BOARDWALKTECH

Enterprise Digital Ledger

Building Enterprise Applications on the Boardwalk Digital Ledger

With Transaction Chaining Technology

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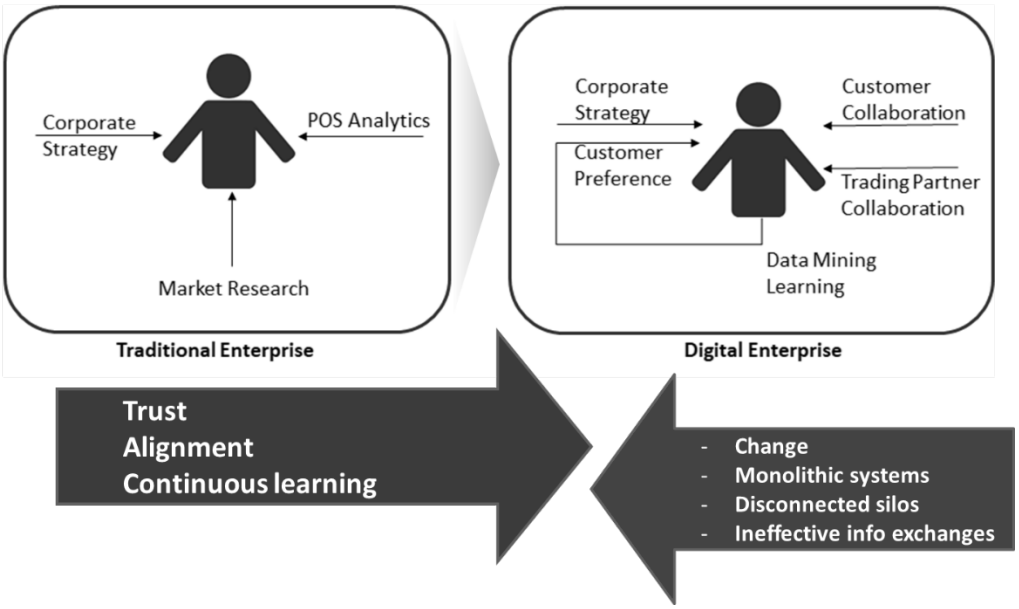
The Digitally Transformed Enterprise

In the envisioned digital enterprise, feedback from the customers, partners, and within the organization continually drives strategic and tactical decision making.

A more fluid, responsive, agile enterprise



- Strategy: To make this a reality, the IT architecture needs to:
  - Gather information from multiple sources such as customer feedback and operational events
  - Build trust in information
  - Enable an "agile information flow" to achieve rapid agreements, speed, and efficiency
  - Continuously learn from customer and operational events
  - Identify risk and improve outcomes.
- Challenge: Enterprises are limited by a legacy environment
  - An environment of monolithic systems results in disconnected silos of structured and unstructured content, processes, people, teams, and organizations.
- Solution:
  - Take steps to empower the digital transformation of the enterprise

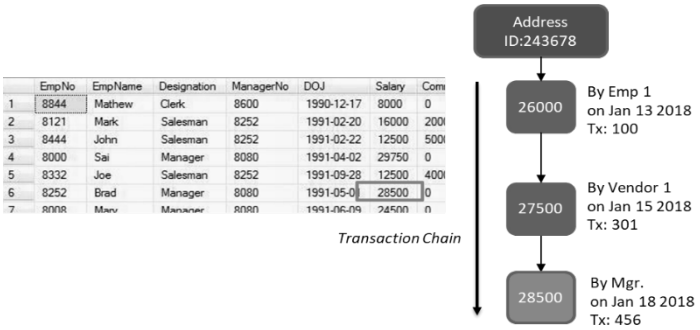
Enable digital transformation by converting enterprise information into Digital Information so it is trustworthy and secure, easily addressable, digitally shareable, changeable, auditable, life-cyclable, and combinable to enable deep learning and prediction.

Digital Information

In the enterprise, trust, alignment and continuous learning of enterprise information increase with a chain of transactions over time which can be used to drive strategic and tactical decision making. This means digital information can be defined as:

"Digital information is an addressable entity defined by a sequence of chained transactions that operate on that entity over time"

In other words, trust, and agreement on the value of addressable information increases with a chain of transactions that verify the current value.



For example, the value of Brad's salary has a Digital Address 243678.

The trust and agreement on that value is defined by the chain of signed transactions that when executed results in displayed value of $28,500.

Defined as such, Digital Information is:

- **Trusted**: One can see the sequence of transactions that led to the latest value. Information can be tracked to the source of creation and modification
- **Addressable**: Each information is assigned a unique immutable address
- **Chained:** One can see the sequence of transactions that led to the latest value
- **Rich in Content and Context**: Learn from change patterns, sequence, and event to event proximity to identify risk and improve outcomes.
- **Highly Granular:** Operates at a "field-attribute information" level rather than a record level.

Limitations of Current Technology Stacks

Legacy Systems

Legacy systems have not been designed to manage Digital Information. And as such, they have created an information management infrastructure presenting formidable barriers to digital transformation. Record-level granularity and lack of time-based data as building blocks of existing data architectures fall short. The legacy systems are built on SQL or No-SQL or Graph databases and as a result, are limited in their impact.

Flat Storage Technologies

Existing data management technologies such as SQL, No-SQL, or Graph databases can be classified as flat data management technologies.

These flat storage technologies have the following attributes:

- Represent a normalized view but not the original view of information
- Data loss while transforming information to the SQL data model
- Stores only the latest value in the database.
- Does not manage the chain or sequence of transactions
- Does not have a way to correlate changes with respect to each other
- Manages timestamps at a high granularity for example at a "tuple" level
- Allows logging, although logs are no replacement for chaining as it requires a lot of custom code to build chains of data from logs. It is so expensive that it is never done in real implementations.
- Does not allow for concurrent evolution of information by multiple parties and resorts to locking and serialization

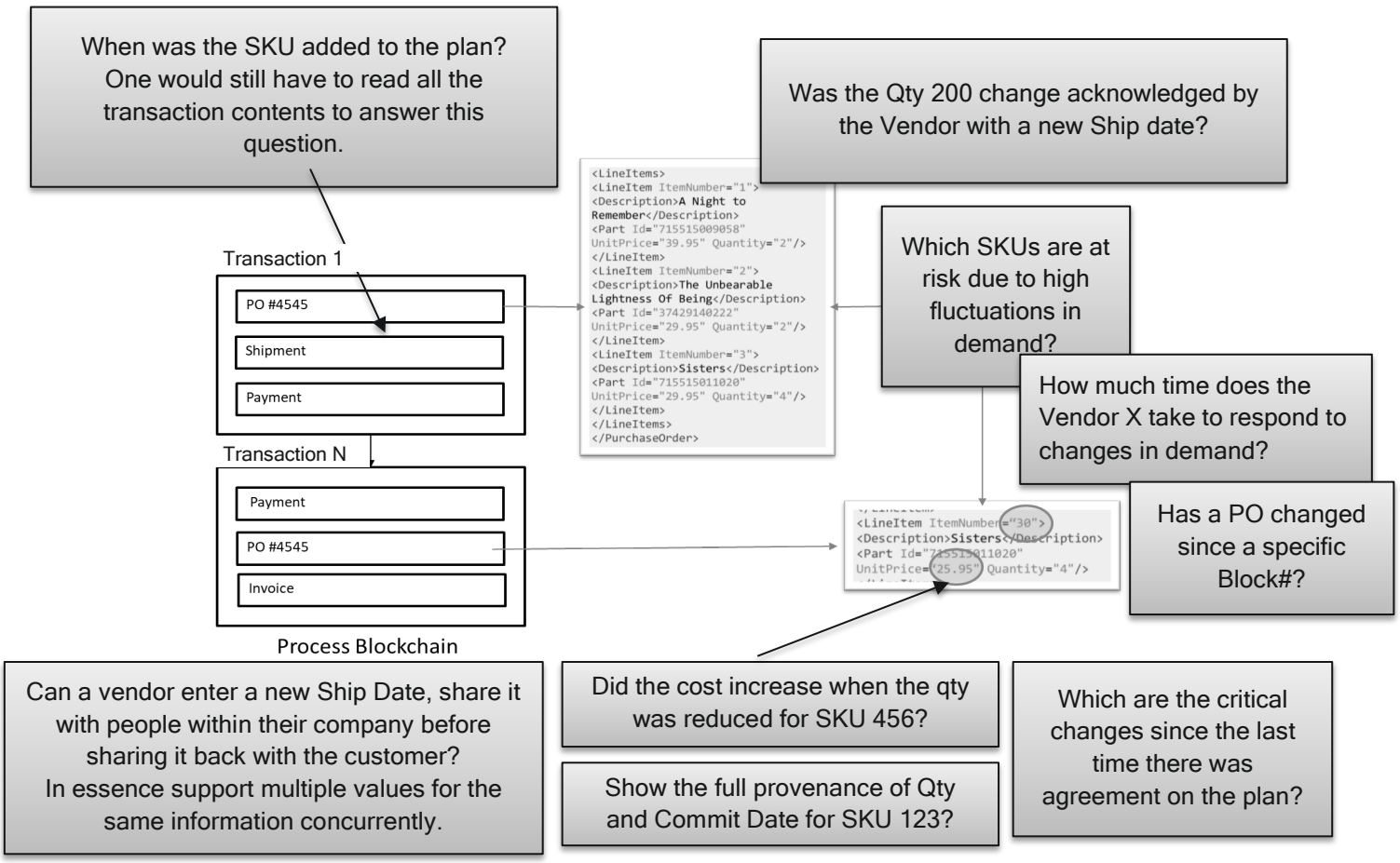
For a more detailed look at SQL, Key/Value Databases and Graph Databases please refer to the **Appendix**.

One might question investing in a Digital Transformation, especially when existing systems appear to be functioning. However, the next wave of productivity and gains for an enterprise will come when the enterprise is liberated from the constraints of its existing information systems.

What can a flat storage technology not infer?

Imagine an enterprise process that is tracking supply chain events such as purchase orders and shipments. Every change event to a PO or shipment would generate a new transaction to the flat storage environment updating the application data, but there's no core capability within a flat storage technology environment to understand and manage these transaction updates. An enterprise application would need to have a transaction log setup against all the existing data elements and then must parse the complete structure and verify it to understand changes.

For an enterprise application, flat storage technology environment faces several challenges where it would be difficult to answer many critical questions such as:



Work-In-Process (WIP) Vs. "Final" Transactions

In traditional enterprise applications, only final transactions are captured.

These WIP activities can be both pre-and post-final transactions to get agreement on transaction attributes and final agreement in executing the agreement.

This leaves businesses grappling with WIP activities which are largely manual back and forth critical information exchanges and often largely responsible for supply chain inertia.

Pre- Final Transaction Work

Post- Final Transaction Work

Majority of work is Outside ERP

Final Transaction In ERP

In other words, today, flat storage technologies are really only a post-agreement environment.

