The Internet of Materials (IoM) Master Plan, Part I

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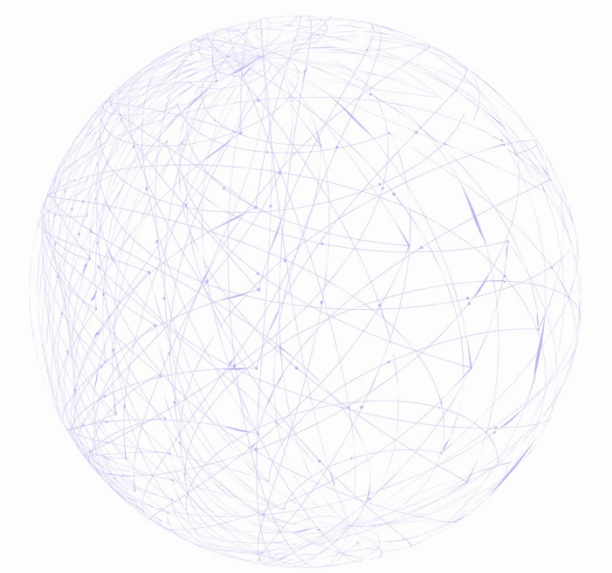
WHITEPAPER

Contents



Abstract

The markets for plastic, paper, metal, glass and biomass are broken. The size, scope and complexity of modern material markets creates unnecessary friction in material transactions, which results in negative economic, environmental and social impact on a global scale. Our aim is to unite stakeholders, materials and information beyond a global materials supply chain to create something altogether new and certain to disrupt. We begin with the premise that maximizing material utility and value maximizes material sustainability. Likewise, less than optimal material utility and value results in less than optimal material sustainability. It stands to reason that the more valuable something is, or the more utility it provides, the more inclined society is to maintain it. Our solution enables the practice of that inclination without burdening existing systems, but enhancing them. We present the Internet of Materials (IoM) to maximize material utility, value and sustainability throughout the material lifecycle. We outline the need and benefits of a dedicated, inclusive supply chain operating network for materials. We introduce smart materials, which provide universal standards for material data and transactions. They enable customizable supply chain automation, reducing risks, and improving supply chain efficiency and visibility. Smart materials also provide an essential interface for practical implementations of Industry 4.0.

Introduction

Materials are the essential matter of things, in part, defining societies and cultures. The stone, iron and bronze ages reflect the importance of materials and the fundamental necessity of materials in daily life[1]. While, today, we live in an information age materials are no less fundamental.

The importance of materials offers a primary, objective basis for material sustainability. As consumers, we are all stakeholders, and we suggest a universal responsibility for resources and their environmental stewardship[2]. From an enterprise perspective, improved financial performance and risk management performance provides profit based incentives for material sustainability within the supply chain. Furthermore, sustainability, as a catalyst for innovation, and a basis to engage and connect with consumers, completes the business case for material sustainability[3].

The following discussion of materials seeks to emphasize the magnitude of the global materials industry and the gaps in material stewardship, e.g. landfilling materials with unrealized value and/or utility. In light of recent and ongoing discussions regarding relative material sustainability we think it is worth noting that we do not identify or advocate material preferences. We advocate for data and innovation. Relative material sustainability is a moving target. Considerations such as water, energy and technology can have swift and significant impact on the relative sustainability of materials.

The global import/export value of materials is almost $3.5 trillion annually[4]. Total tonnage is in excess of two billion tons annually. For plastic alone, recent research estimates that 8.3 billion metric tons of plastic have ever been produced with about 30% still in use and 9% having been recycled[5]. Plastics and metals represent the majority of value and metal and paper represent the greatest tonnage with more than 1.6 billion tons and 400 million metric tons respectively.

Figure 1

To provide some additional perspective, most materials will spend some time on a truck, somewhere in the supply chain, even if the primary transportation mode is air, marine or railway. Using 40,000 pounds as a truckload, and a little more than 2.4 billion tons in annual materials, that would equal more than 122 million truckloads. If placed end to end, the trucks would circle the earth 1.75 times. We remind the reader that this is an annual measure.

