Executive Summary

The rapidly evolving field of reality mining analyzes the flood of data on human behavior patterns emanating from sources as diverse as mobile phone networks, credit card records, and security TV installations. This research is shedding new light on the living habits of populations at the local, regional, national, and global levels.

In the supply chain arena, this technology has significant potential, particularly for demand management applications. Accurately forecasting demand and matching these projections with product supply remains a major challenge for most companies. However, the analytical methods used by reality mining could provide the demand management break that companies are seeking.

Reality mining provides a much deeper and more nuanced understanding of buying decisions – and hence patterns of demand – than traditional forecasting methods. Also, because this fledgling research field brings a new set of data providers to the table, it is not restricted by the organizational silos and demarcations that hamper the use of traditional sources such as point-of-sale (POS).

Still, the technology must overcome some hurdles before it can become more widely used. The most notable challenge revolves around privacy issues, since personal information such as mobile phone records is an integral part of reality-mining analysis. However, there is cause for optimism as efforts are under way to develop credible solutions that could emerge in the near future.

This white paper is part of a series of papers published by the MIT Center for Transportation & Logistics (MIT CTL) on disruptive technologies that could reshape supply chains over the next decade.
The world has entered an era of “big data,” according to Professor Alex “Sandy” Pentland, director of MIT’s Human Dynamics Laboratory. New sources of data on human behavior coupled with an exponential increase in computing and modeling power, are transforming our understanding of the way markets work.

The potential impact on supply chain management – particularly in the area of demand forecasting – is significant. Pioneering researchers such as Pentland are developing innovative ways to mine the flood of data generated by sources ranging from mobile phones to closed-circuit television networks. Called “reality mining,” this emerging field of research provides deep insights into the buying decisions that underpin patterns of demand.

As these methods are refined and become more widely used, they could fundamentally change the way companies model markets. Traditional data streams such as point-of-sale (POS) will be complemented – and perhaps supplanted – by near real-time data derived from the electronic traces left behind by buyers as they transact their daily business. Forecasters will require a new set of skills based on a thorough understanding of machine learning methods and other analytical techniques. This paper looks at the advances in data collection and analysis that are driving reality mining, as well as the potential impact on product demand management.

Just over a decade ago, half of humanity had never made a phone call says Pentland. Today, there are relatively few places on the planet where modern communications networks do not exist. Cell phone subscriptions have reached around 5 billion worldwide, and security camera systems have proliferated. Other sensing devices such as traffic sensors are also part of this vast digital infrastructure.

Pentland calls this global web of networks “a nervous system for humanity.” Communications and sensing devices are the neurons in this network. Up until fairly recently, the cascade of data pouring out of these networks attracted little attention. Now researchers are
“interpreting human behavior and human patterns of activity in light of this data,” says Pentland.

The range and depth of their investigations are surprising. In addition to the sources mentioned above, for example, Pentland has used credit card usage reports, email records, electricity consumption details, and even taxicab movement logs to analyze the living habits of populations at the national, regional, and community levels.

Yet, the most important generator of data on consumer markets may be the ubiquitous mobile phone. These devices are, in effect, personal sensing devices that are becoming more powerful and more sophisticated with each product iteration. In addition to deriving information on user locations and call patterns, Pentland can map social networks and even gauge people’s moods by analyzing the electronic chatter that has become so pervasive. Retailers are gearing up to enable consumers to make purchases by scanning items with their handheld devices, thereby adding financial and product choice information to the electronic biographies sketched by mobile phone traffic.

Moreover, as smart phones continue to morph into personal information hubs with more computing capacity, researchers will be able to glean more detailed information about human behavior.

At the same time, consumers are gaining access to new product information channels designed to support more informed buying decisions. As individuals retrieve information from these databases, the electronic fingerprints they leave behind yield even more information about their preferences and life habits (see Decision Support sidebar).
New Light on Life

Reality mining is as far removed from traditional market research approaches, such as focus groups and consumer surveys, as the mobile phone is from old-style dial-up telephones. Researchers deploy data-mining algorithms and analytical methods such as factor analysis used by social scientists to plumb the oceans of consumer data.

