Executive Edge
Mather Economics President Matt Lindsay on why the devil is in not having details, so get granular

IoT & IIoT 4.0: What’s next

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- Unleash endless business opportunities
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INSIDE STORY

IoT: The next gen

While techies debate the state of the Internet of Things and its potential to transform the way we interact with almost everything, there’s little doubt that the IoT will continue to be a topic of great interest throughout the worldwide analytics community and beyond for many years to come.

For the record, and according to Wikipedia, IoT is defined as the “internetworking of physical devices, vehicles (connected devices and smart devices), buildings and other items embedded with electronics, software sensors, actuators and network connectivity that enable these objects to collect and exchange data.” The Global Standards Initiative cut to the chase and defined the IoT as “the infrastructure of the information society.”

Not to be outdone, the Analytics of Things (AoT) is the layer on top of the IoT that helps turn all the data that the IoT collects into useful information.

We’ve covered the development of IoT and AoT extensively in Analytics magazine for many years, and this issue will add to that legacy, starting with “Industrie 4.0: Analytics everywhere” by Arnab Chakraborty and Thomas D. Meyer of Accenture. A German initiative, Industrie 4.0 is related to the Industrial Internet of Things (IIoT), also known as Industry 4.0 since it’s considered the fourth industrial revolution. Confused? Read the article and “things” will become clearer.

Next, Neeraj Chadha of Cisco explains how “IoT unleashes endless business opportunities” in the era of big data, while Gal Horvitz, CEO of global software company PNMsoft, gives several examples of supercharging the IoT by combining it with business process management in his article, “BPM empowering IoT business users.”

While the world as we know it may soon revolve around the IoT, back here on Earth even more pressing issues persist, such as hacking, information warfare and how best to address them. The CIA, famed for its secrecy in combating such threats, has adopted an open access policy that could be even more effective in winning the information wars as longtime INFORMS member Doug Samuelson reports in “The CIA’s new transparency.”

This issue includes many other articles of interest such as “Driving smarter decisions on pricing and promotion” and “Analytics @ Google,” along with the remarkable story of the first female computer scientist in “Ada Lovelace: poetical scientist.”

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- Christian Olsen, Head of Business Development at Höegh Autoliners
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The devil is in not having details, so get granular

Averages lie to you. One of our publishing clients looked at the average sell-through rate of its online advertising inventory and noted it was 70 percent. “We can launch a metered paywall, and as long as we do not lose more than 30 percent of our inventory, the lost advertising revenue should be minimal,” they thought.

What the average sell-through rate did not tell them was their best inventory was sold out while its lower quality inventory was only 30 percent sold. The 10-article metered paywall reduced its inventory across the site, affecting both high- and low-quality inventory, by about 20 percent, which reduced its digital advertising revenue by several hundred thousand dollars. They removed the meter and re-evaluated its paid content strategy.

Averages can distort your understanding of your business, particularly if there are shared costs and revenues. As an example, a company had business...
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and residential customers. Its business customers had high-density deliveries, meaning several items were ordered and delivered at the same time.

Residential customers typically had one or two items per delivery. In estimating customer profitability, they divided the cost of a delivery stop by the number of packages and determined that residential business was not profitable. “Let’s stop making residential deliveries to save the costs associated with that activity,” they thought.

Before they implemented the plan, they realized that the costs associated with those residential deliveries did not go away if the business was no longer there since the costs were shared with the commercial deliveries. The relevant cost metric for the residential deliveries was marginal cost, not average cost. Once the delivery driver was on his territory, the incremental costs of a residential delivery were minimal.

The solution to the problem with averages is to seek granular insights. Granularity, the level of detail present in a data set, is important for understanding the dynamics of a business. In economics, we focus on the margin, the last unit sold, hour worked or dollar earned. In practical application, marginal effects can be approximated by looking at a business in greater detail and moving away from grand averages. In digital analytics, data-capture tools are often designed for overall audience measurement for advertising applications and not for customer analytics. Audience measurement for advertising does not require the level of detail that customer analytics does, and the application of audience measure data to customers can lead to wrong conclusions and bad outcomes.

In one of our favorite examples of the importance of granular detail in customer analytics, we found the economics of baseball fans in a city can vary dramatically. We worked with a major market newspaper and digital publisher...
to develop the business case for a sports-only digital product in their market.

We initially grouped customers by their preferences for certain sports and estimated advertising and digital audience revenue of each customer segment. We estimated the likelihood of each customer group to subscribe and the potential for lost digital advertising revenue if the sports product was paid versus free.

When we focused on the baseball fans, we noted that the results for the two major league baseball franchises in that city were very different. One team’s fans were national in their distribution, while the other fan base was predominantly local to that market.

The advertising value of the fans outside the market was much lower since local advertisers, who purchased advertising through the direct sales force at much higher effective CPMs relative to programmatic channels, did not value non-local digital impressions as much as in-market advertising inventory. In
addition, local fans were much less likely to subscribe to the digital sports product due to their ability to read coverage of the team from other local outlets without paid access.

As a result, the optimal business strategy was for one team’s fans to receive the product free and the other team’s fans to purchase subscriptions. This type of insight would not have been possible if customers were grouped by all sports fans or even all baseball fans.

An important level of detail that is lacking in most digital data is the combination of digital advertising revenue with content consumption by individual customer. This is a result of the way advertising impressions and content consumption data are captured on most websites.

Google Analytics, both paid and free versions, capture content consumption, typically the number of page views and unique users. Both versions of the product do not offer complete user-level detail for all visitors to the site, but the premium version will offer a sampled set of this level of data if requested.

Google DFP and other advertising servers will capture and report data on delivered impressions, CPMs, and click-through rates. The challenge for analysts is that these data sets do not merge easily, if at all, at the level of the individual visitor. The data must be merged at a “lowest-common-denominator” that is typically aggregated to a day-site section or hour-site section.

As the baseball story above demonstrates, this level of data aggregation can lead to some significant mistakes in determining the best revenue strategy for a digital publisher. Do not make the mistake of using aggregated data to make detailed decisions. Instead, get granular! Your baseball friends and residential delivery fans will thank you.

Matt Lindsay, Ph.D., is president of Mather Economics, a global consulting firm that applies proprietary analytical tools and hands-on expertise to help businesses better understand customers and, in turn, develop and implement pricing strategies. Lindsay has more than 20 years of experience in helping businesses improve performance and drive revenue through economic modeling. He holds a doctorate in economics from the University of Georgia.

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I’ve spent the last few months working with the Human Rights Data Analysis Group. HRDAG has historically focused on unstable regions around the world, scientifically examining data captured by local institutions and grassroots activists to try to discern the truth about the volume and patterns of human rights violations [1]. My work there has been focused on data from Colombia. Over the past several years, HRDAG has done several projects on Colombia, examining deaths, disappearances, torture, sexual violence and violence against union members during the longstanding conflict between armed rebels, criminal organizations and the Colombian government.

My primary project has been to look at output from a previous HRDAG analysis of homicides in Colombia in order to develop insightful visualizations and explanations about the pattern of killings. My results
are intended for a relatively non-technical audience, and that is where I have bumped into a major communications challenge: Because HRDAG’s predictions are based on fairly sophisticated Bayesian Models [2], the results that I am describing are probability distributions rather than point estimates.

As it happens, this is the same problem recently faced by Nate Silver. Like virtually everyone else in the punditry, Silver had predicted that Hillary Clinton was likely to win the election (the final models at fivethirtyeight.com gave her roughly a 70 percent chance of victory). However, as Silver described in a blog post [3] just after the election, Clinton was leading in the vast majority of national and swing state polls going into Nov. 9 but by very slim margins. As such, Silver’s pre-election commentary on fivethirtyeight.com described a variety of possible outcomes, ranging from a Clinton landslide to a narrow Trump victory, citing both the variability inherent in his group’s models as well as potential biases in the polling data [4]. In particular, the scenario in which Clinton captured the popular vote while losing the Electoral College vote was mentioned repeatedly prior to Election Day. In the probabilistic sense, the Donald Trump victory that we observed was clearly “predicted.”

Back here at HRDAG, I keep busy prepping and merging tables in Python, using Hadley Wickham’s ggplot2 package to graph multiple time series in R, and working to understand and explain what is driving the variability in the model estimates. I am intellectually engaged and am learning a great deal. But I am always aware that each of these data sources is a dehumanized digital catalog containing information about thousands of people’s lives.

Throughout history, these types of data sets, euphemistically referred to as “administrative lists” in the statistics literature, have been constructed and utilized for many different purposes, not all of them positive.

As such, President-Elect Trump’s call for a registry of Muslims disturbs me greatly, and not only because this has already been shown to be an ineffective strategy for fighting terrorism [5]. In the digital world that we live in, so much personal data about so many people is captured and stored across so many databases large and small. The social network data in Facebook and LinkedIn is, literally, a roadmap of how we are organized and connected. Organizations that host public or private clouds have extraordinary troves of intelligence about individual citizens living on their servers. The idea of any U.S. president
with an army of data scientists seizing control of all of this data and using it against his or her perceived enemies is truly frightening – and is also contrary to everything this country stands for.

As technology journalist Salvador Rodriguez has noted, “The establishment of such a registry would require engineering prowess and troves of data – both the sort of thing big Silicon Valley companies boast in quantity” [6]. Given this context, I cringe when I see photos of tech industry CEOs assembled in a conference room at Trump Tower. I cheer at the growing list of companies who publicly state that they will not participate in the creation of such a database (as of this writing, this list has grown to include Apple, Google, Facebook, Salesforce.com, and many more). And I shudder when it is reported that Oracle CEO Safra Catz has joined the Trump transition team.

At the individual level, many professionals in the technology industry have also responded by taking a personal stand. To date, several thousand have signed a public online pledge committing “to stand in solidarity with Muslim Americans, immigrants, and all people whose lives and livelihoods are threatened by the incoming administration’s proposed data collection policies. We refuse to build a database of people based on their constitutionally protected religious beliefs. We refuse to facilitate mass deportations of people the government believes to be undesirable. We have educated ourselves on the history of threats like these, and on the roles that technology and technologists played in carrying them out.” You can learn more about this pledge at http://neveragain.tech.

