The Internet of Trusted Things
Blockchain as the Foundation for Autonomous Products & Ecosystem Services

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Includes input from 13 industry leaders

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From wearables to wind turbines, the application of sensors on the ‘things’ around us has become ubiquitous. With a projected 10 billion more devices coming online in the next 4 years and some 44ZB of data flowing from them, such an internet of intercommunicating objects requires a secure and efficient way to track the identities, interactions, transactions, and activities of every “thing” in the network.¹ Business and innovation leaders may be connecting their products, but most still struggle with service-based business models. The shift from material-based economies to information-based economies means value is now defined by how an entire ecosystem of constituents integrates, protects, and leverages product data contextually.

Yet, there is no universally shared architecture to interconnect, nevermind authenticate or monetize distributed machines.

Meanwhile, a recent advancement in record-keeping technology, known widely as blockchain, introduces intriguing solutions.² This Kaleido Insights report analyzes the enterprise opportunities for blockchain-IoT convergence supporting trusted machine identity, interactions, and transactions. Our research finds that, if developed for scale, blockchain (often generalized as ‘distributed ledger technologies’ (DLT)) could offer IoT a level of interoperability, transparency, and security currently absent from today’s architectures, but essential to ecosystem-driven business models and autonomous products and services.
Both IoT and blockchain are still early-stage technologies. Kaleido Insights defines these technology megatrends as follows:

The Internet of Things (IoT) is the interconnectivity of the digital and physical worlds, wherein embedded sensors connect and integrate ‘things’ - objects, animals, plants, people, devices, machines, infrastructure, and environments - to information networks. Interconnectivity between these things digitizes new context (e.g. position) and can generate new value constructs (e.g. location-based services).

Distributed Ledger Technology, (e.g. Blockchain) is an advancement in record keeping in which transactions, authentications, and interactions are recorded across, and verified by the network rather than a single central authority. Some have called blockchain a technological and mathematical breakthrough because it is the first time in history humans have developed a system to reliably coordinate action among many parties without having any central authority.

Although blockchain is used more frequently than (but often synonymously with) DLT, blockchains are but one type of distributed consensus data structure. This report will use blockchain and DLT interchangeably, but acknowledges the lack of global consensus in the market.

Both IoT and DLT tease radical new approaches to traditional business operations and monetization models. Both also suffer from a range of shared challenges and market dynamics.

**FIGURE 1  IoT AND BLOCKCHAIN FACE COMMON CHALLENGES AND MARKET DYNAMICS**

<table>
<thead>
<tr>
<th>Emerging technology markets</th>
<th>IoT is a more mature market than blockchain, but remains highly fragmented. Blockchain primarily POCs and pilots, few at-scale implementations; Lack of consensus in definition, architectures, etc.; Bifurcated vendor landscapes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of standards hampers security</td>
<td>Few or no universal standards for device authentication or authorization, platform configurations involving multi-tenancy, IoT security</td>
</tr>
<tr>
<td>Lack of interoperability exacerbates fragmentation</td>
<td>Poor interoperability across devices, connectivity protocol, networks; across chains, and other areas limit adoption, security, utility</td>
</tr>
<tr>
<td>Impediments to high scale data processing</td>
<td>Cloud-based architectures insufficient for many applications; Connectivity, data processing, analytics, (and associated costs) still hinder reliability, security, and adoption</td>
</tr>
<tr>
<td>Costly deployments</td>
<td>Both IoT &amp; DLT offer significant cost efficiencies, but require significant infrastructure + data management, compliance adherence, security costs to extract value at scale</td>
</tr>
<tr>
<td>Lack of precedent</td>
<td>Architectural, regulatory, legal, collaborative, economic, digital, and even cultural</td>
</tr>
<tr>
<td>Enterprise and industrial leading over consumer</td>
<td>Industrial and enterprises leading adoption and development in both IoT &amp; DLT (vs. consumers)</td>
</tr>
</tbody>
</table>

Kaleido Insights: The Internet of Trusted Things: Blockchain as the Foundation for Autonomous Products & Ecosystem Services
Where IoT is often viewed as a convergence of operational technology (OT) and information technology (IT), DLT’s role as an enabler of the IoT lies in its ability to forge trust, not only at the product level, but across an ecosystem of untrusting constituents.

A recent survey of senior executives at organizations found product companies and manufacturers to be among the top investors in blockchain, with some 42 percent planning an investment of $5 million or more in 2017. While this data may be surprising considering the emphasis in financial services, product companies have been struggling to adapt their monetization strategies away from product-centric, towards service-defined business models. The problem is that basic connectivity, proprietary data and devices—even if useful—aren’t enough. Truly intelligent products and services must be interoperable, contextually aware, proactively improving, and constantly evolving—standards no business can achieve alone.

The value proposition of DLT is protocol-based trust distributed across a network, managed and secured through encoded and permissioned access, smart contracts, and cryptography. Shared visibility and infrastructure also has cost benefits: Instead of collecting, storing, and managing all IoT data in centralized hubs, a distributed architecture can help mitigate single points of attack or failure, offer a ‘single version of the truth’ through shared, immutable records, and reduce costs in infrastructure, reconciliation, and management.

