NETTING IT OUT
How can you create a virtual, yet real-world model of your business? How can you monitor all the inputs and variables in a complex end-to-end process? Whether your business involves running airlines, keeping supermarket shelves stocked, providing cost-effective insurance, delivering electric power, or manufacturing and selling apparel, perhaps there’s a new way to think about monitoring and modeling your business and its ecosystem.

This case study highlights some current best practices in environmental engineering—practices that may also be useful to forward-thinking business strategists. The best practices are:

1. Use multiple, distributed sensors to capture real-time feeds about physical phenomena.
2. Build a virtual model based on these real-time data feeds to understand what’s going on and how things interrelate.
3. Use metadata frameworks that others are using to model similar phenomena so that you can compare and detect patterns.
4. Instrument quickly. Don’t spend years; spend days.
5. Build cross-disciplinary, cross-cultural teams to work on high-learning, high-performance, time-bounded projects.

We have yet to find anyone who is modeling their business in this way, but it seems logical that if scientists and engineers can sense, detect, model, and control real-world ecosystems, we should be able to do the same for our business ecosystems—most of which are made up of physical people doing physical processes.

MODEL LAKES AS EARLY WARNING SYSTEMS
How can you quickly and accurately monitor water quality anywhere on the planet? How easy is it, using today’s observational technologies—sensors, actuators, GPS, computer models, wireless Internet, and off-grid energy sources—to quickly characterize a complex ecosystem that is under stress? Can you compare and contrast the biological processes in lakes around the world? Those are some of the questions that Tom Harmon and his colleagues sought to answer as they headed to Argentina in April 2008.

Dr. Tom Harmon is Professor of Engineering at the University of California, Merced. He is an environmental engineer who has been active in promoting the use of embedded sensors for environmental research. He coordinated this research field trip by convening a group of 12 American professors and graduate students—environmental engineers, biologists, computer scientists, hydrologists, and electrical engineers—with an equivalent cross-disciplinary team of 14 Argentinean researchers. They set out to document the microbial biodiversity on a uniquely variable chain of five inland lakes in rural Argentina in less than five days.

Direct link: http://dx.doi.org/10.1571/cs08-07-08cc
This PASEO\(^1\) project is a good example of how today’s scientists are using distributed, embedded sensors to model the environment. The approach used by the PASEO team could be used in any situation in which it’s important to quickly monitor and model water quality. For example, when a Tsunami, hurricane, or other natural disaster leaves an area devastated, or when there’s a problem with flooding, droughts, or polluted beaches.

The PASEO team’s rapid sampling and modeling approach may also serve as a useful template for others who want to wrap their minds around what’s going on with complex real-world systems really quickly.

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\(^1\) PASEO is the name of the National Science Foundation-funded workshop that spawned the idea for this particular project.

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The Encadenadas del Oeste\(^2\) lake system was once referred to as “the Pearls of the Pampas.” The northernmost lake in the chain is moderately salty; the southernmost lake in the chain is nearly as salty as the Dead Sea. This natural salinity gradient is caused by a combination of the climate, underlying sediments, and the lakes’ relative elevations. Recently, however, Argentinean scientists have become aware that the lakes have become increasingly polluted due to agricultural run-off, municipal waste water effluent, and urban processes upstream. Tom Harmon explained, “For us [the U.S. environmental scientists], it’s a little like going back in time, to what things were like before the Clean Water Act.

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\(^2\) The chain of lakes includes: Alsina, Cochicó, del Monte, and Epecuén, and ending in Del Venado.
A table of sensors that are typically required in water quality studies, published in 2007 in a CENS white paper entitled: Distributed Sensing Systems for Water Quality Assessment and Management.³

went into effect in the U.S. The concentrations of nutrients we see in these Argentinean lakes are 100 times higher than we would have.”

Dr. Gerardo Perillo, the Vice Director of the Instituto Argentino de Oceanografía (IADO) in Bahia Blanca, south of Buenos Aires, was “…excited about this project, because we had been trying to mobilize a group of hydrologists and environmentalists to look at this area. There are a lot of excellent scientists in Argentina. But they have a really hard time getting funding for instruments and gear. To the Argentinean scientists, the issues are obvious. But the rest of the world doesn’t really know about this.” Through a National Science Foundation grant that promotes cooperation between U.S. scientists and scientists in other countries, Harmon was able to provide a win/win experience—his students and colleagues could deploy state-of-the-art sensor technology to model a complex ecosystem, and the Argentinean scientists gained access to the equipment, the experience, and the data they needed to model and document the local environmental issues.