History suggests that in the days and years ahead, we may be called upon to use our analytics skills in ways that may be unconstitutional, immoral or both. These invitations will often come with opportunities for intellectual challenges, financial rewards and/or personal glory, and there will almost surely be other pressures to acquiesce. But we must all be aware that there are real people behind the abstract digital representations in our data sets, that both our data and our models are almost always imperfect, and that our work can reveal information and insights that can have serious human consequences. In a turbulent context, analytics are rarely ethically neutral.

I do not pretend to know what the future holds. But it seems appropriate to develop a probabilistic forecast with significant variability, and to carefully consider some uncomfortable scenarios. Don’t fool yourself: It could indeed
happen here. And our individual choices will definitely matter. History does not write itself.

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REFERENCES & NOTES
2. For more on HRDAG’s estimation methodology, see https://hrdag.org/coreconcepts/.
5. For more on the ineffectiveness of a similar Bush-era registry, see http://www.cnn.com/2016/11/18/politics/nseers-muslim-database-qa-trnd/.

EDITOR’S NOTE:
The views expressed in this column are those of the author and do not necessarily reflect the views of INFORMS or Analytics magazine.
The future of U.S. healthcare analytics

BY RAJIB GHOSH

The 2016 election is a watershed moment for the U.S. healthcare industry. Any presidential election and change of guards come with changes in policies. It happened in 2008 when President Obama was sworn into the office. That led to the establishment of the Affordable Care Act (ACA) or Obamacare. To bend the cost curve, which was swinging up uncontrollably, lawmakers passed a very comprehensive legislative change in U.S. healthcare that expanded insurance coverage for 20 million Americans through Medicaid expansion and the establishment of health information exchanges. When the law was passed, we saw many kinds of reactions – from cautious skepticism to digital health euphoria in the industry. Since then, slowly but surely the industry changed course toward a new model of care delivery and payment. ACA drew scathing criticism from the other side of the aisle with repeated vows to repeal. Given the election results of 2016, we anticipate a move in a different direction. The challenge is the degree of
Legislators are now planning to make this funding a “block grant,” i.e., a fixed amount of money for the program, allowing states to manage their program in their own way. For states that opted for the expansion, this will hurt if the grant money is calculated based on the pre-Medicaid expansion population. If that happens, many people will lose Medicaid insurance, or the Medicaid payment will become so low for everyone that access to care will be impaired. While this might ease the demand on the primary care or the specialty care side, it can increase crowding in the emergency room like it used to be before ACA. But this time, since the population has increased, further crowding is expected to be worse. It also would lead to higher costs.

Disagreement in the views among the lawmakers. A giant financial behemoth such as the healthcare industry can’t be swayed one way or the other so frequently. Much is at stake, and hence the risks are very high.

Regardless of what happens in January 2017 and beyond, a few things about the changes that were ushered in by ACA are expected to continue. Healthcare data analytics will be one of those.

**IMPACT OF THE KEY POLICY CHANGES**

Repeal and replacement of ACA is currently on the table. Alternatives and execution timelines are still being debated. Following is a quick summary of the major changes and their impacts:

**Medicaid changes:** The federally funded Medicaid expansion program is on the chopping block. Only 31 out of the 50 states opted for the program, and the federal government initially funded 100 percent of the expansion program. No limit was imposed on the number of people who could be brought under the program if they qualify for the enrollment criteria.
State run health insurance exchanges may crash: Insurance companies in many states are exiting health insurance exchanges, citing lack of profitability. But many Americans have bought their insurance coverage from insurance exchanges using federal subsidies based on their annual income levels. Subsidies are an expected casualty in the repeal and replacement drive. Without subsidies, many won’t be able to buy insurance, and exchanges won’t be able to generate sustainable revenue to stay afloat.

Personal mandate to buy insurance may be removed: ACA prevented insurance companies from denying coverage for pre-existing conditions. However, to balance risk pool for the health insurance companies, lawmakers made it mandatory for all adults to have insurance or pay a tax. If the personal mandate is removed, then the risk balancing won’t exist. Insurance companies either won’t cover for the pre-existing conditions or hike insurance prices for all to adjust their risks.

Uncompensated care may cost hospital closures or consolidation: Hospital CEOs are worried that their top and bottom line will be severely impacted if the number of lives covered by insurance, government or private insurance via exchanges, reduce substantially. They agreed to accept lower pay from CMS for care delivery since exchanges and Medicaid expansion reduced the uninsured population. Hospitals would have to demand more money from CMS and other plans to offset their lost revenue. In other words, the cost of healthcare could start to increase like before.

WHAT WON’T CHANGE
The movement of ACA and CMS toward value-based care and payment reform programs compelled healthcare organizations to think differently about how they collect and use their data. Let’s look at this from the perspectives of three key stakeholders in the healthcare value chain: providers, payers and the government.

Provider perspective: Care delivery organizations agreed to take less payment from Medicare and participated in programs such as the shared savings program or bundled payment under ACA. To achieve that, they started to shift their focus from volume-based care to improving internal efficiencies and proactive identification of high-risk patient population. The payment structures allowed and incentivized them to become data-driven and supported their journey toward population health management. I don’t see that retrograding. The Electronic Health Record Meaningful Use program pushed more than 80 percent of provider offices...

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to adopt data digitization technology such as EHR, which is critical to data-driven healthcare. However, the cost of data analytics and the unavailability of data professionals are still the key issue for many. I anticipate that the cost will come down under market pressure.

**Payer perspective:** Managing high-risk and high-utilizer patient population was always a challenge for the payers. The cost of healthcare was going up sharply owing to the high cost of drugs, frequent hospitalizations and expensive diagnostics. About 50 percent of the cost was also limited to 5 percent of the population. Managing this population via shared savings incentives is a good way for the insurance companies to control their costs. They wouldn’t like to change that, but they might have to offer more analytics support to small- or medium-sized provider organizations to make this happen.

**Government:** As states become more accountable to take care of their underserved population with a fixed amount of federal money, they must put more pressure and logistics support on the provider organizations to transition to value-based care at an increasing speed. Population health management will become even more important to achieve quality and outcome goals. I won’t be surprised if states take the initiative to set up more aggressive goals for data exchanges and perhaps even fund technology solutions to achieve that at the state or county levels.

There is a still a lot of uncertainty about the proposed changes. A Republican-controlled congress and White House can change some without taking Senate votes through vehicles such as “budget reconciliation,” but for other changes there would be legislative battles. Healthcare for many people in the country is at stake across party lines. ACA is also a very intricate piece of legislation, and repeal and replace may not be as easy as it sounded during campaign rhetoric. There is no silver bullet to fix the broken healthcare system, but frequent change of direction might produce severe change paralysis – that’s the last thing this industry requires in the 21st century.

**Rajib Ghosh** (rghosh@hotmail.com) is an independent consultant and business advisor with 20 years of technology experience in various industry verticals where he had senior-level management roles in software engineering, program management, product management and business and strategy development. Ghosh spent a decade in the U.S. healthcare industry as part of a global ecosystem of medical device manufacturers, medical software companies and telehealth and telemedicine solution providers. He’s held senior positions at Hill-Rom, Solta Medical and Bosch Healthcare. His recent work interest includes public health and the field of IT-enabled sustainable healthcare delivery in the United States as well as emerging nations.
MEETING OF ANALYTICS PROGRAM DIRECTORS

The inaugural Meeting of Analytics Program Directors (MAPD) will be held on April 1 at Caesars Palace in Las Vegas, the day before the start of the 2017 INFORMS Conference on Business Analytics and Operations Research in the same locale.

Sponsored by INFORMS, the goal of MAPD is to provide bachelor’s, master’s and Ph.D.-level program directors of new, established or soon-to-be-launched analytics programs a unique opportunity to:

- discuss industry best practices;
- share common opportunities and challenges;
- learn about current trends;
- enhance engagement with industry and practice professionals; and
- hear from panelists on student recruitment, curriculum, capstone courses and job placement.
The all-day event is free of charge; registration and other details will be available in early January. For more information, contact Bill Griffin, manager, INFORMS Continuing Education Program (bgriffin@informs.org).

STUDENT ANALYTICAL SCHOLAR CASE STUDY COMPETITION

INFORMS will once again offer the SAS/INFORMS Analytics Section Student Analytical Scholar Competition, a scholarship program that will send the winning recipient to the 2017 INFORMS Conference on Business Analytics and Operations Research. Supported by SAS and sponsored by the Analytics Society of INFORMS, the competitive program will recognize one outstanding student who would like to learn more about the practice of analytics at the conference in Las Vegas on April 2-4. The scholarship covers the cost of attending the event and additional networking opportunities.

The purpose of the competition is to practice the process of structuring and presenting a compelling proposal for analytical work. Applicants will be asked to produce a “Statement of Work” (SOW) for a case study based on a real-life project. Such documents are usually created early in a project, after some exploratory work, but may or may not fully define the problem.

SAS will provide a case study. A discussion forum will be available Jan. 30-Feb. 10 for applicants, who are encouraged to ask questions and explore the problem definition in order to put together a viable, professional SOW. The winner will be selected based on the cohesion, proper use of assumptions and demonstrated technical and presentation skills in the SOW, as well as the practicality of the proposed approach to solve the business problem.

The deadline to apply is Feb. 13. For more information, visit: informs.org/SAS-AnalyticsScholarCompetition.

INFORMS UNVEILS NEW LOGO

During the recent 2016 INFORMS Annual Meeting, Vice President of Marketing and Outreach Laura Albert McLay unveiled a new logo that will officially begin to be used with the launch of the new INFORMS website in the spring of 2017.

McLay also previewed the new IOL (INFORMS Online), which is expected to go live prior to the 2017 Conference on Business Analytics and Operations Research in April.
INFORMS LAUNCHES aCAP CERTIFICATION

Since its inception in 2013, the Certified Analytics Professional (CAP®) program has enabled hundreds of organizations across 20 different countries (including 20 percent of the Fortune 100) to meet those challenges through its rigorous process of certifying top experienced analytics professionals. Now, the CAP program is helping organizations expand that ability to tap early career professionals with the launch of its new Associate Certified Analytics Professional (aCAP) program.

The aCAP provides a trusted and independent verification of analytics knowledge of someone who is in the early stages of their career, allowing hiring managers to more easily identify the best possible analytics talent that will continue to grow and contribute to their organization. Likewise, aCAP provides emerging analytics professionals with a competitive advantage over their peers with the distinction of a certification, while affording them the opportunity to build the experience and soft skills necessary for a full CAP certification.