Take, for example, a study of population movements in the city of San Francisco carried out by Pentland’s research team. Based on various data streams, the study identified “tribes” of people that moved within the inner city area (see Figure 1).

These individuals were not members of formal groups, but shared similar demographic profiles and preferences. “Although these people walk past each other and go to adjacent retail outlets, they have very different buying patterns,” says Pentland.

By stratifying these subgroups, the team was able to predict where and when the tribe “members” would shop over a given time period, and even the types of products they were likely to purchase. “We constructed hour-by-hour maps of what people were doing in terms of their fiscal activity,” Pentland explains. “It’s an interesting x-ray of the community.”
The team has used reality mining to study much larger populations. For instance, using telecommunications data for the whole of the United Kingdom (population around 43 million) for one month, the researchers constructed call traffic maps that showed how people were connecting by phone. The analysis yielded valuable information on how communities were accessing local services. It even identified “information ghettos” that flagged communities with social problems by marrying call details with socioeconomic data drawn from town councils. “We have also developed models of consumer behavior for a large part of the US Southwest,” Pentland says.

Through the creative dissection of mobile phone data, the researchers can chart the shape of social networks. Combining data on call patterns and the proximity of personal communications devices, for instance, generates maps of personal relationships. These representations provide insights into how people interact and the structure of their social circles. Such information could be used to analyze the buying patterns of these social groups and hence their impacts on product demand.

A basic example of reality mining – and one that is indicative of possible applications in the supply chain domain – is the tracking of mobile phone usage by car drivers to construct traffic congestion maps. The data provides a real-time picture of traffic flows that not only identifies current congestion points, but also can be used to predict problems at given times. By marrying this data with information on an individual driver’s daily calendar, it is possible to generate a personal transportation schedule that avoids traffic snarls. Similar schedules could be generated for commercial traffic to increase the efficiency of distribution networks.

Supply Chain Applications

Just as reality mining is a departure from traditional market research, so it represents a quantum leap away from conventional demand management analytics. Supply chain professionals are all too familiar
with the shortcomings of established forecasting methods. Despite huge investments in software solutions and endless industry debates, predicting product demand and matching these estimates to supply remains an inexact science at best.

These issues were highlighted at the Capturing Strategic Advantage from Integrated Demand Signals conference on November 16, 2010, which was co-organized by MIT CTL. During the event, a $40 billion-plus food company described how the demand data from stores it used to analyze customer-buying patterns were often 3-to-10 days old. Compounding these inaccuracies was the inability of retailers to measure on-shelf product availability.

The manufacturer analyzed the inventory generated by one product line across 1,500 stores over a six-month period. While the stores and associated distribution centers stocked about 30 million pieces of product, there were only 21 days in each year when more than 1 million pieces were sold. The analysis underlined how the lack of reliable and timely demand signals can create excess inventory and add substantial cost to business operations.

Although companies have developed ways to sense consumer demand and build the data into their production plans, progress has moved at a snail’s pace. Back in 1992, for example, Wal-Mart introduced its Retail Link® sales data retrieval system, which makes valuable POS data available to certain suppliers. Yet, nearly two decades later, upstream applications of such shared POS sources remain relatively limited.

In addition to the shortcomings of conventional demand management methods, external changes are driving the need for better ways to sense and analyze customer-buying patterns. Globalization, the growing demand for customized products, market volatility, and changing demographics are some of the broader trends that are making demand planning more challenging.
A panel of leading industry analysts at the MIT CTL conference recommended companies for their current efforts to improve the management of demand, but the overall conclusion was that no organization has achieved revolutionary change. Entirely different approaches are needed, the analysts agreed.

Can reality mining provide such a breakthrough? A key question is whether the technology can deliver forecasts of product sales over a given period that is timely and accessible to any enterprise willing to pay for the information. Another important issue is whether supply chains will be capable of responding to such highly accurate demand signals at short notice; at present this generally is not the case. On the first question, the answer is yes, notes Pentland. “People go places, do things, and want things,” he says, “and supply chains are built on top of these behavior patterns.”

