

INTERACTIVE VISUAL SALESFORCE ANALYTICS

Completed Research Paper

Kush R. Varshney
IBM T. J. Watson Research Center
Yorktown Heights, New York
krvarshn@us.ibm.com

Jamie C. Rasmussen
IBM T. J. Watson Research Center
Cambridge, Massachusetts
jrasmus@us.ibm.com

Aleksandra Mojsilović
IBM T. J. Watson Research Center
Yorktown Heights, New York
aleksand@us.ibm.com

Moninder Singh
IBM T. J. Watson Research Center
Yorktown Heights, New York
moninder@us.ibm.com

Joan M. DiMicco
IBM T. J. Watson Research Center
Cambridge, Massachusetts
joan.dimicco@us.ibm.com

Abstract

We develop an integrated salesforce analytics application that combines enterprise data from human resources, compensation, and customer relationship management systems, produces predictive data-driven analytics insights to effectively manage organizations with many salespeople, and has an interactive visual interface that allows business users to explore the data and analytics at their own pace and under their control. Named SellerScope, this application addresses many shortcomings of existing salesforce management-related offerings, including the difficulty of use, the lack of interactivity, the lack of timeliness in information reaching stakeholders, and the limited combined analysis of disparate enterprise data. The various data and analytics solutions are described in the paper. The interface is shown through screenshots in the paper, and also in animated form in an accompanying video. The business innovations of the application and the ways in which the visual interface facilitates understanding and trust by the user are discussed.

Keywords: Business intelligence, visualization, machine learning

Introduction

Businesses are increasingly turning to data- and analytics-driven decision making (Davenport and Harris 2007; Varshney and Mojsilović 2011). The adoption of data-driven decision making is associated with a 5% or 6% increase in productivity beyond what can be explained by information technology (IT) investment and other factors (Brynjolfsson et al. 2011). Top-performing companies are beginning to apply analytics rather than intuition in making decisions across all areas of management, including operations and production, business development, sales and marketing, customer service, and workforce planning and allocation (LaValle et al. 2010).

Managing and properly deploying the salespeople of large, global organizations is filled with much complexity and myriad challenges yet it has great importance due to the direct influence on organizations' revenue goals (Singh et al. 2011; Skiera and Albers 2008). Combining aspects of sales and marketing, and workforce planning and allocation, salesforce analytics—defined as data-driven, algorithmic insights and decision making applied to managing sellers—is helping transform corporations worldwide (Baier et al. 2012).

Enterprise data, such as that maintained in human resources (HR) systems, in compensation systems, and in customer relationship management (CRM) systems, is meant for specific management tasks within the realm of each specific system. However, this data reveals a comprehensive view of selling activity if combined. Our research and development is focused on combining and exploiting this data for the development of a suite of descriptive, predictive, and prescriptive salesforce analytics solutions. Questions critical in deploying and managing sellers and sales teams that we have addressed include:

- which salespeople are at risk of missing their quota;
- which salespeople are at risk of voluntarily resigning from the company;
- what is the strength of the salesforce in various regions and brands;
- which team of technical and non-technical sellers should be assigned to a particular client; and
- what is the productivity ramp-up profile of new sellers that join the organization and how can the headcount be managed by taking this profile into account.

These questions are not fully addressed by existing salesforce automation programs, and are certainly not addressed in a unified manner that allows a massive-scale, transformative reshaping of complex salesforce planning in a corporation (Dimension Research 2012; Baier et al. 2012). The required analytics span hiring, assignment of teams and resources to clients, remediation of weak points, and talent retention. The first three of the above questions are detailed in this paper; the latter two are more fully described by Baier et al. (2012). Based on answers to these questions, business decision makers can take actions such as providing help to sellers at risk of missing quota, instituting retention programs to keep sellers from resigning, investing in training in particular regions or brands, assigning sales teams to clients optimally, and planning hiring decisions in advance.

Developing the predictive models and mathematics that lead from data to decisions is a major component of business analytics, but equally important is presenting the results to business leaders in terms they understand and in ways that allow them to trust the insights (Fry 2011). One method of presentation is through interactive visualization. In fact, 28% of business users cite the lack of interactivity (including ability to drill down and filter) and 19% cite difficulty of use as current challenges in salesforce analytics (Dimension Research 2012). Interactive visualization of analytics addresses the challenges of business users, while also enabling more timely access to relevant information for decision makers and allowing 65% better leverage of scarce IT resources (White 2012). By giving the decision maker interactivity and control, IT staff members do not have to spend large amounts of time producing ad hoc reports and modifying dashboards.

Due to these compelling business motivations, we have developed SellerScope, an interactive visual salesforce analytics application, to be used by leaders in enterprise sales organizations. SellerScope is described and demonstrated in this paper and video. In the remainder of the paper, we begin with a more detailed discussion about the business innovations of this work. Then we discuss the scientific motivations for developing an interactive visual interface, specifically to encourage trust in the insights.

We then provide a brief summary of the salesforce analytics problems, data, and analytics algorithms that we have addressed, utilized, and developed. Next, we give an overview of the visual interface we have developed, followed by a more detailed description of the components. We then walk through a set of analyses that a user might go through, emphasizing the business decisions and value of those analyses. The interactivity and animated components of SellerScope are shown using a video. Finally we discuss design rationale and conclude.

Business Innovation

Business analytics is an emerging field with an ever-increasing number of businesses using data to support their tactical, operational, and strategic decision making. However, the term business intelligence (BI) still predominantly refers to reporting and charting capabilities (Chaudhuri et al. 2011). Here we consider predictive analytics as another way of creating business insight from data and providing a business user with an insight on “what might happen.” Today, the users of software systems are exposed to predictive models and machine learning algorithms mainly through recommender systems, which have been an area of study for quite some time (Melville and Sindhwani 2011). For example, recommender systems are used in the business realm to help understand clients’ purchasing decisions, or predict responses to marketing campaigns (Schafer et al. 1999). However, predictive modeling is seldom used beyond these applications, and almost never in support of complex decision making in the enterprise.

Existing salesforce enablement solutions focus on recommender systems, client segmentation, and wallet estimation as tools for creating new insights for individual sellers, thereby improving their productivity (Lawrence et al. 2007). To our knowledge there are very few salesforce solutions in the marketplace that optimize sales planning with the exception of territory optimization software (Zoltners and Lorimer 2000). For example, in existing BI suites, sales productivity analysis is conducted via reports that show how many units of a product were sold in a particular region, or by a particular seller. But there are no ways to easily and objectively benchmark different regions, different sellers, or different quota plans to understand the reasons for performance disparities (Singh et al. 2011).

Another novelty of the application herein is its integration of the different enterprise data sources (CRM, sales territory assignment, client revenue opportunity estimates, sales transactions, seller quota systems, and HR), but more importantly, its use of the integrated information for an entirely new purpose: to improve the productivity of people-centric processes. The ability to capture all of these diverse pieces of information, put them in a usable form, and then marry them with new kinds of analytics allows organizations to plan better, to execute operations better, and to enable people within the process.

Visualization for Trust

As is the case with any data analysis, the results of salesforce analytics can be represented in many forms. The most straightforward way to present predictions of the future actions of salespeople is in the form of a table listing of each salesperson and the confidence of each prediction. Within the scenario of a sales manager tracking the performance of his or her sales department, each manager could be given ranked lists of the employees at most risk for missing their sales quotas and the employees at most risk for leaving the company.