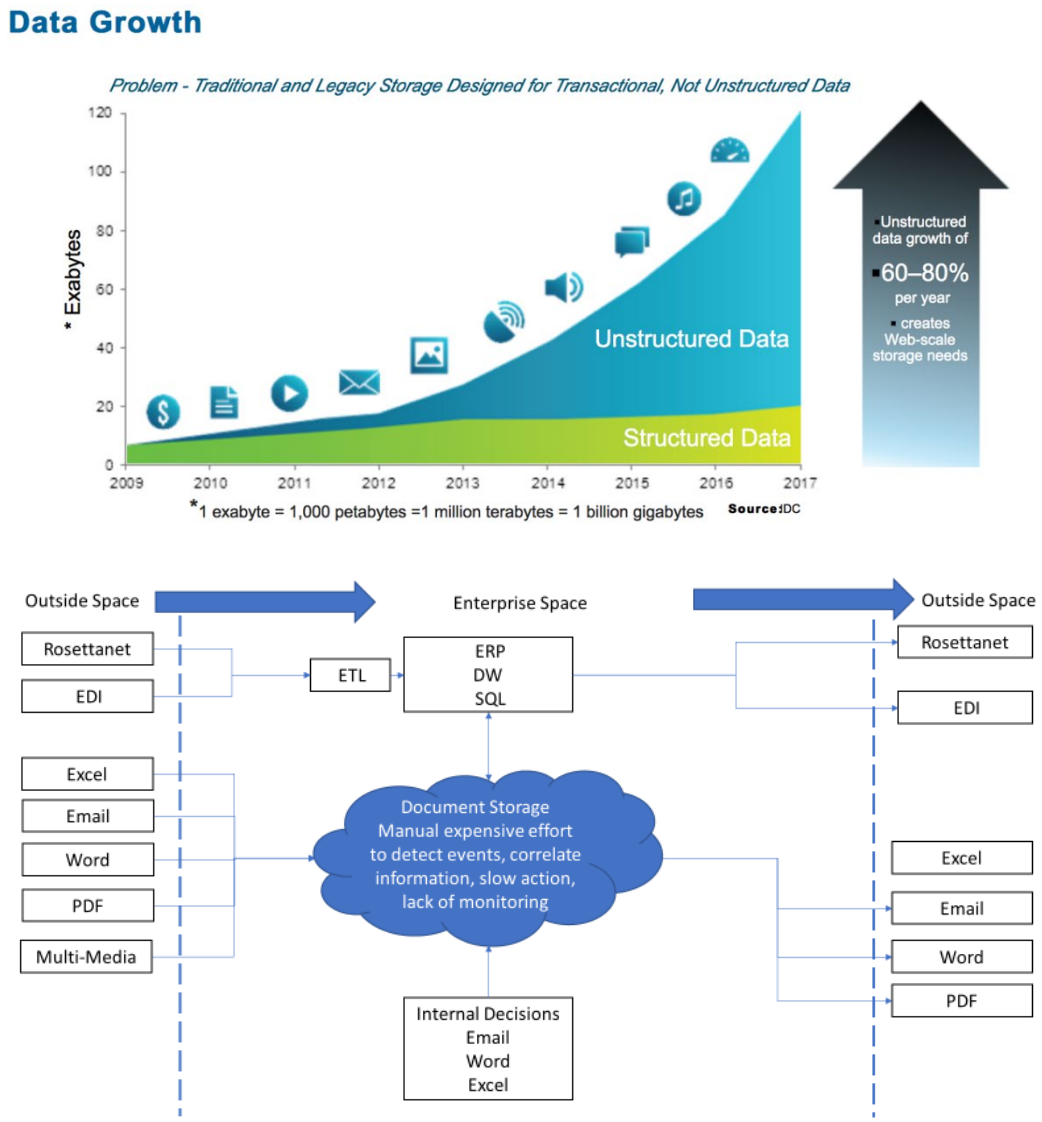
Enterprise's information is always in flux and evolving and just managing specific states of the information does not build trust and integrity.

Final Transactions captured using flat storage technologies are not enough for widespread business adoption.

Business groups need solutions that lead to quick alignment and agreement with multiple parties.

The Explosion of Unstructured Data

It is a well-known fact that unstructured data is growing at an unprecedented rate and that current storage methods are not designed for unstructured data. To this effect, the only tools to tackle this problem are Machine Learning or Custom Big data engines.



Today unstructured content lies in Document storage, uncorrelated with critical business information such as inventories, business plans, manufacturing plans, customer orders, etc. This results in delays in detecting ripples that could be beneficial or disruptive to the enterprise.

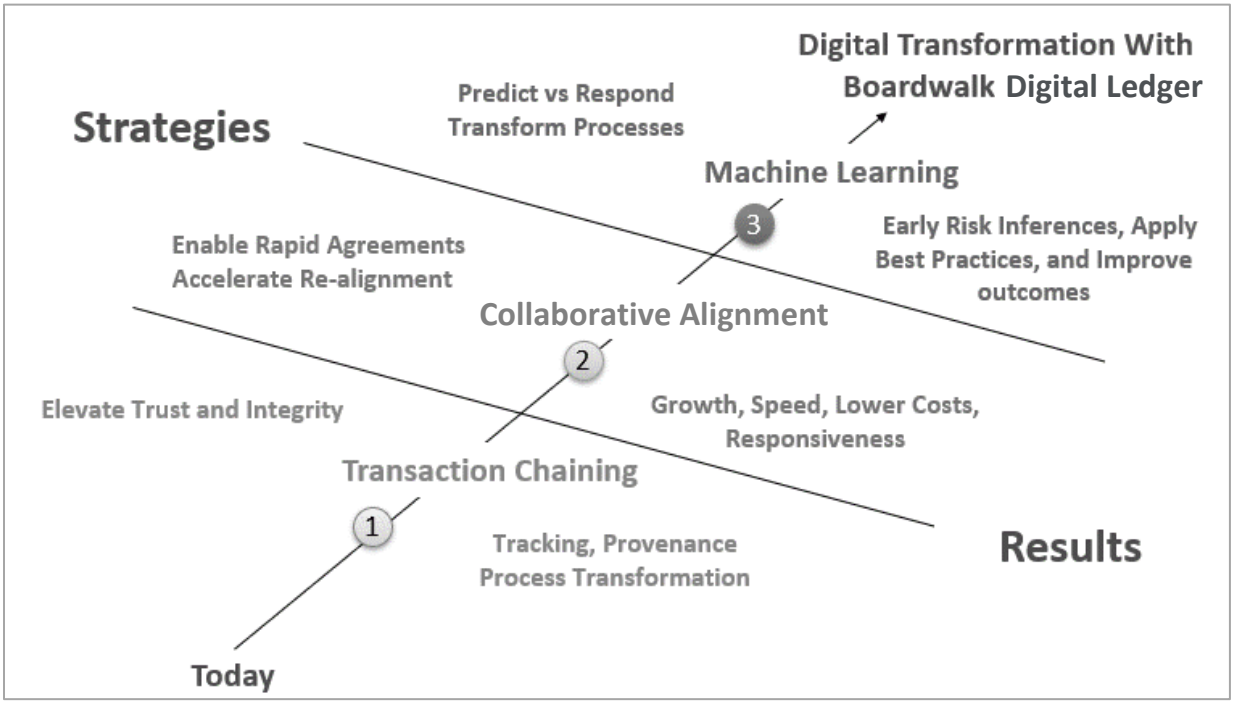
Boardwalk Enterprise Digital Ledger Applications

Boardwalktech is a leader in the enterprise application space and has deployed its patented transaction chaining technology in production environments since 2004. Boardwalktech is a center of excellence in change management, isolation, and sharing, transaction chaining, and convergence of structured and unstructured information. Boardwalk has deployed its core digital ledger – which fully leverages transaction chaining

technology - in active production deployments in Fortune 500 customers for over 10 years. The Boardwalktech solution overcomes the numerous enterprise application deployment challenges discussed above creating an opportunity for unprecedented productivity in enterprise information, processes, and workflows by enabling information capture, isolation, distribution, and collaboration.

Boardwalktech presents a three-pronged strategy to adopt digital ledger technology for enterprise applications.

1. Capture digital information using transaction chains
   - Elevate trust, provenance, data integrity
2. Use digital information to align people, process, systems, teams, and organizations
   - Growth, speed, responsiveness
3. Use Machine Learning to identify patterns, risks, and to uncover best practices
   - Predict and manage outcomes



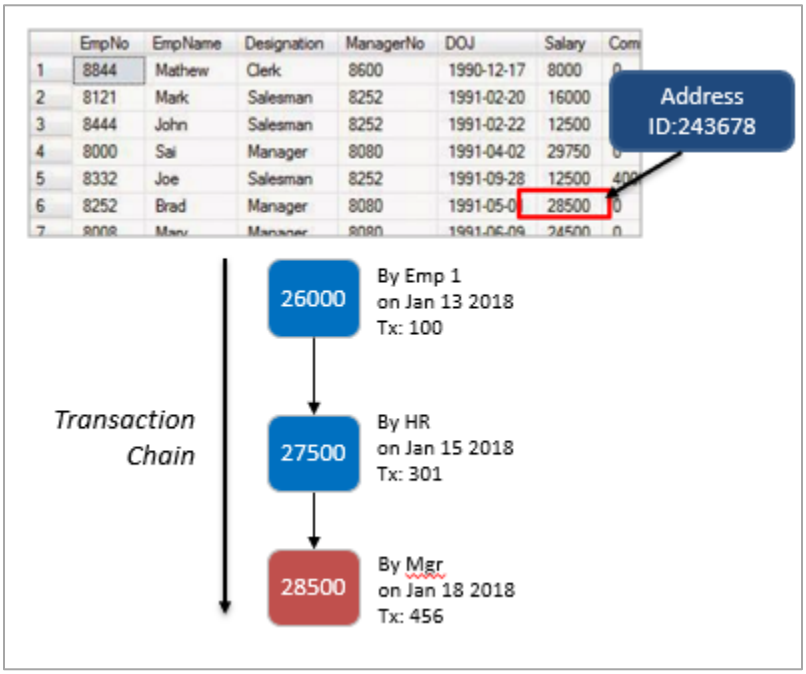
Address Value Transaction Chains

The Boardwalktech Digital Ledger (Boardwalk) imagines the world of information to be made up of immutable addresses. The addresses are the atomic elements of this data organization.

Boardwalk allows users to work with information at its natural granularity, not constrained by concepts such as records, objects, documents or files. Each information is unique in the Boardwalk ecosystem and can be directly referenced, irrespective of whether it constitutes a larger piece of information.