Globally, municipal solid waste (MSW) is estimated at more than 1.3 billion tons annually, with an estimated cost of more than $205 billion. An estimated two million people act as informal waste pickers contributing to international markets for recycling[6]. The top twenty-five countries for MSW recyclers highlights how much room there is to improve recycling rates globally. Germany at the top of the list has a recycling rate of 66.1%, only the top ten exceed 50%, and the US rate, last on the list, is a disappointing 34.6%[7].

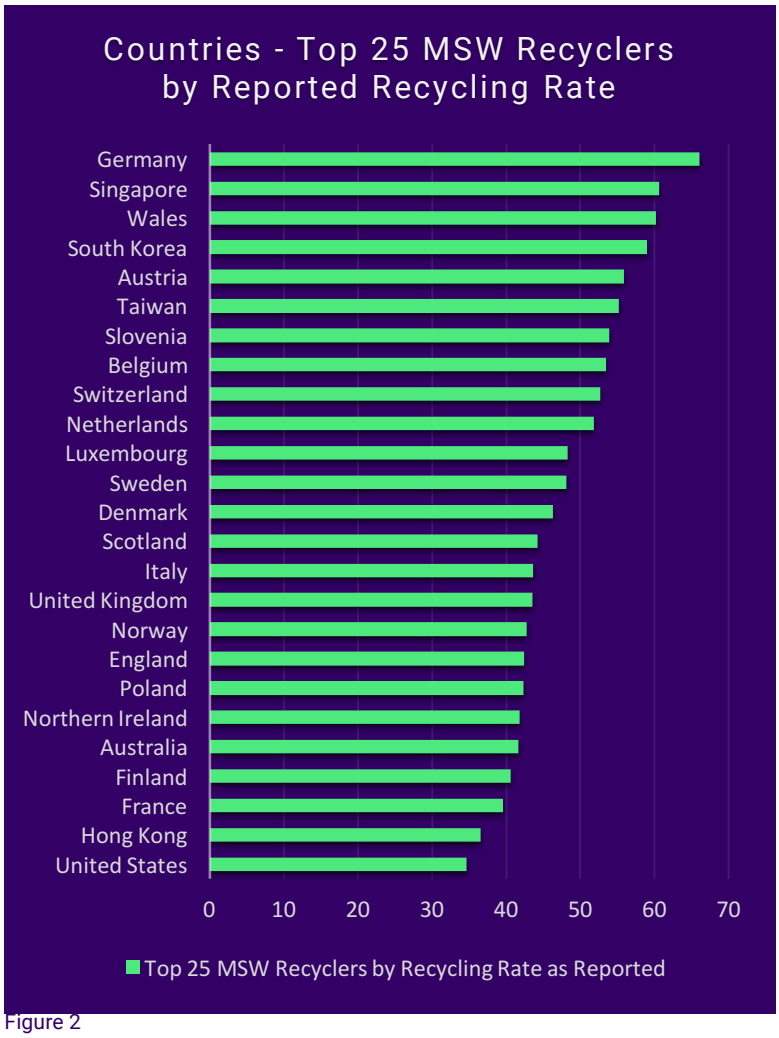


Figure 2

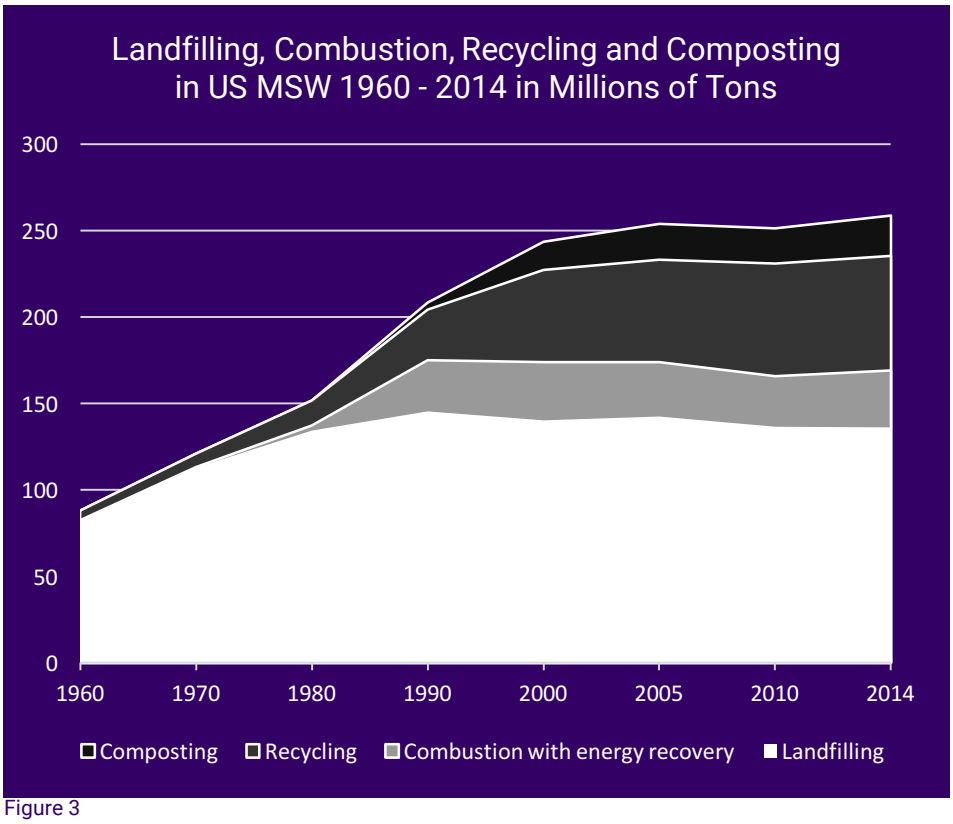


Figure 3

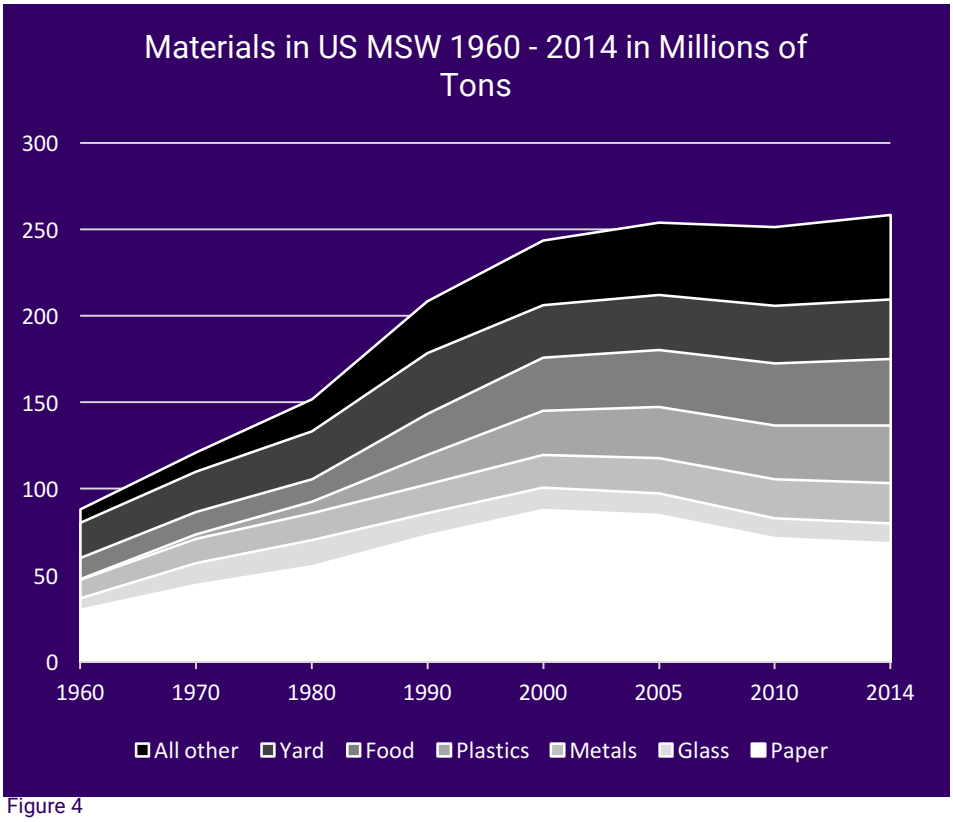


Figure 4

Overall, US MSW in 2014 was in excess of 250 million tons with more than half going to landfills. Paper, glass, metal and plastic, all of which are highly recyclable, accounted for 47.4% (14.3%, 5.2%, 9.4% and 18.5%, respectively) of the total weight landfilled[8].