Both the CAP and the aCAP programs are managed by INFORMS. For more information, visit https://www.certifiedanalytics.org/.

2017 INFORMS ANALYTICS CONFERENCE ACCEPTING SUBMISSIONS

The deadline for submitting proposal presentations for the 2017 INFORMS Conference on Business Analytics & Operations Research is Jan. 15. The conference will be held April 2-4 in Las Vegas. Speakers selected through the approval process will receive a discount off regular registration rates.

The Conference Selection Committee welcomes proposals in all areas and all topics within the business analytics and O.R. arena. Both presentation content and speaking expertise will be considered in selection, with priority given to real-world business topics and high-quality academic work geared to real situations.

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Does advertising work? Few will deny that advertising plays an important role in building awareness. The idiom, “out of sight, out of mind,” speaks to the importance of being seen in order to even be thought of. Looking back over the years, however, there’s a strong case to be made that advertising as we know it has been a mixed bag financially. And while emerging forms of advertising improve our ability to target, modern channels are being questioned just as much as traditional media in terms of overall effectiveness. What appears to be certain is, as consumers have greater access to information, the link between an ad’s effectiveness and the intrinsic “compellingness” of what’s advertised is likely to increase.

Academic literature appears to validate the often-quoted dictum that half of advertising falls short financially. According to Leonard Lodish (Wharton School of Business), Ye Hu (Bauer College of Business), et al., there’s greater than a 50 percent chance that TV advertising won’t be profitable. Their analysis is based on roughly 30 years of data in which they estimate that a 1 percent increase in TV ad spend generates about a 0.1 percent increase in sales on average [1]. To put this in context, a $500,000 increase in ad expenditures for a $1 billion brand spending 5 percent of sales on advertising
would create $1 million in extra sales. The extent to which this is profitable, of course, depends on underlying operating costs. However, a 2:1 sales lift to advertising expense ratio doesn’t seem great given that cost of goods or services sold still need to be accounted for.

Broader meta-analysis indicates that newer products and services are likely to benefit the most from advertising, but ad effectiveness in general has decreased over time. For example, Gerard Tellis (Marshall School of Business) together with Raj Sethuraman and Richard Briesch (Cox School of Business) reviewed studies including hundreds of advertising elasticity estimates and found levels for products in the growth stage of the lifecycle 45 percent greater than for those in the mature stage. However, they also found that average elasticities dropped by close to 25 percent for all products considered over the half century reviewed. Increasing clutter is claimed to be a key culprit [2].

Much of the publically available research on advertising effectiveness relates to traditional channels. But as digital receives greater attention, the story doesn’t appear to be any more positive. The infamous AT&T banner ad that appeared on HotWired in 1994 had a 44 percent click-through rate according to some involved at the time [3]. Today, Google’s Display Benchmarks Tool puts U.S. click-through rates at less than 0.2 percent on average. Dave Chaffey of Smart Insights provides a thought-provoking review of click-through rates by format and platform, illustrating how performance can be improved through effective targeting. However, even the highly targeted example he shares only had a click-through rate of 1.3 percent. Chaffey highlights the increasing challenges that digital faces, explaining that ad blockers now account for 35 percent of ads in some countries, and just 45 percent of digital ads are clickable due to poor visibility [4].

In 2014, The Atlantic published an article titled, “A Dangerous Question: Does Internet Advertising Work At All?” Writer Derek Thompson argues that the Internet has led to greater media fragmentation, reducing the impact of advertising. Thompson hypothesizes that by providing
greater access to information, consumers are now able to make more informed decisions without advertising. He writes, “The Internet was supposed to tell us which ads work and which ads don’t. But instead it’s flooded consumers’ brains with reviews, comments and other digital data that has diluted the power of advertising altogether.” Thompson also puts paid search under the microscope, calling out how predispositions may exaggerate reported ad effectiveness (what he refers to as the “I was gonna buy it anyway” effect) [5].

Beyond “advertising” per se, perhaps there’s a deeper issue at play. Apple provides an interesting case in point. Apple’s 1984 Super Bowl commercial is widely recognized as one of the most successful ads of all time. What’s often forgotten is that one year later, Apple aired another commercial during the 1985 Super Bowl, “Lemmings,” considered by most to have been a flop. What’s the difference? The “1984” ad announced the launch of Macintosh, a milestone product that greatly increased the affordability, functionality and ease of personal computing. The 1985 commercial announced Macintosh Office, much of which was still under development and wouldn’t be available for one to two years later. As Owen Linzmayer writes in “Apple Confidential,” “Lemmings” might have been received differently had it introduced another breakthrough product like Macintosh. Quoting Steve Hayden, copywriter on both ads, Linzmayer sums it up with, “You can’t write a check with advertising that the product can’t cash” [6].

So, what does all this mean for marketers? As an investment, advertising brings with it the chance of both profit and loss. To improve the likelihood of positive results, never before have relevance and uniqueness, in terms of message and channel, been more important. Similarly, predicting the likely success of an ad and explaining its impact is ultimately tied to understanding the appeal of what’s being advertised, which creative elements can bring to life but can’t replace.

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REFERENCES
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KEYNOTE SPEAKERS

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Operations Research Center
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Brian Denton
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The CIA’s new transparency

Analytics plays a role in opening access.

BY DOUGLAS A. SAMUELSION

The CIA wants the public to know much more about what it’s doing, and analytics plays a key role in the agency’s new approach. This development is not just a few pronouncements to build public support, but a major change in how the CIA and other intelligence agencies will function.

Surprising as this may seem to long-time watchers of the intelligence community, the Central Intelligence Agency (CIA) is serious about changing its policies, practices and organizational structure, trying to move toward open information sharing with other agencies and the public. The intelligence community’s mission is expanding from keeping and collecting secrets to winning at information warfare. Disseminating the story the U.S. wants told is emerging as a key mission.

Last October, the CIA created a new Directorate within the agency, the Directorate for Digital Innovation. This is the first such organizational structure change for the CIA in more than 50 years. Along with this came the creation of a new position within the agency, “transparency officer.” These efforts are aligned with the “Principles of Intelligence Transparency” [1] issued this past summer by the Director of National Intelligence, who oversees...
“The rationale was that technology is moving incredibly quickly, and we need to keep up,” explains Ben Huebner, the CIA’s Privacy and Civil Liberties officer who is also the lead officer for implementing the Principles of Intelligence Transparency. “Now the information we get is not necessarily on paper and can be voluminous, so it’s hard to see how the rules apply.”

One striking example of the difference is the intelligence community’s longstanding preference for its people to keep a low all the intelligence agencies. The major component agencies of the intelligence community are the CIA, Defense Intelligence Agency (DIA), National Security Agency (NSA), National Geospatial Intelligence Agency (NGA) and National Reconnaissance Office (NRO). The Federal Bureau of Investigation (FBI), state and local law enforcement, and various parts of the Department of Homeland Security are affected and involved as well, perhaps to a lesser degree. This list is not complete.
profile and its policy of excluding from its premises any electronic devices that could be used to move data from inside to outside. “Most new hires these days have been living on cell phones and social media all their lives,” Huebner notes. “They’re not happy about being told to check their cell phones at the front door and pick them up when they leave. At the same time, we need to know more and more about what’s happening on social media. So we’re reexamining what those rules ought to be.”

Deciding how the rules apply is critical. “We need to distinguish between release and classification,” Huebner says. “Release is actually the easier problem of the two. CIA has an established and pretty effective process on the release side — when we’re looking at release, we have subject matter and classification experts reviewing, and we give them a number of resources to determine what has been classified and released previously. For example, we still need to protect sources and methods.”

So some seemingly innocuous information may need to be kept classified and not released. And many analysts and reporters have had the experience of being asked or directed to redact some parts from reports about what were identified as unclassified materials, as innocuous pieces of information can still be compromising when combined.

Release continues to be monitored and controlled carefully. Even former directors and deputy directors of CIA must submit their proposed opinion pieces to the Agency’s Publications Review Board. “We have folks here at CIA whose full-time job is to make clear and unbiased decisions about whether something is classified or not, and those decisions are binding,” Huebner says. “I spoke to those folks before this interview [with OR/MS Today].”

Not surprisingly, the CIA does not share the view of some people, at one point even including then-Attorney General Eric Holder, that there was some public service benefit in Edward Snowden’s revelations about the extent of government intelligence collection and potential for misuse. CIA Director John Brennan, in a wide-ranging mass media interview several months ago [2], “disagreed vehemently” with that assessment. No one person, even the director of an intelligence agency, would have all the information needed to make good decisions about what information could safely be released.
“But everyone agrees that we do have a problem of over-classification,” Huebner adds. “The incentives are such that when in doubt, people assign a higher classification level. This affects day-to-day work, because to the degree that we have over-classification, it prevents us from sharing that intelligence even within the intelligence community. This has been one of the biggest lessons learned in the past 15 years.”

Steps to combat this problem include training. “We have made classification training a priority, from day one and ongoing,” Huebner states. “We teach that over-classification can be just as big a problem as under-classification. This topic is on the small list of things everyone has to know here.”

Another step in this area is a new research program: trying to automate classification decisions to some extent. The CIA is working with National Archives and the University of Texas to develop software to suggest classification level using machine learning and big data. “We have had a lot of interest around the intelligence community in how this is going,” Huebner adds.
“CIA is doing the pilot, but we’re keeping a large number of people informed.”

Improved classification addresses some of the difficulties now associated with release. “Information is classified at birth because of its content or because of possibly revealing sources and methods,” Huebner explains. “There can be instances when information is classified but not properly marked; that’s a training issue. There is a process, by executive order, for reclassifying material that’s found to be more sensitive than we’d realized – but that’s done only in the narrowest of circumstances.”

As for whether increased pressure and scrutiny from Congress and the news media may have made people within the intelligence agencies more risk-averse and secretive, Huebner responds, “Quite the opposite. It’s been the overriding theme in every task force that the intelligence community needs to find better ways to share information and leverage resources, and at the same time protect privacy and civil liberties. This has been a loud and clear signal to the intelligence community.”