This vision leads to the broader imperative and shared objective of both blockchain and IoT. The “network effect” (and imperative) basically refers to the fact that, in a DLT architecture, the broader the set of constituencies that participate, the more valuable the system becomes. In one food safety-supply chain pilot, IBM and Walmart began with just three companies. Scaling up to 10 nodes alone “could save billions of dollars,” according to Paul Chang, IBM’s head of global supply chain solutions. The value of both IoT and blockchain depends on the network effect, but until disparate parties can trust one another, this conundrum (of needing the network to prove the value of the network) is the single greatest dictator of development and adoption.
To understand the potential for DLT-enabled IoT, Kaleido Insights conducted primary research with business leaders on both supply and adopter side of the market. We analyzed the opportunities associated with both the ‘thing’ (i.e. how blockchain supports the integrity of the object/product) as well as those supporting the ‘network’ (i.e. how blockchain enables trust across an ecosystem). Our analysis finds that blockchain supports product trust across three domains and network trust across five broad ecosystem opportunities. Use cases associated with a connected product generally fall into three categories, depicted in Figure 2:

**FIGURE 2 BLOCKCHAIN SUPPORTS IoT PRODUCTS ACROSS THREE USE CASE CATEGORIES**

DLT offers certain security advancements with each use case as well as across the stack and the network. Distributed architectures, cryptographic signatures occurring at the block- or transaction-level, plus smart contract and identity authentications, permissions, public, and private keys strengthen security. DLT can support greater security in device authentication and access; updates to firmware, software, gateways, etc.; service provisioning; data-sharing protection and compliance; and reduction of fraud, counterfeit, or tampering. Different IoT topologies require different security configurations and strategies; for instance a mesh network involving millions of smart meters has different considerations.
than a factory floor or consumer’s smart home does. Blockchain is not a silver bullet solution, rather it offers new design considerations and applications for cryptography.

Shared visibility, controls, and compensation will improve trust at the product level, but the real value blockchain offers IoT is at the ecosystem level. Our research identified 5 categories of ecosystem-based opportunities for where IoT-blockchain convergence will serve numerous constituencies across a shared network.

**FIGURE 3 USE CASES FOR BLOCKCHAIN – IoT CONVERGENCE INVOLVE BOTH PRODUCT & ECOSYSTEM**

1. **SUPPLY CHAIN** (e.g. food safety, anti-counterfeit, provenance, reconciliation)
2. **IoT NETWORK MANAGEMENT** (e.g. remote monitoring, administration, configuration, security across devices as in smart cities, telecom, healthcare, etc.)
3. **END USER AUTHENTICATION** (e.g. biometric authentication, identity access, loyalty programs across brands)
4. **ON-DEMAND ASSET SHARING NETWORKS** (e.g. sharing/renting of physical or digital assets, such as car-share, equipment-share, energy-share, data-share)
5. **SMART CONTRACTS & COMPLIANCE** (e.g. multi-party compliance adherence, automation, or visibility in industries such as insurance, manufacturing, healthcare, financial)

What follows are descriptions, analyses, and examples of product-level opportunities and how they translate to ecosystem value.
Trusted Product Identities: A Single Truth for Product Lifecycle Tracking

Product Identity: in which DLT provides an immutable way to authenticate the who, what, or origin of a product and its components.

Digital has changed the very definition of a product. Data flowing into, from, and between sensors and software in a connected product digitize its context, provide a virtual ‘twin,’ and provide products with rich identity. But such a digital identity is not a static representation. The challenge of product identity exists across the product’s lifecycle, compounded by multiple stakeholders. Virtually every product undergoes a series of phases in its existence: growth, design, sourcing of components, manufacture, distribution, retail, service and repair, ownership transfer, and so on. By adding sensors and network connectivity to products, we gain visibility into these phases. But to date, visibility remains highly siloed and opaque across parties. Another challenge for physical assets and components is counterfeit goods, an estimated half-trillion dollar global industry. Currently there is no shared, immutable, or systematic way to gather, authenticate, or trust a product’s identity across multiple phases and participants in its lifecycle.

The opportunity: Registering an item, its design, or its components digitally “at source” on a distributed ledger creates an immutable, digital representation of its identity. This renders tracing and tracking simpler and forgery much more difficult. Using DLT to provide a ground truth for product identity is foundational to all other use cases outlined in this report. This is a logical starting point for product companies interested in piloting DLT.

This use case also extends into high value/luxury goods such as jewels, arts, or antiquities, in which cases IoT sensors such as RFID or camera sensors would be used to provide additional validation of an object’s authenticity. Everledger is a company using both public and private blockchains and adjacent technologies like sensors and computer vision to create a 90+ data point permanent record for products including fine wines, diamonds, and fine art.

Why this matters: A trustworthy mechanism for device identification is the bedrock for any use case in which IoT devices are involved in automated interactions or transactions. It also represents a significant step towards eliminating counterfeits, as an immutable way to verify the authenticity of any object.

“Blockchain enables us to re-imagine product identity as we know it today, explains Anant Kadiyala, director of IoT and digital industry solutions at Oracle. “Not only can we more tightly manage the provenance of raw materials, components, assemblies, and products, but by layering additional context around product identity, we can unlock innovations in design, operations, and monetization.”

Case in Point: CarPass is an effort to centralize automotive identity across distributed parties

In an effort to centralize and digitize all information about a car to a shared and immutable database, immune to fraud or tampering, a company called BigChainDB is developing CarPass alongside German blockchain company Spherity GmBH, energy company Innogy, and Volkswagen Financial Services (VWFS). The concept was born in a hackathon in which the companies conceptualize what could be included in a car’s digital record. The first phase of this ‘machine identity’ initiative registered a car’s title, prior damage, service providers, maintenance history, and inspection history to a ledger.
The second phase includes telematics and sensor data, mileage, environmental data, financial services data, and other 3rd party data streams. The velocity of telematics data introduces new challenges of scale for DLT. As such, Spherity GmBH is working with a start-up called IOTA, touted for its ability to scale without blocks or transaction fees, to experiment with integrating its DLT technology into a telematics devices, potentially even with sensors and actuators.