The orchestration of material markets, consisting of billions of tons of materials, both upstream and downstream, delivered through multiple modes of transportation around the world is complex enough. It is compounded when considering the various systems and software, often proprietary and expensive, that power the modern customer and supplier enterprises, as illustrated in figure five. Complexity not only drives costs, but can do further damage by hindering innovation[9].

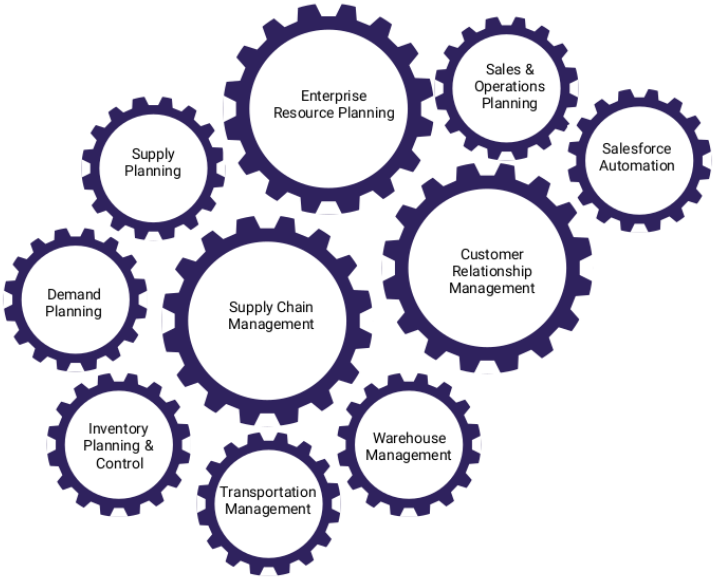


Figure 5

Furthermore, a complete material transaction requires payment processing, which adds yet another layer of complexity. While this concern is not unique to materials markets there are distinct challenges with materials. First, materials are often a narrow margin business, which limits the use of credit cards and similar electronic payments with significant fees. Second, it is very common to have cross-border transactions. In part, this is why we emphasize the import/export value of materials totaling trillions of dollars in the preceding paragraphs. Third, material transactions can be large. A container or railcar of material might cost more than $50,000 or $100,000, and a large customer might purchase ten containers/railcars or more at once, driving the transaction value over $1,000,000. Finally, currently used payment methods such as letter of credit, checks and wires are cumbersome, contributing to inefficiency and adding costs.

Research on, informational friction in commodity markets by Sockin and Xiong[10], and joint pricing and inventory control models by Yao[11], demonstrate that improved, trustworthy data – reality, versus a model of reality, improves operational efficiencies, reduces risk and optimizes profit. Supply chain operating networks (SCONs) and supply

chain on blockchain are evolutionary contributions building on existing supply chain platforms leveraging the wealth of data generated by the modern enterprise. The primary benefit of these approaches is improved data. Typically, the SCON or blockchain is owned by the platform in which it is integrated. From the perspective of the supply chain platform this provides a competitive advantage, and a fair value to their customers. However, considered objectively, this approach creates inherent market friction due to costs and technological barriers.

The overall cost and complexity of supply chain platforms, integrations, and the development and implementation of pricing and supply models, makes them prohibitive to all but the largest participants. This again, creates inherent friction for materials markets because the overall reach and power of this information and technology is limited to participants who can afford it. The result is a technology proliferation race, at the expense of enterprise core competencies, and material utility, value and sustainability.

In other words, if software eats materials, we all lose – the customer and supplier enterprises, the consumer and the environment.

Ethereum

Blockchain is a distributed database with inherent data security. Network nodes broadcast and validate transactions and valid transactions are stored in blocks. Each block contains a hash of the previous block chaining them together.

Ethereum is a public blockchain that runs smart contracts on a decentralized, global platform. Smart contracts, "run exactly as programmed without any possibility of downtime, censorship, fraud, or third party interference.[12]" Ethereum imposes fees in the form of gas for network operations. Fees are based on the complexity of the operations performed including the amount of data stored.

Because the blockchain is replicated on every node in the network there are practical limitations to its ability to scale. This is not an immediate concern for the IoM because we don't recognize the need for high frequency trades. A moderate delay in the completion of an Ethereum transaction will not have a significant impact on material transactions. In the long-run contributions such as state-channels, the Plasma Framework and blockchain interoperability provide adequate, practical solutions, which sufficiently mitigate risks in regard to scaling so as not to add friction to material transactions.