Example of information managed by a digital ledger - “Salary for Brad”:

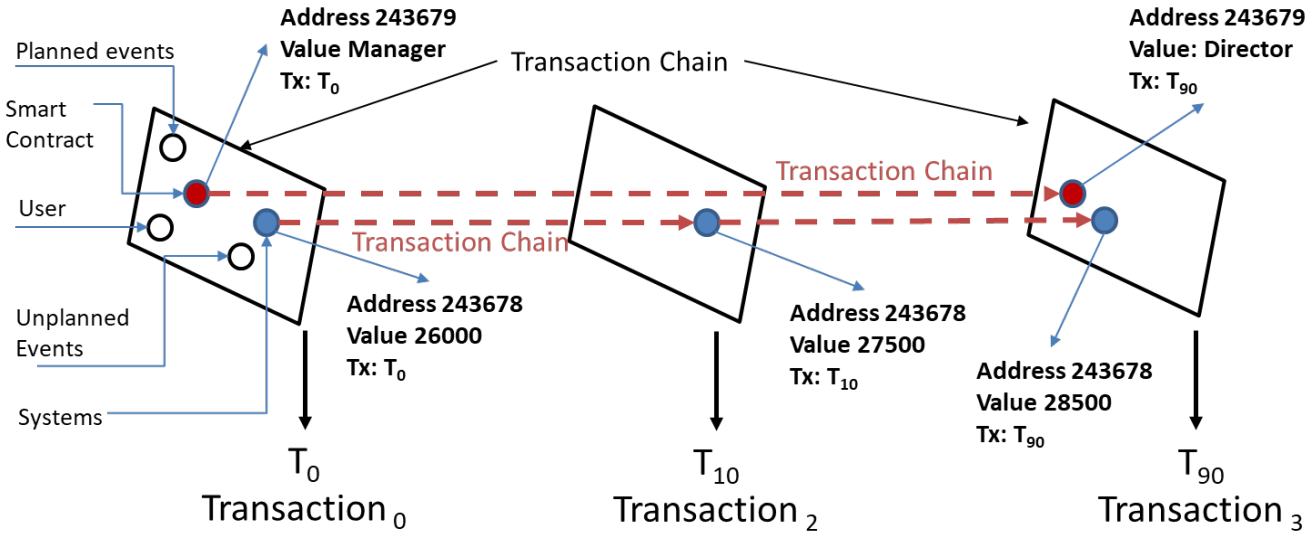
- “Salary for Brad” is assigned an address 243678 with a genesis block with value 26000
- The address 243678 is the atomic element of this data organization
- The addresses are linked to values with immutable transaction identifiers
- The transaction identifiers contain the timestamp and the user who created the link between the value and the address
- These transactions are chained together



Boardwalk can trace the evolution of information as it treats each change in data as a transaction. Since information is recorded at its atomic level, every manipulation gets recorded. This allows not just a review of changes, but also revert and referencing information by time.

Example of Transaction Chaining information managed by a digital ledger application - “Salary for Brad”:

We can see that the “Salary for Brad” was modified to 27500 and then to 28500, which is the current/ final value at this address. Boardwalk can answer questions such as “How did Brad’s salary change in the last 6 months” or what was the salary for Brad before he was a Director?



As shown above, Boardwalk chains the transactions.

This has a huge advantage over other implementations which leave the tracking of the individual values to the enterprise application

The key advantages that are derivable out of Transaction Chaining are:

- Immutable address, accessible, embeddable anywhere in the enterprise
- Speed and efficiency and high-speed collaboration between partners
- Out of the box tracking of individual information over a period and across transactions
    - For an HR data set, it can infer "How did Bard's Salary change in the last six months?"
- Sequencing of the information with respect to other information
    - How did Brad's salary change with respect to his title?
- Out of the box learnings and intelligence of the value change trends of individual information
    - How did the salaries change in Engineering versus Support in the last three months?

Transaction Identifiers

A new value enters the Boardwalk Digital Ledger by creating a new link between the value and a new address or an existing address. The link is marked by a transaction identifier. The transaction identifier contains the time, the identity, and the reason for the link. The transaction identifier provides a way to group all the address-value links that were "deemed" to be created at the same time.

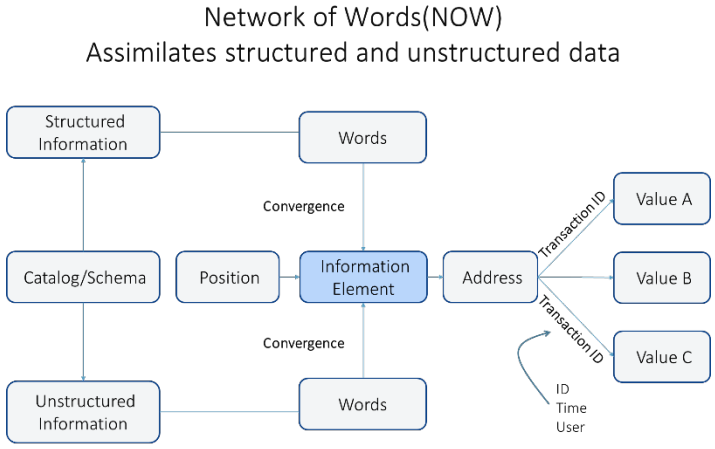
The transaction identifiers are lined up in an ascending sequence that allows an easy way to compare the transactions and consequently the links that were associated with those transactions. This allows the ability to look at the information as:

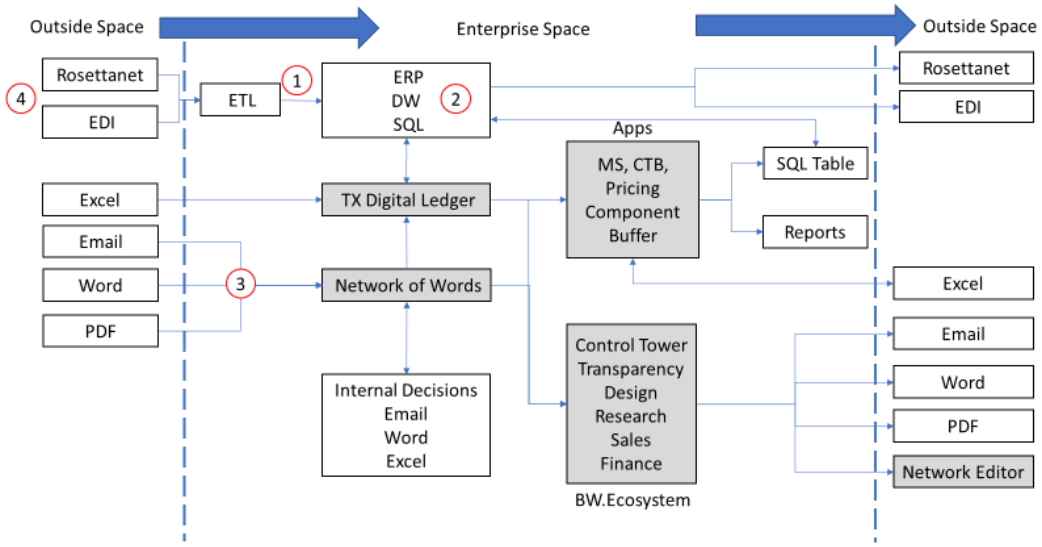
- Links created as of a specified transaction
- Links that were created between two specified transactions
- Links that were created before a specified transaction
- Links that were created after a specified transaction

This provides a powerful way to branch the information into multiple branches and reconcile them to a single value, as necessary.

Converging Structured and Unstructured information using NOW (Network of Words)

We showed how the value element, a **"word"** from a SQL table or an Excel sheet can be stored in the information element and data management techniques can be applied to track changes over time.
Similarly, information elements from unstructured content such as word, pdf, video, social media postings, audio files can be reduced to its smallest value, a **"word"** and can be managed similar to a word from a SQL table. Thus, by storing the words from both structured and unstructured words in the same data management architecture we are able to correlate a word from both worlds, thereby creating a network of words. We call this technology **NOW**.





		Current Technology	Digital Ledger	BW.Ecosystem	Boardwalk Advantage
1	ETL	Rigid Loss of information	Flexible Data Model No Data Updates Timestamped inserts		• Clean Data • Accuracy • Transparency • Ripple Effect • Correlation • Collaborative • Trust Factor • Reports • Time to Market • Reduced effort
2	ERP/SQL/DW	Lack of Provenance	Provenance/Traceability		
3	EXCEL	No support Loss of internal decisions	Collaboration Integration Reports		
	PDF, WORD, EMAIL	No support Lack of correlation, communication		Collaboration Correlation Provenance/Traceability Reports	
4	EDI/ROSETTANET	Loss of smaller suppliers	100% coverage	Correlation Provenance/Traceability	

By introducing the NOW technology, the BW.Ecosystem of products can deliver highly competitive advantages to the business enterprise.

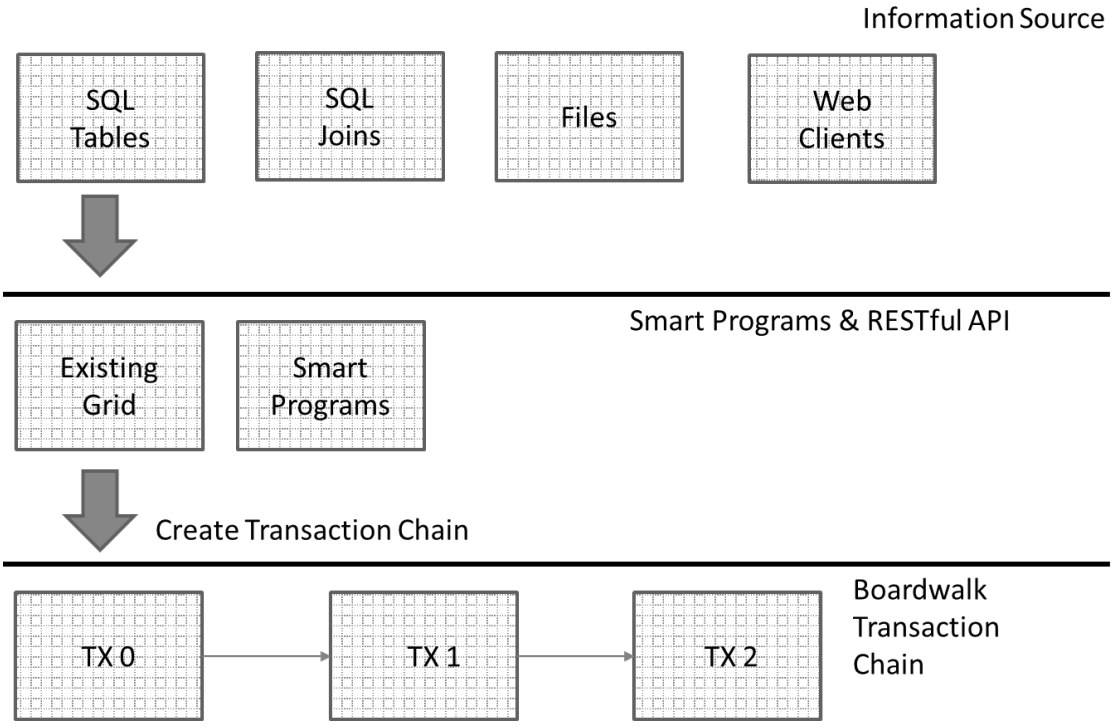
Grid-Based Transaction Chains

Typical enterprise applications either chain file-level transactions or provide a key/value ledger and expect the developer to build a full application stack. This is very expensive and is like building a new application from scratch.

Boardwalk has a unique patented solution to this problem.

Boardwalk Address Values can be arranged in a Grid structure to provide application semantics/logic and rapid deployment of the digital ledger applications.