While ranked lists are clear and provide the information a manager would hope to get from a predictive algorithm, there is a missing element: trust. Before acting on these predictions, a sales manager needs to trust that these predictions are plausible and match his or her own mental model of how employees are performing within the sales department. Additionally, the manager also may want to have context in the sense of knowing how or why an individual has been rated as being likely to voluntarily resign or likely to miss a sales quota. Although important, developing trust between a user and an information system is difficult (Muir 1987). Notably, by having control and active involvement, users are more trusting of information systems (Li et al. 2004).

This is where an interactive visual presentation of the analysis plays a role. Through interactive visualization, the manager can explore the multiple dimensions that feed the analytics: viewing the

population of salespeople by the different factors such as region, division, and compensation levels. By progressively exploring the analytics to see which segments of the sales population are predicted to fall into certain outcomes, the manager can test his or her own hypotheses of which factors lead to certain predictions. Within the visualization community, this type of affordance is referred to as *progressive disclosure* (Chuang et al. 2012; Alper et al. 2011). The concept within visualization is to allow a user to dive deeper into the analytics through visual exploration to view the basic factors that fed the analytical result. Chuang et al. (2012) identify progressive disclosure as one of the primary ways of establishing a user's trust of an analytical result.

In addition to trust, the goal of data visualization, as discussed by Thomas and Cook (2006), is not just to paint a pretty picture, but to facilitate the decision maker's analytical reasoning by making use of the human ability to understand complex information visually. Thus, the SellerScope application is a research investigation at the intersection between predictive analytics and visualization, exploring how sales decision makers can be presented with algorithmically-based insights from disparate enterprise data sources that they understand and trust, and can then act on.

Salesforce Analytics Data, Problems, and Algorithms

In this section, we describe the HR, compensation, CRM and sales data that we have integrated and unified, the business decision making related to managing salespeople that we intend to support, and the algorithms we employ toward this end.

Data

Corporate databases and data warehouses are often siloed (Herschel and Jones 2005), and it is a non-trivial task to combine data recorded from various sales-related business activities. In addition to the shortcomings of current salesforce management offerings mentioned in the introduction, 49% of business users cite the lack of combined analysis of sales, marketing, finance, and operations data as a shortcoming (Dimension Research 2012). In managing salespeople, several types of information are relevant. First, human resources data that indicates the job role, business unit, management chain, length of service, promotion history, performance ratings, and skills information of individual sellers is of relevance. The second type of relevant data is compensation data that contains information for individual sellers about base salary, variable pay, commissions, and specifics about the compensation plan (Raju and Srinivasan 1996). The third is information found in sales and customer relationship management system data, such as the assigned quota of individual sellers, their to-date progress towards meeting their quota, the clients to whom they have been assigned, and details about the opportunities in their sales pipelines (Trailer and Dickie 2006).

Problems

Three salesforce analytics problems are addressed in SellerScope. One of the most important tactical insights for sales managers is the prediction of which of their sellers are at risk of not being able to meet (or exceed) their assigned quotas. The managers would like to know this as early as possible in the sales cycle so that they may change the assigned clients of the salesperson, or offer training or assistance so that the quota may be met by the end of the cycle. A second important area of salesforce management in today's highly competitive marketplace is predicting which salespeople are at risk of voluntarily resigning and joining competitive organizations. If such sellers can be identified, retention actions can be initiated. A third topic of interest to executives is the ability to understand the strength of the salesforce in different subdivisions of the company. Are the sellers in one particular geography weaker? Are the sellers of a few particular product lines stronger? In addition to simply gauging the salesforce strength, the executives are also interested in understanding the factors leading to that strength or weakness, so that actions can be taken to improve the productivity in the weak divisions. It helps leaders ensure well-rounded team assignments, aids in territory planning, and provides guidance for skill development.

Algorithms

In order to predict both quota attainment and voluntary attrition for individual sellers, we follow the general machine learning paradigm of supervised classification (Bishop 2006). We employ algorithms that examine the historical data of the sales organization, with sellers labeled by meeting and missing quota or remaining and resigning. The algorithms then find patterns in the historical training data that will generalize to predict attainment or attrition in the future based on the features of the sellers. The features for quota attainment prediction are seller attributes and seller performance, attainment in the current planning cycle, and pipeline analytics. The features for voluntary attrition are mostly related to human resources fields and compensation fields. We employ decision tree classification algorithms, which deal well with missing data and categorical features, and provide interpretable sets of decision rules as learned prediction models (Quinlan 2004). By having interpretable decision rules rather than being a black box, the outputs are transparent to the business user, which better allows him or her to trust the algorithm.

In addition to quota and attrition prediction models, we have also developed a numerical score of seller strength named the strength-of-salesforce index. The overall index is composed of four individual indices related to different factors. The first factor relates to quota attainment, the second to performance ratings, the third to skills, and the fourth to churn, specifically the amount of time a seller has been in his or her current job role (new sellers require time to acclimate before becoming productive (Varshney et al. 2011)). The strength indices for each factor are quantile-based and are combined to form the overall index. The overall strength-of-salesforce index and the individual factor indices are quantized to three levels (low, medium, high) for ease of interpretation.

Interactive Visual Interface

The results from the salesforce analytics algorithms described in the previous section could be presented to sales managers and executives as static reports, i.e. lists of names, attributes, and predicted values, but such a presentation would encounter the understanding and trust issues discussed in previous sections. Therefore, we developed an interactive visual interface for SellerScope that allows the business user to truly manipulate the salesforce data, predictions, and insights. The various components of the interface are described and contextualized in this section.

The interface has three main panels, as shown in Figure 1. The right panel is a visual representation of the salesforce with each hexagonal cell representing one seller. (The salesforce in the figure has 7,500 salespeople.) The interactions that the user makes with the data are reflected by changes in the number, layout, sorting, color, opacity, and selection of the hexagonal cells. Selected cells are highlighted with a smaller inset white hexagon. The view shown in Figure 1 is the honeycomb mode.

The choice of hexagonal cells to represent sellers was made for a variety of reasons. First, hexagonal cells optimally tessellate the plane. Second, hexagons are a simple-enough shape that thousands may be quickly rendered. Third, the hexagonal cells are reminiscent of bees; bee hives are exemplars of well-established principles of good business management (O'Malley 2010). Fourth, early experiments with rectangular cells showed a strong Hermann Grid illusion effect, with distracting visual artifacts appearing between corners of the cells.

Other visualization modes include the bar chart mode and table mode. The top left panel has various controls for displaying, filtering, and presenting the results of analytics. The display options tab lets users choose the visualization mode and change the binding of the available seller attributes to visual characteristics. The bottom left panel is a display area for presenting the attributes and predictions for individual sellers and for groups of selected sellers. Note that the data shown in all figures is for a fictional company that sells software products, but the formulation described in this work could easily be applied to any company in any industry with a large salesforce. Fictional, but plausible, data is shown in the paper because publically revealing such operational data is sensitive for real-world corporations.