Another interesting set of issues is the rapid growth of information gathering and analysis capabilities in the private sector. “It certainly is the case,” Huebner acknowledges, “that government is differently positioned than the private sector. Amazon and Google have tremendous resources, but they don’t have government power. Government plays by a different set of rules, and should. The intelligence agencies have broader constraints, by statute and executive orders. There are very particular requirements about how we acquire information, what is retained, who has access, and what is disseminated and how and to whom. Those rules apply across the board no matter how we get the information – including buying it from the private sector.”

Of course the new presidential administration may change some policies and practices. Longtime readers of *OR/MS Today* may recall our coverage of the ideas proposed by then-Maj. Gen. Michael Flynn and two associates, in charge of intelligence efforts in Afghanistan, to overhaul the intelligence gathering and analysis system, encouraging much more integration and cross-training [3]. Now a retired lieutenant general having moved on from Afghanistan to command DIA for two years, Flynn is President-Elect Trump’s pick for national security advisor. Quite understandably, Huebner made it clear that neither he nor anyone else he knows at CIA wishes to make any comment whatsoever about the transition. Nevertheless, without any such comments, we are free to surmise that Flynn’s influence over the intelligence processes will be interesting to watch.
No matter what the new administration decides, the changing nature of the intelligence agencies’ missions and resources, and of the world at large, seem most likely to drive the intelligence community further in its new direction. Hence the CIA’s transparency and digital innovation initiatives appear to be here to stay, of great importance, and of particular interest to analytics professionals who can help automate the summarizing, connection and classification assessment of vast amounts of intelligence data.

References


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he consumer goods industry thrived for years on its ability to please the average shopper. From toothpaste to soap powder, it knew how to give people what they wanted – and how to sweeten the purchase with the right price, a tempting discount or a great deal. But for the last decade the sector has struggled to grow – both in terms of revenues and margins.

The world has changed, and consumer goods companies have – by and large – found it hard to adapt. Brand loyalty is harder to come by, as more people shop at discounters or go online for the best deals. Digital disruption has opened the market to new companies with different business models. Recent EY research found 45 percent of companies in the industry were struggling to keep pace with changing consumer needs and behaviors.

One way companies can turn the tide is to make better use of the $200 billion they collectively spend each year.
Partly, that’s because they lack the experience. Another reason is the lack of accountability mentioned above. If everyone accepts that this is an area of “hit-and-miss” decision-making, where the price you set or the discount you offer is based more on your relationship with the retailer than hard facts, then there’s little incentive to break that pattern and do something different.

But as the sector comes under increasing cost scrutiny, that thinking – where it still exists – can’t hold for much longer. There is great room for improvement. To highlight just how much, we recently studied more than 2,000 promotion events over a two-year period across 14 U.S. retailers and 25 promoted on trade promotion such as discounts and special offers. While the amount of money involved is vast, investments in trade promotion can, to be polite, seem haphazard. There’s often little or incomplete measurement of whether promotions actually work and minimal accountability for poor performance.

Analytics can shine a light on this area of spending and enable companies to cut waste while driving profitable growth. But only 17 percent of consumer goods companies feel confident in their ability to use analytics to make better decisions on product pricing, placement and promotion, according to our research, and 34 percent say they are ineffective.

There’s often little or incomplete measurement of whether promotions actually work.
product groups. The events included a range of categories and channels. Our results are summarized in the report, “Can smarter pricing and promotion reduce the emphasis on discounting?”

We found that, overall, companies invested almost 20 percent of their total gross revenue in trade promotion, but nearly seven out of 10 promotions lost money. That is a huge waste of resource. By analyzing such a large number of promotion events across a wide range of scenarios, we identified many practical ways companies can use analytics to make pricing and promotion work harder. Here are five:

1. **Set the right everyday price.** Consumer goods companies depend heavily on discounts and offers. But in 80 percent of the cases we analyzed, they could have increased volume, revenue or profitability by changing their everyday (or non-promoted) prices. About half of them could boost profitability by taking their prices up, with limited impact on volume or revenue. If they used analytics to better understand their price elasticities at more granular levels – the effect of price changes on demand segments – they could create better pricing strategies and spot opportunities to drive margin, volume and revenue.

2. **Use smaller discounts.** A big discount sounds attractive, but in almost 40 percent of the cases we analyzed the companies could have made their promotions more profitable by offering smaller discounts. Typically, these companies relied too heavily on deep, temporary price reductions.

3. **Run longer promotions.** People hate to miss a bargain, so putting a time limit on an offer can drive shopper action. But our analysis found that companies often close their promotions too quickly. Four to five weeks is the ideal length of a promotion, we found. This is where most companies achieve optimal ROI. But the average promotion only runs for around a third of that time (i.e., one to two weeks).

4. **Master the details.** Due to tight budgets, lack of resources and other reasons, companies often apply general strategies to a product category or channel. That can fail to reflect the way consumer needs and shopping behaviors change; for example, people think and act differently in a convenience store (where they’re shopping for 10 minutes and have to carry whatever they buy) to a megastore (where they’ve come for an hour and have the car outside). Companies can achieve better results if they use analytics to find the best pricing and promotion strategies for each unique product and channel.

5. **Help the retailer to succeed.** Too often retailers and consumer goods companies see pricing and promotion as a
“zero-sum” game – i.e., a win for one side implies a loss for the other. But opportunities for both sides to improve their business performance occur more frequently than conventional thinking would have us believe. Over a third of the promotion events we studied were “win-win” – defined as having positive incremental profit for both manufacturers and retailers. And these events consistently outperformed other events for both manufacturers and retailers.

These five ideas are about fine-tuning the levers of market tactics. We also found that companies in our study struggled to analyze the results of their promotions; two-thirds had not automated the analytical process; most only had the analytic resources to evaluate a few of their biggest promotion events; and many didn’t have the predictive capabilities needed to simulate an outcome and share their thinking with a retail partner.

As we said, there is much room for improvement. And the benefits are enormous. Consumer products companies that can build a clearer, fact-based understanding of what actually drives successful promotion can manage those levers far better. They can then run promotions that strike a better balance between investment and return. They can change the nature of the conversation with retailers. And bottom line, they can achieve profitable growth at an affordable cost.

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Disclaimer: The views reflected in this article are the views of the authors and do not necessarily reflect the views of the global EY organization or its member firms.
Through advances such as big data and the Internet of Things (IoT), the field of analytics has been growing by leaps and bounds. However, much of the focus, particularly in the United States, has been in the consumer (i.e., business-to-consumer, or B2C) market. Indeed, much of the innovation coming out of Silicon Valley, and from disruptive digital companies with new business models and no legacy infrastructure to contend with, remains in the context of personalization and the consumer experience.

However, organizations too often focus on analytics simply as a tool for incremental gain, with data siloed throughout the business and used by different groups, each focusing on different goals, unable to unlock new value and outcomes. As a result, their business intelligence is out of sync with the business itself, and they’re missing out on a tremendous opportunity to get the most value from their analytics investments and reap the full benefits that analytics can offer. To move past business intelligence and toward becoming an “intelligent business,” companies must...
embed analytics across the entire value chain.

THE EXAMPLE OF GERMANY

That is starting to happen, as evidenced by the Industrial Internet of Things (IIoT), also known as Industry 4.0 (for the fourth industrial revolution). Engineering and manufacturing ecosystems are getting reshaped because of the IIoT – particularly sensor technologies and the vast amounts of data they can provide – which is enabling the creation of “smart” products and services connected to each other through generally available platforms. It’s no surprise that Germany is among those leading the charge in this area, given the country’s role as one of the world’s most-innovative manufacturing markets and its technological leadership in industrial production R&D, as well as in academia, with many universities making advancements in IIoT-related areas of robotics, sensor technologies and artificial intelligence.

The core of Industry 4.0 is connected, intelligent products that communicate with users or other products, enabling new digital business models that harness collected data to offer additional services and as-a-service products – a fully digital value chain. Production processes in all sectors, from high tech to manufacturing and industrial equipment, are being transformed by digital technologies, with leading companies integrating these technologies to improve and evolve pillars of their value chain across entire industries. Innovative manufacturers recognize that enhancing the manufacturing process for even simple products presents new opportunities for growth.

Germany’s commitment to this digital evolution is evidenced through its public-private strategic initiative designed to establish itself as a leading provider of advanced manufacturing solutions. The purpose of this initiative, known as Industrie 4.0 (related to, but not to
be confused with, Industry 4.0), is to connect the IoT to traditional industrial manufacturing, leveraging digital technologies including advanced analytics, big data and cloud computing. Industrie 4.0 and other programs such as Smart Service Welt represent a paradigm shift from “centralized” to “decentralized” smart manufacturing and production, where intelligent machines, systems and networks are capable of autonomously exchanging and responding to information to manage industrial production processes through edge analytics.

By designing their systems for broad-scale adoption and enabling connected “things” to make decisions – while also empowering individuals to use data, gather insights and make informed business decisions that require a “human touch” – leading companies in Germany are re-orientating themselves around data to realize the full value of their analytics investments and to unlock new sources of value. By encouraging the adoption of agile technology platforms and tools such as data visualization to increase the reach of data-driven insights, Industrie 4.0 has touched on a cultural change we’re seeing throughout Germany. New work models are being developed to scale collaboration across organizations, with analytics embedded to transform the value chain and deliver real outcomes, with new efficiencies freeing up time across the organization to focus on the development of new revenue sources.

The list of major companies leading in the Industrie 4.0 ecosystem is long. Just recently, Lufthansa Technik – the Lufthansa Group subsidiary that provides maintenance, repair and overhaul services for aircraft, engines and components – announced that in early 2017 it will launch an independent platform, called Condition Analytics, to predict precisely when components should be replaced, delivering results faster and saving operators money. This is another example of Lufthansa’s strategy to blend digital analytics with engineering expertise to make component maintenance, repair and overhaul more predictive.

Agricultural-equipment company Claas is leveraging this type of continuous remote monitoring technology by developing ways to transmit information from its harvesters operating in fields to farmers or grain experts thousands of miles away automatically via satellite networks. Operators of Claas combine harvesters can use the company’s smartphone app to help control machines – and can even leave them to operate alone.

