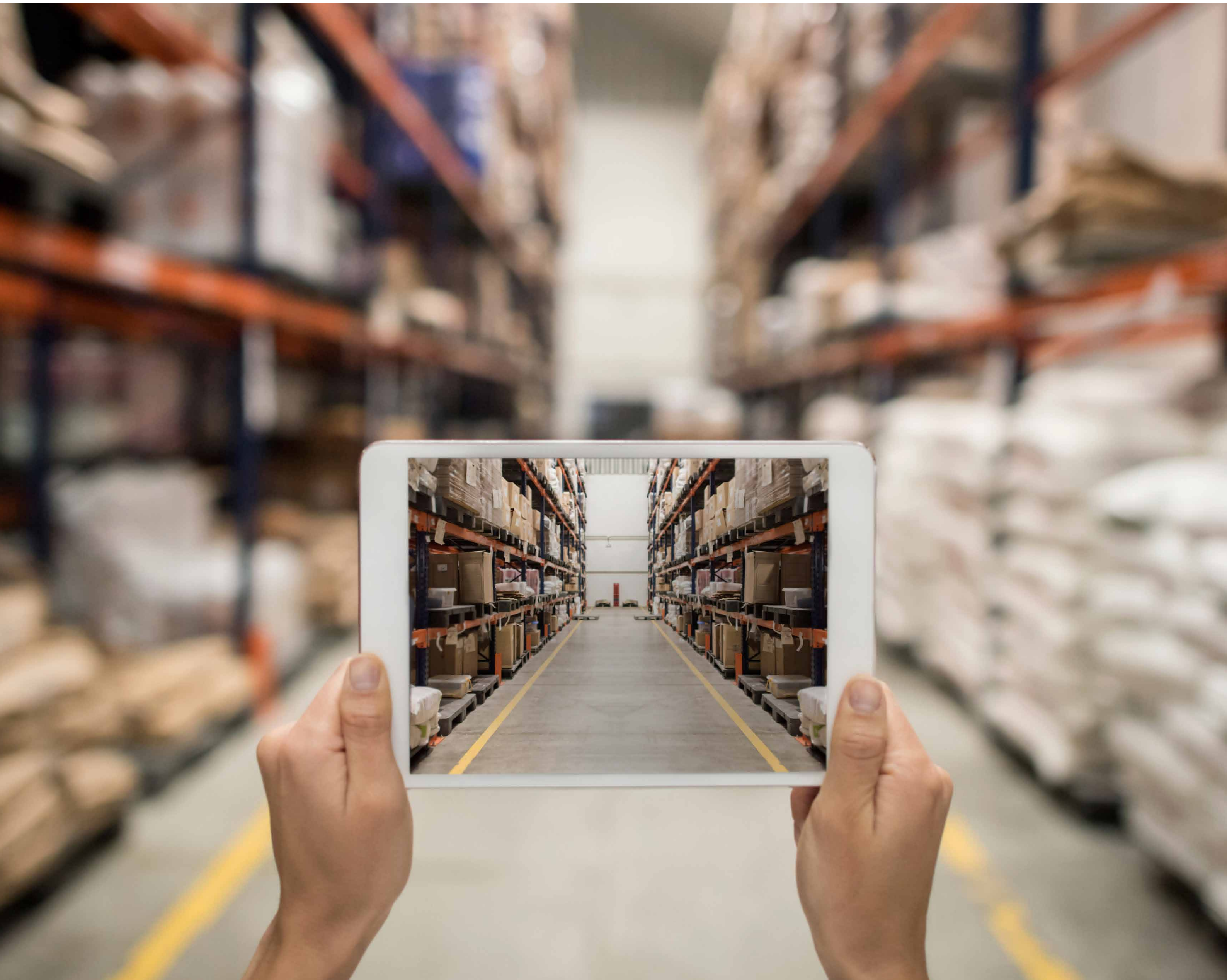
Deloitte.

The warehouse of tomorrow, today
Ubiquitous Computing, Internet of Things, Machine Learning



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The past half-a-decade has seen the birth and explosive adoption of technologies which not only redefined the game, but also became or are becoming "a given" of everyday life and business.