The SellerScope application interface is implemented in Java, building upon the open-source Piccolo2D structured two-dimensional graphics framework for zoomable user interfaces (Bederson et al. 2004). The user can smoothly zoom in or out of the visualization to see an overview or fine detail; enlarging the

visualization can make selection of individual sellers with a pointing device easier. A small panel in the visualization's upper right corner is excluded from zoom changes, and displays information about any seller that the user's cursor is over, which aids in selection and sense making. Menus within the application allow programmatic selection of sellers according to attribute values.

The hexagonal cells representing the sellers mellifluously transition between different views, sorts, and layouts. These animated features of SellerScope and others, such as context menus and tooltips are best shown through a visual medium rather than in the static print medium. A video showing many of the features of SellerScope is available at: <http://vimeo.com/41405614>. We incorporated the use of carefully designed animated transitions in data visualizations because doing so has been shown to provide significant advantages to users, including helping to keep viewers oriented and engaged, and facilitating learning and decision making (Heer and Robertson 2007).

SellerScope reacts to user manipulation of display options with staged animated transitions. For example, when changing from the bar chart mode to the honeycomb mode, all of the bar labels simultaneously fade out. Next, the viewport zooms out as necessary to ensure that all nodes remain visible while their positions are being updated. The cells then simultaneously animate to their new positions in the honeycomb arrangement, and lastly the viewport zooms in so that the honeycomb fills the viewport, efficiently using the available screen space. Animation stages that are not needed to show a display option change are skipped. For example, if the visualization is in the bar chart mode and the user only changes

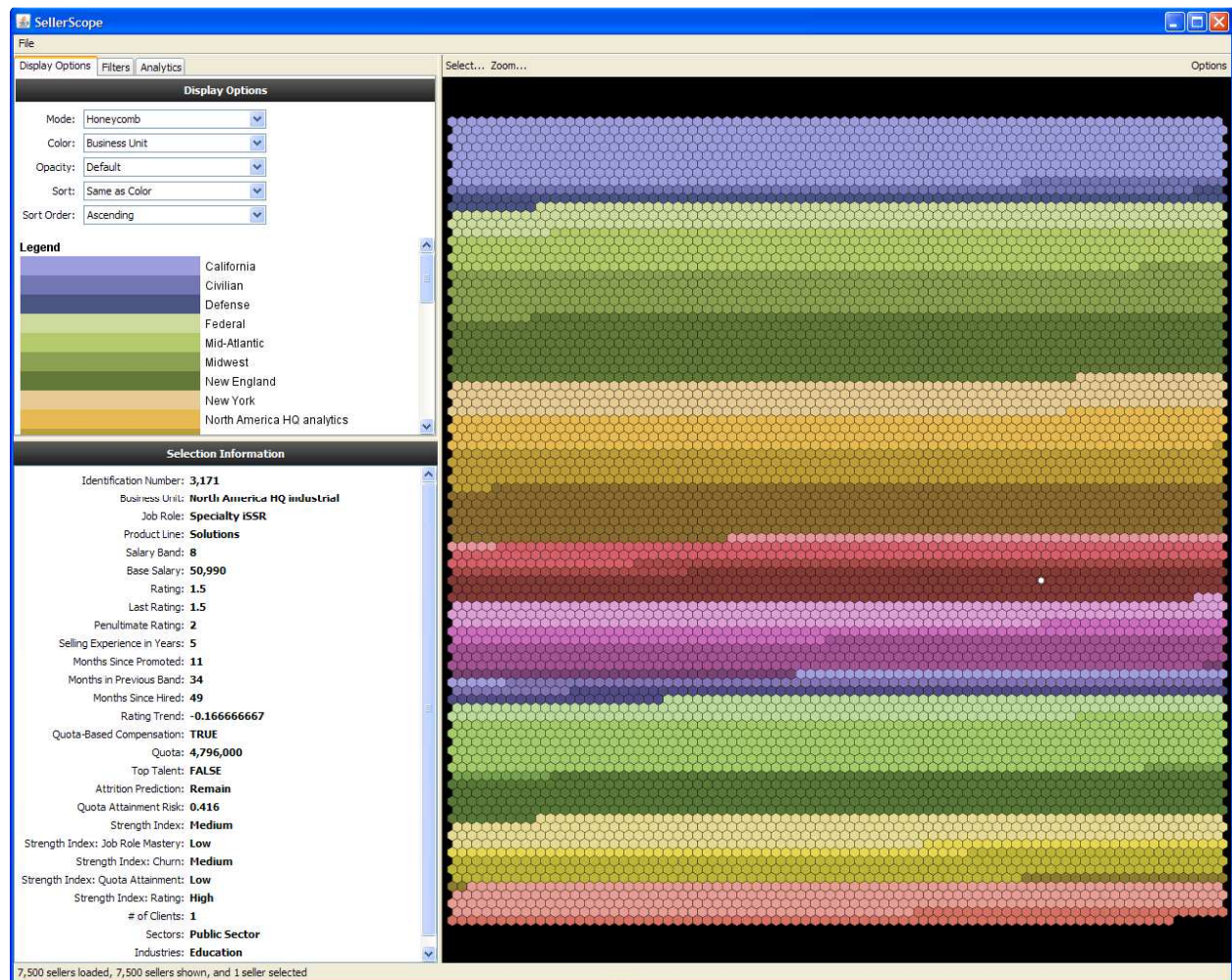


Figure 1. SellerScope Interactive Visual Interface

the sort order, it is not necessary to change the bar labels or to zoom, as all hexagon position updates occur within the bounds of the bar. The animated transitions are also skipped if the number of scene items is large enough that the transition would be too slow or just a confusing blur of motion.

The interface allows the business leader to easily and rapidly ‘slice and dice’ and ‘drill down’ in the data and predictions; the user is able to draw his or her own insights and examine different scenarios. This interactivity gives the business leader control of the data and analytics. The interactive visual interface can be manipulated by the user in real time, but the data and analytics results at the core of SellerScope are not refreshed and refined in real time. This is because in the salesforce management application, the underlying human resources, compensation, and sales data is updated yearly, quarterly, monthly, or weekly, but typically not at a faster pace than that. Additionally, the decisions on salesforce management are also made at that time scale.

In the next section, we show several screenshots with different views as we walk through some salesforce management analyses enabled by SellerScope.

Visual Analysis Example

In this section, we proceed through a few analyses that a sales leader may pursue using SellerScope. The first operational question in the mind of a sales leader is about quota attainment in the current