“Our objective is to extend trust into the vehicle’s infrastructure down to the sensor level.”

Carsten Stöcker, founder of Spherity GmBH, former leader of machine economy innovation with Innogy.

Shared visibility into a trusted ledger benefits all parties. Governments can better audit car safety and enforce environmental laws; consumers gain transparency into the integrity of parts, wear and tear, and avoid lemons; technicians can assess maintenance history and user interactions; manufacturers and service centers can offer value-added data services such as replacing parts before they wear out.

Other Scenarios Product Identity Supports Trust Across the Ecosystem

<table>
<thead>
<tr>
<th>Supply Chain &amp; Compliance: Transparency into product integrity (e.g. legal sourcing, fair labor, compliance adherence, conditions, expiration, etc.) extends value to both businesses and consumers.</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-Demand Asset Sharing Networks: The rise of 3-D printing requires a way to verify copyright/IP or design integrity to ensure safety, compliance, and resource efficiency.</td>
</tr>
<tr>
<td>IoT Network Management: A reputation system for autonomous devices in rental/subscription models, coined by security researcher Alasdair Allan; using device reputation as a method of security validation. “Well that looks like an attractive and useful sensor reading, let’s see what others think about its reliability! Check the reviews!”</td>
</tr>
</tbody>
</table>
Most people don’t associate devices or machines with the ability to make transactions on their own, never mind negotiate or accumulate any kind of revenue. That said, new revenue opportunities unlocked through machine interactions, and the ability to automate these interactions are two principal value propositions of IoT. Although IoT can drive significant efficiencies, most machines still aren’t generating net new revenues. Even when transactions are scanned or entered via device, transaction processes still require swaths of middlemen and complicated legal structures and largely exist offline. The current IoT space lacks a transaction structure for a network of distributed machines.

**The opportunity:** DLT offers an architecture which could enable devices or machines themselves to conduct transactions on behalf of their owners or users, or potentially autonomously on behalf of themselves. Specific technologies within the DLT umbrella, such as smart contracts, oracles, public-private encryption, and others could also provide additional security around transactions, so that devices exchange the correct amount with the correct parties at the correct time.

Blockchain-based configurations can vary widely and such transactions could leverage digital currencies like Bitcoin or Ether or built-in assets like tokens or credits. As such, this can include ‘microtransactions’ in which non-monetary assets are monetizable through tokenization. This opens up a universe of applications in which IoT products could be used as microtransaction agents in areas like online storage, energy barter, gaming, loyalty programs, digital advertising, and far beyond.

This also opens up potential new streams of monetization in areas such as energy, where traditional infrastructure monopolies can be usurped, extended, or supplemented with peer-to-peer energy trading. “We are early on amidst an energy revolution and blockchain is a key enabler,” explains Nick Gogerty, co-founder of Solarcoin, a solar energy blockchain project. “This transition is driven by three factors: first, cheaper solar; second, ever cheapening storage; and third, autonomous trading which will be driven by blockchain and AI.” Smart contracts and smart agents help automate pricing for electrons, yield for energy, available resources, and base loads. But this doesn’t just represent new surface area for electrons, it could shift energy economics as trillions in stranded assets (e.g. fossil fuel supply resources) are threatened by an autonomous, dynamic, and distributed grid of energy-trading devices, electric vehicles (EVs), charging stations, and infrastructure nodes.

**Why this matters:** In effect, any network-connected object could become an actor capable of financial and operational transactions.

“IoT is focused on the visibility of every interaction in real-time; blockchain today is focused on visibility into every transaction. Merging the two together means we are merging real-time reliability with immutability and distributed ledger verification,” says Jean Chaanine, CEO of Smart Decision and former head of telecommunications and innovation global department for Sodexo. “Add impacts such as reduced margin of error, counterfeit resiliency, traceability, auditability, and multi-party risk reduction and we enable greater trust than in current IoT deployments.”
Case in Point: Oaken Innovation demonstrates car as a mobility wallet for seamless M2M transactions
Oaken Innovation recently demonstrated the idea of a blockchain-enabled tollbooth in which both car and tollbooth have Ethereum nodes which use smart contracts to trigger a machine-to-machine (M2M) transaction.\textsuperscript{11} Piloting the concept using a Tesla, the car automatically pays as it passes through the toll booth. Here a blockchain configuration presents significant potential cost savings compared to current server and payment infrastructure, fees, and time required for traditional tollbooth transactions. According to Oaken, this configuration reduces transaction times from days to seconds, and fees from ~3\% to .01\%.\textsuperscript{12} Oaken submitted the pilot to (and won first place in) the United Arab Emirates (UAE’s) GovHack for smart city innovations. Since then, the company has partnered with Toyota’s Research Institute (TRI) developing similar technology supporting P2P car-sharing, autonomous parking, short-term vehicle leasing, and other ‘mobility-as-a-service’ transactions.

