



IN-MEMORY NOSQL DATABASE

WHITEPAPER

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INTRODUCTION

It's no secret that today's retail environment poses significant challenges for retailers with brick-and-mortar presence. Squeezed between big-box mega-stores that can dominate suppliers and pure online retailers with lower overhead, many retailers face eroding margins and the fading effectiveness of their traditional tools for influencing consumer behavior. With consumer-technology trends moving in what's often characterized as the "wrong" direction, there's an increasingly urgent need to adapt to a future defined by new consumer preferences and habits. But how?

At Aerospike we not only understand the changing retail landscape, we embrace it. That's because the same new technologies that are disrupting brick-and-mortar retail present a huge opportunity for forward thinking retailers who realize how to harness that technology to serve their merchandising needs. Intelligently implemented, these new technologies enable automated in-store customer service at previously unimagined levels of relevance, timeliness, and efficiency, sealing the deal in the right place at the right time. What does "intelligently implemented" mean in this context? This document provides a framework for understanding the answer to that question.

There is no shortage of proposed systems to cope with the challenges retailers face, or of big claims about the impact those systems can make. So finding the way forward to a real solution can be confusing. It requires a thoughtful assessment of how the environment shapes requirements, and then of how those requirements can best be met. So we'll look here first at what's happening in retail, how consumer use of technology is changing, and how that affects the ability of retailers to influence in-store purchasing decisions. Then we'll develop a set of requirements based on the situation we've found, and see where those lead in terms of possible solutions. Let's get started...



A CHANGING RETAIL ENVIRONMENT

As we've already noted, trends in today's retail environment pose significant and growing challenges for brick-and-mortar retailers:

■ The rise of the mega-stores and ecommerce-only sites

Very few brick-and-mortar mega-retailers have sufficient leverage to extract favorable treatment from suppliers. Those that do, can lower prices, which in turn exerts downward pricing pressure in the overall marketplace. As reported in the Wall Street Journal, for example, a 2012 report from research firm Kantar Retail included the conclusion that "Walmart plans to further its downward pressure on price" to maintain advantage over retail rivals such as Target. As the power of mega-stores increases, it becomes that much harder for everyone else to maintain margins.

In almost every category, it's less expensive to operate online than brick-and-mortar retail outlets. Those lower costs allow lower prices, and which again increases pressure on everyone else's margins.

■ The ubiquity of pricing information

For many commodity items, the decision of where to purchase is often driven by price. And because technology makes pricing information available to all, consumers no longer need to go to a given store to get prices that can be compared with other stores. For retailers who are on the losing end of a price comparison, getting the sale is an uphill battle.

■ The advent of showrooming

Showrooming allows shoppers to take advantage of the brick-and-mortar experience but give the ultimate sale to an online retailer. A 2013 survey by Forrester Research ("Meet the Changing Needs of Connected Customers") found that nearly 20 percent of mobile phone users now use those phones to check online prices while in a physical store. There are mitigating strategies for this. For example, some retailers will match online prices upon request. In addition, value added products and or services presented by a sales professional can cement the loyalty of that customer, and leverage the advantage of the personalized, in-store experience to make the customer feel special.

■ The rise of shopper tracking

Every move a consumer makes on a website or in app helps build a profile that could be used to direct that consumer to relevant, timely offers and information. Consumers are increasingly interacting with retailers via multiple touch points; according to a 2013 study by comScore (“Marketing to the Multi-Platform Majority”), more than half of digital consumers in the U.S. already engage online via both computers and mobile devices. It’s challenging enough even for online merchants to move past data-siloing and compile information collected across multiple channels into a truly useful customer profile. When storefronts and call center touch points are thrown into the mix, the task becomes particularly difficult. The result is that brick-and-mortar retailers are disproportionately losing out on opportunities to convert customer data into sales. Having said that, the great advantage of a multi-channel retailer is that behavior from both channels can be gathered, integrated and acted upon. No matter the channel the customer comes through on, techniques of recognition, special offers and especially detailed product information can be offered. This builds brand loyalty *across* channels, cementing the relationship with the customer.