These are just a couple of the countless examples of German companies
getting involved and taking a lead in analytics and Industrie 4.0, saving time, creating new operating efficiencies and creating new revenues. Accenture is working with many of these and other companies around the world to help them embed analytics across their businesses and throughout their value chains to transform the culture of their operations, unlock the greatest possible value from their analytics investments, and ultimately create new business models.

In Germany and elsewhere, much of what we see taking place as organizations begin embedding analytics across the value chain entails developing new digital and data-driven prototypes that help accelerate digital journeys toward becoming “intelligent businesses.” We often bring clients into the Accenture Labs and Accenture Liquid Studios to leverage immersive environments and help them quickly develop analytics-based prototypes. One such example is what we call Future Camp, an immersive analytics innovation space where we combine design thinking and individually tailored workshops to develop insight-driven

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**CREATING NEW BUSINESS MODELS ACROSS INDUSTRIES**

In the same way as manufacturers have been placing sensors in shop-floor equipment to feed information directly to an analytics engine – enabling them to identify, predict and then proactively address machine-related maintenance issues – this can be done with other technologies and in other industries. For example, by embedding sensors in its vehicles, a trucking company can identify potential operational issues, such as when a part is likely to break down; the truck’s likely location when it will break down; the potential locations for repair; and the optimal repair times to maximize in-service time. Based on these insights, the fleet manager can make effective decisions regarding ordering spare parts necessary for repairs, scheduling repairs with the garage, and even planning a motel stay for the driver during this time.

Some of these tasks can now be fully automated, removing the need for time-consuming human intervention. So rather than just selling its customers the vehicles it manufactures, the company can sell them ancillary services related to the ongoing operation of the vehicle, helping customers maximize the vehicle’s up-time. In this way a truck manufacturer can now be so much more, providing additional services and creating new revenue streams by taking advantage of the insights powered by analytics to unlock value and, in many cases, provide something unexpected but highly appreciated to clients. Across industries, we’re seeing new business models like this being powered by analytics, and Germany is at the forefront of this activity through initiatives such as Industrie 4.0, which play on its manufacturing heritage.

**CREATING A DIGITAL ECOSYSTEM**

Of course, leveraging the full power of advanced analytics requires more than just a solid technology infrastructure and the latest technologies. What’s needed is a cultural shift within organizations so that each element of the value chain uses analytics to work toward the same business goals.

To get as much value out of data as possible in such a fast-paced environment, companies need to think beyond the confines of the four walls of their own organizations to the broader analytics ecosystem. This might entail partnering with technology companies or vendors that have expertise (and data scientists) unavailable in your own organization; participating in industry or academic activities in the field; or
perhaps even teaming with competitors to make the greatest advancements as quickly as possible. A rising tide lifts all ships, as they say.

At Accenture, we recognize the potential of open innovation and have focused on establishing a strong ecosystem through our collaborations with vendors, academic institutions, start-ups and research organizations. In Germany, one of our key relationships is with the German Research Center for Artificial Intelligence (DFKI) – the world’s largest research center in the field of AI – with whom we’re collaborating to develop and apply deep learning capabilities that will solve complex and challenging business problems. With an initial focus on next-generation retailing and, in the manufacturing sector, smart products, we are able to pair DFKI’s labs and skills with Accenture design-led approaches to analytics and our own AI expertise to facilitate ideation and achieve innovative solutions faster than either of us could alone.

THE ROAD FORWARD

The first three industrial revolutions came about as a result of mechanization, electricity and IT. The introduction of the Industrial IoT and related services into the manufacturing environment has ushered in a fourth industrial revolution, one that has already shown the potential to bring differentiated products and services at scale and create new customer experiences.

Germany’s Industrie 4.0 initiative is a great example of how collaboration between a wide variety of organizations across the public and private sectors is helping drive innovation, enabling organizations to become agile, innovative and disruptive. By applying analytics to drive digital disruption in the industrial and manufacturing sectors, leading companies in Germany are creating intelligent products and smart services to deliver unique outcome-based customer experiences. By following a similar model, companies in the United States and elsewhere would be well-positioned to create new and novel business models – and prosper from the new sources of value they provide.

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Imagine a sensor inside an offshore drilling rig. The sensor checks for damage to a critical valve. To do so, the sensor regulates pressure in the oil well 7,000 feet below the ocean’s surface. This sensor generates data that might have gone unnoticed half a decade ago. Back then, the rig operator had no way to tap into this ground-level information.

That’s not the case anymore. With the right technology, organizations can now find everyday data instantly, no matter where it is created – right away, on the fly – exactly when this data is most useful.

THE ERA OF BIG DATA

What is different now from five years ago? It’s known as the Internet of Things (IoT). The IoT universally connects people, mobile devices, machines and devices via networks. The implications of this sea change for business, government and all of society are only just beginning to show. IDC predicts that the IoT’s installed base will be roughly 212 billion machines
and devices worldwide by 2020’s close. This includes 30.1 billion installed connected (autonomous) things.

Before the IoT, organizations generated most of their data: files, presentations, spreadsheets and databases. They sent this self-generated data to a centralized repository. They stored it until they could analyze it. During the data warehouse era, organizations ran their operations and made decisions based only on this warehoused data. It could take days, weeks or even months to attain intelligence from this centralized data. It could take even longer to make decisions based on these findings. In the age of the IoT, that’s not fast enough, and it leaves out too many additional sources of valuable information.

During the last half decade, there has been an explosion of unstructured data, giving rise to the term “big data.” It’s coming from Google, Amazon, Facebook and Twitter. It’s also coming from mobile devices such as phones or tablets, and from machines like smart oil wells.

The IoT generates massive amounts of big data every instant about how people are living, working and purchasing, and how machines and networks are operating. Today, organizations must use big data; it is critical unstructured data they need on top of the data they create. Based on this data, organizational decision-makers can ask questions they weren’t even capable of posing before, let alone answering.

**COMPUTING CLOSE TO THE EDGE**

The IoT has ushered in an entirely new way of discovering new patterns such as edge, or “fog,” computing. Fog computing is close to the edge compared with cloud computing. It takes place right
where people are using mobile devices, and right where sensors are tracking and reporting performance and condition within industrial systems. The oil rig sensor’s signal is an example of an edge activity captured in the big data torrent, and it can be tracked and analyzed using fog computing.

Big data does not have a long shelf life, however. Even if it takes only hours to go to a data center before it is analyzed, big data risks becoming obsolete. If the rig’s sensor reports a sudden change in pressure, the valve might fail before the rig operator knows there’s a problem.

Big data has to be analyzed on the network edge, right where people, devices and machines are generating it – right when a decision based on the intelligence from that data can make a difference. Storing data in a warehouse and waiting on decisions doesn’t cut it anymore.

**CONNECTED DATA OFFERS RICH OPPORTUNITIES**

The IoT hyper-connects people, process, data and things. This is what makes big data so significant. Hyper-connection alters the role of information and promises tremendous opportunity.

Organizations must focus on improving the quality of each decision they make. How much value they obtain from the IoT depends on how well they secure, aggregate, automate and draw insights from their data and big data . . . and do it with lightning speed. Over time, the results can pay off in a big way. If the rig operator discovers the valve flaw in time to replace it during routine maintenance, it averts the huge cost of an unexpected shutdown.

**DIGITALIZATION PRESENTS CHALLENGES**

The digital transformation also brings technology challenges. These include stronger engines to accelerate applications and power data-intensive analytics. An operating environment that is common to the data center and the edge sources of new computing demand. This operating environment must bridge traditional and emerging applications and manage varying workloads better.

In a 2014 Cisco study, 40 percent of companies surveyed identified big data as an area that most needed improvement within the organization. Almost 40 percent said that within three years, smart devices at the network edge will process most data. They also identified analytics tools for big data as the most important enablers of connected device networking.

To make effective use of the IoT, they highlighted four areas for improvement:
1. **Data**: Capturing, storing and analyzing data from connected machines and devices.

2. **Process**: Updating business and operational processes.

3. **People**: Enabling workers to exploit the IoT through training and easily used systems.

4. **Things**: Connecting the right machines, devices and equipment to capture truly useful data.

The IoT is like the New World in the day of Christopher Columbus. Its potential is undiscovered. Organizations that upgrade their technology for the journey will sail toward unlimited rewards.

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IoT (Internet of Things) devices have become increasingly popular in recent years. They are all around us—from fitness trackers on our wrists to smart thermostats in our homes—and adoption will only continue to grow in the coming years. In fact, Gartner, Inc. reported that 5.5 million new things were connected in 2016 alone, upping the total of connected things worldwide to 6.4 billion, a 30 percent increase from 2015. Gartner projects we will reach 20.8 billion by 2020.

IoT devices are continuously tracking and using data and information about the way we interact with the physical world. With this data, they make our everyday lives easier. The business world is taking notice of this growing market and the benefits that can be gained. Companies have begun to deploy IoT solutions into their business operations. For example, UPS uses IoT sensors on its delivery trucks to collect data on drivers’ routes, delivery efficiency and truck performance. Disney World employs IoT in its wearable “MagicBand” wristband, which not only allows guests to get on rides quickly, but also uses RFID tags to collect data and track their activities in the park.

While this data is useful, there is still a disconnect in integrating these powerful IoT devices with mission-critical business processes. Business process management (BPM) is the key to bringing together IoT data and business processes to unlock positive results. It has become the leading technology in fast, enterprise-changing
systems that optimize and streamline workflows for organizations across an array of industries.

UNLOCKING THE POWER OF COMBINING IOT AND BPM

Let’s start by reviewing the pros of IoT and BPM. IoT devices excel at sensing, alerting, augmenting reality and generally interacting fluidly with the wearer or user, while BPM excels in system integration, data processing and process logic areas. Together, they fill each other’s technological gaps.

BPM is an extremely time-sensitive and responsive technology that allows time-critical, dynamic business processes to be changed quickly and while processes are still in progress. This means that BPM systems can take advantage of the real-time nature of data coming out of and going back into IoT devices. It’s an ideal fit for business applications.

Both systems can support human-centric, system-centric and hybrid scenarios. In a human-centric scenario, the BPM system factors in the human element in the business process, putting the person in the center of decision-making and action. This makes it a great match for IoT medical and wearable technology advances.
IoT devices send collected data over a cellular or Wi-Fi network to a centralized database. The BPM software then monitors this database for changes. When a change is detected, the BPM software will start a process to initiate an optimal response. When this important change – also known as a “business moment,” a disruptive, sometimes unpredictable change that occurs during short windows of time within a business ecosystem – is found, key personnel and resources will be able to quickly identify and make well-informed decisions in a timely manner for the best course of action.