The Internet of Materials

The purpose of the Internet of Materials is to maximize material utility, value and sustainability by reducing transaction friction and facilitating the global trade of materials.

The IoM is intended as a technology foundation for materials, similar to HTTP(S) for the Internet, or SMTP for sending email. It provides standards for data exchange and material transactions. It is unopinionated about the technologies it relies on or those that rely upon it.

The ecosystem consists of a supply chain operating network (SCON) and its participants or stakeholders, tightly coupled with smart materials and an Ethereum ERC20 token, all supported by free and open-source software. This architecture enables a single, global environment for complete, friction optimized/frictionless material transactions.

Software developers are integral stakeholders in the IoM. We do not expect to predict every use case. Rather, we emphasize free and open-source tools, building blocks that enable developers to leverage their expertise and benefit from the value they provide. The goal is a culture of rapid innovation through inclusive diversity that enriches the ecosystem to the benefit of all stakeholders. Initially, development will be guided by the needs and priorities of our early partners. However, in the long-term we believe future innovation of the IoM will be driven by a robust development community.

The IoM is free forever. Stakeholders own the network and there is no direct cost to participate in the IoM. The IoM is distinguished by a network first approach and a bring your own platform philosophy, rather than a platform first, use our network philosophy. This preserves and optimizes the network effect, eliminating the inherent friction that comes with proprietary platforms and networks, which charge license, subscription and/or other fees to access the SCON.

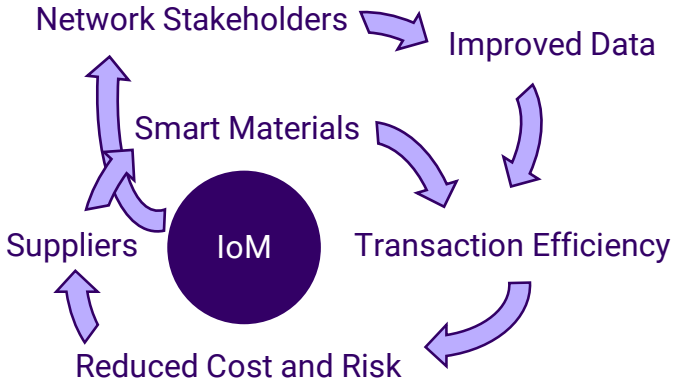


Figure 6

Figure six illustrates the IoM as a growth and efficiency machine. Smart materials contribute to the overall efficiency of transactions through supply chain automation and as an interface for enterprise software and systems supporting transactions. This increased efficiency reduces the costs and risks associated with transactions, driving supplier profit, which drives supplier participation. This provides an incentive for suppliers to join the IoM and bring their customers and vendors in to the network increasing the number of stakeholders participating. The growth of the network improves

the available data for all IoM stakeholders, which in turn further contributes to transaction efficiency, reinforcing the entire cycle.

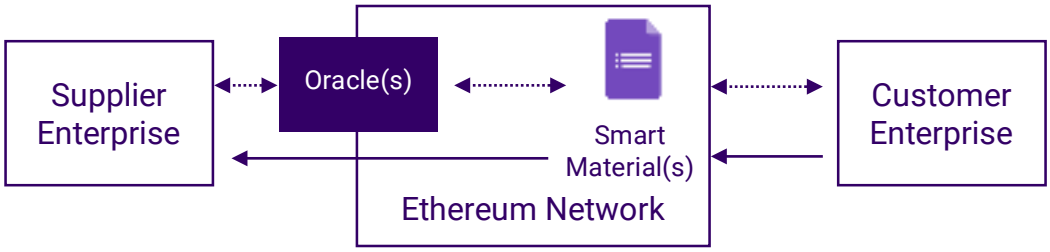


Figure 7

Figure seven describes the relationship between suppliers, customers, oracles and smart materials at the transaction level. The supplier and customer enterprises are inclusive of the systems and software described in figure five. The dashed arrows represent information and the solid arrows represent payments made with IOM Token. Material suppliers create smart materials, representing a material volume available for sale, broadcasting the opportunity to the IoM. Customers purchase IOM Token and pay the supplier for the material with it. The supplier uses an exchange to convert that token to cash.