Case in Point: Share & Charge demonstrates collaboration across numerous private & public parties
German utilities company innogy, alongside Slock.it, Motionwerk, and XTECH, demonstrated a Share & Charge pilot which allows owners of charging stations to share energy with others (rather than sit unused).\textsuperscript{15} While there are 6,148 public electric vehicle charging stations in Germany, an estimated 45,000 Germans have personal charging stations and EVs. Facilitating secure energy transactions between these stations significantly increases the available charging stations (and ability to monetize) for all. German EV drivers no longer have to worry about being stranded with empty batteries, as both private and public charging points are listed. Similar to the AirBNB model, both users and service providers have pricing transparency and control. Charging station owners and set prices individually, according to their requirements, and those charging their vehicles can see all prices before charging, all their transactions, and pay credit balances directly from the app.

Other Scenarios Product Transactions Support Trust Across the Ecosystem

| Supply Chain: Releasing funds or payment for goods shipped, once scanned into warehouse facility, demonstrated in a recent pilot in which payment was executed as soon as bales of cotton as soon as GPS sensors on the shipments arrived in China. |
| End User Authentication: Using biometric and/or other sensor data to trigger authenticate loyalty rewards. Start-up Shping rewards consumers for scanning and interacting with products through tokens called Shping coins.\textsuperscript{13} |
| On-Demand Asset Sharing Networks: Peer-to-peer (P2P) economies, in which users submit their own physical or digital assets (e.g. a bike, home, energy, online storage) to a shared ledger and receive tokens or compensation for rentals. AirBNB’s recently hired the majority of the team from a Bitcoin-based micropayments provider, ChangeCoin, to advance their vision towards smoother guest-host transactions. Using smart contracts, the idea is to execute payment the moment the guest places the key in the door of the host’s property.\textsuperscript{14} If AirBNB doesn’t offer such a DLT solution themselves, they risk disintermediation by P2P home-sharing technology, similar to how Napster disrupted traditional media companies in the early 2000’s. |
Trusted Product Interactions: The Foundation for Ecosystem-Based Business Models

Product Interactions:
in which DLT provides an immutable way to centralize all interactions, events, and updates associated with a product.

The advent of IoT means sensors and network-enabled machines become the instrumentation layer for very granular information into product performance and interactions. Sensors like GPS, RFID, NFC, temperature, and others offer previously absent visibility into product interactions at every level:

- User-product interactions
- User-business interactions
- Business-partner interactions
- Product-product interactions
- Product-environment interactions

Visibility into these interactions is reshaping how product companies formulate business models. For example, monitoring real-time performance data can inform proactive and predictive maintenance of a product, instead of responding reactively once a product has faltered.

But the shift away from proprietary product-based business models to ecosystem-driven service-based business models has been easier said than done. Managing and analyzing data is still lofty hurdle for many traditional companies, nevermind operationalizing actions based on data. Infrastructure and storage costs associated with scale (e.g. installation, integration, maintenance of large centralized data centers) are expensive, as is secure configuration and compliance across multiple stakeholders. Beyond proprietary products, ensuring security at every level of the stack remains a daunting challenge, one exasperated by reliance on third parties and advancing cyber threats. Diversity of ownership (i.e. of those controlling devices and cloud infrastructure) limits sharing and interoperability—both technically and culturally.

Today there is no shared architecture to centralize, permission, and authenticate all interactions associated with a product.

The opportunity: Similar to what TCP/IP, the de-facto standard for transmitting data over networks, did for the Internet, the sharing of data across physical networks requires an interoperable layer for recording the events associated with the data. "Think of the opportunity as a next generation public key infrastructure, required for but currently absent from IoT," summarizes Chris Boscolo, CEO of LifeID.

A decentralized approach to IoT networking and M2M interactions would not only provide a standardized communication model to process (perhaps trillions of) interactions and transactions between devices, it could also significantly reduce costs associated with:
• **Security:** by mitigating the risk of network failure because the integrity of the system is no longer reliant on penetrating single nodes
• **Scale:** by distributing computational and storage needs across devices in the network, instead of relying on central servers
• **Reconciliation:** by immutably registering interactions to a shared ledger, multiple parties can track conditions in real-time; immediately identify and rectify anomalies or tampering

But the opportunity runs deeper than mere efficiencies. In the age of interoperable devices, value is now defined by how an entire ecosystem of constituents integrates, protects, and leverages product data contextually. The real promise DLT brings to IoT is to automate trusted services through code intermediating the flow of data. Consider the opportunities for disparate manufacturers, brands, service providers, advertisers, insurance companies, energy providers, etc. to leverage each other’s platforms to extend and improve their services.

**Why this matters:** When product interactions are permissioned, immutable, and shared across a spectrum of service providers, it offers the potential for ecosystems to generate and move value with vastly greater efficiency and security.

“We can all ascertain the efficiency gains,” shares Diana Adachi, Global Blockchain Lead at Accenture. “But what slowly becomes apparent is the transformative nature blockchain has on business economics, to unlock new revenue models and to connect to customers in ways that weren’t just weren’t possible before.”

**Case in Point: IBM & Samsung’s ADEPT Project illustrates the missing layer in IoT business models**

One of the earliest enterprise blockchain-IoT projects called ADEPT (Autonomous Decentralized Peer-to-Peer Telemetry) brought to life a distributed ledger facilitating various types of IoT transactions between devices. In it, IBM and Samsung partnered to prototype a secure and low-cost “universal digital ledger” to manage roles, permissions, behaviors, transactions, and events, via interconnected multi-party devices. While the technology has advanced since this early POC, it remains a critical illustration of the IoT-blockchain opportunity: tracking and securing interactions on a universal digital ledger for business model endurance.