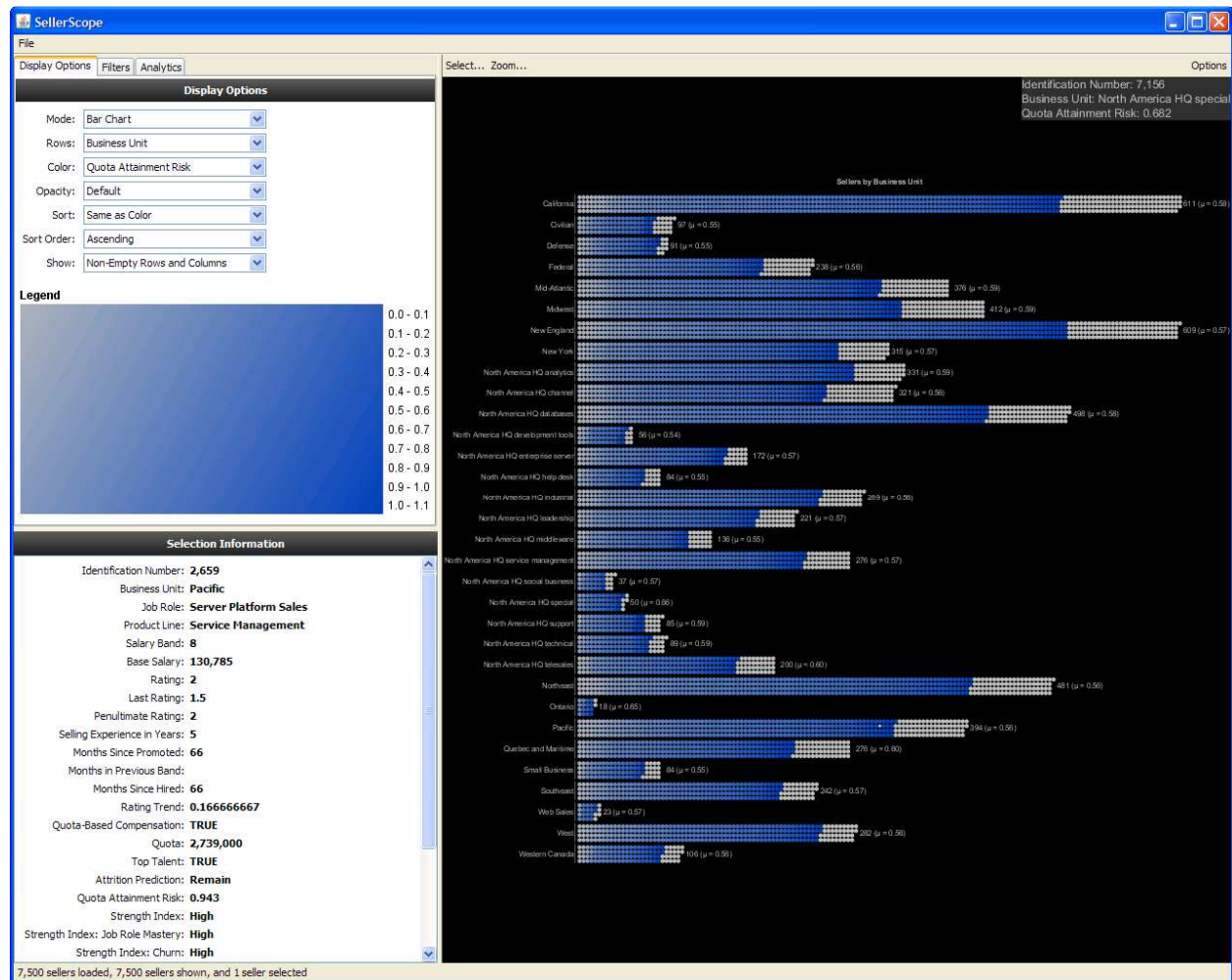


Figure 2. Quota Attainment Risk in Different Business Units

cycle. Which sellers are at risk of missing quota? If such sellers can be identified early in the cycle, then actions such as changes to their territories (i.e. the list of assigned clients) or extra training can be initiated to possibly improve the ability of meeting revenue targets. To support this analysis, the honeycomb view can be colored by the analytics-predicted quota attainment risk: zero (light blue) is “definitely will meet quota” and one (dark blue) is “at high risk of missing quota.” The sellers with gray color are those for which the analytics was unable to produce a predicted score, including those sellers that do not get assigned a quota.

A further question of the leader is to examine this quota attainment risk by business unit. The risk is shown in bar chart mode where each bar represents one business unit in Figure 2. In the figure, it can be seen that some of the business units have a higher average quota attainment risk than others—they are darker blue in color and also have the average value listed next to the bar in parentheses. This is more apparent if we zoom in on some of the bars, as seen in Figure 3. Specifically, the two business units of this fictitious company with the highest average quota attainment risk are the North America HQ special business unit (0.66) and the Ontario business unit (0.65). Within Ontario, the selected seller has had high performance ratings and has high job role mastery, but his or her strength factor related to quota attainment is low and for the current cycle, the quota attainment risk score is quite high: 0.852.

The visual analytics afforded by SellerScope transform the business processes around assessing quota attainment risk. Without the analytics, the business user would be lost in anecdotal past information on

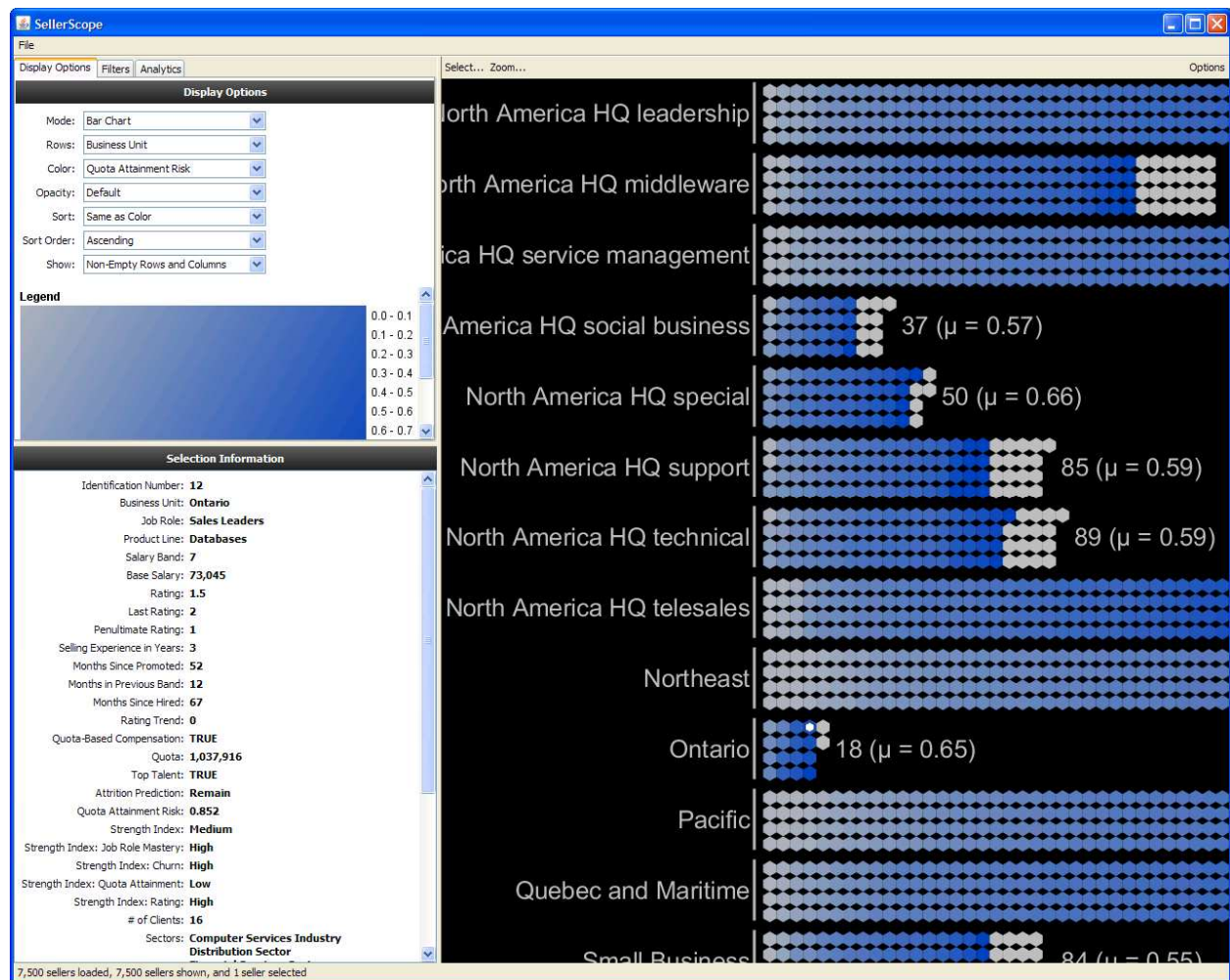


Figure 3. Quota Attainment Risk in Different Business Units Zoomed In

selling performance and would not be able to systematically examine the future selling outlook and find problem areas and individuals. With the analytics and interactive visual interface, the user has a precise numerical risk score that can be understood and acted upon at various levels of granularity from the entire salesforce down to individual sellers.