Their goal was to study the relationship between water salinity and the biodiversity reflected in the bacteria and phytoplankton across the chain of lakes, and to use observational sensors to document the water quality and mixing conditions in the lakes. An equally important goal was to give students and researchers the opportunity to plan and execute a challenging international scientific collaboration in order

to gain a more global perspective about their research.

The PASEO Project: Argentinean and U.S.
Team Model a Complex Lake System

What’s unusual about this particular environmental survey is that it was not only carried out by a cross-disciplinary, cross-cultural team of scientists, but that these engineers and hydrologists were able to monitor and correlate, in parallel, 14 different environmental parameters in real time. “Engineers love to try to describe systems with math,” Tom Harmon explained. “We think we know what a lake is going to do. We can simulate it using physics-based models. The water flows from the high end to the low end. We can use hydrodynamic equations to model how the water will move around. These are complex models with lots of parameters, and lots of interrelated changes in time and space. Until recently, such modeling of a lake in real time has been an ill-posed problem. We didn’t have the streams of data we needed to build and test our models. The old approach was to put on your hip waders and grab your clipboard and collect samples. It can take years to see a trend that way.”

In the past, a research project of this scope would have taken months of manual sampling and analysis. But, by using sensors to analyze the air, soil, water, wind, and weather, and by analyzing phytoplankton and bacteria from lake to lake, this cross-cultural and cross-disciplinary research team was able to characterize the ecology of these inland lakes in four short days. They met in Buenos Aires, traveled 11 hours to the lake site, deployed sensors to take measurements, did their analysis, created

4 Except for the biological samples; it still takes a while to prepare and to process them.
simulations, and then uploaded the information onto the Internet for other scientists around the world to analyze and comment upon. When they returned to their labs at the end of the week, they were able to further analyze and document their findings.

The goal of this research project was three-fold:

1. Quantify the biodiversity of microorganisms over a substantial salinity gradient present in a chain of inland lakes in the context of a bi-national, multi-disciplinary, student-led sampling campaign.

2. Use distributed sensors to quickly collect and monitor a wide variety of environmental factors (both natural and anthropogenic) and upload that data to the Internet.

3. Assess the suitability of one or more of the lakes for addition to a growing network of instrumented lakes that will enable us to monitor their health globally.5

The researchers involved in this project are hopeful that this kind of environmental monitoring will soon be able to be carried out by local practitioners who may not be environmental engineers or computer scientists, but who will be able to quickly deploy low-cost sensors, collect data, and stream it onto the Internet for remote analysis and modeling.

What’s Needed to Understand Complex Environmental Problems?

“There are many big environmental problems that don’t become understood very well or very quickly because things are changing in time and space, and we can never afford to observe them in enough places and times to get a clear picture of the patterns,” Tom Harmon explained. That’s why today’s distributed and networked sensors are critical to the success of environmental engineering.

Affordable, Distributed Sensors. Tom Harmon is Professor of Engineering at the University of California, Merced, one of the founders of the Center for Embedded Network Sensing (CENS6), and an advocate for distributed sensing systems. “We know that, if we could make affordable, distributed observation systems available to environmental scientists and environmental engineers”—like the hundreds of sensors that are routinely built into cars—we could detect these important patterns much more quickly. “Think of how much earlier we could have documented global warming if we had had dense arrays of temperature sensors logging data all over the globe for the past 50 years!”

Deploying Distributed Sensors Requires a Cross-Disciplinary Skill Set

If you’re going to develop and deploy new cutting edge environmental observation technology, you can’t just leave it to the technology people, Tom Harmon explains. You need “application people”—environmental engineers and ecologists who work in the field. They are the ones who create the models and know what to monitor. But you also need electrical engineers and computer scientists to design and refine the technology.

That’s why CENS was created in 2002. “We marry environmental engineers with computer scientists and/or electrical engineers in true collaboration.”

~ Dr. Tom Harmon, Professor, School of Engineering, UC Merced

5 The biologists for the expedition represented the Global Lake Ecological Observatory Network (GLEON), a grassroots network of limnologists, information technology experts, and engineers who have a common goal of building a scalable, persistent network of lake ecology observatories (www.gleon.org).