**FIGURE 4 ADEPT’s VISUALIZATION OF A UNIVERSAL DIGITAL LEDGER**

![Image Source: IBM](image-source-url)
A connected washing machine registers itself to a shared ledger containing all historical information about its sourcing, manufacturing, distribution, etc. Sensors inside a washing machine [or any other device] autonomously negotiate with peer devices to optimize energy use and schedule cycles during hours of lower electricity demand. If its user needs assistance, the machine itself could authenticate other users (e.g. a certified technician) to run an automated safety or cleaning checklist, update features, order necessary parts, etc. If the machine has an issue, say a leaky pipeline, telematics communicate the issue, but smart contracts process the transaction documentation necessary to trigger operational queues and communications, automatically submit and verify insurance claims, solicit repair services, and even allocate payment across counterparties.

Not only does this reduce risks associated with malfunction (which can be dangerous), it saves headcount, time, and costs related to identifying and resolving the problem, as well as reconciling information and transactions for those involved.

**Case in Point: DLT could support innovation through secure ecosystem-wide data-sharing**

One of the most valuable assets for sharing is data itself, particularly when it comes to societal innovations. The Autonomous Vehicle Data Exchange (AVDEX) is a DLT-built data exchange developed by TRI and BigChainDB in an effort to open up data silos for autonomous car R&D. Data providers can upload data sets and data consumers can search, buy, and rate data. Using blockchain, the exchange is meant to provide a shared, secure storage mechanism to share data and be compensated for it, while fostering an open marketplace, and expediting the development of safe self-driving cars—the development of which will take an estimated 1 trillion miles to capture all edge conditions necessary for safe operations. The exchange itself is owned by the entire network as its tokens (Datacoins) are held by those contributing data, and value increases as the network grows.

Other Scenarios Product Interactions Supports Trust Across the Ecosystem

<table>
<thead>
<tr>
<th>IoT Network Management: A security system for IoT devices, including app installation/uninstallation, device provisioning, messaging, etc. Cisco recently filed a patent for a blockchain platform capable of identifying and distinguishing different devices, monitoring their activities, and evaluating the trustworthiness of any network connected device.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart Contracts &amp; Compliance: Verification that device has received security patch or update; runs a diagnostic to remain compliant, etc.</td>
</tr>
<tr>
<td>On-Demand Asset Sharing Networks &amp; End User Authentication: In shared economy scenario, data associated with an individual can be authenticated for secure user access, personalization, etc. GM, for instance, is looking at enhancing its current Maven car-sharing program using blockchain technologies. Already, users are sent reservations using a cryptographically secure electronic key that is tokenized, and upon nearing the vehicle, it authenticates with the user’s phone using Bluetooth Low Energy (BLE). The idea is to deepen the value of this program by extending the authenticatable data associated with both user (e.g. personalized vehicle settings) and vehicle (e.g. maintenance record, diagnostics). “This is one of numerous areas we are testing DLT applications,” shares Nick Pudar, Director of Strategic Initiatives at GM. “Above all, we look at the impact on customer experience, with the security and scale our customers and partners expect.”</td>
</tr>
</tbody>
</table>
Exchanging or generating new value across an ecosystem of service providers represents the greatest economic opportunity for IoT. To date, this opportunity has been limited by a lack of shared universal ledger architecture—for identity authentication across a product’s lifecycle, for securely permissioned transactions, and for immutable multi-party interactions.

The journey will take time. The broad shift we’re seeing from centralized networks—operational, technical, and financial—to the edge, marks a profound change in how economic structures work and demands new mechanisms for trust. Kaleido Insights estimates DLT development will be fragmented across geographies and occur in waves over the coming years.

**From the Internet of Things to the Internet of Value**

Exchanging or generating new value across an ecosystem of service providers represents the greatest economic opportunity for IoT. To date, this opportunity has been limited by a lack of shared universal ledger architecture—for identity authentication across a product’s lifecycle, for securely permissioned transactions, and for immutable multi-party interactions.

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**FIGURE 5 THE IMPACTS OF BLOCKCHAIN –IoT CONVERGENCE WILL COME IN WAVES**

<table>
<thead>
<tr>
<th>IMPLICATIONS</th>
<th>2-5 YEARS</th>
<th>5-10 YEARS</th>
<th>10+ YEARS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>KEY DEVELOPMENTS</strong></td>
<td>Product identity and interactions are centralized for multi-stakeholder product lifecycle management using DLT</td>
<td>Product transactions: DLT provides an immutable and secure way to authenticate and automate the exchange and settlement of a currency-based or tokenized asset</td>
<td>Autonomous products and services, enabled through adjacent technologies, trusted and monetized through DLT</td>
</tr>
<tr>
<td><strong>SUPER HUMANS</strong></td>
<td>Greater transparency into product integrity (e.g. food safety; second-hand markets)</td>
<td>M2M transactions accrue personal wealth, enhance reputation and trust across peers, contribute to sharing networks</td>
<td>On-demand P2P models enabled as people have a trusted system to buy, sell, and rent out their own products and services from one another</td>
</tr>
<tr>
<td><strong>FLUID ORGANIZATIONS</strong></td>
<td>Greater transparency into product provenance, track and trace</td>
<td>Cost efficiencies generated through shared processing, reconciliation, security enhancement, reduced regulatory penalties and costs associated with integrating systems across partnerships</td>
<td>New revenue opportunities derived via monetization of services made possible by devices negotiating for themselves; data collected across participants: P2P transactions</td>
</tr>
<tr>
<td><strong>ENLIGHTENED ECOSYSTEMS</strong></td>
<td>Greater transparency across supply chain partners; greater willingness</td>
<td>New value constructs introduced across networks (e.g. self-servicing autonomous machines)</td>
<td>M2M economy automates wide range of intermediation processes; many ‘middlemen’ industries cease to exist</td>
</tr>
<tr>
<td></td>
<td>More secure interoperability and network management</td>
<td>Certain “greenfield infrastructure” regions will leapfrog in DLT adoption (e.g. energy bartering)</td>
<td>Third-party services or industries (e.g. payment, microinsurance) arise using DLT infrastructure</td>
</tr>
<tr>
<td></td>
<td>Increased compliance adherence</td>
<td></td>
<td>Shared assets and infrastructure requires less sunk investment and could be more environmentally friendly</td>
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</table>