■ The rise of automated customer service

Another aspect of customer tracking is that online shopping sites and apps have the ability to react in real time to customer navigation and actions. This automated responsiveness to customer needs and preferences can provide deep levels of service quickly, efficiently and cost effectively. To compete, some savvy stores arm sales personnel with smart devices so they can check on stock, suggest complimentary items and services, and fulfill shopping lists quickly and efficiently. However, this is costly and attainable only by large, high-end brands or by small boutiques that can’t compete as well online.

These trends present brick-and-mortar retail with the following dilemma:

- Costs inherent in their business model put them at a disadvantage in trying to maintain healthy margins while competing strictly on price.
- If they don’t compete on price in an increasingly price-conscious market they risk losing customers unless they compete in other aspects of the overall shopping experience, which makes service critical.
- Providing quality customer service in-store is more costly than it is online using automation, and that greater cost once again adversely impacts margins and tilts the playing field toward online sellers.

THE PROMISE OF IN-STORE SERVICE

If the dilemma above were the whole story, it might be tempting to assume that brick-and-mortar retail is trapped in a downward spiral. But before the eulogies are composed let's consider some other important factors:

- **Online sales are dwarfed by in-store sales** — For all their prominence in the mindspace of retail pundits, the 2013 Forrester Research report “U.S. Cross-Channel Retail Forecast, 2012 To 2017” cites U.S. Commerce Department figures in concluding that e-commerce in 2012 accounted for 5.6% of total U.S. retail spending (which includes gasoline and restaurant meals). Forrester projects that number will grow to 10.3% by 2017. Does this mean that online sales pose no threat to in-store sales? Clearly not. But it does mean that for those who choose an intelligent strategy and start implementing it now, it's not too late to adapt. In order to fully leverage the power of multi-channels, data must be collected in real-time at the showroom. This data must then be migrated to the shopper's web account so that everything they learned in-store is available to them on the web. This is a very powerful experience and now it doesn't matter where the customer converts, we have a 360 degree view of the customer, their purchases and decision to buy.
- **Showroomers need showrooms** — The fact that showrooming is now so widespread indicates the extent to which consumers still want to be able to see and touch many types of merchandise before buying. If brick-and-mortar retailers can turn browsers into buyers in the store they have a clear advantage over online-only sellers.
- **Shoppers value service** — Price is clearly a major influencer of shopping behavior, but it's by no means the only factor in making a sale. Large segments of the population actually enjoy shopping as a form of entertainment, and the immediate, bird-in-the-hand gratification that comes from making an in-store purchase. They are often willing to pay a little more in return for a more enjoyable shopping experience. Needless to say, if store operators cut costs to preserve margins and service suffer as a result, then a key advantage of in-store shopping is lost in the process.
- **Shoppers are already equipped for automated in-store service** — If service is crucial but personnel is limited, then automated service becomes key. The conduit for this approach is the smartphone consumers already have in hand in the store. A 2012 study by Deloitte Consulting (“The Dawn of Mobile Influence”) found that 48% of U.S. in-store shoppers own a smartphone, and the above-referenced 2013 study by comScore put the number of smartphone users in the U.S. at over 140 million. Smart phones could assist the shopper in store, suggesting complementary services or products based on previous sales and personal shopping habits.

- **Mobile use influences in-store shopping** — Shoppers don't just own smartphones, they use them a lot when making buying decisions. The 2012 Deloitte study found that of the 48% of U.S. in-store shoppers who say they own a smart phone, 58% of those have used their smart phones for store-related shopping, and once they start using them for shopping they typically use them for 50-60% of their store shopping trips (depending on store category). The 2013 Forrester study found that 75% of smart phone owners who access the Internet do so in-store. Part of that is to compare prices, but shoppers also take photos of products to share with their network, find coupons, read customer reviews, and check in-store product availability.

Based on what we've learned so far, the following key points emerge:

- Nearly all consumers still use brick-and-mortar stores.
- Good customer service is a key component of the physical shopping experience.
- Automated in-store service offers a cost-effective alternative to human service, helping to protect against erosion of profit margins.
- A large and growing number of consumers are using smartphones, meaning that the automated service pipeline to the end user is already in place.