6 CENS is a National Science Foundation-sponsored Science and Technology Center, which is hosted at the University of California, Los Angeles (UCLA). The other four partners include the University of California, Merced; University of California, Riverside; University of Southern California; The California Institute of Technology. These five organizations’ faculty, staff, and students partner in the Center for Embedded Networked Sensing (CENS).
“Illustration of a multi-scale sensing system. Multi-scale sensing systems can share data among different platforms for efficient use of sensing resources. For example, low resolution images mounted on a robot moving between trees can communicate measurements to static or mobile sensors below to identify areas requiring higher resolution measurements. Illustration: J. Fisher, UC Merced.” Figure 2.5, page 17 published in 2007 in a CENS white paper entitled: Distributed Sensing Systems for Water Quality Assessment and Management.

Address Global Problems with Global Teams

The National Science Foundation recognizes that American researchers need to have a more global perspective. That’s why the NSF created the Office of International Science and Engineering (OISE). “As I became more experienced and better known as someone who knows how to put distributed sensors out in the world,” Tom Harmon explained, “the OISE asked me to organize a workshop to foster collaborative environmental research in South America.”

THE ORIGIN OF THE PASEO PROJECT: PASEO WORKSHOP

Tom Harmon and Harold Stolberg, the NSF Director of the OISE, made a reconnaissance trip to Buenos Aires in September 2006 to meet with the workshop co-organizer, Daniel Lupi, at the National...
PASEO Project Team Starts Their Four-Day Study

Arriving at the shores of the first lake, the project team launched a boat to start taking measurements on the lake. (At least one member of this team was from the UCLA contingent, judging from the sign!)

Institute of Industrial Technology (INTI) in Argentina. They met with a number of environmental scientists at several research agencies, all of whom agreed to support the collaboration. Gerardo Perillo, the Vice Director of the Instituto Argentino de Oceanografía (IADO), offered to co-host the workshop at his research facility in Bahia Blanca, along the southern coast of the Buenos Aires province.

The four research scientists (Lupi, Perillo, Harmon, and Stolberg) hand-picked the workshop participants and planned the agenda. Together, they recruited 24 participants from 18 different universities and research institutions. They paired 6 technologists and 6 environmental scientists from North America with 6 technologists and 6 environmental scientists from Argentina (and 1 from Brazil). Two of their NSF sponsors—Harold Stolberg and Patrick Brezonik—also participated in the workshop itself.

Focus: Find Comparative Research Projects in North and South America

The Pan-American Sensors for Environmental Observatories (PASEO) workshop was held June 25th-27th, 2007 in Bahia Blanca, Argentina. The workshop’s goals were:

1) To support the use of the latest techniques for environmental observation, e.g., using embedded networked sensing to analyze, visualize and model data in real time.

2) To foster collaborative research in terrestrial and freshwater settings. (There is already a fair amount of international cooperation in ocean research, but international collaboration has not been as common in freshwater or terrestrial, “perhaps due to the tendency to observe these systems in the context of local to regional scales associated with watersheds, ecosystems, and resource management boundaries.”)

The team members were able to monitor the validity of the samples they were collecting to make sure that the sensors were working and everything was correctly calibrated. The home-made pontoon boat had several sensors suspended underneath.

3) To “explore the potential benefits of comparative investigations of terrestrial, freshwater, and coastal systems across international boundaries.”

PASEO Workshop Results: Identified Four Initiatives for Future Collaboration

The workshop was very successful. Tom Harmon reported, “The workshop went very well. We got a good mix of technology people and environmental applications people.”

The participants quickly agreed on a set of research principles and challenges and began to identify common research initiatives. The scientists agreed that it would be possible to establish comparative environmental test beds in North and South America for the study of lakes, estuaries, and water resources management. These research projects could be used to train graduate students both in the application of new observational technologies as well as in international collaboration. Many of the workshop participants were already involved in appropriate projects. For example, Tim Kratz, from the University of Wisconsin, is one of the champions of the volunteer Global Lake Ecological Observatory Network (GLEON).