Kaleido Insights: The Internet of Trusted Things: Blockchain as the Foundation for Autonomous Products & Ecosystem Services
In developed countries, product identity will impact how users, businesses, and ecosystems understand and prioritize supply chain integrity. Forward-looking constituents driving smart cities, telecom, public health, etc. will explore the DLT opportunity for more secure IoT network management, but overcoming incumbent structures will be a very slow process. In the meantime, less developed ‘greenfield infrastructure’ regions will leapfrog many developed countries’ blockchain adoption, as fewer incumbent technical, regulatory, economic structures exist.

Over time, the combination of IoT with blockchain could transform connected objects and machines into economically independent devices able to securely transact and interact amongst each other. With the advancement of myriad adjacent technologies—AI technologies, autonomous vehicles, edge processing, augmented reality, cryptographic techniques, robotics, to name a few—new capabilities and use cases will influence DLT’s development. External forces will inevitably shape the narrative too as people, companies, and society grapple with the digitization of everything and its impacts on data protection, identity, economics, and environment.
Blockchain’s potential to generate significant value across counterparties depends on the “network effect” and this dynamic could either thwart momentum or accelerate adoption quickly. Although these technologies are nascent, the sooner organizations understand their potentials and risks, the faster and more secure their development. Kaleido Insights recommends businesses of all types take the following steps towards practical blockchain application.

**Lay the Groundwork for Grassroots Ideation.**

As is often the case, people are slower to change than technology. Although DLT is evolving rapidly, virtually all companies interviewed pointed to challenges associated with change management. Most of the companies experimenting with blockchain aren’t doing so in response to an acute problem, rather they are exploring the possibilities of an intriguing technology across multiple solution areas. As such it can be difficult to get people onboard, never mind that blockchain is a relatively difficult technology to grasp. Developing teams of internal evangelists and multiple blockchain ‘lunch & learns’ were common tactics mentioned to help educate other employees across other functions. Executive champions are critical for leadership and funding, but interviewees also point to the value of bottom-up education, as SMEs connect the dots more rapidly than generalists.

“We slowly built a team of volunteers who were curious about blockchain,” explains Lydia Krefta, principal product manager of emerging technologies and grid innovation at utilities giant Pacific Gas & Electric (PG&E). “They came from all over the company: people from customer solutions, mobility, cybersecurity, electric operations, and so on. Collectively we worked to understand the technology and capabilities, and educate other teams. Once people understand it, they naturally look for ways it could apply in their areas of expertise. Together we developed a catalogue of 40 use cases, which we grouped into four broad categories and have used to further educate, prioritize, and seek funding.”

**Engage Across Community to Foster Ecosystem Collaboration.**

One of the most important areas for collaboration is in the development of logic and templates that translate existing processes, laws, and frameworks to smart contract execution. Fostering an environment for this type of collaboration is a central role and enabler of consortia such as the IoT-Blockchain Consortium, the Trusted IoT Alliance, the Linux Foundation’s Hyperledger Project, the Energy Web Foundation, among countless others. These projects are aimed at developing common protocol to accommodate the unique attributes of IoT environments and blockchain execution, including interoperability, security, scalability, identity authentication, and smart contract execution across multiple chains.

Enterprises should note the dual value of consortia—beyond technical standards, fostering collaboration between other (sometimes competitive) enterprises, start-ups, regulatory bodies, and industry groups is equally as important, perhaps even more difficult. Remember, one of the unique opportunities of blockchain deployment is the difference in value the technology delivers when it is deployed at scale versus with few participants.

In addition to consortia, it’s critical that companies develop engagement strategies to embrace (not alienate) the broader ‘crypto’ community, one that generally subscribes to a deep ethos of decentralization. Many open-source blockchain developers and engineers in this community comprise some of the most talented DLT architects; Relationships with crypto-enthusiasts can drive validation; Understanding public-private blockchain interoperability will be essential for many enterprise applications. “Ironically, one of the most tightly-knit communities in the world is the one enabling the evolution of decentralized architectures,” says Joshua Shane, managing director and VP of strategy at Viewstream, an agency specializing in deep tech. “Companies simply must have these relationships, if you don’t have them, you need ways to adopt them.”
**Contribute to and Derive Value from Open (Source) Ecosystems.**

From global public blockchains to highly permissioned private enterprise blockchains, virtually all DLT development shares a common trait: open source is an accelerator of adoption. Many consortia and working groups have the chief objective to advancing reliability, security, and scalability of code, software, and frameworks used to transact on distributed ledgers. This is especially relevant in mission critical/high volume realms such as Financial Services, Transportation & Mobility Services, and Energy. Toyota’s Research Institute (TRI), for example is working with MIT’s Media Lab, part of the Blockchain IoT Consortium, and even building its own blockchain consortia to help lead the automotive industry’s adoption of blockchain.20

The blockchain is a technology that works only when it’s part of an ecosystem,” says Chris Ballinger, TRI’s chief financial officer and director of mobility services. “It’s not something you can do on your own as a company, because you have to have an ecosystem of suppliers, customers, and mobility service providers all using it. That's when it becomes valuable.”