Much of the enterprise information exists and is used or viewed in Grids. Existing information can be used to create Grid Enterprise Applications.



Once the Grid has been imported into the Boardwalk Digital Ledger, the information stored in the Grid gets the following facilities out of the box:

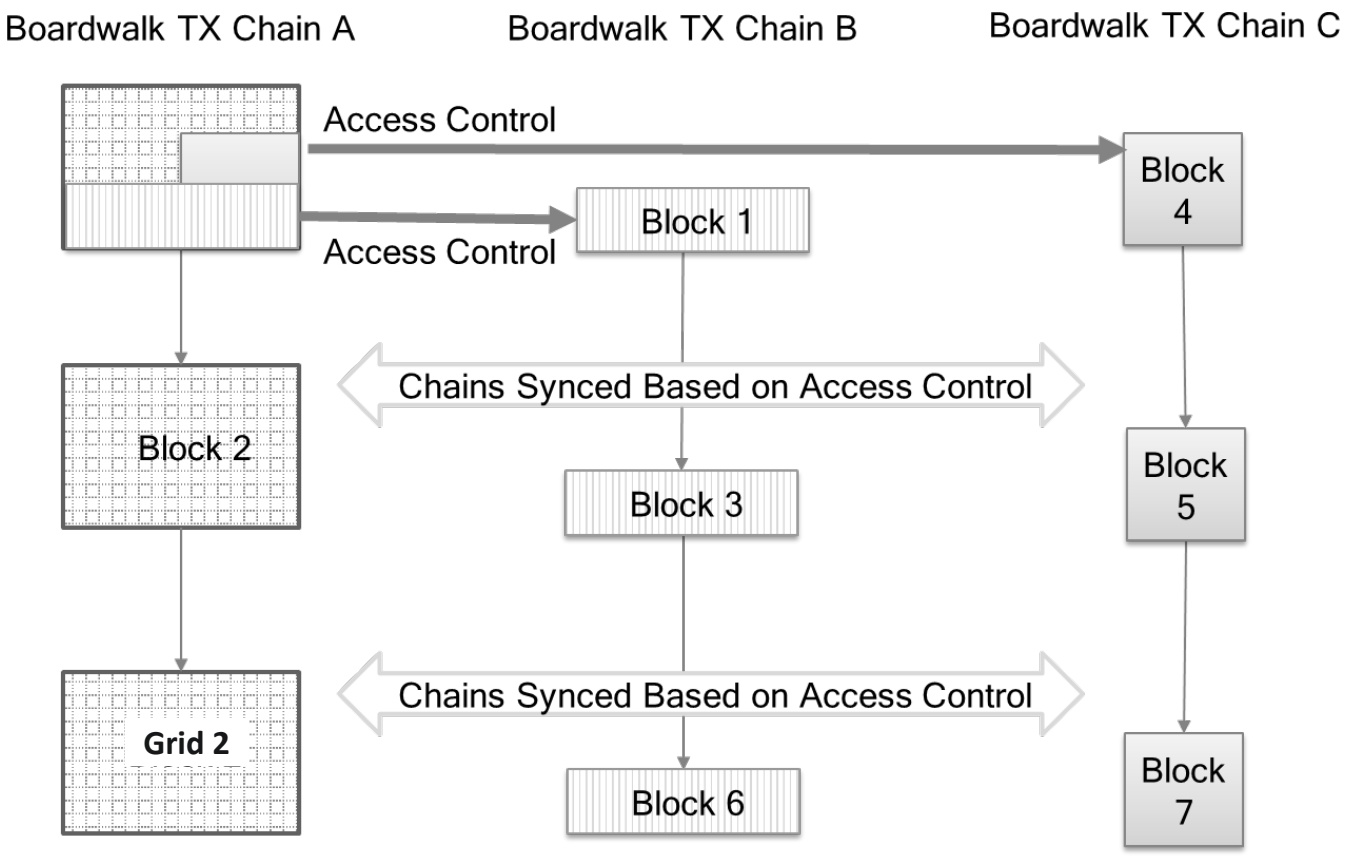
- Address/Tx Chains
- Provenance
- Persistence
- Access Control
- Alignment and Collaboration
- Integration
- API's
- UI Editors

Non-Grid interfaces

All Boardwalk Digital Ledgers are available via Restful APIs and client libraries in multiple programming languages. Developers can build custom web apps on top of the Boardwalk Grids that suit their application requirements to create web apps or mobile apps.

Access Control

Boardwalk defines access control on Grid Applications. Access control definitions control the section of the Grid Enterprise Application (specific sets of rows and columns) that a person or system will have access to. This allows for concurrent evolution and secure access to sections of the Grid by different roles, groups, and organizations.



The access control can define the Grid sections and these sections can be synchronized with different nodes. The enterprise can also control the features and functions available at each node to edit or access the Grid. For example, as shown in the previous diagram, different sections of the Grid can be given access concurrently to multiple participants.

A further example; one node may just have read access to a Grid section while another node can see 10 columns but edit only 6 of them for a specific set of rows. This means very fine-grained control can be applied such that complex information-sharing scenarios can be set up using the Smart Contract Designer.

> Concurrent access and evolution of the same digital address is possible in Boardwalk due to the granularity at which information is synchronized.

Immutability

Boardwalk Digital Ledger stores all new information as new chains. All new events result in new inserts in the storage. Thus, in the Boardwalk Digital Ledger and unlike flat storage technologies, new changes never overwrite old information. This naturally supports the immutability of information that can be trusted and verified

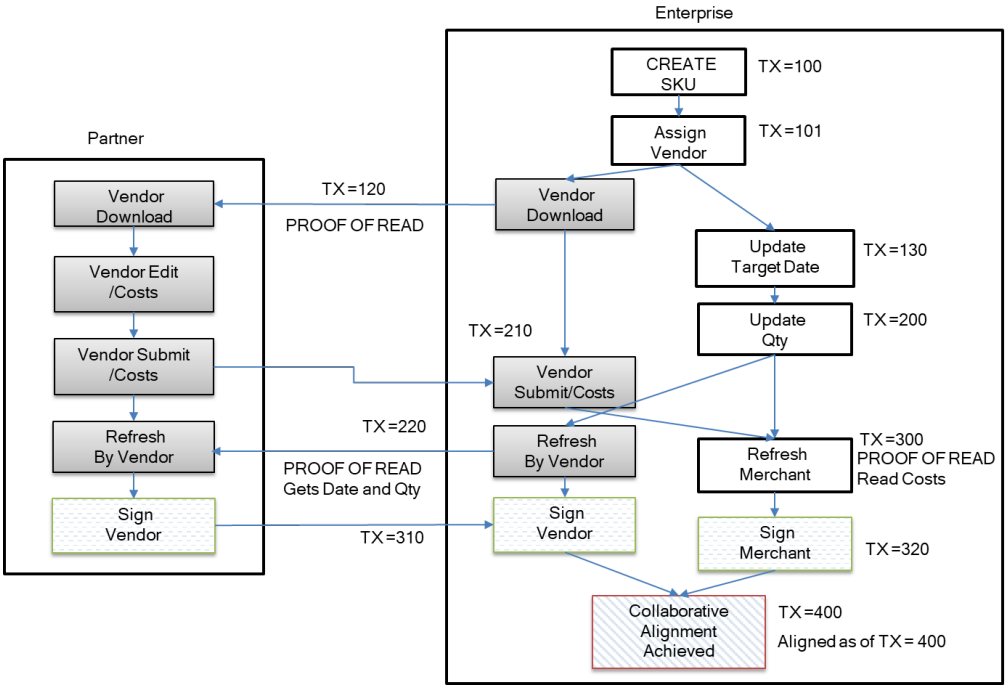
using a Boardwalk Digital Ledger based transaction chain capability that provides complete verification and trust capabilities.

Workflow and Alignment

Enterprises see tremendous value in building trust in the information and proving provenance but unless all the parties are aligned on the information in the application, the application is of no use. Thus, getting rapid alignment on information and decisions is key to maintaining supply chain inertia and reducing misalignment and friction between parties.

Collaborative Alignment

- Multiple participants can evolve these transaction chains in complete isolation, for example, a merchant can edit the date and qty of the PO while the disconnected vendor concurrently changes the costs.
- This is a key to success in enterprise application deployments because constant sync enforced by other enterprise technologies does not allow for participants to work through their response in isolation.



- This is possible only with Boardwalk as Boardwalk supports address information level organized in transaction chains. Once the partner is ready then the chains synchronize between these nodes. This allows for rapid data evolution, collection, and alignment.
- Once the teams come into alignment, they can either approve the changes or sign the agreement and mark it with the transaction id of the agreement.

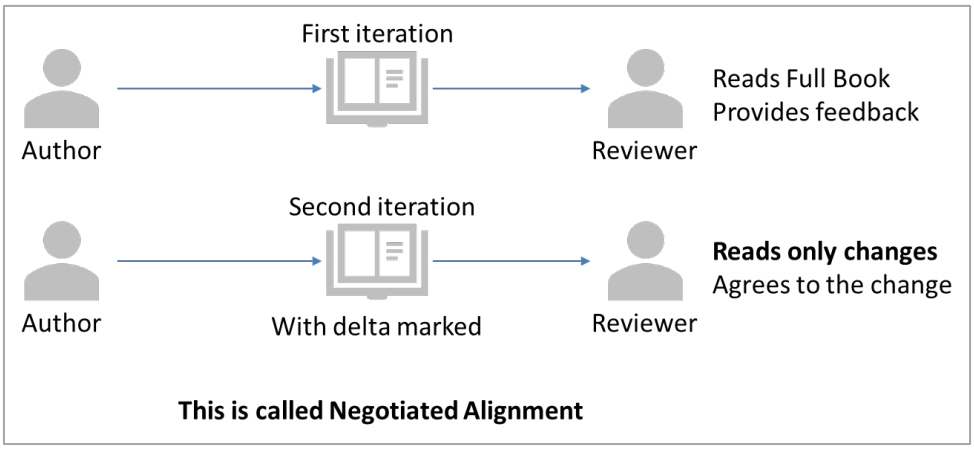
Boardwalk Digital Ledgers can run in an isolated or disconnected mode for large periods of time and thus fits well into current work practices within and outside the enterprise.

This is called collaborative alignment. This typically reduces a 4-week process cycle iteration to a 1-week (or less) iteration.

Negotiated and Programmatic Alignment

Boardwalk Digital Ledgers allow for rapid collaborative alignment enabled by concurrent evolution and on-demand synchronization of changed Grids. Boardwalk brings further efficiency by allowing for a negotiated alignment.