One Follow-On Project: Collaborative Research on Lakes—Build on the GLEON Framework

In the PASEO Workshop Report, “the workshop participants identified GLEON (www.gleon.org) as an excellent framework on which to build a collaborative research agenda for comparative lakes studies in Latin America, initially focusing on Argentina and the U.S. Argentina has lake-rich regions which bear remarkable similarity to lake-rich landscapes in the glaciated regions of the northern hemisphere.”

“The goal of GLEON is to build a scalable, persistent network of lake ecology observatories. Data from these observatories will allow us to better understand key processes such as the effects of climate and land use change on lake function, the role of episodic events such as typhoons in resetting lake
dynamics, the rapid wax and wane of algal blooms, and carbon cycling within lakes.”

QUICK WIN: Follow-Up Collaborative Field Research Project. Tom Harmon had some funding left over from the workshop project. “It turned out that things are cheaper in Argentina than I thought they were. So we had some money left over. After we returned, I told our NSF sponsors, ‘I could send this money back to you, or we could actually DO something we had talked about at the workshop. Let’s get some students down there and do a project together.’”

The First PASEO PROJECT: Characterize a Chain of Argentinean Lakes

Within three months, Tom Harmon received the go ahead from NSF to undertake the first follow-up research project—to study a chain of inland lakes in Argentina. After lots of planning and coordination, the field trip to the Encadenadas del Oeste lakes took place in April 2008. The research team consisted of a dozen professors and graduate students from three U.S. universities (University of California, Wisconsin, and Cornell) and 14 professors and graduate students from several Argentinean research institutions.

The team picked four of the lakes in the chain to model: Alsina, Cochicó, del Monte, and Epecuén. These lakes are interesting from a biological point of view. “They are big shallow lakes with lots of evaporation and salty soils,” Tom Harmon explained. “These lakes all have the same weather, the same vegetation around them, yet there’s this big change in salinity from the lakes at the top of the chain to the very salty ones at the bottom of the chain. The researchers wanted to see if they could get organized, get down there, characterize the lakes, measure the necessary parameters, and grab samples in four days.” And, of course, they wanted to be able to understand what was going on in these lakes from an ecological point of view. “They’re like a gigantic Petri dish,” Tom Harmon explained. Not in the sense that they’re pristine—because they’re far from it; but in the sense that this string of lakes is a great ecosystem to study, particularly when you can measure a lot of parameters simultaneously. These lakes have been sitting there and have all been subject to the same stresses at the same time. How are they evolving biologically? “Saline lakes are a relatively unique subset of lakes that warrant study so we know how they fit into the overall picture.”

Tom Harmon described the expedition for the U.S. participants, “We had 12 people that flew into Buenos Aries from around the U.S. Then we had a nine-hour bus ride to the research center, followed by a five-hour bus ride up to the lakes themselves. Every day, we would drive about two hours to the lake we were studying that day, get the gear out, deploy our sensors and launch a boat. It was all pretty intense. It was an amazing experience for the students to do the planning, the checklists, the international communications, and to make sure that everything shows up and runs. You realize there’s just no way to get replacement parts when you’re out there, so you have to try to think of everything and then be inventive when you need to be.”

The team used 14 different kinds of sensors to characterize each of the lakes and surrounding soil. They monitored the effects of weather on the lakes, including the amount of water mixing that was occurring based on the wind. “We were lucky. We arrived during a wind storm, so the water was pretty thoroughly mixed throughout our four-day stay,” Harmon said. The team used a Vaisala weather station to gather high-quality, real-time data and a CompactRIO system from National Instruments to control and log the data for the weather station in a compact unit that could be easily transported and used in remote locations.

The team recorded data for four days. The team’s most dramatic moment occurred on the shores of the last (and saltiest) lake. When they reached the shores of Epecuén, they found themselves standing in a ghost town.

“Apparently, they built a town on the banks of the lake during a dry cycle. But then the town became inundated with floods, and everyone had to move out. We found ourselves standing on the shores of this deserted town at the point where a waste water treatment stream from another town enters the lake. And all around us were submerged crypts and tombstones. It was pretty spooky!”

