHG continues this journey, we will look to companies like SAS® to continue innovating in the analytics space to help us along the way.

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