**IoT AND BPM INTEGRATIONS IN ACTION**

Here are three examples of how IoT can take part in business processes across various industries:

- Energy/utility provider field agents who carry sensors, detectors and other equipment. Such devices can be integrated with business processes such as safety checks and client provisioning.
- Defense/security equipment and operatives with smartglasses. Glasses can take photographs of a situation area, and send these along to a situation room to process.
- Travelers whose flights have been cancelled because of bad weather.

Once the bad weather has been detected, the flight cancellation triggers a process that sends an alert to the traveler’s cell phone and updates the hotel desk personnel and rental car company of their customer’s later arrival.

Remote medicine or “telemedicine” is a growing trend for healthcare providers worldwide. The trend is being fueled by the increasing amount of IoT medical devices that are being used in the field. According to a Research and Markets study (November 2015), the IoT healthcare market is being driven by rising demands for improved healthcare, reduced cost of care and evolution of high-speed networking technologies, and is expected to grow from $32.47 billion in 2015 to $163.24 billion by 2020.

Let’s now dive a little deeper into a healthcare case study on how a major European hospice is transforming patient care by combining IoT medical devices with an intelligent BPM solution.

**CASE STUDY: HOSPICE**

*Background:* The hospice has been using telemedicine and cardiac telemonitoring devices for 20 years, but its leadership sought a solution that would allow their doctors to provide better care. The hospice wanted...
non-technical staff to be able to rapidly build and change forms on a browser for their customers/patients, as well as manage all aspects around the care of hospital patients and the internal procedures for medical staff.

**Problems and challenges:** Although the hospice had mobile devices in place, one of the biggest challenges it faced was what to do with the data it was collecting. Data alone (sometimes too much data) was becoming too confusing to healthcare providers, and the information was not intelligently integrated with any of its medical processes. The hospice also experienced the following problems and challenges:

- Device diversity and interoperability
- Lack of data integration
- Inability to scale, handle data volume and see overall performance over time
- Systems were not flexible and could not handle the evolution of applications being implemented and used
- Lack of data privacy

- Data required medical expertise in order to determine next process of care
Although IoT and BPM integrated technology is still in its infancy, it will continue to become more prevalent and complex. This means that more integrated systems will be needed. As the technology adapts and grows, more decision-making processes will be added and managed in these types of systems.

Intelligent solutions will be able to learn from past history, perform pattern recognition, access millions of pages of research and data, provide advice and even perform actions independently. We'll start to see more advanced applications across all industries.

Where is the human role in this increasingly systemized world? The beauty of IoT and BPM is that the technology becomes an important factor for its users. Systems can guide and advise, and leave the most difficult decisions to the experts. Hand in hand, users and their system will be better equipped to provide easier, faster and more optimized service. The integration between IoT devices and BPM presents a viable solution with a bright future – one that will connect people, things and systems together as part of business-critical processes.

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The mission of Google, Inc. is “to organize the world’s information and make it universally accessible and useful.” This has spawned efforts as diverse as optical fiber to the home (gFiber), longevity research (Calico), smart home automation (Nest), YouTube, glucose-detecting contact lenses (Verily), self-driving cars and many others. Such broad-reaching innovations are possible due to robust search and ads businesses.

It is well known that web search was the foundation of Google. Recognition that a web page is important if it is pointed to by other important pages translates into math: PageRank’s importance scores are the stationary values of an enormous Markov chain [1]. With this start, it is not surprising that Google’s culture goes hand in hand with analytical literacy.

Working as an operations research (O.R.) practitioner surrounded by highly analytical colleagues brings, by contrast, new meaning to the term “isolated practitioner.” Wandering around Google, one sees whiteboards everywhere, filled with equations, graphs, pseudo code and probability distributions. Widespread
respect for data to inform decisions is accompanied by healthy skepticism; numbers can also mislead.

For example, peer reviews and presentations at all levels have the primary intent of improving the analysis. A presentation where the audience politely listens and applauds at the end represents a failure to engage. A successful presentation features frequent interruptions, challenges to assumptions and analysis, and lively debate with the audience. This holds true even in executive presentations, where the O.R. is vetted with deep experts in computer science and statistics, technical minds imbued with a broad grasp of the business. In contrast to organizations where advanced analytics methods remain shielded, Googlers pry open the Black Box and engage. For experienced hires from other companies, this can be initially disconcerting, but over
time, they discover that they gain trust and impact by embracing this method of collaboration.

Organizing information at scale often relies on software. Each day, Google’s systems crawl 20 billion web pages, stream hundreds of millions of hours of YouTube videos and activate 1.5 million Android devices. This scale requires a massive physical infrastructure: Google’s unparalleled worldwide cluster computing system. This infrastructure includes 13 data center campuses of staggering size. The Council Bluffs, Iowa, campus is the largest in the world, with multistoried data center buildings that have building pads over a third of a mile long. In addition, Google has presence in dozens of cities across more than 33 countries, with a global network of fiber optic cables connecting it all, to bring information and services quickly and reliably to its end users.

Building and growing this infrastructure requires insights provided by hundreds of advanced analytics projects. Ongoing operations require efficient allocation of compute, storage and network resources across internal product areas and external cloud customers. Advanced analytics also make up the core function for many Google products, from improving users’ search results to finding an optimal driving route for Google Maps directions.

Advanced analytics techniques go beyond what we traditionally define as O.R., and include methods from fields such as statistics, robotics, control systems, game theory, econometrics and risk analysis. For example, machine learning (ML) is used to improve search results, automate language translation, protect Gmail and Chrome users from spam and malware, and even improve data center energy efficiency (Google is the largest corporate purchaser of renewable energy on the planet; Google’s data centers are among the most energy efficient in the world). Google has published hundreds of papers related to ML (see http://research.google.com) and has open-sourced many ML tools through TensorFlow (see www.tensorflow.org).

A VIBRANT COMMUNITY OF QUANTS

O.R. practitioners are often interested in how companies organize their O.R. employees: in central teams, embedded within functional domains or some hybrid. Google uses a hybrid approach and augments it by providing clear direction on how individuals’ careers can advance, building and sustaining a community of quantitative analysts, and retaining that community’s identity.

At Google, operations researchers need to be generalist problem solvers,
and they typically work in roles such as data scientist (quantitative analyst), software engineer or research scientist. As such, they are held to the standards of their associated job ladder. These ladders describe expectations at each level throughout a contributor’s career. Through committee-based decision-making, the ladders provide consistency across interviewing, hiring, calibrating performance ratings and evaluating promotions. This discipline sets a uniformly high bar for hiring and promotion across the company, and the consistent expectations facilitate rotation among teams. Furthermore, because all professionals participate, they become deeply familiar with each other’s work.

The data scientist, or quantitative analyst, ladder includes several hundred analysts, most with a statistics background, a significant minority with an O.R. background, and small groups from fields such as biostatistics, economics and computational engineering. The number of analysts supporting a domain can vary from a few to a few dozen. The ladders enable that degree of domain specialization while preserving consistently high standards for technical hiring and work and embedding the analyst in a broader technical community.

In addition to job ladders, Google uses forums for professionals to share their work freely within the company, such as informal lunch series, tech talks, a data science blog and more formal global summits. By providing these community-building activities and job ladders, Google sustains community identity and career direction for its O.R. analysts while positioning O.R. practitioners in both centralized and embedded teams.

The following section highlights two centralized teams: one with a functional focus on the technical infrastructure domain and the other with a focus on methods and tools used across multiple application domains.

**CORE O.R. TEAMS**

*Operations Decision Support (ODS):* This Mountain View, Calif.-based...
team is comprised of operations research Ph.D.s who focus on Google’s technical infrastructure: optimizing the hardware supply chain, planning data center and wide-area network capacity, optimizing server deployments and lifecycles, and improving the utilization of compute and storage resources. Many of the projects are variants of well-known trade-offs to optimize cost: the Newsvendor problem, timing for technology refresh and determining build frequency economic order quantities. ODS’s focus on cost optimization led to its strong reputation for total cost of ownership management.

For example, Google positions network gear in multiple cities around the world in order to connect with peers (Internet Service Providers) closer to their end users. How many and which facilities should be used, and which gear should be placed where, require trade-offs between facility and fiber costs to connect gear across sites. The team uses simulation to cost-optimize strategic roadmaps for evolution of peering support within Google’s network.

Another example is deciding when to replace an older server with one from the newest generation, which requires optimizing various costs. Analyses such as this inform many thousands of decisions, some in the form of a policy, some as a simple calculator, and some as a complex decision support tool, run either periodically or on demand.

ODS also does forecasting and capacity planning. ODS produces a range forecast of the fleet, which consists of compute, storage and power capacity needs in the data centers. This is used in making many downstream decisions including acquisition of land and utilities, new construction and network capacity augmentation. Moving from point forecasts to quantification of the variation implied by forecast error, and using this variation to set inventory buffers, necessarily involves substantial organizational transformation as well as analysis. As in most companies, this integration of hard and soft skills is an essential ingredient in the toolkit of an O.R. practitioner at Google.

Beyond these examples, ODS applies advanced analytics to optimize Google’s fleet. It uses mixed integer programming (MIP) models to plan server deployments across the fleet and to optimally add and reshape compute and storage capacity within each cluster of machines. ODS also uses simulation and machine learning models to overcommit and schedule compute and storage capacity to improve utilization.

**Operations Research Team (O.R.):**
While the ODS team is organized around application domains, the O.R. team is
organized around methods. This Paris-based group develops and supports combinatorial optimization software and applies it to large-scale, real-world problems across the company. This software engineering and research team originated out of a challenge posed by Google Street View.

Obtaining Street View imagery requires efficiently routing cars down streets around the world to capture all the needed images. Solving this classic Chinese Postman Problem led to savings on labor and car maintenance, reduced emissions and more up-to-date imagery through shorter and thus more frequented routes. This problem motivated the founding of the O.R. team as Google’s in-house vehicle routing team, and the team’s expertise quickly expanded from there.