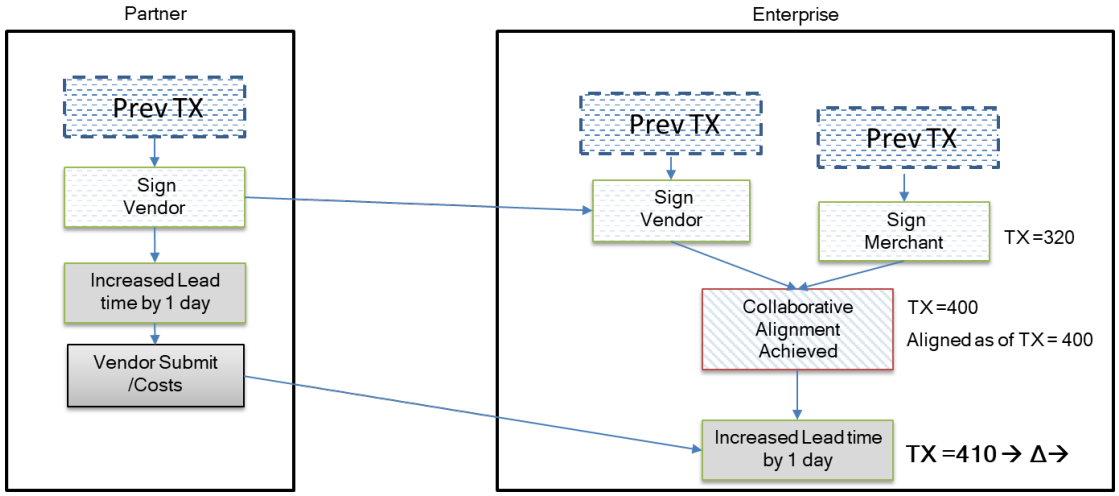
To illustrate this concept, let us look at the process of a book review between the author and the reviewer.



Here the ability to see the delta change during the second iteration allows the reviewer to quickly come into alignment with the author.

This is key to process speed and efficiency.

With a Boardwalk Digital Ledger, the delta enables the reviewer to see if the change is insignificant for a quick negotiated or programmatically automated alignment, or large enough to require a collaborative re-alignment.



Continuing our supply chain example from earlier, the Address Transaction Chain captures changes at the granularity of each value. This immediately tells us that the lead time change is insignificant, and the teams come back into alignment.

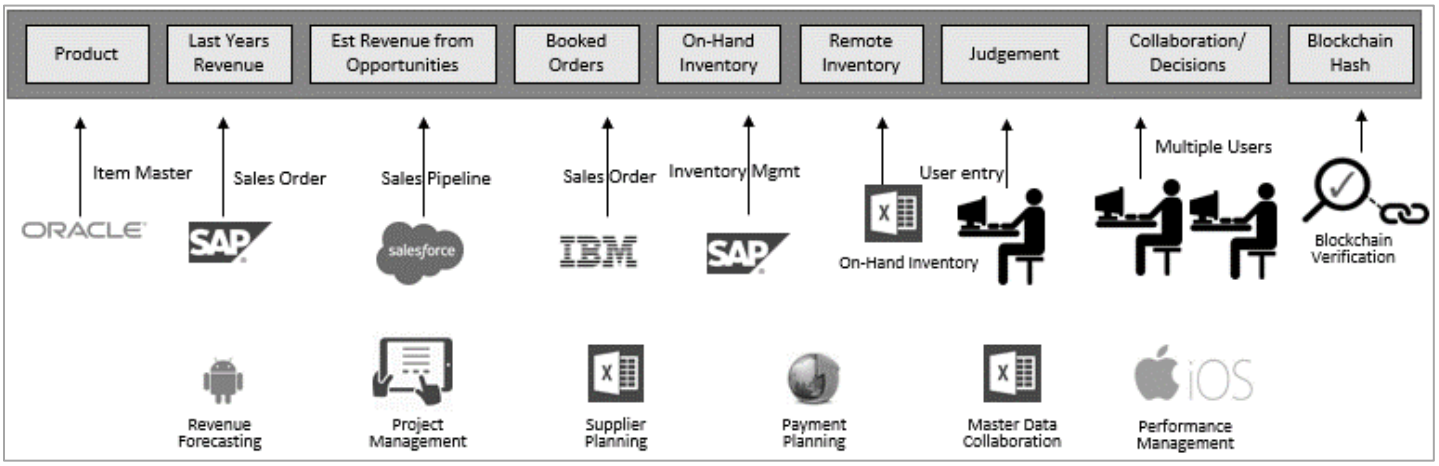
Boardwalk Digital Ledger supports Negotiated or Quantitative alignment out of the box due to the patented Transaction Chaining technology.

Consensus and Approval

Boardwalk Digital Ledgers achieve consensus by approval workflow that uses the alignment functions and reports to highlight the changes made or not made since the agreement was reached. Boardwalk can execute multiple approval workflows to get either serial or parallel approvals on the data.

System Alignment and Integration

Integration aligns Boardwalk Digital Ledger with enterprise systems and plugs into the SOA architecture.



Extract-Transform-Load-SuperMerge

Boardwalk supports an ETL based integration that maps normalized data models like SQL or tabular files into Enterprise Application Grid Models. This allows for integration into systems such as ERP and Data Warehouses. Boardwalk integration is completely configuration driven and needs no programming support.

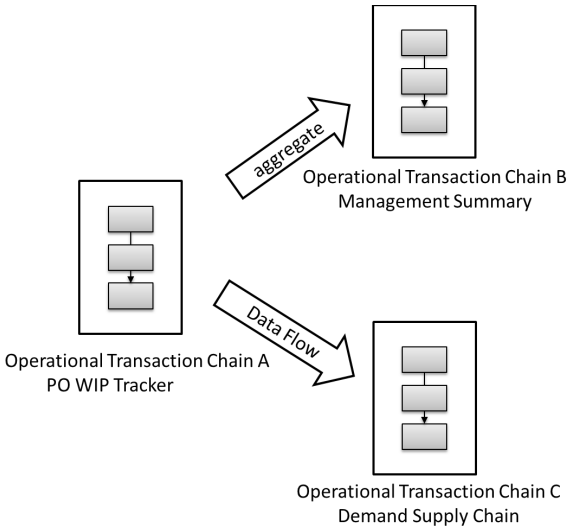
Restful API's

Boardwalk supports Restful APIs with client libraries available in Java, JS, Python, etc. This allows for SOA based integration and development of custom web applications on Boardwalk.

Data Flows Between Enterprise Applications

Boardwalk can setup data flows between enterprise applications.

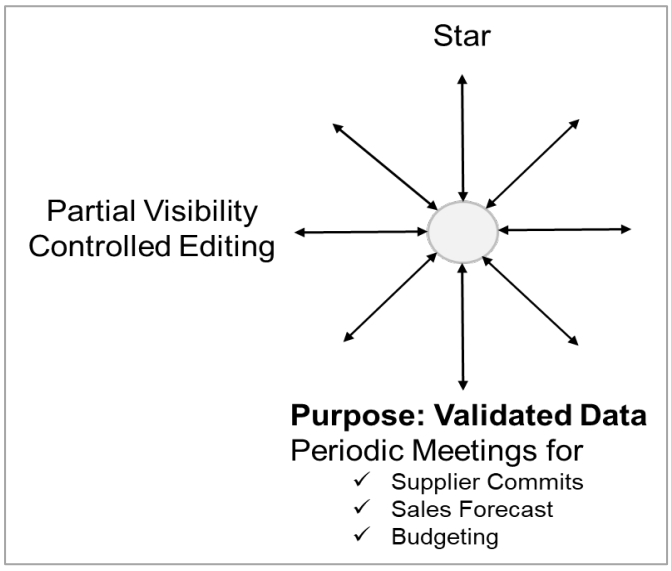
For example, the PO WIP details application may aggregate to the management summary application.



The PO WIP can be pushed selectively to a downstream application that manages demand and supply or forecast changes at a family level which can then be disaggregated proportionally to the contributing items.

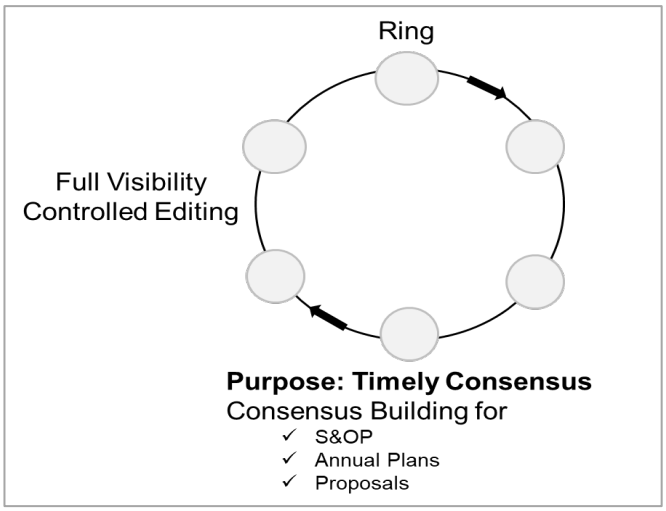
Business Process Configurations

Boardwalk Digital Ledgers support Star and Ring business process configurations.



STAR CONFIGURATION:
It allows a central authority to collect inputs from their teams. The central authority will typically allow partial views of the information to each of the teams.

The central authority then will iterate back and forth with each of the nodes to get an eventual alignment of their goals with all the teams.



RING CONFIGURATION:
Typically allows full visibility of all information to all the nodes participating in the process.

The control to edit the data may be passed along the ring as a token.

The nodes around the ring may be given control to edit different grid sections or different grids. The control will then move through the in an iterative manner to get an eventual alignment of their goals with all the teams.

Complex configuration patterns can be created using Star and Ring configurations by interconnecting them in a variety of ways

Decentralization

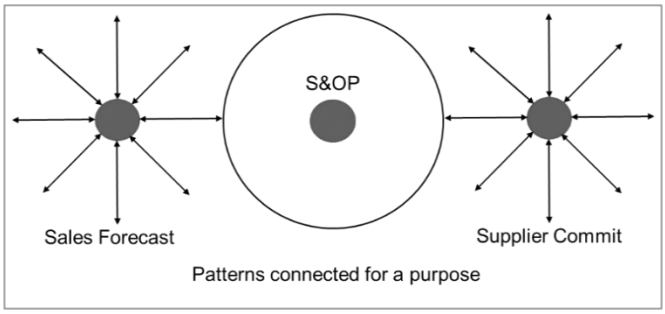
Decentralization is typically adopted in currency management because there is:

- Lack of trust
- Open internet deployment
- No security investment
- No stakeholders
- No investment
- Motivate miners
- No need for access control

None of these are factors for the enterprise process deployments

Boardwalk Digital Ledger offers a practical, common-sense solution for enterprise applications:

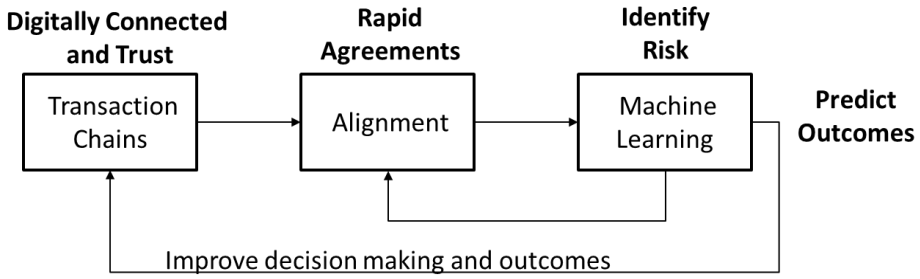
- The enterprise will act as the controlling authority making an investment into the cloud hardware, software, and security.