Once quota attainment is addressed, the next question to arise in the sales leader's mind is about retaining salespeople that might be about to leave the company. In Figure 4, we show attrition rule analytics in the top left panel. Our machine learning algorithm has automatically extracted a set of rules that predict employees to be at risk of voluntary attrition using historical data from the same fictional business. One of the rules has been expanded to reveal its innards. Rule 5 has five conditions that must all be satisfied for us to predict that an employee is at risk of leaving:

- Job Role = Specialty iSSR;
- Base Salary $\leq 75,168$;
- Months Since Promoted > 13 ;
- Months Since Promoted ≤ 30 ; and
- Quota-Based Compensation = FALSE.

The 13 sellers that satisfy the conditions are selected and highlighted in white in the display panel. Aggregate attribute data for these sellers is shown in the bottom left panel.

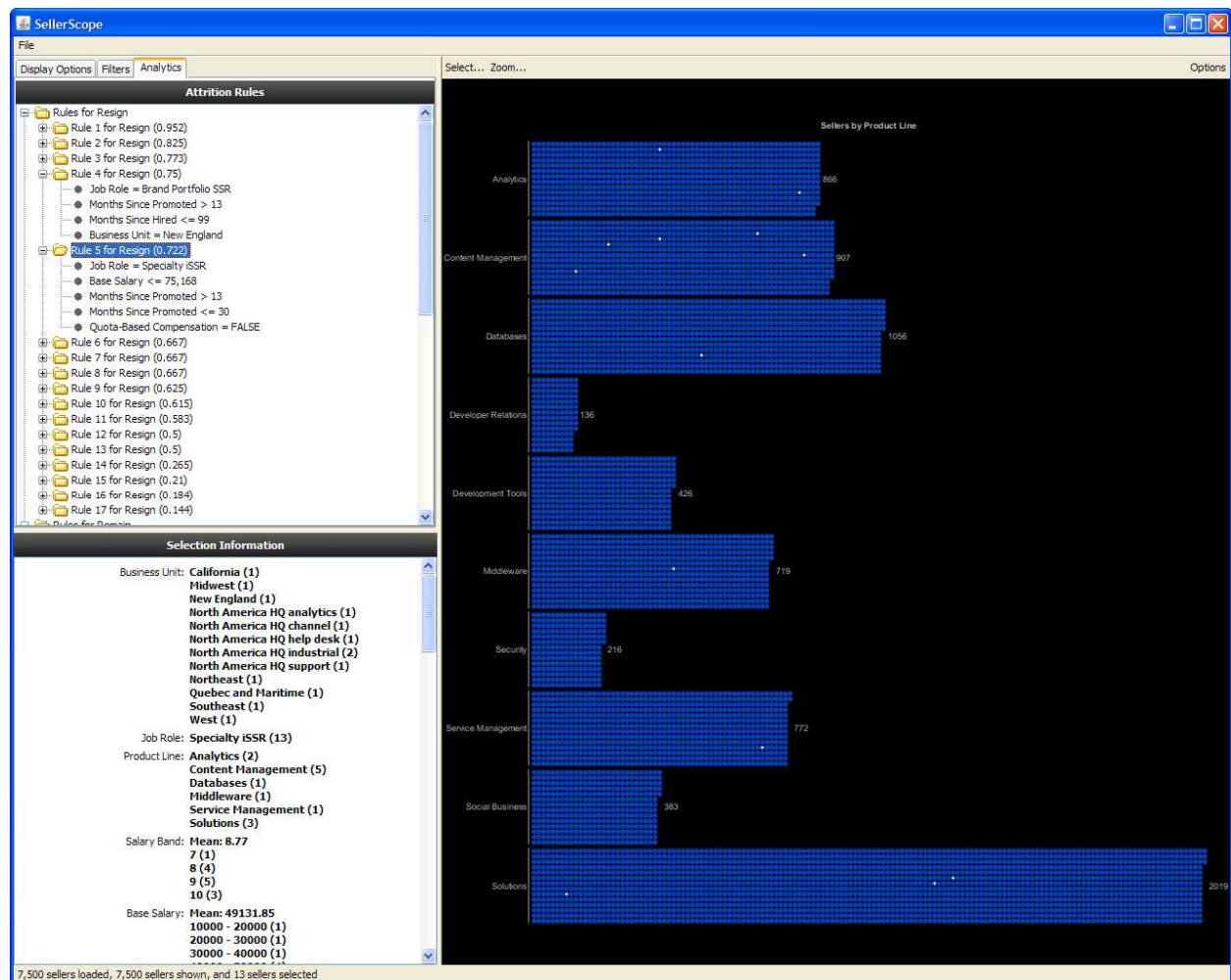


Figure 4. Sellers Highlighted as at Risk of Voluntary Attrition According to Rule 5

The display panel is in bar chart mode with each row representing a different product line. According to this particular rule, the highest number of sellers to be predicted to be at risk of attrition is in the Content Management product line. The specific rule conditions suggest actions that can be considered for retention: namely increasing base salaries to be above 75,000, offering promotions, and changing the compensation plan to be quota-based.

Existing management practices do take into account factors for voluntary employee turnover and retention, such as salary growth, promotion, advancement opportunities, extrinsic rewards, flexible work arrangements, organizational commitment, and organizational justice, but only in a broad sense (Trevor et al. 1997; Hausknecht et al. 2009). However, the scalpel-like analytics for extracting combinations of factors along with cutoff values, and also identifying individuals at risk of resignation seen above is not yet incorporated into business practices. Companies currently focus on broad retention efforts, but through SellerScope, they can initiate very targeted efforts.

Finally, the sales leader would like to examine the strength of the salesforce. Figure 5 shows all sellers in bar chart mode by business unit. The color is the overall strength index and the opacity is the performance rating trend. Green indicates high strength, gray indicates medium strength, and red indicates low strength. The more opaque sellers have a declining performance rating. In this view, it can be seen that two of the business units: New York, and Quebec and Maritime, have lots of red-colored sellers, meaning low strength.