IOM Token

IOM Token, pronounced "yum token," is an Ethereum ERC20 compliant token[13]. Ethereum ERC20 tokens are smart contracts running on the Ethereum Network. Smart contracts are incorruptible and run exactly as written. The ERC20 standard requires the following minimum basic functionality:

type	name	return type
function	totalSupply	uint
function	balanceOf	uint
function	transfer	boolean
function	transferFrom	boolean
function	approve	boolean
function	allowance	uint
event	Transfer	
event	Approval	

A fixed quantity of 7.5 billion tokens is planned. This is a symbolic number to represent the number of people on the planet today[14] and the universal responsibility for environmental stewardship.

A common feature for tokens is the ability to "mine" them. This comes from the Bitcoin use of the term as analogous to mining gold[15]. IOM Token cannot be mined. Rather,

materials can be “mined” through established collection methods and then traded for IOM Token through the IoM.

IOM Token is the currency of smart materials. It is required by smart materials to transact. The value of IOM Token is defined by the value of the IoM and not any single component or contribution. Today, the value of IOM Token is zero. As a result, purchasing IOM Token would be a purely speculative endeavor. The exception to this are stakeholders that not only purchase, or accept IOM Token, but also participate in the IoM, thereby adding value to the ecosystem, and adding value to the token. Initially, we expect participating stakeholders that are material producers and suppliers will realize the greatest benefit from the IoM. This is a feature and not a bug. This provides an incentive to devote valuable enterprise resources to participate in the IoM.

By creating a separate token as opposed to using Bitcoin or Ether for transactions we seek to insulate stakeholders from fluctuations that may be caused or influenced by factors far outside the priorities, and realm of influence of the IoM. Fluctuations in the price of both Bitcoin and Ether, whether due to speculation, perceived risk or community influence, could impact material transactions with unforeseen, unrelated and unnecessary friction. This risk works directly against our objective of reducing supply chain risk in order to protect material utility, value and sustainability. IOM Token provides the practical benefits of a single, unified currency, similar in principle to the Euro, without the risks of politics, or the concerns in regard to sovereignty.

Stakeholders, are a broad group that facilitate or participate in material transactions. To establish a baseline utility of the IoM and a corresponding value of IOM Token endswapper will distribute free and/or discounted IOM Token to early partners including, but not limited to, the following categories:

- Material producers/suppliers/recyclers
- End-users, i.e. manufacturers
- Industrial AI/autonomy/machine learning
- Independent software developers
- Enterprise software providers
- Enterprise service providers
- Logistics providers
- Financing providers
- Waste collection
- Non-profits and schools

Smart Materials

Smart materials are smart contracts on the Ethereum network that represent physical material inventory (existing or planned) that utilize IOM Token to transact. Creating smart materials in smart contracts elevates materials to first-class citizens. They have the ability to self-destruct and create new materials. Smart materials make use of EIP165 for

standard interfaces to indicate the interface use and version. This makes it simple to identify smart materials and modify the interface in the future.

Summary of smart material core functionality:

- Approve a transaction
- Accept IOM Token
- Implements a standard material interface
- Material description
- Material specifications
- Material media
- Material offer terms
- Shipping terms
- Self destruct

A simple implementation of a smart material allows automated marketplace functionality. For example, a smart material can execute a transaction and process a payment.

Sophisticated implementations enable smart materials as logic-bound, autonomous participants in the IoM. This means that by interacting with existing technology and enterprise systems smart materials are no longer passive objects or assets within the enterprise, but valuable contributors to the enterprise.

For example, an unfilled plastic material could decide, based on the data in existing systems, to add glass fiber or a mineral additive to satisfy a more profitable demand for filled material. The processing required, whether internal, or third party, could be negotiated, scheduled and managed by the smart material. Material mobility can be achieved simply by interacting with existing scheduling and warehousing systems. A smart material could schedule a shipping appointment, and when then truck arrives, it notifies employees or an autonomous fork-lift that it should be loaded on to the truck. Additionally, a smart material could negotiate with logistics providers to get the best rate, prioritize warehouse space or deliver to customers just in time. Smart materials could also interact with freight forwarders and provide documentation to customs departments.

It's important to note that the possibilities discussed are not available "out of the box." Smart contracts, and therefore smart materials, cannot just automatically interact with existing enterprise systems without additional help. The use of oracles is required to provide an essential link between off-chain data and smart materials, which are by definition, on-chain. Oracles will also manage the ongoing needs of gas required by smart materials for Ethereum network operations. We will provide versioned system/implementation specific standardized oracles on an ongoing basis.