Given the above, it's fair to say that if the promise of automated in-store customer service can be realized effectively and efficiently then brick-and-mortar retailers can look forward to a bright future. That will require retailers to figure out what it takes to get their shoppers to make purchases on the spot rather than buying from a competitor. But it will also require that the technology that enables automated in-store customer service — the “customer interaction platform” — be designed with three overriding priorities:

Personalization



Relevance



Real-time Interaction



A UNIFIED CUSTOMER VIEW

It may seem counter-intuitive at first to speak of an automated system being personalized. But as more and more information about consumer shopping patterns is collected from a growing number of diverse touch points, automated systems have the potential to access a great deal about a customer's preferences and habits — information that it would be both time-consuming and intrusive for an in-store sales associate to learn on the spot. By knowing more than an associate could or should, an automated customer interaction platform can be more personalized, thus making customer service more helpful and increasing the chances of making a sale.

It stands to reason that an increase in the variety of modes through which customers interact with retailers also increases the challenge of piecing together a complete view of those customers. And the current trend is clearly toward a rise in the number of such modes:

- The Forrester Research study cited above concludes that more and more consumers “cross devices and platforms at will. Customer interactions are no longer contained within a single moment in time or a single touchpoint.” Forrester cites a 2012 study by Google (“The New Multi-Screen World”), which found that 90% of customers cross devices in pursuit of a single goal like shopping. Of that study's 1,450 survey respondents who said that they have started activity on one device and continued on another, 67% percent did so for online shopping.
- As indicated by the Deloitte research referenced above, the multi-channel phenomenon isn't limited to online; growing in-store smartphone use is another example of a shopping experience that increasingly involves interaction across multiple channels.



The result of this trend is that the customer experience of a retailer is increasingly heterogeneous, cutting across platforms (smartphone, desktop PC, standard phone, mail, etc.) and channels (search engines, apps, web sites, email, catalogs, call centers, physical stores). In one sense this is a positive, because more touch-points provide more data points, and information gathered in different contexts may yield a more nuanced picture. But that's only an advantage if the tools are in place to reveal that picture and proactively respond. By and large that's not currently the case.

One big hurdle is that today much of the information captured about consumers is organized and stored based on the corporate function for which it was originally collected. If it remains siloed into individual databases under the management of separate departments, its value will be left largely untapped. To be useful, customer data must be aggregated into an up-to-date profile and analyzed for insights. Given the short timeframe available to influence a customer's in-store purchase, this extraction of actionable insights can't realistically be executed from a fragmented data set. Now that you can effectively combine structured and unstructured; 3rd party and 1st party; clickstream and behavior, these data become even more valuable. Exposing the untapped value of all the siloed data to drive sales, delight customers, and increase customer lifetime value translates into a powerful call to action.

It's all about customization, understanding who is doing the shopping right here, right now and giving them maximum value for their time. That's a dimension that can't be forgotten.

- Tushar Montañó, Principal at VentureSoft Global

ESCAPING THE SILO

To realize the full potential value of customer data gathered from different sources, retailers must think outside their siloed data stores and deploy customer interaction platforms that support an omni-channel customer view. Omni-channel platforms, already in widespread use in the digital advertising industry, enable the following key capabilities in the retail context:

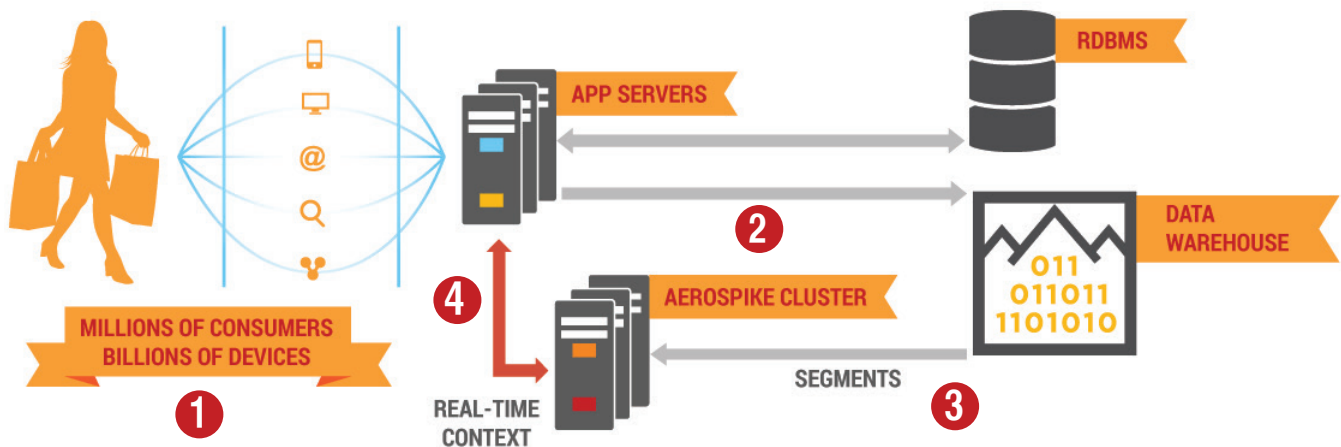
- **Capture and aggregate from all available sources** — Customers now interact with retailers across a multitude of settings, including websites, apps, CRM and call center systems, POS systems, email marketing systems, social media systems, and more. Every click, swipe, search, or share is an opportunity to build a personalized profile of user behavior. Data may also be appended to this profile from outside consumer-data providers.
- **Incorporate unstructured data** — As the big data trend accelerates, the total amount of data that is stored by businesses of all types is projected to grow rapidly over the next few years. According to widely-quoted studies by Gartner, unstructured data, which does not readily fit into SQL database fields, will account for about 80% of this growth. Data from customer interaction falls primarily into the unstructured category (e.g. text-based data from surveys, emails, forums, social media, and CRM systems). A 2011 survey of customer care executives by Coveo found 84 percent agreeing that the management of unstructured content will determine how effectively and efficiently their companies are able to serve customers.

- **Analyze for patterns and insights** — Using Hadoop and other big data analytics technologies, gathered data may be analyzed to discover patterns and insights that are encapsulated in segments. It's these segments, not the diverse data sources from which they are derived, that contain the actionable essence of what's known about an individual customer. For the system to work in real time, access to these segments must be effectively instantaneous.
- **Recognize context** — Context, including platform, channel, and location, is vital to ensuring the effectiveness of response to customer data. It's one thing to know that a customer has been looking at an item online, and quite another to know that the customer is in your store at this very moment, perhaps standing in front of that item's display case. Context also involves information from non-customer-centered departments, such as current in-store inventory, pricing, promotions. etc.
- **Integrate insights and context into action** — Combining the insights represented by segments with the context allows an effective customer interaction system to respond to the current situation with an action that maximizes the chance of making a sale. It's a matter of being in the right place with the right offer — one that is both personalized and relevant — at the right time. And the “right time” means right now, in real time.

ARCHITECTING REAL-TIME PERFORMANCE

Implementing a next-generation, omni-channel customer interaction platform with the capabilities outlined above often requires new thinking about IT-system architecture, with an emphasis on real-time technologies. But it doesn't require setting off into uncharted territory. Real-time interaction platforms are already in use at Internet scale in the digital advertising space, where the right to serve an ad to an online viewer is won via an extremely low-latency bidding process. The general idea is that based on what is known about a given viewer an evaluation is made of the viewer's desirability to a given advertiser and of the value to that advertiser of placing a targeted message in front of that viewer. A bid is then placed, and if that bid is highest then an ad is served. The entire process completes within 100 milliseconds.

The list of companies involved in providing services along these lines include AppNexus (the largest independent ad exchange), BlueKai (the largest data exchange or DMP), BrightRoll (the largest video ad platform after Google), Chango (the Internet's largest search re-targeter, which handles more searches than Yahoo and Bing combined), Gree (the largest social gaming company), and many others including Millennial Media, PubMatic, and Acxiom. While the companies are diverse, what they have in common is the underlying IT architecture that they've chosen to implement their speed-intensive missions:



- 1** App servers interact with millions of consumers, access a variety of enterprise systems like product catalogs, inventory, pricing, payments, logistics etc, track all user activity in a Hadoop cluster or data warehouse, manage recent user context in Aerospike and use this real-time context to personalize interactions.
- 2** App servers feed all user activity and context data, structured and unstructured, to a large-scale main data store (Hadoop cluster or data warehouse) whose capacity may be petabytes. In a retail context the main data store may also be populated from the data stores of many internal departments that each are responsible for different aspects of the customer experience (forums, social media, emails, billing, returns, POS, call centers, etc.) and other aspects of running the business (e.g. inventory and promotions, etc.). This data is analyzed using a variety of tools and algorithms and users are tagged or categorized into segments.
- 3** Segment data is periodically moved to augment user profiles in Aerospike.
- 4** App servers also write clickstreams and current user activity data, for example 1-100TB of the last 30-90 days of data, into an Aerospike cluster. They map session-ids, cookies, device-ids, ip-addresses and other user identities across the entire spectrum of platforms and channels.

When a user clicks, swipes or otherwise interacts with the application, the app servers draw on data from the Aerospike cluster — identity and segment information combined with real-time context and real-time analytics — to determine the appropriate real-time response to the current situation. The app servers interact with the Aerospike cluster via client APIs that handle transactions and cluster awareness.

SPEED-DRIVEN DATABASE DESIGN

The system outlined above uses a tiered approach to data store management in which a smaller set of high-value, time-sensitive information is stored independently of a larger set of raw data that is less time-dependent. Making this arrangement work requires that the high-value data store not only meet or exceed all the usual benchmarks for database reliability and “ACIDity” but also meet the key additional requirements of speed (to enable real-time interaction) and flexibility (to accommodate unstructured data).

The ability to handle unstructured data is inherent in databases such as Aerospike that fall into the general category of NoSQL. But the core reason that the leading performers in the digital advertising world have chosen Aerospike out of all the NoSQL options is because, unlike databases optimized for analytics, Aerospike, an in-memory NoSQL database, is designed from the ground up to deliver precisely the kind of speed required to handle real-time interaction with negligible latency. Aerospike’s speed derives from several basic design attributes:

- **Hybrid memory system™** — Aerospike uses a hybrid approach: indexes are in DRAM and data can be in either DRAM or Flash (Solid State Drives or PCI-E cards). Aerospike can run in DRAM alone, but most customers take advantage of the price/performance benefits of Flash.
- **Proprietary log-structured file system** — Aerospike accesses SSDs and/or PCI-E cards using a proprietary log-structured file system that is optimized for Flash.
- **Smart transaction design** — Aerospike uses small block reads and large block writes to reduce wear. Access is highly parallelized for maximum efficiency.

The characteristics above set Aerospike apart from databases that cache data in memory and are sold as “accelerated by flash.” If data is accessed via the Linux file system, which was built for a time when data storage meant spinning disks, the performance boost that can be achieved by using SSDs instead of rotational drives is modest at best. Aerospike is not limited by these performance constraints.

The performance advantages of the Aerospike approach are confirmed by a recent analysis from the software development services firm Thumbtack Technology, which conducts and publishes independent database benchmarking tests. The report (“Ultra-High Performance NoSQL Benchmarking: Analyzing Durability and Performance Tradeoffs”) used a modified version of the open source Yahoo Cloud Serving Benchmark (YCSB) from Yahoo! Research to measure areas such as throughput (balanced and read-heavy) and latency (read and update). Comparing Aerospike with NoSQL

alternatives Cassandra, MongoDB, and Couchbase 2.0, Thumbtack concluded that “the data strongly suggests that for synchronously replicated, durable data, Aerospike was able to outperform the other databases by a wide margin...”

Beyond the exceptional speed with which it writes to and reads from its hybrid memory system, Aerospike allows job prioritization and allows multi-core optimization. It also benefits from an extensible data model that provides all the tools required to support effective real-time interaction including Strings, Integers, Lists and Maps, Lookups, Queries, and Scans, User-defined functions and Distributed aggregations.

COST AND RELIABILITY

In addition to exceptional performance, Aerospike’s rapid adoption in the time-sensitive digital advertising sector may also be explained by the economics of system implementation and operation. Compared to a DRAM-only NoSQL system, Aerospike’s hybrid approach to memory allows more data to be stored per server, which translates into requiring on average, only one tenth the number of servers for a given load. Consider, for example, a system with a throughput of 500,000 TPS, 10TB capacity, and a 2x replication factor. A DRAM-only system would require 186 servers compared to just 14 in a cluster using Aerospike’s hybrid DRAM/SSD approach. Taking into account the cost to purchase, power, and maintain each system for two years, the all-DRAM approach would cost about \$2.5 million compared to just over \$236,800 for the Aerospike approach. In a competitive environment where cost savings go directly to the bottom line, even systems operating at 50,000 TPS or managing just 1 TB of data can be deployed with 4x lower costs.