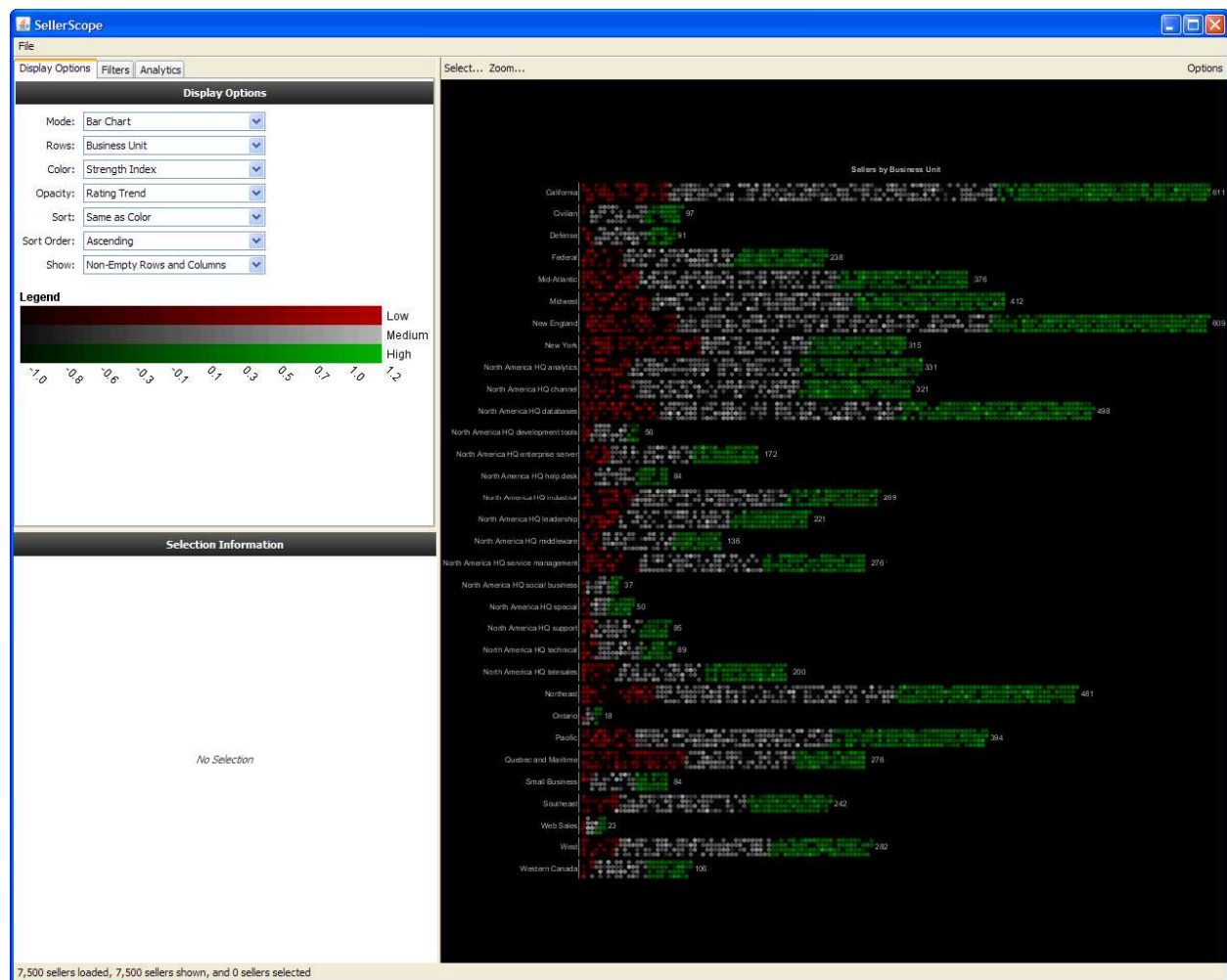


Figure 5. Strength of Sellers (Color) and Rating Trend (Opacity) by Business Unit

As a next step, the user may want to filter down to just one of those business units to try to understand the factors leading to the low strength. In Figure 6, the salesforce has been filtered to just the 315 salespeople in the New York business unit. In Figure 7, we see these New York business unit sellers viewed in table mode, with the rows being the job role mastery factor of the strength and the columns being the churn factor of strength. The colors in the figure indicate the job role of the seller. In this view, we see that most of the sellers have low job role mastery, i.e. a low level of skill in the tasks that their job entails. We also see that most have a high value in the churn strength factor, which indicates that these sellers are not predominantly new to their job role; they have been in their job role for some time. Thus, it is not the acclimation phase in their job when they would be learning new skills. Therefore, this business unit requires extra training to bring up the skill level and remedy the low strength.

Excellence by individual salespeople in the different strength factors contributes to long-term service-oriented customer relationships and favorable word-of-mouth for the salesforce and company as a whole (Anderson and Oliver 1987). The visual analytics approach enables improved behavior-based salesforce control by facilitating the organizational leaders' task of monitoring salespeople's activities and results as well as of providing managerial direction and intervention; such monitoring and intervention are much more difficult logistically without an application like SellerScope. Such an application may even lead an organization to convert from strictly outcome-based salesforce control to behavior-based salesforce control (Anderson and Oliver 1987).