We are primarily concerned with software, hardware and third party oracles. Within the context of the IoM software oracles will provide a connection between enterprise

software such as ERP, CRM and SCM platforms. This is also where our bring your own platform philosophy shows its value. You can use whatever technology you prefer and still have complete integrations with standardized oracles. Hardware oracles will provide a connection between industrial robots, sensors, RFID and similar technologies. Beyond the benefits of deep integrations hardware oracles lay a foundation for Industry 4.0 capabilities. Third party oracles present a vast landscape of possibilities to leverage new and existing services utilizing aggregate data from the IoM, that include, but are not limited to:

- Artificial Intelligence
- Analytics
- Know Your Customer
- Machine Learning
- Robotics
- Public Key ID

CRISPY

CRISPY is a free and open-source software product, a decentralized application (dApp), for smart material creation and interaction where there is no existing enterprise software. The name is inspired by CRISPR the basis for genome editing technology as we are concerned with the “DNA” of smart materials.

CRISPY is based on an existing application featuring a materials marketplace with complimentary services. That application has been discontinued in order to devote resources to the IoM. The primary purpose for CRISPY is to make the IoM accessible to anyone, expanding the network, to the benefit of all stakeholders. However, it may also be used and adapted without restriction within the enterprise where another interface is lacking or unnecessary. Furthermore, it may be used as a basis for third party developers to provide dApps and services for the IoM.

The basic functionality CRISPY provides is a light wallet to manage IOM Token and a user interface to allow non-technical users to create and interact with smart materials. Templates make it easy to implement proven best practices.

The target audience is recycling facilities, non-profits, public and private institutions, and individuals without the resources or need to support large-scale enterprise software solutions.

Governance

Initially, the IoM will be managed by endswapper through the early development stages and heavily influenced by early partners. A private foundation will be created to support the long-term development and maintenance of the IoM. Following that we expect to establish mechanisms to maintain and guide future development that will be inclusive of all stakeholders. Some of the ideas being considered are a rotating board of advisors

comprised of stakeholders and voting that would require a negligible amount of IOM Token to cast a vote. This is in addition to IoM Request for Comments and IoM Improvement Proposals, which may make simple, obvious and otherwise trivial modifications very rapid.

Development Roadmap

Q3 2017

The work of adapting our original application to a dApp in the form of CRISPY has already begun.

With the release of this whitepaper we are simultaneously initiating our early partner campaign. We will work with early partners to deliver complete integrations with their existing systems. This work will be done for free. In order to provide complete solutions, we will provide the same benefit for their supply chain partners and vendors who choose to opt-in.

Early integrations will be reduced to modular pieces and published as free and open-source modules. This will allow anyone to complete similar implementations, customized to suit their own needs, with minimal overhead. During this process all contributions will be published to our GitHub account at: https://github.com/endswapper in advance of a comprehensive technical whitepaper. Initially, our integration emphasis will be on existing enterprise software with the largest installed base for supply chain management, enterprise resource planning and customer relationship management.

We will begin formalizing partnerships and perform the required discovery to complete the implementations described above. We will distribute the details of the IOM Token initial token sale.

Q4 2017

Our technical whitepaper will be published providing practical examples of real-world implementations. We will also execute the initial token sale for IOM Token. These contributions will enable broad development and testing for the IoM development community.

Q1 2018

Alpha testing of CRISPY and early partner integrations.

Q2 2018

Beta testing and final release of CRISPY and early partner integrations. Following the final release of CRISPY and the early partner integrations our attention will turn to broad internationalization. The preceding work will be adapted for partners around the world in their native languages. These partners, their supply chain partners and vendors will receive the same benefit of free integrations.

Q3 2018

Governance whitepaper release.

Conclusion

By aligning all stakeholders - consumers, enterprises and even materials themselves we identify a path for global material sustainability. Through a combination of technologies, and a basis in free and open-source software we make the path accessible for everyone. The Internet of Materials drives growth and efficiency, supporting material utility, value and sustainability. Not only is the IoM a self-sustaining mechanism for material sustainability, but also the necessary next frontier to realize the promise of Industry 4.0.

Acknowledgments

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