**Plan for Hybrid Architectures & Interoperability.**

Blockchain will not replace existing structures and infrastructure overnight; rather, it will evolve alongside incumbent systems, existing standards, complementing, then supporting, and then making certain workflows irrelevant. Technology providers must prioritize integration and interoperability in any platform or application development, particularly so as to not neutralize security protections or erode potential avenues of monetization.

“Companies using DLT infrastructure have no choice but interoperability because monetization will not exist at the core of a platform” says Carsten Stöcker. “Differentiation comes through services at the edge—personalization, flexibility, virtual aggregation, AI or analytics—these will drive business cases and competition, not infrastructure.”

Simultaneously, external forces could accelerate DLT as legal and regulatory standards such as the Global Data Protection Regulation (GDPR) will be essential at the M2M layer. Businesses should not think of blockchain as a replacement for databases because it may not be feasible, compliant, or sensible to process all data ‘on-chain.’ “On-chain information is typically auditable information that acts as shared non-repudiatable truth that multiple parties need to know,” explains Anant Kadiyala, director of IoT and digital industry solutions at Oracle, “For example, when shipping temperature controlled goods like vaccines, multiple parties (e.g. manufacturer, distributor, shipper, insurance company) need to know if the temperature was not maintained accurately during the product journey.”

Permissioned DLT development in the coming 12-18 months will focus heavily on how, where, and to what extent data are captured--on or off-chain; block size; consensus mechanisms; forking as an enabler of scale, etc. This means enterprises must design for both hybrid architectures and applications that can run across different types of DLTs (e.g. Hyperledger, Ethereum, Bitcoin, IOTA, Hashgraph, etc.).

**Consider UX when Defining Use Cases Across Ecosystem Partners.**

Although DLT is hardly considered a consumer-facing technology, our research finds the importance of user centricity persists. When conceptualizing and designing applications blockchain could support, participants continuously cite the need to remember the end user, whether an employee, business partner, consumer, citizen, patient, or otherwise. Through this lens, DLT presents new possibilities that could simultaneously improve UX while complicating competitive structures, such as designing loyalty programs across ‘any’ retailer; energy-bartering across both public and private providers of charging stations; or centralizing a user’s digital identity controls to the user herself.

In fact, the very notion of an entirely “open” device interaction ecosystem, such as the one conceptualized in the ADEPT example above presents an inherent friction with service-based subscription business models that manufacturers are developing today. Put simply, if devices themselves can shop around for optimal pricing, services, energy, etc., the strategy of securing customers by way of locking them into subscription models quickly grows obsolescent.
When It Comes to “Blockchain Strategy” Invest Broad, Test Narrow.

Our analysis of innovation programs—often the home of blockchain pilots—finds many companies struggle to define whether to begin with broad enterprise-wide strategies (“tankers”) vs. dabbling in small proofs of concept to simply test and learn with agility (“speedboats”). While we see innovation teams deploying both types programs, many of the companies we interviewed and analyzed for this research are exercising a dual approach:

- **Investing in the tanker:** Invest in deep education for executives and SMEs to understand the scope of opportunity DLT presents and how it could apply across business functions, monetization, and cost savings models.

- **Testing with the speedboats:** Test the waters with small POCs and pilots. This help immerse internal teams in designing for multi-stakeholder deployments, development using DLT tools and groups, discover unforeseen barriers associated with scale, power consumption, legal structures, data sharing, reliability, while establishing baseline metrics and best practices.

The VP of strategic alliances with a large financial institution shares how “in the same approach as we taken with IoT innovations, multiple teams including Security, Partnerships, M&A, and others are experimenting with blockchain in different ways without being tied to one specific P&L. Our innovation lab taps the ecosystem to explore, helping incubate and germinate ideas across seven blockchain companies, all looking at different use cases.”

Kaleido Insights research finds large enterprise adopters are tapping different partners for tankers vs. speedboat deployments, with large technology vendors and SIs supporting high level tanker analysis and innovative start-ups earning business and POCs on the speedboat projects.

**Blockchain Isn’t the Only Show in Town.**

A kaleidoscope of emerging technologies is advancing alongside blockchain technologies and they will no doubt influence and be influenced by one another. From computer vision to deep learning, from 3D printing to high performance embedded chips, many of these will see uptake prior to and alongside mainstream blockchain adoption. Others, such as quantum computing and more yet to be named, may shift development paradigms as well. Chief information officers (CIOs) and strategists should be actively pursuing multi-disciplinary collaboration and experimentation with innovators, incumbents, and regulators to explore the economic benefits of blockchain, as well as the risks, lessons learned, and unintended consequences across all such technologies.

**Conclusion**

The convergence of physical and digital is underway, but we are in the infancy of the information age. Today, digital represents the digitization of information. Emerging technologies are unlocking new transformational layers: the digitization of perception, of language, of intelligence. Blockchain represents an architecture for the digitization of identity, of value exchange, and potentially of trust itself—a most essential, if still missing layer, for the future of automation.
About Us

Jessica Groopman specializes in automation technologies impacting organizations including IoT, AI, and blockchain. She concentrates on the application of sensors and machine learning with a focus on user experience, data integrity, and convergence with blockchain. Past clients range from start-ups to media agencies to large brands including Technicolor, Microsoft, Cisco, Qualcomm, Dell, Intel, DuPont, Pandora, and numerous vendors to develop research, content, and digital strategies.