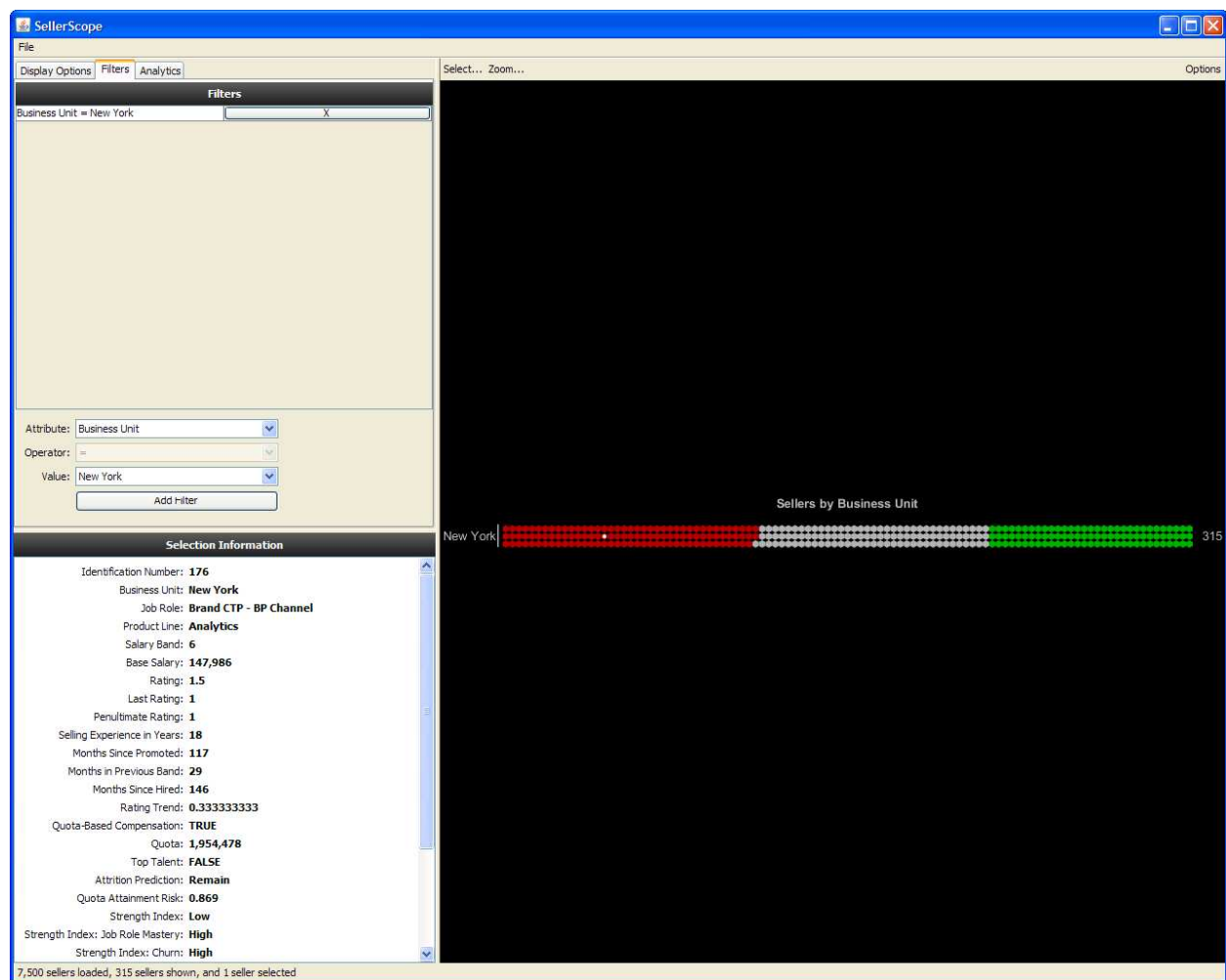


Figure 6. Sellers Filtered to a Business Unit of Low Strength

In this section, we have gone through a few analyses that a business user may perform to illustrate several of the features of the SellerScope program and also showcase the business process transformations that it enables and facilitates. The interactive nature, however, allows the user to perform any sort of analysis that they wish. The video that we have prepared walks through a different set of specific analyses.

Conclusion

In this paper and video presentation, we have described an end-to-end salesforce analytics application that integrates salesforce-relevant enterprise data, mines that data to produce actionable insights and recommendations for sales executives, and displays the data and analytics results in an interactive visual interface. This application addresses many of the desiderata of business users, including the ability to have a 360° view of individual sellers and the overall salesforce in directions ranging from human resources, to sales pipeline and quota attainment, to compensation; the ability to receive data-driven algorithmically-produced recommendations for decision support; and the ability to view, filter, and control the data and analytics interactively.

The SellerScope analytics are currently in the process of being integrated into the business processes of a large, global corporation. One of our goals in developing the interactive and animated interface was to facilitate trust in the analytics recommendations. Anecdotally, we have observed users trusting the

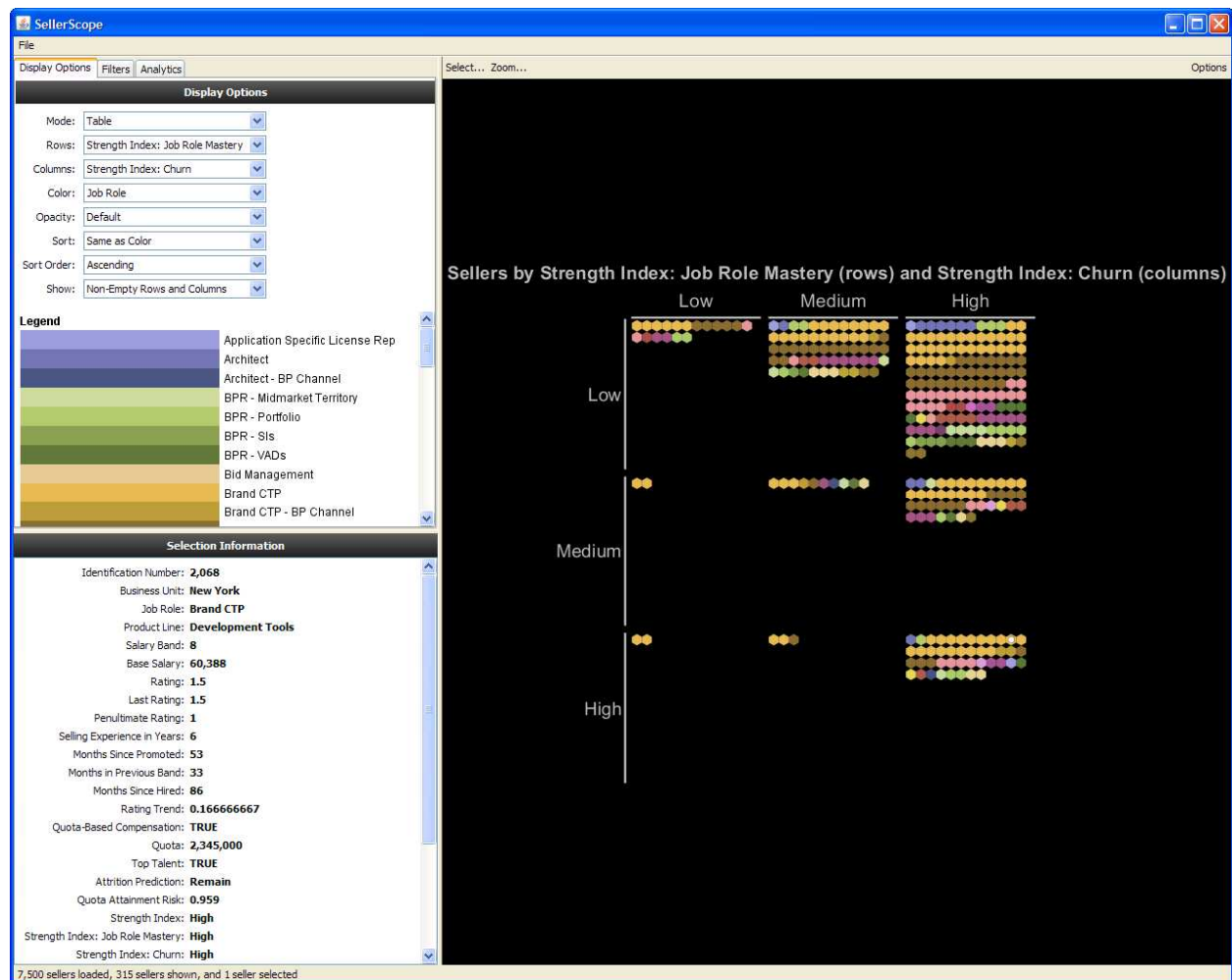


Figure 7. Strength Factors Job Role Mastery and Churn for a Business Unit of Low Overall Strength

salesforce analytics precisely because of the interactivity. Moreover, in initial pilots within this global corporation, several millions of dollars of additional revenue was attributed to the quota attainment analytics; in a separate ongoing pilot of the voluntary attrition models, retention actions based on the attrition modeling have thus far led to a significantly smaller voluntary attrition rate than expected without retention actions.

We have not yet performed controlled user studies to observe sales leaders working with SellerScope to accomplish their managerial duties. A future direction of study is to perform such studies and to refine the visualization, interactivity, and underlying analytics based on feedback. A related piece of work is to quantify the benefits of the visual analytics as opposed to static reports. Furthermore, the intended use of SellerScope is not in isolation, but in conjunction with other information systems. We have neither investigated how use of the application is mediated by interactions with other systems nor considered this aspect in its design.