Of course, the performance and cost-effectiveness of an Aerospike system wouldn’t mean much if they were gained by sacrificing reliability. Instead, Aerospike delivers field-proven 100% data and service availability, with no Aerospike deployment having ever experienced loss of data or access.

Aerospike utilizes the following strategies to maximize reliability:

- Synchronous replication to ensure immediate ACID consistency
- Automatic re-routing of requests if a node fails
- Automatic fail-over and re-balancing if a node or rack fails
- Synchronous replication of data across identical nodes using an algorithm that automatically balances data to prevent hotspots
- Asynchronous data replication across clusters in different data centers
- Business continuity processing (BCP) during catastrophic failures
- Rolling upgrades to eliminate downtime and maintenance windows

TURNING INTEREST INTO SALES

We now know that it's possible to deploy a customer interaction system whose database design is up to the challenge of near-zero-latency performance, and with which we can draw on the following factors to influence customer behavior in real-time:

- A unified customer profile composed of high-value insights distilled from an aggregated view of every channel
- An up-to-the-moment understanding of customer context
- A current view of retailer context such as inventory and promotions

We're seeing the confluence of technologies like scale-out data management, behavioral analytics and real-time personalization. We are at the beginning of a brand new business cycle.

- Tushar Montañó, Principal at VentureSoft Global

How can a brick-and-mortar retailer benefit from such a system? Here's a partial list of the types of mechanisms that, when employed at strategic moments, can turn consumer interest into actual sales:

Real-time offers

One time coupons

Deals near you

Best sellers

Related items

Real-time availability

Dynamic pricing

CONCLUSION

Based on this data it's possible to draw a few key conclusions about how retailers with brick-and-mortar presence can adapt to the new retail environment and continue to thrive:



Face the future — Change is coming. In fact it's already here. Those who understand and respond now will be best positioned to prosper as current trends accelerate.



In-store service is a key differentiator — Online-only retailers enjoy many advantages in controlling their overhead, making it difficult to compete on price alone. But shoppers don't shop on price alone. A customer interaction platform that enables state-of-the-art in-store service can tip the scales toward brick-and-mortar.



Service must be personalized — The old adage “know your customer” is still sage advice. More complete customer profiles translate into a better understanding of what each customer wants, which in turns yields greater success in pitching each customer with the right offer. And a huge part of making customer profiles more complete is to unify information from across all touchpoints into a single omni-channel view in a data store that supports unstructured data and mining for insights.



Service must be relevant — Insights alone aren't enough. An effective customer interaction platform must be able to follow up insights with action at precisely the moment when such action is most likely to influence customer behavior. That means that the system must be context-aware (e.g. is the customer at home, driving to the store, in the mall, in the store?) and must also be able to respond in real time to customer actions (checking a price, looking at reviews, etc.).



Performance flows from design — Databases and the IT infrastructures they run on are not all equally effective at all tasks. A generic design that might be fine for back-office tasks or for analytics cannot be relied upon to perform effectively in operational applications requiring Internet-scale volume and real-time speed. Instead, what's required to enable personalized, relevant service is a database architecture that is specifically optimized to take advantage of today's fastest available storage technologies to deliver the fastest possible performance.

It follows from the above that the time to implement a real-time customer interaction system is now, and that the platform on which that system is built must be as fast and reliable as possible. We strongly believe that the Aerospike approach, which combines the strengths of NoSQL with the speed of DRAM combined with Flash, merits consideration as the foundation of your customer interaction platform, and that you'll find Aerospike to be a surprisingly cost-effective solution. Technology research firm Gartner recognized agrees, having selected Aerospike as the sole database vendor in Visionaries Quadrant of their 2013 Magic Quadrant for Operational Database Management Systems.

For further insight into how Aerospike's unique strengths can be applied to your own specific situation, please contact an Aerospike representative:

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