~ Dr. Tom Harmon
Parallel Measurements Gathered in Each Location

With the field weather station, they measured:

- Air temperature
- Relative humidity
- Wind speed and direction
- Precipitation
- Solar radiation

In the soil surrounding the lakes, they measured:

- Heat fluctuation
- Soil moisture
- Soil temperature
- Soil salinity

In the lakes themselves, the team measured the amount of respiration and the production of the algae in the lakes at different depths. They needed to be able to tell how much the water was mixing vs. stratifying in order to determine how many measurements to take. They built and deployed a small buoy using PVC pipes as pontoons to suspend the sensors listed below. On the boat, they used a Networked Infomechanical System (NIMS) actuator to raise and lower the water sensor used to measure dissolved oxygen.

In each lake they measured:

- Electrical conductivity (for salinity)
- Water temperature
- Light
- Dissolved oxygen
- Photosynthetically Active Radiation (PAR)
- Turbidity (cloudiness)

They also collected samples for further study by the biologists on the team of:

- Bacteria
- Phytoplankton
- Algae growth

SCIENTIFIC RESULTS: Successful Detailed Model Correlating Chemistry, Biology, Hydrology, Limnology, and Weather

The physical data analysis and results were great, according to Tom Harmon. They were able to capture and analyze everything in situ. “The range in salinity we found was terrific,” Tom reported. “It ranged from less-salty (1 micro-semen per centimeter) to very salty (80 micro-semen per cm).”

On the biology side, the team is optimistic that they will see dramatic findings once the bacterial analysis is completed. By the end of the year, they expect to have the DNA, phytoplankton, and bacteria tests completed from the samples—many of which are still on ice. “We’re hoping that there some of the results will show that there are significant differences in the bacteria,” Tom explained. “What I gleaned from talking to the biologists is that, as you get into the harsher more extreme conditions, there should be less biodiversity.”

Mary Cynthia Piccolo, director of the Instituto Argentino de Oceanografía (IAD) and one of the principal investigators of this study, described the benefits derived from using 14 different sensors and monitoring four lakes in the same week. “With the equipment the U.S. team brought, we were able to collect new data and perform comparisons between each of the lakes simultaneously, since it makes no sense to measure one lake and, after a month, measure another lake.” Piccolo explained the Argentinean team’s aim of better understanding the diversity of hydrographic environments through a lot of simultaneous measurements. “We want to know more about the plankton in the lakes and then link that data with fisheries and bacteria. This is a new kind of study we had never been able to do before,” said Piccolo.

Gerardo Perillo, deputy director of IAD, emphasized the intensive nature of the investigation. “It is very difficult to make measurements for a week at a particular site, such as happened on this occasion.” He also pointed out that the two teams combined the use of highly sophisticated instruments as well as equipment built - at very low cost - by the staff of the IAD. “To compare the two sets of equipment, we were able to make sure that we measured simultaneously with the same quality and for at least a week. That’s an important outcome,” Perillo explained.
PORTABLE WEATHER STATION

Windspeed Measured on the Del Monte Rooftop

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**National Instruments’ CompactRIO was used to capture the weather data gathered at each point. It was windy all four days, which was good for gathering water samples that were well mixed.**

**ACTIONS TAKEN: Argentinian Researchers Have Created a National Network for Monitoring Lakes and Wetlands**

Perhaps the most important result of the PASEO workshop and the week’s worth of follow-up field work is a new commitment on the part of Argentinian researchers to create a national network for modeling all of the lakes, estuaries, and wetlands in the country.

As a result of their introduction to the Global Lake Ecological Observatory Network (GLEON) at the PASEO workshop, the Argentinean research team joined GLEON and participated in the group’s Spring 2008 conference (which was held at the Archbold Biological Station in Lake Placid, Florida). Shortly after the successful Encadenadas del Oeste field study, IAD hosted a workshop during which they decided to create a national network to monitor lakes and wetlands (a unique initiative in Argentina), allowing for measurements similar to those obtained in Las Encadenadas del Oeste.

“We have learned from the experience of GLEON, which is an international institution to which we now belong. It is monitoring what is going on in all lakes in the world, and gradually they will integrate more lakes,” Piccolo explained. “GLEON has now arrived in Argentina and soon will travel to Brazil. We realized that, in our country, although there are many endeavors in this direction, we need a comprehensive monitoring network of lakes, lagoons, wetlands, estuaries, dams, and reservoirs.”

**Next Steps**

Based on the success of the first PASEO workshop and the follow-on hands-on research project at the lakes, the NSF has funded PASEO II, a more hands-on study and training institute for 50 early
career scientists from both the U.S. and Latin America for the Spring of 2009. This training session will combine theory and field practice, using the same mix of computer scientists and application scientists from two different cultures. “25 North American scientists and 25 Latin American scientists will spend two weeks together – so two weeks of fun in the water and soils!” Tom Harmon exclaimed.