- The enterprise will set up access control and invite multiple parties to participate in the process to take advantage of the ability to
  - Capture all events and sequence them
  - Gain trust and immutability
  - Rapid alignment
  - Draw learnings and inferences in order to continually improve the process
- Invited participants can download a lightweight Boardwalk Virtual Machine that runs on their laptops or tablets and connect into the Boardwalk Digital Ledger without their IT involvement.
- Partners can start the VM and download only the section of the chain they have access to and start participating in the process

Machine Learning and Artificial Intelligence

With information history captured in transaction chains organized in Grids, using sophisticated access control, isolation and process-workflow configurations, information collected in the Boardwalk Digital Ledger can lend itself to advanced Machine Learning and Artificial Intelligence algorithms to create predictive models.



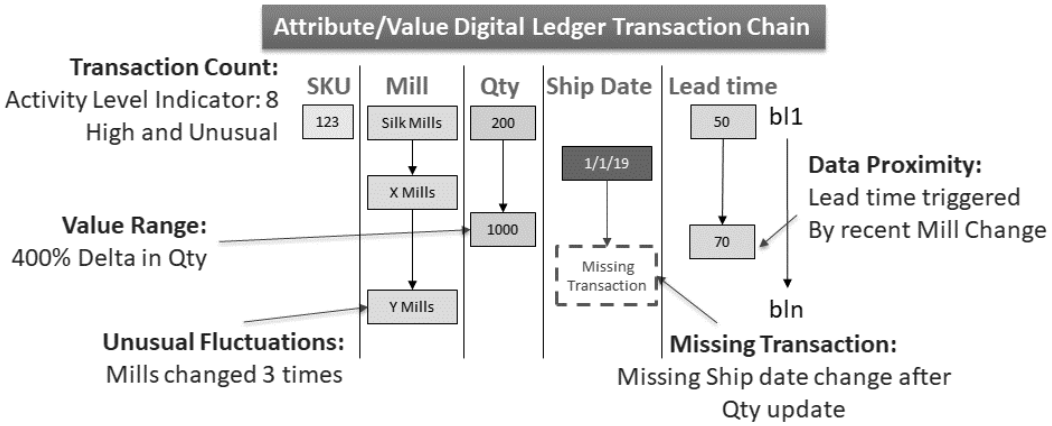
Each transaction chain is perceived as a series of change events that transition the state of enterprise information.

These change events indicate event provenance and proximity amongst other things.

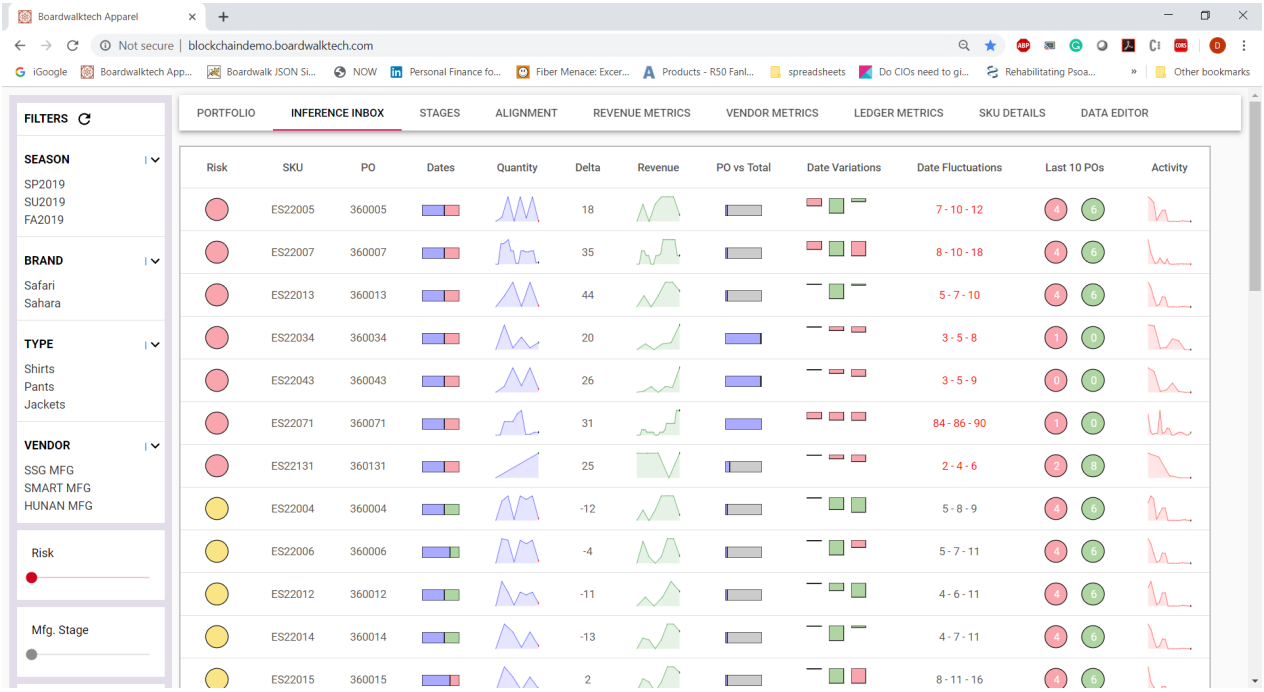
Predictive Learning & Chain Intelligence

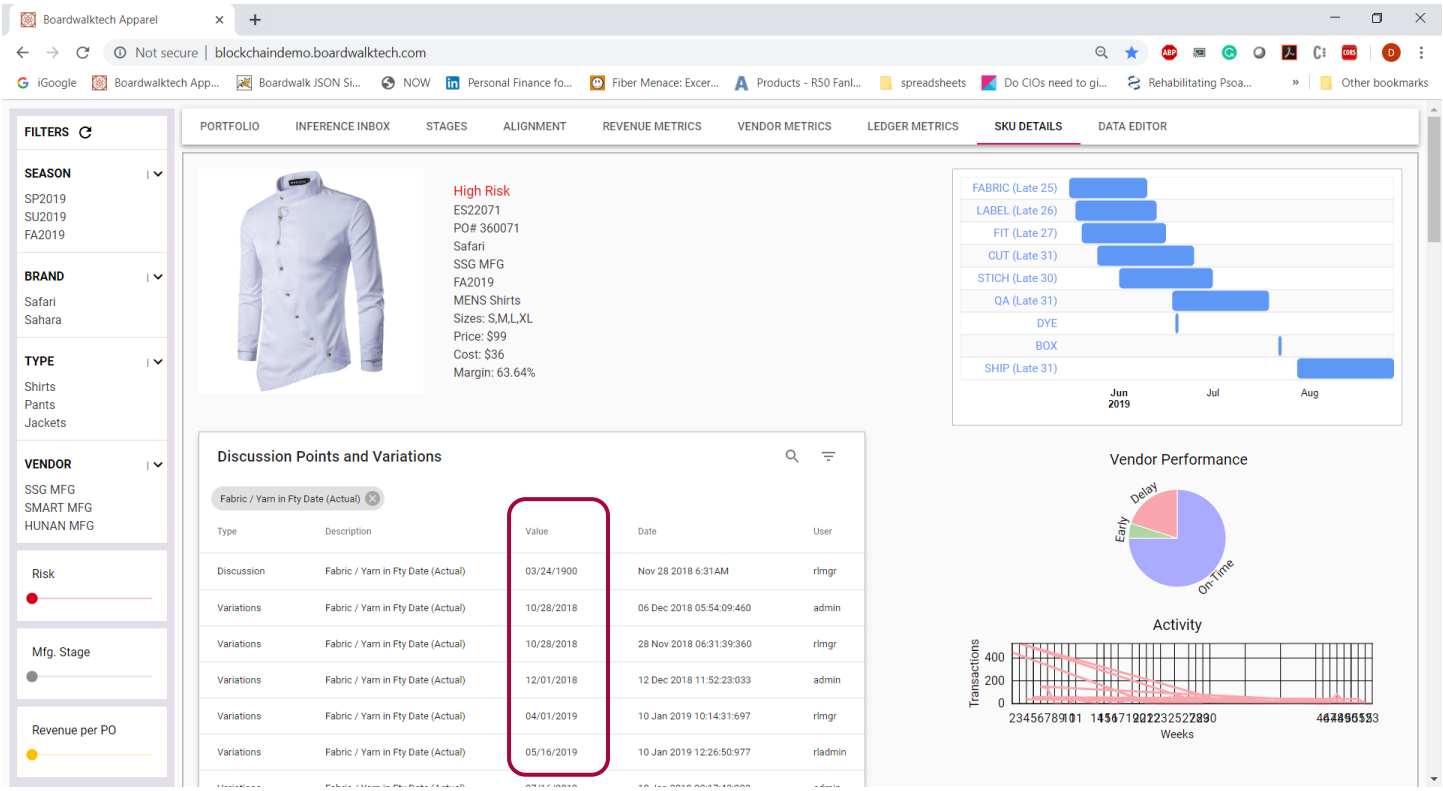
These Transaction Chains can be fed into Machine Learning neural networks and chain intelligence crawlers to identify predictive analytics and identify patterns and risks and uncover best practices from the operational digital ledger applications.

For example, when a supply chain intelligence crawler is applied to a transaction chain events, it can identify high-risk information based on activity level, fluctuations, value spectrums, event proximity, and missing data events.

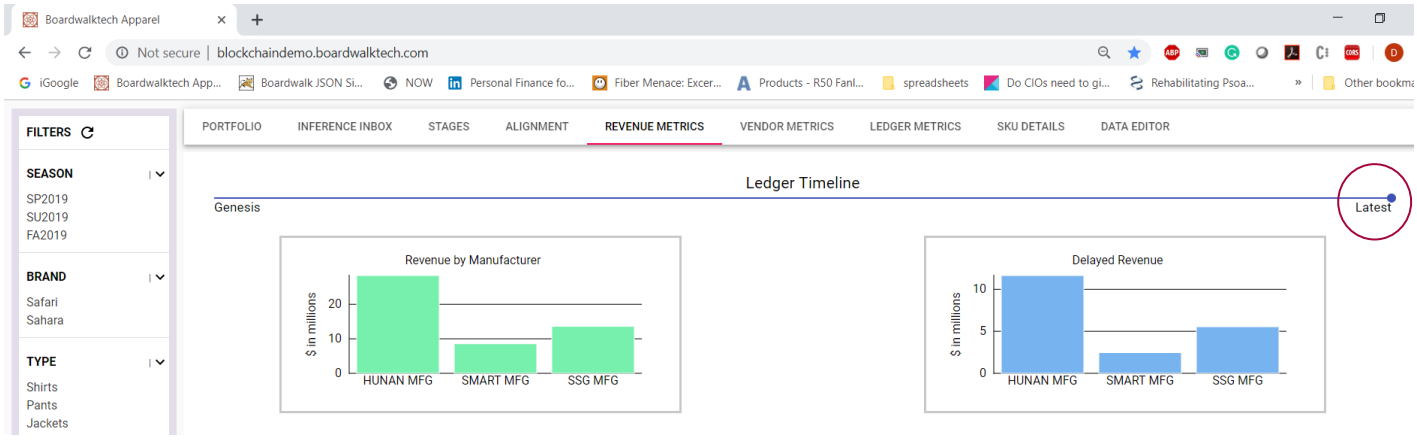


These inferences can then be delivered to business executives to identify high-risk outcomes so corrective action can be taken right away to address the issues.