Take, for example, a study along the lines of the San Francisco project described earlier. According to Pentland, it is possible to generate forecasts of product purchases based on the movements and buying habits of the groups of consumers identified by the study. Researchers can track the spending habits of these individuals down to which retail outlets they prefer and the times they tend to make purchases. Moreover, he maintains that analyses like these can be scaled up to the regional, national, and even global levels using a combination of electronic data sources for different populations.

The data can be sliced and diced to yield more specific information. Reality mining, for example, can identify the types and numbers of buyers attracted by a sales promotion at a specific retailer. In addition, the data reveals which other outlets these individuals are likely to patronize when they take advantage of the promotional campaign. The information could be used to plan inventory levels for sales promotions.

It also is possible to combine behavioral data with other sources to create a more granular picture of buying patterns. Including data on
weather conditions and stock market surges would provide insights into the impact of these occurrences on product sales, for instance. Taking account of external factors could benefit supply chain risk management strategies by helping companies to prepare for the peaks and valleys in demand caused by perturbations such as extreme weather conditions.

In addition, combining detailed maps of consumer movements within specific geographic areas with data on traffic flows has the potential to help companies streamline distribution networks. Knowing which stores and when consumers are likely to visit them also offers valuable insights into the optimum locations for new outlets.

Clearly, the true potential of reality mining in the supply chain space will emerge as the technology evolves. Meanwhile, here are some further possibilities:

• A more accurate and timely picture of demand patterns, since the data is derived from near real-time sources such as store visits, in-store mobile information queries, and, increasingly, sales transactions mediated by personal mobile phones and contactless payment systems.

• Nuanced market views that provide a much deeper understanding of the factors that influence purchase decisions. Reality mining taps into an extremely diverse range of data sources, and draws on research into human behavior. As our knowledge of buying psychology becomes richer, the potential for applying this expertise to operational tactics and strategies is limitless, including designing highly responsive supply chains that serve very specific markets and fine-grained segmentation strategies. As marketers strive to reach smaller, more specifically defined consumer groups, supply chain professionals are grappling with the problem of how to support these fractured markets. Reality mining could bring new insights into this challenge since the technology excels at identifying consumer “tribes” defined by common behavioral traits.
• Clear data ownership since organizational silos restrict the use of traditional sources of demand data such as POS. Marketing departments tend to claim ownership of consumer data, for example. Reality mining represents a complete break with these practices, since the providers of the data are players such as telecommunications and media companies (see next section).

Obstacles

The analytical and modeling capabilities required to make reality mining a mainstream business tool are available. Over the next few years, these methods will become even more effective as they are applied to particular problems. But first, the barriers to using this analytical approach – which revolve around the issue of privacy – must be overcome.

Turning the growing mountain of personal electronic data into business intelligence has Orwellian connotations that could easily provoke a backlash from consumers and regulators. The good news is that these conflicts are being addressed by researchers and supra-national organizations such as the World Economic Forum. Pentland is optimistic that real progress is being made.

“You have to construct a ‘new deal on data’ that not only lets you use the data for commerce, but also protects individual rights,” he explains. For example, allowing individuals to opt into data-sharing arrangements in return for rewards or preferential access to products and services would allay many of the concerns over who has access to the information.

Moreover, the organizations that generate the data have a compelling incentive for creating such win-win deals. “For many industries, this is the next big thing. The finance, media, and telecommunications sectors are looking to this as a major, if not the major, source of revenue for the future,” he says. Giving customers control over how the data is used offers these enterprises a way to develop a new business model.
Another issue is that industry forecasters will require new skills if they are to exploit reality mining to its full potential. They will need to learn unfamiliar analytical techniques and gain a deep understanding of machine learning methodologies, says Pentland.

However, the potential rewards are huge. The level of analytical detail possible when using reality mining to delve into customer-buying decisions is unprecedented. “As you really begin to understand the dynamic nature of human preferences and activities, you can start to design supply chains and value propositions in a much more dynamic way than has ever been done before,” says Pentland.

**Next Steps**

MIT CTL is exploring potential supply chain applications for a number of cutting-edge technologies. For more information, contact: Jim Rice, Deputy Director, MIT CTL, at email: jrice@mit.edu.
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