**Policy and Practical Recommendations from Tom Harmon**

1. “We need better packaging for equipment that will be left in the field, including lower power consumption, good integrated solar power, and integrated cellular telemetry using GSM. It’s pretty easy to monitor these devices remotely if you have built-in telemetry. For example, if you’re no longer seeing the sun warm things up, you know that someone has moved the box!”

2. “If we could create some systems that non-scientists could replicate around the world, the result would be dramatic. We would have fewer water borne diseases, as well as better allocation of resources to critical areas in developing countries. In the more developed nations, more real-time environmental data gathering and real-time analysis would lead to better policy making, for example, in situations in which you’re advising people like farmers about best management practices.”

3. “We need the U.S. Congress and NSF to support the funding for the WATERS Network. [http://www.watersnet.org/](http://www.watersnet.org/).” The WATERS network is a national multidisciplinary research initiative that will make it possible for the U.S. to manage its water resources. Here’s an explanation from the WATERS.org Web site:

> “Growing and wealthier populations, increasing urbanization, and climate change are tipping the balance between water supply and demand and impacting the quality of our existing water resources. We need real-world information and multidisciplinary knowledge on the coupled processes linking humans and biota to the natural and engineered water environment. Only with this knowledge can we make critical decisions needed to effectively manage our water and protect both humans and ecosystems.”

4. “If we could create an autonomous method for monitoring lakes, we might be able to use the lakes themselves as sensors for water quality on the planet. This is analogous to the idea of having thousands of thermistors all over the globe for the past 50 years (to warn us about climate change). How might we be able to see how our aquatic ecosystems and water resources are changing if we had ‘lake sensors’ all over the globe?”

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### Take-Aways from the PASEO Project for Business

What can we learn from the PASEO project that could be applied to business projects?

1. Think about modeling your business by capturing the real-time information flowing in and around your business and its ecosystem. Don’t limit yourself to your present day data gathering of transactions. Think about capturing more real-world signals – including weather, temperature, traffic patterns, customer behavior, etc.

2. Use a cross-disciplinary approach to model your business. Combine market researchers, ethnographers, engineers, and computer scientists, for example.

3. Take advantage of modern distributed sensor technology to monitor real-world phenomena. Use multiple distributed sensors (a dozen or more) to observe and model complex systems in real time. Model multiple similar systems in different parts of the country or the world.

4. Build your models based on your assumptions and hypotheses. Then gather multiple streams of data and monitor them in real time in the field to look for anomalies and correlations that warrant further investigation. Use technology platforms that enable you to accept and analyze multiple analog signals in parallel.

5. Form cross-cultural, cross-disciplinary study teams to work on high-learning, high-performance, time-bounded projects.

6. Share the learnings of your teams with other subject matter experts around the world so that these outside experts can also analyze patterns, ask questions, and add valuable insights.

7. Design your field studies and use instruments that can be set up and monitored by students, laypeople, and non-technical employees in order to make it easy to deploy and to continue observations.

8. Join forces with other subject matter experts who have established frameworks and metadata to log and report your data in a way that can contribute to a distributed global model.
ABOUT THE AUTHOR

With 30 years of experience consulting to customer-centric executives in technology-aggressive businesses across many industries, PATRICIA B. SEYBOLD is a visionary thought leader with the unique ability to spot the impact that technology enablement and customer behavior will have on business trends very early. She assesses and predicts how new and evolving technologies will impact customers. She forecasts the ways in which both business and consumer customers will make new demands on companies in many different industries.

Seybold provides customer-centric executives within Fortune 1000 companies with strategic insights, technology guidance, and best practices. Her hands-on experience, her discovery and chronicling of best practices, her deep understanding of information technology, her large, loyal client base, and her ongoing case study research enhances the thought leadership she provides.

Seybold uses a coaching, mentoring, and learn-by-doing consultative approach to help clients achieve their goals as they transform their corporate cultures to be more customer-centric. She helps her clients’ teams redesign their businesses from the outside in by inviting their customers to invent new streamlined ways of accomplishing their desired outcomes, using their own real-world scenarios.

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