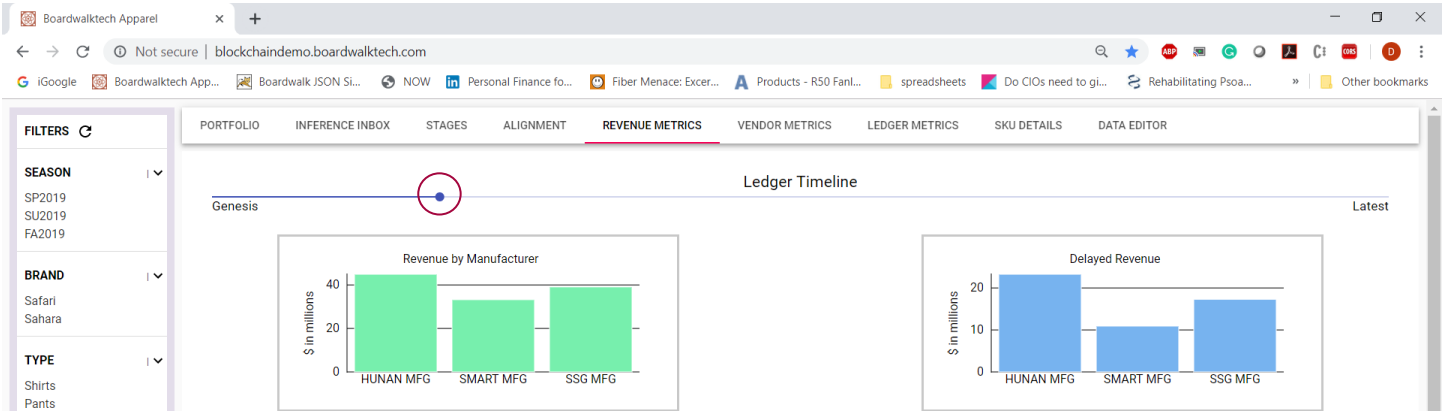




Latest Revenue By Manufacturer



Older Snapshot



Digital Ledger Enterprise Application Designer

Boardwalk supplies an Application Designer that can enable a business analyst to configure Grid Applications, approval models, access control, roles and responsibilities, and workflow logic.

Virtual Machines

All parties involved in the Boardwalk Digital Ledger application can download a lightweight virtual machine to start interacting with the Boardwalk Digital Ledger. These lightweight virtual machines can run in the desktop environment in Excel or in the Web browser or in multiple language environments like Java or Python.

> This allows for partners to engage with the Boardwalk Digital Ledger without downloading a full-fledged node that is expensive and time-consuming to set up and run.

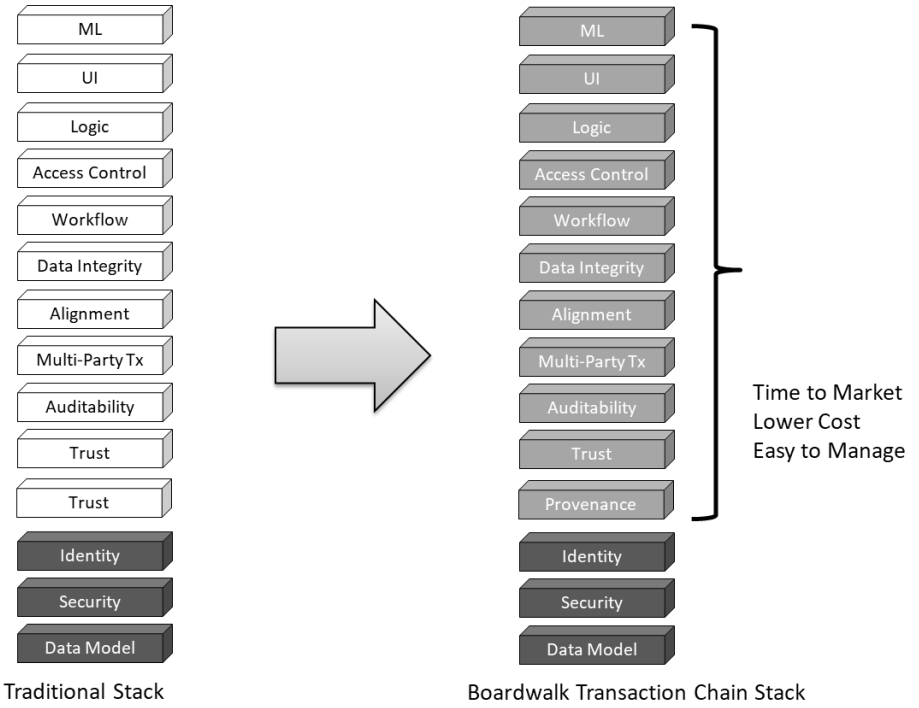
Boardwalk Digital Ledger can sync to a remote Virtual Machine depending on the configured access control. User groups connected to this Virtual Machine can evolve these chains in complete isolation. As data evolves in different nodes, they can later be brought together for a merge to create the complete picture.

Boardwalk Digital Ledger Stack

Enterprise Applications are pushing more and more functionality into the stack so enterprises can focus on their core competencies. The Boardwalk Digital Ledger takes a step further by pushing the following aspects into the stack.

- Alignment
- Multi-Party transaction integrity
- Workflow
- Access Control
- Functional Logic
- UI (Desktop/Browser/IOS)
- Machine Learning/Inferences

This results in faster time to market, the lowest total cost of ownership (TCO), faster adoption, and faster change to new market conditions.

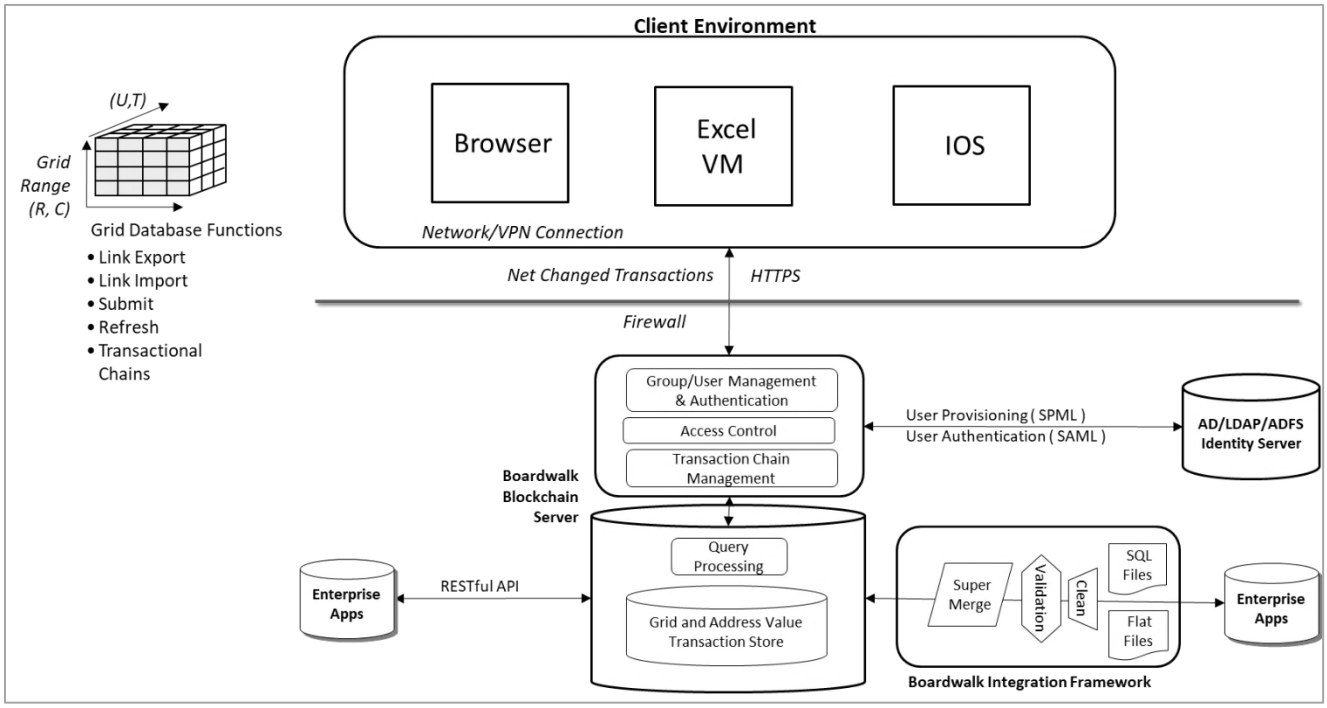


Deployment Architecture

The Boardwalk Digital Ledger server is deployed in a secure private environment in the cloud or behind the enterprise security system.

The Boardwalk client virtual machines running the browser, desktop or in IOS memory and can connect and participate in the Boardwalk Digital Ledger without a full-scale node deployment.

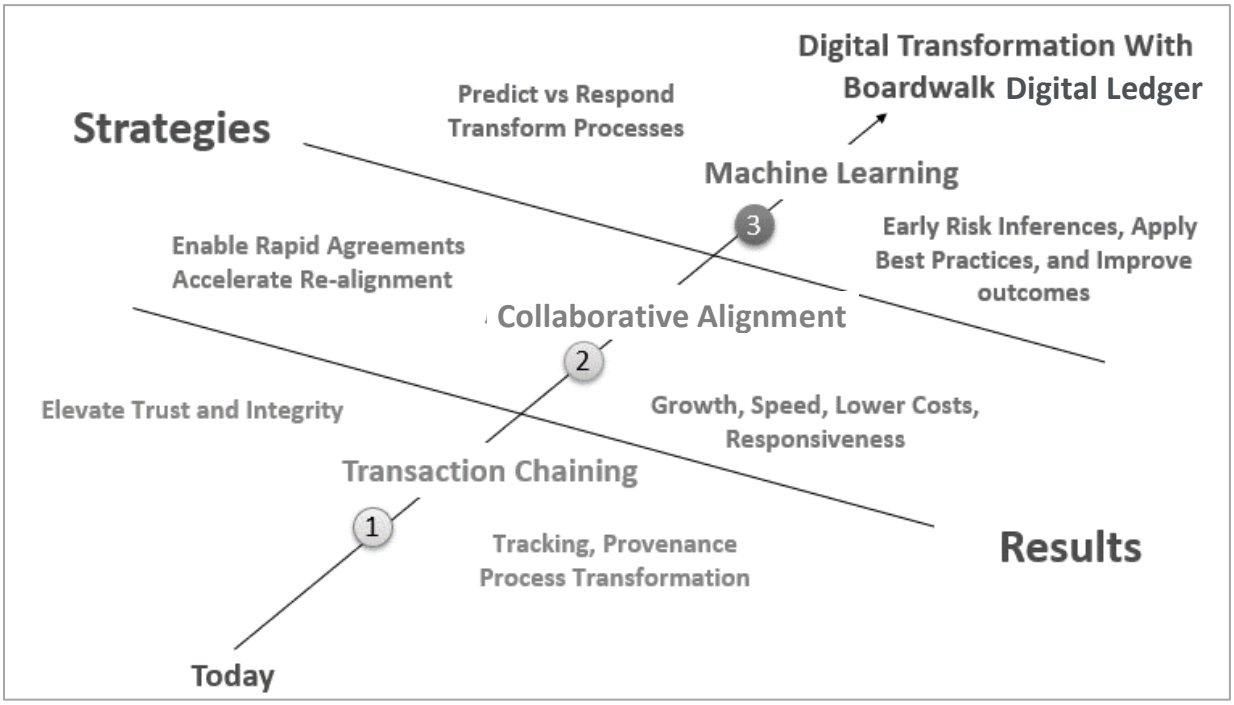
The Boardwalk Digital Ledger server authenticates and authorizes the user against enterprise identity management systems and builds on top of the enterprise investment in network and access security.