Mobile and cloud are standard nowadays

Analytics, big data and AI / machine learning are forecasted to constitute a 100 Billion market within the decade
(Wikibon, A.T. Kearney)

The Internet of Things (IoT), is predicted to reach a massive 10 Trillion (yes, with a T) in revenues within the same timeframe
(Forbes)

Wearables such as Google Glass and VR hardware such as Oculus Rift have taken the brave leap onto the market and are steadily gaining ground

Supply chain and intralogistics seem to have remained rather indifferent to these technologies and trends, yet this state of affairs may find itself momentarily challenged by the business environment, either demand or competition driven. The "how" follows.

Ubiquitous computing

Ubiquitous computing (ubicomp) is a concept in software engineering and computer science where computing is made to appear anytime and everywhere. In contrast to desktop computing, ubiquitous computing can occur using any device, in any location, and in any format.

There are software houses that have on offer intralogistics apps for smartphones and tablets, to replace hand-held and PC terminals. This provides superior user experience, maintainability and upgradability, cheaper hardware and the potential to deploy BYOD* services, to facilitate certain activities (e.g. monitoring, automation control) without being physically on site.

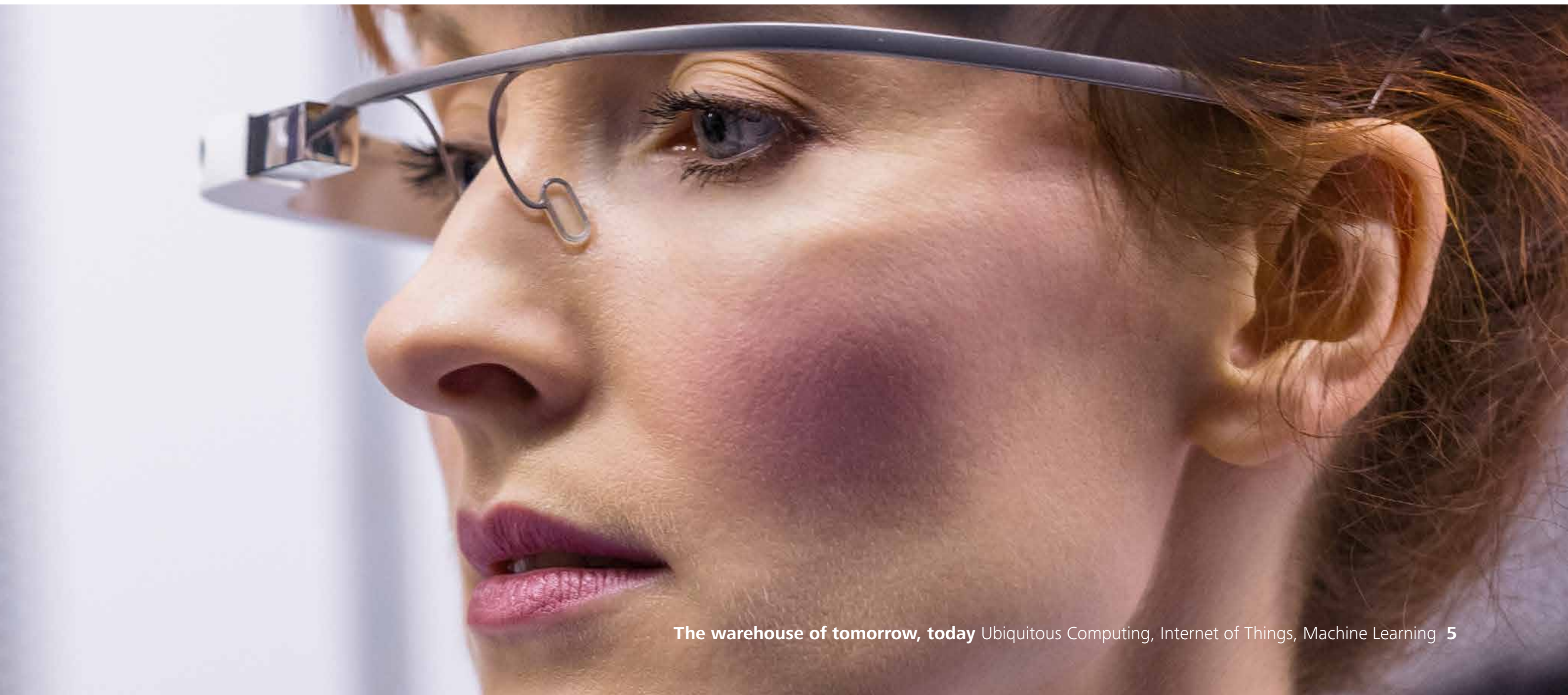
Virtual reality devices such as the Oculus Rift are already being used as pre-sales and marketing tools for warehousing, to present virtual site simulations and walkthroughs.