Jessica is a frequent speaker at IoT industry events. She is also a frequent contributor to numerous blogs and/media outlets. She has been principal analyst with Tractica where she contributed to their automation and robotics practice. She has also served as contributing member of the International IoT Council, the IEEE's Internet of Things Group, IoT Guru Network, and FC Business Intelligence's IoT Nexus Advisory Board. Jessica was also included in Onalytica's list of the 100 Most Influential Thought Leaders in IoT.

Jessica served as research director and principal analyst with Harbor Research and as an industry analyst with Altimeter Group. Earlier, she lead research at Focus Research and was a research analyst at Tippit Research.

Jeremiah Owyang focuses on how new technologies impact business models and how corporates must innovate. He focuses on how disruptive technologies—such as social media, collaborative economy, autonomous world, blockchain and more—and how they impact the relevance to corporations. He is well recognized by both the tech industry and the media for his grounded approach to deriving insights through rigorous research.

Jeremiah is frequently quoted in top-tier publication and cited in books and press and media. He was featured in the "Who's Who" in the Silicon Valley Business Journal, and his Twitter feed was named one of the top feeds by Time.

He is also the Founder of Crowd Companies, an innovation club for Fortune 500 companies, which he also manages independently from Kaleido Insights. Jeremiah was an Industry Analyst at Forrester Research, a founding partner at Altimeter Group, and a web marketing leader at Hitachi.

ABOUT KALEIDO INSIGHTS

Kaleido Insights is a research and advisory firm focused on the impacts of disruptive technologies on humans, organizations, and ecosystems. Our industry analysts provide business leaders with clarity amidst a fragmented technology landscape. Kaleido advisory relationships, webinars, speeches, and workshops are grounded in research rigor, impact analysis, and decades of combined expertise. Innovators are realizing that implementing each new technology isn’t enough, especially as business models are disrupted. Keeping up is becoming more difficult. Our mission is to enable organizations to decipher foresee, and act on technological disruption with agility, based on our rigorous original research, trends analysis, events, and pragmatic recommendations.

If you’re interested in building a relationship with our analysts, we’d love to hear from you. Please email info@kaleidoinsights.com to start a conversation, or visit www.kaleidoinsights.com to learn more about our offerings.
RESEARCH METHODOLOGY
This research was developed through extensive primary and secondary qualitative research methods. We interviewed 13 market influencers, vendors, and adopters between October - December, 2017. We also conducted countless briefings and discussions with industry innovators in the blockchain, connected device, and related software markets. Input or mention in this document does not represent a complete endorsement of the report by the individuals or the companies listed herein.

ECOSYSTEM INPUTS
1. Carsten Stöcker, Founder of Spherity GmHB, former Leader of Machine Economy & Innovation at Innogy
2. Lydia Krefta, Principal Product Manager, Blockchain & Grid Integration & Innovations at Pacific Gas & Electric
3. Nick Pudar, Director of GM Strategic Initiatives at General Motors
4. Anant Kadiyala, Director, Blockchain & IoT Industry Solutions at Oracle
5. Diana Adachi, Global Blockchain Lead at Accenture
6. Christopher Boscolo, CEO at LifeID
7. Joshua Shane, Managing Director & VP of Strategy at Viewstream
8. Nick Gogerty, Co-founder at Solarcoin
9. Jean Chaanine, CEO at Smart Decision
10. Stefano Pepe, CEO at UniqueID
11. Pete Wassel, CEO at Augmate
12. VP Strategic Alliances with Enterprise Financial Institution
13. VP Digital Technologies with Enterprise Retailer

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ENDNOTES

1 In 2014, IDC projected that by 2020 the digital universe will reach some 40 zettabytes (ZB), which is 40 trillion GB of data, or 5,200 GB of data for every person on Earth. The study also found machine-generated data is a key driver in the growth of the world's data, and is projected to increase 15x, accounting for 10% of the digital universe by 2020. “IDC Study: Digital Universe in 2020.” 2014. Accessed 2017 October 15. https://www.emc.com/leadership/digital-universe/2014view/index.htm

2 Although blockchain is used more frequently than (but often synonymously with) DLT, blockchains are but one type of distributed consensus data structure. Given the nature of enterprise IoT applications, most of the DLT applications in this report involve private or permissioned blockchains. Variations include BigChainDB's decentralized database and IOTA's blockless DAG architecture known as the Tangle. This report will use blockchain and DLT interchangeably but acknowledges a lack of global consensus.


4 Relevant to the notion of product identity is the concept of a “digital twin,” defined as a dynamic virtual representation of physical product. Sensor data translates and simulates the product mathematically, enabling its definition in software, which can then interact with other software. This is essential for businesses to understand, analyze, predict, and securely orchestrate IoT products. A digital twin is an important concept for IoT product companies, but will be covered in greater depth in future Kaleido Insights reports.

5 In 2016, the Organization for Economic Cooperation and Development (OECD) estimated that imports of counterfeit and pirated goods were worth roughly a half a trillion dollars a year, or around 2.5% of global imports. http://www.oecd.org/industry/global-trade-in-fake-goods-worth-nearly-half-a-trillion-dollars-a-year.htm


12 Shping is an Australian-based start-up which rewards consumers for scanning product barcodes to access and register product provenance information with loyalty coins. https://www.shping.com/