The team develops its optimization software libraries to handle the speed, scalability and security that Google-scale projects demand. More than 150 teams at Google use these libraries, and most of them have been open-sourced as the or-tools suite, available on GitHub. These libraries include a gold-medal winning constraint solver, vehicle routing library, linear optimization solver, Boolean optimization solver, knapsack solver and libraries for solving flow and assignment problems (see https://developers.google.com/optimization/).

Although it grew out of Street View, the O.R. team works on projects all across Google. The team has developed optimization algorithms to stabilize YouTube videos, direct navigation for the Loon (Internet balloon) fleet, and even assign people across Google to serve on promotion committees. The O.R. team has also worked with Terra Bella, Google’s subsidiary formerly known as Skybox Imaging.

Terra Bella has satellites that orbit the Earth in short cycles and capture
An O.R. problem that arises often in Google infrastructure is dynamic, multi-dimensional bin packing and load balancing. One example is job scheduling in Google’s massively parallel computing environments. Here, the multidimensional items are jobs that need to be placed on machines (bins) subject to multiple hard and soft constraints, such as available CPU and RAM, job preferences, priorities and specialized hardware needs. The infrastructure-related Algorithms and Analytics teams work with the relevant engineering teams to improve both online dynamic algorithms and offline MIP-based solutions for scheduling jobs, adding resources to data centers and answering related capacity planning questions.

The Large-Scale Optimization research team, based in New York, works with the relevant engineering teams to improve the efficiency and robustness of Google’s computational infrastructure, such as the backend systems that serve search and Google’s external cloud offering. For example, the team applied balanced graph partitioning algorithms to cluster search terms according to how often they co-occur in search queries, then used this clustering to govern how queries are distributed among machines in the search backend. This change greatly increased the rate at which queries can be served via improved caching.

High-resolution satellite imagery of places all around the world. Fixed orbit paths limit when locations are in view of each satellite, and data downlink opportunities are available only when the satellites are near fixed ground stations. The O.R. team developed a MIP approach to schedule the timing and location of satellite captures of target images and downlinks of satellite image data.

**ISOLATED PRACTITIONERS (NOT)**

In addition to the large O.R.-focused teams, there are many individual and small groups of O.R. contributors all across Google linked together by the community mechanisms described above.

Several O.R. practitioners work across Google Express, Google’s online delivery service providing fast delivery of products from popular retailers. They solve problems such as demand forecasting, capacity planning, scheduling and routing to help deliver products from retailers to customers. For example, some practitioners work on forecasting the number of orders by time of day and location to be able to schedule drivers and store operators via optimization algorithms that account for constraints such as the very short lead time of orders, staff preferences and consistency in individual staff schedules over time.
A software engineering team in Network Architecture does capacity planning and risk analysis for Google’s wide area network of fiber optic cables. Their models seek to minimize cost while ensuring availability, speed and scalability, three key components of Google’s network. They use MIP models to determine the cheapest network that can route flows during a given set of fiber failure scenarios. A Monte Carlo simulation tests the resulting network against availability and latency service level requirements to determine additional failure scenarios to include in the MIP in the next iteration.

O.R. IS EVERYWHERE

In summary, advanced analytics permeates work at Google. It might seem easier to describe where it hasn’t been applied. But this impression is quickly contradicted by nontraditional cases such as human resources identifying an optimal number of candidate interviews or a job posting for a food service analytics and insights manager. There are always new problems to solve and new impacts to deliver. The relevance of O.R. and advanced analytics is stronger than ever in this burgeoning high-tech industry.

Working here is perhaps best summed up by a recent quote from a Google analyst: “Google is like a candy store for O.R. practitioners.”

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REFERENCE

Once upon a time, in a kingdom far, far away, a blue-blooded girl was born with one of the most well-known family names in history. Her mother hated her father so much that her mother decided to nurture this little girl as everything opposite to what her father stood for: passion, romance, poetry. And so the mother taught her daughter science, mathematics and logic. The mother would not even let the girl see any portrait of her father till the age of 20!

Nevertheless, nature gave the daughter a romantic heart, and nurture gave her a logical brain. She became the first female computer scientist, and the Pentagon even named a computer language after her. She is Ada Lovelace, the daughter of poet Lord Byron. She was also the first to question if a machine could think. Alan Turing called it “Lady Lovelace’s Objection.” Coincidentally,
believed that man with his wisdom could overcome everything and come up with a rational solution. This period witnessed an unprecedented development in science and engineering, and daily lives were fundamentally changed. Rational thinking was considered as the ultimate answering tool to gain knowledge. From knowledge, one could reach Utopia.

Afterward came a new group of people who were idealists in the sense of every meaning of that word – they valued “wholeheartedness, sincerity, the purity of soul, the readiness to dedicate yourself
WHAT HAS ADA LOVELACE DONE WITH HER POETICAL SCIENCE?

Augusta Ada King (née Byron, 1815-1852), Countess of Lovelace, was born with the most famous (or infamous) name of her time or even of all time [4]. Her father was the great romantic poet Lord Byron, but she had been separated from him since birth. Lady Byron was a disciplined lady, and she was very supportive of Ada’s education in mathematics to drive her away from the spirit of her father [5].

The difference between a good and a great scientist is that the great one always has a feeling about the direction of his or her research. Their intuitions might be off or immature, but this is a key point in shaping and crystallizing ideas. Nevertheless, Ada found the division between art and science deterred people from understanding the essence of an idea. Ada believed in the importance of intuition and image in mathematics and science. She called this “Poetical Science.” The key features were observation, interpretation and integration. They were relevant a hundred years ago and are still relevant today.

The first stage is careful observation. She believed that people should pay close attention to details in order to arrive at insights. She often used analogy and metaphor to explain key concepts because she needed to be able to run them through her head first to assure understanding. We should note that her metaphors were both concise and precise, a reflection of deep understanding. This is a skill we urgently need now. We are working in more specialized fields, and very often we communicate in jargon that no one even in related areas could fully understand, not to mention the general public or other learned people. A good metaphor captures the attention of people as well as facilitating discussion.

Poetry has had metaphor since its inception, but it is mostly drawn from one or more parallel features. Romantic poems often project romantic images through various literate means. When Wordsworth wrote, “Till all was tranquil as a dreamless sleep” in “The Prelude,” it did not mean dreamless sleep always happens in tranquility. This is a typical example of how the Romantics used metaphor. However, the metaphors used by Ada were different. She used them to highlight key features that anyone could understand.
For example, people at that time would have no problem picturing a weaving machine. So she called the “Analytical Engine” (the first programmable computing machine proposed by Charles Babbage and with extensive notes and improvements added by Ada) a weaving engine that wove algebraical patterns rather than pictures of flowers and leaves. This was an imaginative yet pragmatic approach to explain abstract situations; this also combined the rich imagination from the romantic side with the precise nature of the rationalist/scientific side. When Babbage constructed the “Difference Machine,” he was thinking about a special-purpose machine to do a specific type of computation. When he started to work on the “Analytical Engine,” he was still considering it as a pure computing device. It was Ada who saw the true potential.

Ada’s most important contribution was not her technical interpretation that became her legacy but her imagination that foretold the arrival of general-purpose computers nearly a hundred years before they were made. Take another example of an imaginative solution – the Fan Chart produced by Florence Nightingale on mortality in the Crimean War. This was the creative use of data in a familiar environment that cemented her reputation as a statistics pioneers (and also the first female Fellow of The Royal Statistical Society). Her charts were so impressively precise that it changed public opinion on the war, as well as a policy change to improve the hygiene as a treatment for the soldiers in her hospital. As a result, modern nursing was born.

The second part of Ada’s poetical science is interpretation. Strong mathematical training gave her the tools to correctly interpret the solutions, whether they were quantitative or qualitative. For instance, she was able to articulate the essence of the dual-properties of wave function using functional analysis after serious study under the famous mathematician Augustus De Morgan, one of the earliest professors of University College London (UCL). Her involvement in science was motivated by her friendship with Mary Somerville, the first female member of Royal Astronomical Society (Somerville College in Oxford was named after her).

Nowadays, it is easy for us to use a software package to calculate, estimate or simulate almost any kind of results, but does the analyst understand the true meaning of the answer? For example, we heard of a senior analytics executive who told people that their results must be correct just because they had a large sample size, without considering the sampling bias. This is a classic example of misinterpretation; we know the price of everything and the value of nothing.
When we build quantitative models, it is important to be able to interpret the results properly. It is even more important to build a model that can be interpreted, especially those models built for business in regulated industries such as banking or insurance.

Suppose you have two models for lending decisions: one for Facebook and another one for your website. If you cannot properly interpret the explanatory factors of your models, you might come up with a discrimination lawsuit. It is because someone might accuse you of “knowingly” discriminating against certain groups based on their political belief or race from their Facebook profile!

The last part of Ada’s poetical science is integration. This is another area where Ada’s talent shone. In writing the note for Charles Babbage’s “Analytical Engine,” her approach stated the overall issues and then the defining terms, a very systematic method indeed. She used the same approach to teach mathematics to young students; she invoked the visual elements using colored pens, which were considered vulgar instruments at that time. Nevertheless, this was an ingenious way to integrate abstract models into pragmatic applications. How to integrate conceptual models into implementation is also a big, and probably the most, challenging aspect of analytics.

A few years ago Netflix had a competition to build the best predictive model for movie recommendations. The winning model was not implemented due to its complexity. A great analyst can see the key aspects of a problem and find the best integrated solution, not just the best algorithm or the most elegant model or the latest technology. This is not unlike the current system thinking approach to problem-solving!

**HOW WOULD THAT WORK?**

Ada emphasized using imagination to see connections between subjects that have no apparent connection and then to penetrate the world around us in the world of science. Books on innovation can fill up a whole room, and even a famous writer, Walter Issacson [6], has devoted a chapter on the importance of Ada’s innovative imagination – a critical part of the advances in technology that ultimately led to the founding of Silicon Valley. Coincidentally, in the “Industrializing Analytics: Delivering Analytics at Scale into Core Organizational Processes” seminar hosted by the Department of Management Science & Engineering of Stanford University on April 21, 2016, Professor Blake Johnson suggested a new type of analytics professional – the business scientist – who can design and deploy industrial analytics and can execute rather than pursue a better
Algorithm. This echoes the view that data scientist could learn from history because technological advance, outsourcing and innovation diffusion could make those with just technical skills obsolete [7].