Taking the concept further into operational applications, wearables such as Google Glass can be deployed into tasking, scanning, recognition and routing activities within the warehouse.

*Bring Your Own Device: commonly referred to as IT consumerization, it is the policy of permitting employees to bring personally owned mobile devices to their workplace, and to use those devices to access privileged company information and applications.

Fiori, SAP’s new user experience (UX) software, is a solid solution to build on top of current SAP supply chain and warehousing platforms. It applies modern design principles and represents a personalized, responsive and simple user experience across devices and deployment options.

A detailed investigation on device mobility in the warehouse has been conducted in Deloitte’s study titled “Leverage the power of mobile devices: integrate the latest technologies within the WMS”.



Internet of Things (IoT)

More connected user devices will be echoed exponentially by connecting every physical element of the warehouse and supply chain.

As companies have deployed big data and analytics strategies, they are now moving on to even greater use of data through IoT: nearly every device connected to enhance customer experience and to enable manufacturers and distributors to track the effectiveness of their products throughout their life cycle. Everything we denominate as "SKU" (Stock Keeping Unit) will send continuous streams of real-time data.

Market realities show 4.9 billion "connected things" in 2015, to grow by 30 percent in 2016 to 6.4 Billion, and to 25 billion by the turn of the decade. Deloitte predicts that 60 percent of all IoT devices will be bought, paid and used by enterprises and industries; 90 percent of the services revenue generated will the enterprise, as more than one in two companies have initiatives in place today.

Commonly used IoT technologies are mobile apps, digital cameras, scanners and sensors. In supply chain and intralogistics, sensors would form the backbone of IoT:

- Revolutionize the supply chain by connecting its moving parts of suppliers, manufacturers, distributors, retail centers and customers;
- Create the "connected warehouse" by linking-in all intralogistics elements: doors, Handling Units (HUs), storage elements, conveyors, automation and mobile devices; then integrate this network at supply chain level.

There are compelling, both quantitative and qualitative reasons to deploy IoT in logistics:

Real-time visibility of anything that is moving in the warehouse: from HU to forklift movements, sensors continuously capture and transmit "when, where & what" data from the floor. Without real-time visibility, warehouses are operating in the dark, relying on best guess rather than actual information to optimize routing and flow performance.

In-transit visibility: a HU with an e.g. RFID chip, paired with a device integrated in the transport vehicle, generates data to identify the HU and not only share its position using GPS coordinates, but also pull additional weather and traffic information, and driver-specific data (i.e., driving pattern, average speed) to generate real-time statues and estimates.

Productivity also goes hand in hand with real-time visibility. The more information about what is happening on the floor, the better the targeted improvements, and lower the asset loss and waste.

Continuous monitoring insures no divergence of machines from the intended operation parameters, thus avoiding entire processes to back up or bottleneck.

Optimized travel times and costs by monitoring and analysis of warehouse operator and machine activities and movements

Inventory accuracy: eliminate manual data entry errors leading to inventory disorder and time waste chasing lost or misplaced Hus: every HU is automatically accounted for and physically tracked to the millimeter. Sensors effectively avert error, potentially leading to 100 percent inventory accuracy and preventing out-of-stock situations.

Automation can benefit from real-time visibility, as the data collected can dictate operational tactics adaptations, coming from either pre-programmed alternatives or intelligent systems.

Reduced downtime: automatic alerts to system and machine errors

Safety by monitoring forklift positions and movements

ERP, Supply Chain Management (SCM) and Warehouse Management Systems (WMS) are already well integrated, yet IoT will augment these solutions by intelligently connecting people, processes, data, and things via devices and sensors.