The paradigm of data-driven, analytics-based salesforce management is in the incipient stages of a likely proliferation in the business world. Such transformations from management by gut instinct to management by algorithmically-produced insights can only happen when supported by analytics such as those highlighted in SellerScope. Moreover, analytics results are only impactful when translated into decisions and actions, which requires understanding and trust of business leaders. As discussed in the paper, interactive visualization like that of SellerScope contributes to both understanding and trust.

Acknowledgement

The authors thank John H. Bauer for his analytics assistance.

References

- Alper, B., Yang, H., Haber, E., and Kandogan, E. 2011. "OpinionBlocks: Visualizing Consumer Reviews," in *Proceedings of the IEEE VisWeek Workshop on Interactive Text Analytics for Decision Making*, Providence, RI.
- Anderson, E. and Oliver, R. L. 1987. "Perspectives on Behavior-Based versus Outcome-Based Salesforce Control Systems," *Journal of Marketing* (51:4), pp. 76-88.
- Baier, M., Carballo, J. E., Chang, A. J., Lu, Y., Mojsilović, A., Richard, M. J., Singh, M., Squillante, M. S., and Varshney, K. R. 2012. "Sales-Force Performance Analytics and Optimization," *IBM Journal of Research and Development*, in press.
- Bederson, B. B., Grossjean, J., and Meyer, J. 2004. "Toolkit Design for Interactive Structured Graphics," *IEEE Transactions on Software Engineering* (30:8), pp. 535-546.
- Bishop, C. M. 2006. "Pattern Recognition and Machine Learning," New York, NY: Springer.
- Brynjolfsson, E., Hitt, L., and Kim, H. 2011. "Strength in Numbers: How Does Data-Driven Decision-Making Affect Firm Performance?," in *Proceedings of the 32nd International Conference on Information Systems*, Shanghai, China, paper 13.
- Chaudhuri, S., Dayal, U., and Narasayya, V. 2011. "An Overview of Business Intelligence Technology," *Communications of the ACM* (54:6), pp. 88-98.
- Chuang, J., Ramage, D., Manning, C. D., and Heer, J. 2012. "Interpretation and Trust: Designing Model-Driven Visualizations for Text Analysis," in *Proceedings of the ACM SIGCHI Conference on Human Factors in Computer Systems*, Austin, TX, pp. 443-452.
- Davenport, T. H. and Harris, J. G. 2007. "Competing on Analytics: The New Science of Winning," Boston, MA: Harvard Business School Press.
- Dimension Research. 2012. "The Current State of SFA Business Analytics: A Survey."
- Fry, C. 2011. "Closing the Gap Between Analytics and Action," *INFORMS Analytics Magazine* (4:6), pp. 4-5.
- Hausknecht, J. P., Rodda, J., and Howard, M. J. 2009. "Targeted Employee Retention: Performance-Based and Job-Related Differences in Reported Reasons for Staying," *Human Resource Management* (48:2), pp. 269-288.
- Heer, J. and Robertson, G. 2007. "Animated Transitions in Statistical Data Graphics," *IEEE Transactions on Visualization and Computer Graphics* (13:6), pp. 1240-1247.

- Herschel, R. T., and Jones, N. E. 2005. "Knowledge Management and Business Intelligence: The Importance of Integration," *Journal of Knowledge Management* (9:4), pp. 45-55.
- LaValle, S., Hopkins, M., Lesser, E., Shockley., and Kruschwitz, N. 2010. "Analytics: The New Path to Value," Somers, NY: MIT Sloan Management Review and IBM Institute for Business Value.
- Lawrence, R., Perlich, C., Rosset, S., Arroyo, J., Callahan, M., Collins, J. M., Ershov, A., Feinzig, S., Khabibrakhmanov, I., Mahatma, S., Niemaszuk, M., and Weiss, S. M. 2007. "Analytics-Driven Solutions for Customer Targeting and Sales-Force Allocation," *IBM Systems Journal* (46:4), pp. 797-816.
- Li, X., and Valacich, J. S., and Hess, T. J. 2004. "Predicting User Trust in Information Systems: A Comparison of Competing Trust Models," in *Proceedings of the 37th Hawaii International Conference on System Sciences*, Waikoloa, HI.
- Melville, P. and Sindhvani, V. 2011. "Recommender Systems," in *Encyclopedia of Machine Learning*, Sammut, C. and Webb, G. I., eds. New York, NY: Springer-Verlag, pp. 829-838.
- Muir, B. M. 1987. "Trust between Humans and Machines, and the Design of Decision Aids," *International Journal of Man-Machine Studies* (27:5/6), pp. 527-539.
- O'Malley, M. 2010. "The Wisdom of Bees: What the Hive Can Teach Business about Leadership, Efficiency, and Growth," New York, NY: Portfolio.
- Quinlan, R. 2004. "Data Mining Tools See5 and C5.0," retrieved from <http://www.rulequest.com/see5-info.html>.
- Raju, J. S. and Srinivasan, V. 1996. "Quota-Based Compensation Plans for Multiterritory Heterogeneous Salesforces," *Management Science* (42:10), pp. 1454-1462.
- Schafer, J. B., Konstan, J., and Riedl, J. 1999. "Recommender Systems in E-Commerce," in *Proceedings of the 1st ACM Conference on Electronic Commerce*, Denver, CO, pp. 158-166.
- Singh, M., Bhattacharjya, D., Deleris, L., Katz-Rogozhnikov, D., Squillante, M., Ray, B., Mojsilović, A., Barrera, C., Kakrania, D., Richard, J., Saha, A., and Fu., J. 2011. "The Growth and Performance Diagnostics Initiative: A Multi-Dimensional Framework for Sales Performance Analysis and Management," *Service Science* (3:1), pp. 82-98.
- Skiera, B. and Albers, S. 2008. "Prioritizing Sales Force Decision Areas for Productivity Improvements using a Core Sales Response Function," *Journal of Personal Selling & Sales Management* (28:2), pp. 145-154.
- Thomas, J. J. and Cook, K. A. 2006. "A Visual Analytics Agenda," *IEEE Computer Graphics and Applications* (26:1), pp. 10-13.
- Trailer, B. and Dickie, J. 2006. "Understanding What Your Sales Manager is Up Against," *Harvard Business Review* (84:7/8), pp. 48-55.
- Trevor, C. O., Gerhart, B., and Boudreau, J. W. 1997. "Voluntary Turnover and Job Performance: Curvilinearity and the Moderating Influences of Salary Growth and Promotions," *Journal of Applied Psychology* (82:1), pp. 44-61.
- Varshney, K. R. and Mojsilović, A. 2011. "Business Analytics Based On Financial Time Series," *IEEE Signal Processing Magazine* (28:5), pp. 83-93.
- Varshney, K. R., Singh, M., Sharma, M., and Mojsilović, A. 2011. "Estimating Post-Event Seller Productivity Profiles in Dynamic Sales Organizations," in *Proceedings of the IEEE International Conference on Data Mining Workshops*, Vancouver, Canada, pp. 1191-1198.
- White, D. 2012. "Picture This: Self-Service BI through Data Discovery and Visualization," Boston, MA: Aberdeen Group.
- Zoltners, A. A. and Lorimer, S. E. 2000. "Sales Territory Alignment: An Overlooked Productivity Tool," *Journal of Personal Selling and Sales Management* (20:3), pp. 139-150.