Integrating the evidence with feasibility is instrumental to any successful program. This is an area where we could use the poetical science framework. We need to open our hearts to listen to other voices and concerns (give empathy), open our minds to different approaches (use metaphor) and open our brain to alternatives (be imaginative). “When we integrate poetry and science it can change our perception of reality” [8]. We often fail to notice that logic and passion can live under the same roof. This may be the future of the analytics profession, a poetical scientist.

Even medical schools are incorporating liberal arts education into their training because medical professionals need to be imaginative and go beyond science [9].

CONCLUSION

Dr. Betty Toole, Ada’s biographer, said Ada could be a derivative trader if she were alive today, as she had a keen interest in betting on horse racing. We beg to differ, as she could probably be a popular writer/presenter/celebrity like Malcolm Gladwell because she was able to articulate abstract concepts in animated terms, as well as having a burning intellectual curiosity. Her poetical science idea was so far ahead of her time that it is still relevant today and probably will stay as relevant in the foreseeable future. We will conclude with the “Stanzas” of Lord Byron: “To do good to mankind is the chivalrous plan. And is always as nobly requited.”

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REFERENCES & NOTES

Viva Las Vegas! Analytics 2017 set for Caesars on April 2-4

The 2017 INFORMS Conference on Business Analytics and Operations Research will take place in Las Vegas on April 2-4 at Caesars Palace. Caesars is one of the most prestigious casino hotels in the world, as well as one of Las Vegas’ largest and best-known landmarks.

Analytics 2017 will bring together nearly a thousand leading analytics professions and industry experts to share ideas, network and learn through real-life examples of data-based analytical decisions. Long-formatted talks offer an outlet to hear the complete story of successful analytical projects from inception through implementation. This conference also offers substantial networking opportunities, making it the analytics event of the year for anyone who works in the analytics, operations research or management science fields.

HAND-PICKED TOPICS AND SPEAKERS

The conference has seen huge growth and success year after year due in part to the conference program committees. They develop the topic tracks, select
speakers and organize the presentations that comprise the heart of the conference. Maher Lahmar, IBM Solutions Executive, chairs the conference. The 38 members of the program committee include analysts and managers from companies such as Accenture, BNSF Railway, Chevron, Deloitte, Gartner, Google, Innovative Decisions, Intel, InterContinental Hotels Group, Kroger, Lockheed Martin, Mayo Clinic, The MITRE Corp., SAS, Schneider and Walt Disney Company, as well as leading universities and government agencies.

The conference committee has designated nine topical tracks for the 2017 invited speaker program: “Analytics Leadership and Soft Skills,” “Analytics on Unstructured Data,” “Decision and Risk Analysis,” “Emerging Analytics,” “Entertainment and Gaming,” “Internet of Things,” “Marketing Analytics,” “Revenue Management and Pricing” and “Supply Chain Applications.” The program will be rounded out by six tracks of hand-picked, member-contributed talks, software tutorials from vendor sponsors and poster presentations.

The following speakers are confirmed for Analytics 2017: David Simchi-Levi, MIT; Tammy Farley, The Rainmaker Group; Xingchu Liu, BlackLocus/Home Depot Innovation Lab; Mei Zhang, American Airlines; Dave Schrader, Teradata; Jean Utke, Allstate; Stephen DeAngelis, Enterra Solutions; Tauhid Zaman, MIT; and Garrett Van Ryzin, Columbia/Uber.

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Interested students and professionals may submit a poster proposal and receive a discounted registration rate if selected to present at the meeting. The poster format is great for works-in-progress on which the speaker is looking for feedback or successful projects that may not be extensive enough for a 50-minute talk. The deadline for all poster presentations to be submitted is Feb. 20. If your poster is selected you can take advantage of a discounted registration rate of $1,070.

Early rates of $1,175 for INFORMS members and $1,470 for nonmembers are available until Feb. 6. Organizations can take advantage of the $1,070 team discount rate when they send three or more attendees to the conference. A $1,070 newcomer rate is also offered. This special rate applies to any INFORMS member who is attending the conference for the first time. All meals for two days are included in all registration fees.

For information regarding conference registration or submitting a presentation, visit meetings.informs.org/analytics2017.
This article is going to do two things I’ve never done before: first is to include a co-author, and second is to write about the same topic using (almost) the same data. To recap, in “The Force Awakens,” Kylo Ren fears that he will succumb to the light because he is not as dark as his hero, Darth Vader. We considered this problem in July 2016 using “Darkside Envelopment Analysis.” We repeat the data used as Table 1 (spoiler alert) slightly updated to reflect events of “Rogue One.”

Our previous work “shot first” by using data envelopment analysis implemented in MS Excel’s standard Simplex LP solver to maximize the ratio of “goods” to “bads” for each force practitioner’s achievements. To complete our training, we must unlearn, and move from mathematical optimization to correspondence analysis (CA), in this case wielding R package “ca,” an elegant weapon for a more civilized age. In this, we will create a biplot of achievements and failures, with Vader as the reference (Figure 1).

By this metric, Luke is the most Vader-like. It also suggests that Ren’s journey to the dark side is not
yet complete. CA indicator score analysis of data separated into achievements and failures suggests that Vader is not necessarily the dark standard to which Ren should strive to achieve. There is another.

"Make ten lines of code feel like a hundred!"
– Cassian Andor

These indicator scores are calculated in three steps:
1. Transform data into a contingency table.
2. Use R’s ca package to create biplot row/column coordinates.
3. Perpendicularly project column points onto row point lines and measure point-intercept distances to/from segment endpoints using a custom R script that performs the calculations onto the coordinates made available from the ca package.

This problem has the interesting – and surprisingly common characteristic – that the data fields are not inherently ordinal. While we might all agree that “destroying a planet (if you’re a Sith) or Death Star (for Jedi) is really good and that losing a Death Star is really bad,” but how do aerial victories compare to force choking and/or lightning lifting? Aerial victories are achievable by half-witted, scruffy-looking nerf herders, while force choking can punish a disturbing lack of faith.

We can create a more nuanced analysis by considering the CA indicator score analysis of achievements with multiple perpendicular projections. We will start by calculating Vader’s achievement CA indicator score set (see Figure 2).

<table>
<thead>
<tr>
<th>Achievements</th>
<th>Vader</th>
<th>Ren</th>
<th>Luke</th>
<th>Palpatine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant-sized objects destroyed</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Force Choking</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Lightening Lifting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 1: Achievements and failures contingency table of Vader, Ren, Luke and Palpatine.

![Figure 1: Correspondence analysis biplot featuring blue achievement/failure points and red force practitioner points. The black lines are Euclidean distances between non-Vader practitioners and Vader (red, near center). Increased distance implies increased dissimilarity. Ren’s Vader-distance (2.08) is the greatest of the non-Vader candidates.](image-url)
The general formula for calculating a single score $S$ via projection onto line $(i,j)$ is:

$$S_{ij} = \omega_i + (d_{ij}^* / d_{ij})(\omega_j - \omega_i) = \omega_i + R_{ij}(\omega_j - \omega_i)$$

where $R$ is the intercept distance $d^*$ over projection space while weights $\omega_i$ and $\omega_j$ are the assigned achievement weights. Applying this to our previous data, we get Table 2. Table 3 compares three final indicator score calculation methods.

This analysis agrees broadly with our previous work, but introduces a different way to consider these types of data sets.

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A technical note: Exploratory factor analysis of failure loads the same latent variable onto unrecovered computer drives and major stations lost, thereby confirming the relationship between increased station vulnerability and computer drive security while adding quantitative context as to why many Bothans died (and others) to retrieve the information on those drives.

A personal note: In the coming year, I don’t plan to have any regular co-authors, but would like to start bringing in some of the many padwans I’ve met along the way. It is my sincerest hope that eventually the students will become the masters.

<table>
<thead>
<tr>
<th>Achievement Score</th>
<th>Failure Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vader</td>
<td>12.44</td>
</tr>
<tr>
<td>Luke</td>
<td>9.82</td>
</tr>
<tr>
<td>Palpatine</td>
<td>5.60</td>
</tr>
</tbody>
</table>

Table 2: Force practitioner CA achievement and failure scores, sorted by achievement scores.

<table>
<thead>
<tr>
<th>Achievement/Failure Ratio</th>
<th>Normalized Difference</th>
<th>CA Score Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luke</td>
<td>4.13</td>
<td>0.84</td>
</tr>
<tr>
<td>Palpatine</td>
<td>3.57</td>
<td>0.41</td>
</tr>
<tr>
<td>Vader</td>
<td>2.22</td>
<td>0.20</td>
</tr>
<tr>
<td>Ren</td>
<td>1.14</td>
<td>-0.84</td>
</tr>
</tbody>
</table>

Table 3: Force practitioner indicator score comparisons, sorted by achievement/failure ratios.
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LAS VEGAS

April 2-4

http://meetings.informs.org/analytics2017
A popular game in the Apple and Google app stores is a space adventure game where, among other things, you need to decide which spaceship to buy. There are dozens of different spaceships to choose from, all with varying capabilities and costs.

Ten of these ships are shown in the accompanying table. Although there are additional ship capabilities in the game, only consider the ones shown in the table.

**QUESTION:**

Which is the most undervalued ship?

Send your answer to puzzlor@gmail.com by March 15. The winner, chosen randomly from correct answers, will receive a $25 Amazon Gift Card. Past questions and answers can be found at puzzlor.com.

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**John Toczek** earned his BSc. in chemical engineering at Drexel University (1996) and his MSc. in operations research from Virginia Commonwealth University (2005).
The Peterson Institute for International Economics (PIIE) presented the results of a pre-election analysis of the economic implications of the proposed trade policies of the two presidential candidates: Clinton and Trump. The analysis traces the impacts of major changes in trade policy on macro aggregates: consumption, investment, government expenditure, and international trade. The results indicate that any shock to US international trade has serious effects on employment, including many sectors indirectly linked to exporting industries – when workers lose their jobs, they no longer go to restaurants.

**Effects of Proposed Trade Policies on Employment**

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The modeling framework contained several components, including a GAMS input-output model, a Python module to disaggregate the results to the state and county level, and a GIS platform to display the results.

For further information please visit: https://goo.gl/2ghNx5

**Most-affected US counties**

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