The aforementioned thirty-fold increase in Internet-connected physical devices by the year 2020 will significantly alter how the supply chain operates, impacting on how supply chain leaders access information, among other things.

Combining real-time sensor data with environmental data provides a higher degree of intelligence to all stakeholders, by making information available well before any activity happens, thus moving the supply chain process from a reactive to a context-aware, proactive mode.

Most importantly, the purpose of all supply chain efforts, is the client: IoT sensors embedded in the purchased products will generate unprecedented insight by means of visibility into customer behavior and product usage.

SAP's in-memory HANA-based IoT platform can help users quickly develop, deploy, and manage real-time IoT and machine-to-machine (M2M) applications; use the platform to automate processes at the core and connect to almost anything at the edge of their network.

Machine Learning

As the first two sections depict the connected warehouse and supply chain, bringing together users and components, a top layer is needed to manage and interpret the vast volume of generated data.

Advanced analytics such as machine learning can bring predictive (what) and prescriptive (what, why, how) abilities to the intralogistics decision-making and operating processes, to face todays' applications with more and more products, growing complexity, extreme seasonality, or simply too much (big) data

Machine learning, a form of Artificial Intelligence (AI), is about learning (automatically, without human intervention or assistance) to do better in the future based on what was experienced in the past. These abilities can be augmented by aggregating various environmental or business data.

Machine learning is commonly implemented by means of Artificial Neural Networks (ANNs) which discover, analyze, learn, remember and compare complex patterns in data, beyond human abilities, even when the data are noisy, ambiguous, distorted, variable or incomplete.

Machine learning will aggregate all of an enterprise's cumulated past and present supply chain and warehousing data, decisions and actions, rights and wrongs, into insight actionable in real-time, for demand forecasting and optimal setups of order structure, routing, slotting, shipping etc.

Furthermore, a strong variation in a supplier's or customer's market value, or significant weather conditions can be interpreted by AI into dynamic decisions to block or move stock, wave design, do pre-work for orders, modify orders and routing, travel times estimations etc.

These operational improvements will increase service quality and response times, reduce business risk and operating costs, respectively provide continuous monitoring and audit.

Furthermore, these will constitute continuous optimization in the purest definition of the term, as ANNs automatically adapt to changes in the environment, learning by experience and self-improving; an added bonus is given by the resulting flexibility and ease of maintenance.

Computing power and "wisdom" is not all: machine learning has enabled R&D and industry to master many technical challenges in computer vision and natural language processing, out of reach until just a few years ago, and applicable to document interpretation and processing.

Another application is in customer segmentation, where grouping of different customer characteristics can be enhanced with machine learning techniques, to scour customer records for unexpected correlations in buying and ordering habits. At the other end of the spectrum, AI can be applied to analyze supplier information and determine quality and risk.

SAP offers an array of solutions to build on the momentum of machine learning, aiming at predicting and influencing business outcomes and responding to change before it happens, by combining capabilities such as predictive modeling, Big Data mining, the Internet of Things, existing data sources, real-time business intelligence (BI), and data visualization.

Simpler applications can be delivered based on HANA and its Predictive Analysis Library (PAL) on Big Data. The Lumira-powered Predictive Analytics (PA) package aims to cover the more complex applications, by offering the Expert Analytics module. This contains algorithms that can be used to build models for machine learning, further extensible by the option to create custom R code.

All together now!

Imagine all the IoT data that can be gathered, interpreted and executed into optimization strategies and tactics - there is no better technology to handle, interpret and act on these vast volumes of information (at petabyte level) than machine learning. Finally, how to better deliver the generated AI results and decisions, than in a split-second straight to the highly mobile end-user devices.

A real-world application scenario, of how an "unidentified" pallet gets to fulfill urgent orders hindered by traffic, may look like this:

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An operator finds a pallet with product, abandoned on the floor. She uses her Smart Glasses headset to scan or photograph the label.

In case the label is damaged or missing, she can scan or photograph the labels/barcodes of the products on the pallet, data to be subsequently aggregated and matched by machine learning to historical pallet data.

An RF device is used to scan the pallet. In case the label is damaged or missing, the pallet is stored in a "QA" area for further investigation.