External systems and applications can integrate with Boardwalk using the SuperMerge ETL engine or using the RESTful APIs.

Summary

The Boardwalk Enterprise Digital Ledger's three-pronged strategy to adopt digital ledger technology in the enterprise embraces the strategy that Digital Transformation and digital ledger go hand-in-hand.



For an enterprise to effectively deploy digital ledger technology as an application platform for elevating the trust of multi-party information exchanges, it must provide the following key capabilities:

1. Capture Digital Information using Transaction Chains
    - Elevate trust, provenance, data integrity
2. Use Digital information to align people, processes, systems, teams, and organizations.
    - Growth, speed, responsiveness
3. Use Machine Learning to identify risks, best practices
    - Predict and manage outcomes

The Boardwalk Enterprise digital ledger solution leverages 10 years of proven enterprise technology deployments.

Boardwalktech is a leader in enterprise digital ledger applications and has a patented transaction chaining technology developed in 2004. Boardwalktech has deployed its core digital ledger in active production deployments at customers such as Coca-Cola, On-Semi, Levi's Strauss, and PricewaterhouseCoopers.

Appendix

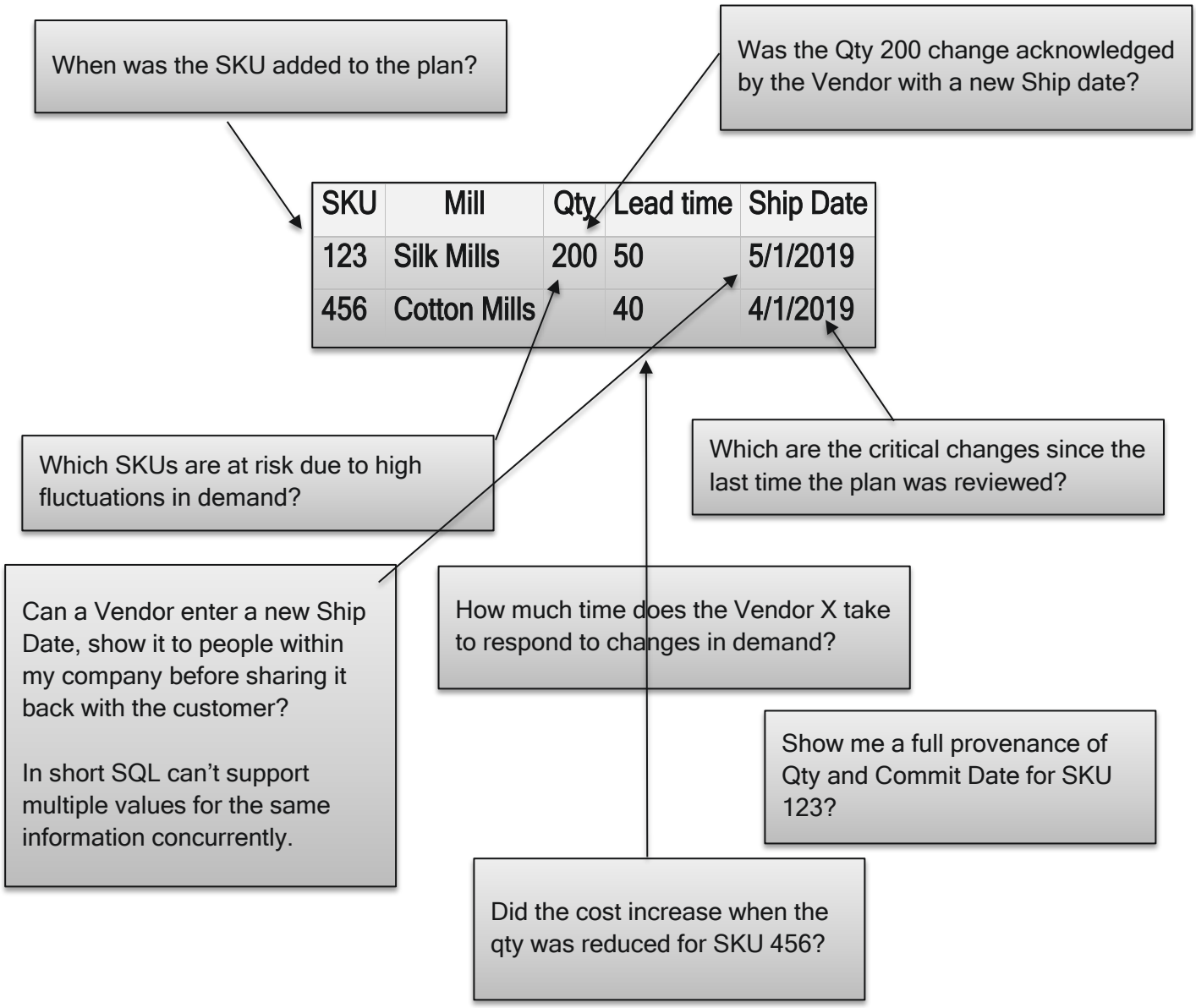
SQL

A database, especially a relational database system, is the dominant SQL technology for maintaining enterprise information. Point solutions, ERP systems, and custom applications all store data in databases.

It is important to understand the fundamental limitations of SQL on how it can manage digital information.

Loss of Provenance	No sequence of changes is available, only the latest value is stored
Lack of Trust	Does not keep a digital signature of transactions authenticating the source
Serialized updates	Maintains the data at a tuple level, resulting in serialized updates or locking
Lack of multiple states	Information that exists in multiple states evolved over time or even concurrently. Databases can retain only one state of the information.
Lack of addressability	In SQL values can be located only using expensive query operations affecting the availability of information in a digitally connected enterprise
Information is lost in translation	There is a loss of translation between business requirements and the IT solution. Once the solution is deployed, further changing business requirements are even harder to accommodate and the distance between the process and solution increases.

Here are some of the key business questions which can't be answered by SQL



All these limitations in technology like SQL are seriously impacting the ability of the enterprise to function in a competitive environment.

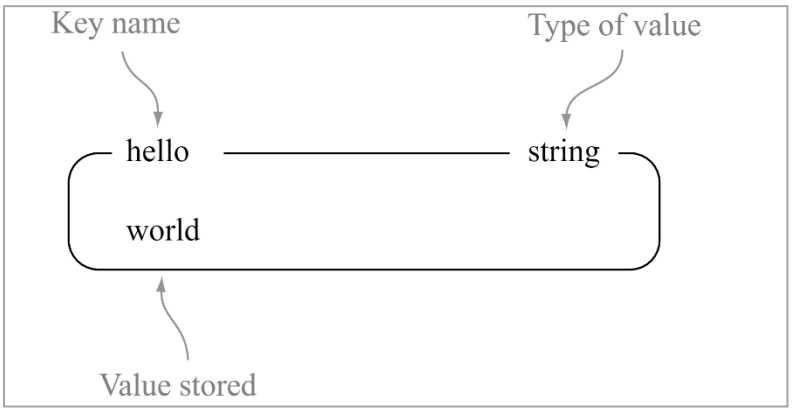
Unless the core information management systems are rich enough to manage the true time-based and event-related nature of enterprise information, it will limit the ability of the enterprise to be a disruptive agile force in the marketplace.

Key/Value or Document Databases (Mongo dB./Redis)

Key/Value Databases store a value or a list of values against a key and use data structures like hash, lists, or simple key/values to store information.

These models are flat storage models like SQL and store no time or transaction-level information and do not chain the values for a key as it changes.

For example, let us consider Redis, one of the most highly used NO-SQL databases.



The code below sets the value of a key “hello” first to “world” and then to “universe”. But when the value of “hello” is fetched there is no way to get the value “world”. That value is overwritten when the value was set to the “universe”.

```
$Redis> set hello world

$Redis> get hello world

$Redis> set hello universe

$Redis> get hello universe
```

The values are tied to key names and when keys themselves change, the storage model suddenly needs refactoring. The reality of data modeling is that primary keys are in flux, 30 years ago SSN was a great key for a user object but fast forward to today and not everyone has an SSN. Therefore, it is important to assign a digital address independent of the semantics for storing a value.

In summary, the key/value databases do not have the following fundamental notions:

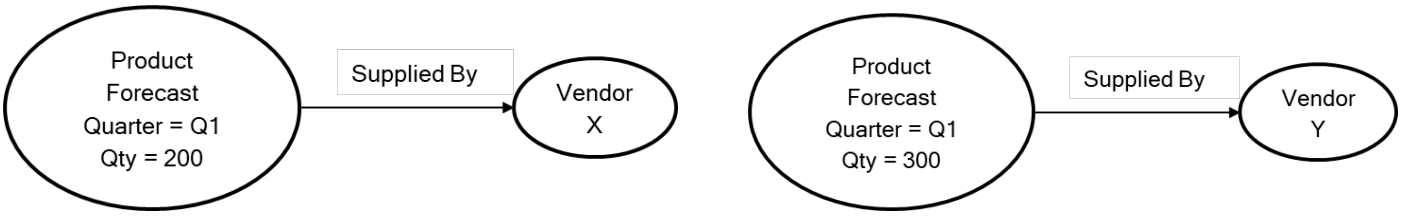
1. A unique address for values
2. The notion of transactions to capture time, user
3. Sequencing of changes to capture change events
4. Transaction chaining
5. Transaction Blocks

This shows that key/value No-SQL databases are not designed to store digital information.

Graph Db

Graph Databases like Neo4j are being used for specialized applications. Graph databases work on the notion of Nodes that store object attributes and edges that express relationships.

For example, the first node below captures the Product Forecast for Q1 with a value of 200. This product forecast is committed by Vendor X.



Initial State Changed State

Every time the value for Quarter changes or the Qty changes, the values are overwritten just like other flat storage systems. If the Vendor changes from X to Y, then the old relationship to Vendor X is overwritten and lost.

In summary, graph databases do not have the following fundamental notions:

- The notion of transactions to capture time, user
- Sequencing of changes to capture change events
- Transaction chaining
- Transaction Blocks

This shows that NO-SQL Graph databases are not designed to store digital information.