Use case ended.

Instant image recognition powered by machine learning collects, identifies and displays all relevant SKU and process data (e.g. which process was the pallet a part of, for how long it was idle, what action was pending, which operator manipulated it last etc.), and decides to store the pallet.

For a readable label, shipping data may be read.

If the WMS "knows" the pallet, it decides to store it. In care it does not "know" the pallet, it is stored in a "QA" area for further investigation.

Use case ended.

"Internal" IoT technology immediately signals several close range compatible free storage locations, after confirming their availability with the WMS system.

The WMS dictates a free storage location. This location is free in theory, yet should it be occupied, the operator needs to signal this to the WMS and identify a new location.

The system computes the optimal putaway scenario considering the closest location of and shortest path for the first available forklift.

The system determines the closest available location compatible with the products on the pallet.

At the same time, an "external" IoT process notifies an inbound delivery delay caused by real-time traffic, which cannot be avoided, but can be minimized. Still, even this minimization cannot resolve the fulfilment of certain A-mover orders, completely dependent on the incoming goods.

The driver may or may not signal his delay. The transport manager does not have insight into the open picking orders and incoming picking waves in order to react. The picking manager is not aware that the truck will be late.
Order fulfillment is delayed.

The system recognizes an alternative in the initially abandoned pallet and selects it for picking, even if still in transit toward its putaway location.

It is rerouted to the open picking location closest to the current position of the forklift.

The system will be able to recognize an alternative in the initially abandoned pallet and select it for picking, after it has been confirmed in its putaway location.

Order fulfillment is delayed.

Picking is being executed straight from the pallet using Smart Glasses, or at a physical picking station where the operator has previously logged-in by connecting his BYOD device to the location.

Every single item picked is confirmed to destination either visually by means of headset identification or mobile device scanning and confirmation. Stock is updated consequently.

Picking is done by means of RF devices, either straight from the pallet location (if possible) or from a picking station.

A machine learning protocol already investigates the processes in which that pallet has been involved prior to its “discovery”, and will identify the error that caused its “abandonment”.

The ANN will then adapt the afferent process designs to ensure this event will not occur in the future.

Picking is done by means of RF devices, either straight from the pallet location (if possible) or from a picking station.

Finally, economic market realities (e.g. seasonality) indicate to the ANN that the demand for the product type on our abandoned pallet will fall drastically.
In consequence, machine learning changes the product type to C-mover and relocates it to the closest available-responding IoT C-locations, along with all the other newly demoted C-mover SKUs,
While at the same time issuing transport orders for the “elevated” movers to new more accessible storage and picking locations.

The change of the ABC product classification will be done manually, at a later point in time, potentially as a reaction to ERP statistical data. Suboptimal product management.

Putaway is being executed either straight from the pallet to smaller bins (decanting into totes, IoT signals available empty storage locations to WMS) using Smart Glasses, or directly to a pallet storage bin by forklift.

Bin sensors confirm putaway and stock is updated consequently.

Location management is done in WMS, decanting and confirmations by means of RF, by the operator.

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Many other such scenarios may transform into real-world applications, based on intervariable constructions involving mobile devices, anything moving or which could transmit data in the supply chain, respectively predictive and prescriptive processes. This would initially and especially generate interesting results if applied within large entities, who are the sum of many moving parts and act across vast surfaces and territories.

One of the prime advantages of all these new technologies will be a better understanding of the metrics such as cost per transaction, process based information, equipment utilization for a specific task, downtime reasons, etc.; this will help warehouse and supply chain managers to take informed decisions.

Taken individually, ubicomp, IoT and AI, even if still gathering momentum, can bring significant advances to intralogistics and supply chain, many of which we may not foresee today. Taken in symbiosis, they have the potential of leading to a both exciting and constructive shift of the current operating paradigms, a fact supply chain professionals should be attentive to and consider its potential.

These new technologies will still reside side-by-side with relatively old ones, such as RFID, barcodes and voice systems and, in fact, further enhance them.

A fully connected environment, augmented by deeper intelligence into supply, demand, operations and environment will not only benefit manufacturers, distributors and retailers in working smarter, but also consumers, as their demands can be better met in today's larger-picture digital business landscape.

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