

LOOMIA TILE

A Decentralized Platform for Identity and Personal Data

MADISON MAXEY, EZGI UCAR, SOLOMON LEDERER PHD, AND JANETT LIRIANO

August 22, 2017

Abstract

The LOOMIA Tile is a hardware device that transforms clothes into data-collecting tools by means of a blockchain protocol, allowing users to collect and sell data about their lifestyle to market researchers. It works in conjunction with the LOOMIA Electronic Layer (LEL), a soft fabric circuit embedded into textiles with the ability to sense changes in its environment, and the LOOMIA Platform, a P2P software program for aggregating data from the LEL and selling it to authorized buyers. In a world where personal data has become a precious commodity sold in secret by large corporations, the LOOMIA Tile gives individuals the right to own their own data, along with the freedom to choose how much of it to sell and to whom. Meanwhile, the LOOMIA Tile's unprecedented ability to associate an individual's "physical" identity, contained in their fingerprint and their personal data, with their "digital" identity, contained in their online profiles and activities, presents an interesting starting-point for a wide range of third party integrations, which could use LOOMIA technology to verify identity and facilitate secure payments passively and seamlessly, with no manual record-keeping and no screens.

I. INTRODUCTION

Personal data is the new oil of the Internet and the new currency of the digital world.

Meglana Kuneva,
European Consumer Commissioner

Right now, your identity is a string of numbers, dates, passwords, and images. Anyone with these digital assets can pretend to be you in the physical world. LOOMIA suggests a protocol for multi-factor identity verification that bridges the physical world and the digital world to prove that the physical you is the digital you. We do this by using personal data collected from your garments, synced to an online profile and verified with a fingerprint. In short, we ensure that you are you by collecting personal data from what you wear.

Companies that collect personal data about their users typically claim ownership of that data for themselves and make a profit reselling it to large corporations. Personal data is

bought and sold at a premium behind closed doors in a shadowy industry whose value might be anywhere from \$156 billion to \$300 billion. LOOMIA does not believe in this future. The LOOMIA protocol ensures that your personal data continues to belong to you. Instead of companies profiting off of your identity, you can own and sell your data to brands, researchers, and other organizations who are interested in learning more about how you use their products and systems, thus creating a closed feedback loop with no middleman and allowing you to profit from being you.

In the process, LOOMIA's system solves a key problem for brands as well: smart apparel alone is projected to be a \$130 billion global market by 2025, and yet there is no good way to track the performance, use, and failure of apparel and other soft goods once they leave the store. Customer research can cost a brand or research group upwards of \$100,000 per product to conduct surveys and focus groups, predict product outcomes, track inventory, and evaluate marketing campaign

reception, and even after doing all those steps, the information they get is still be very incomplete, collected with very limited context. LOOMIA provides an ethical way for brands and market researchers to obtain much more detailed data sets than ever before from a much larger number of users, without the effort and expense of mounting campaigns to harvest it themselves.

LOOMIA's solution is a system with three levels: the LOOMIA Electronic Layer, the LOOMIA Tile, and the LOOMIA Platform, which supports the LOOMIA Data Exchange.

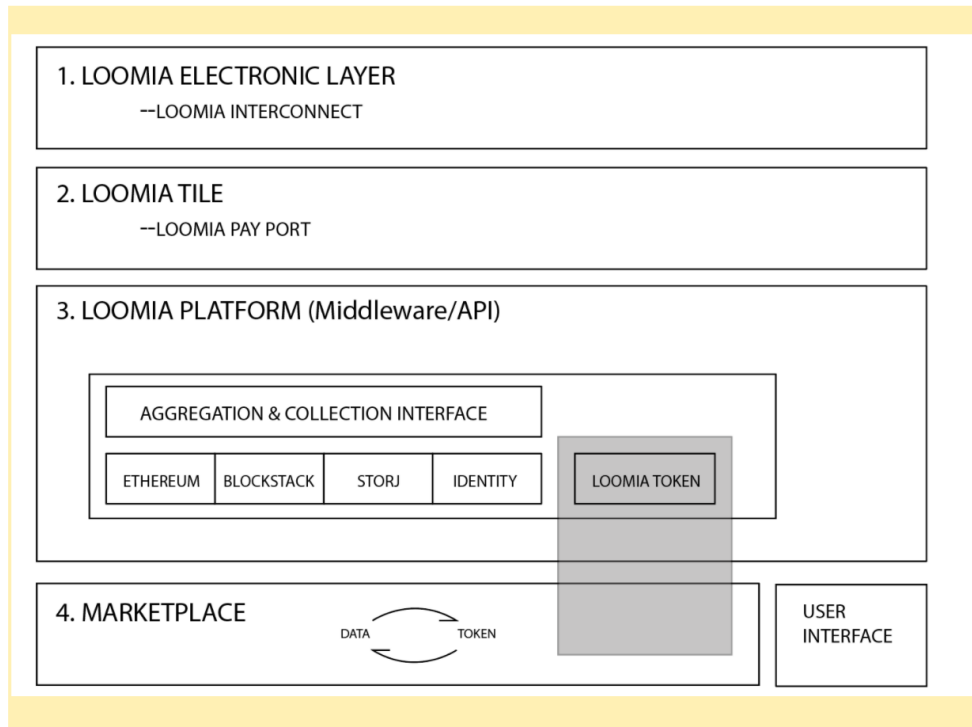
- **The LOOMIA Electronic Layer (LEL)** is a soft, flexible integration to garments that perform heating, lighting, sensing functions and gathers data about the user. The LEL is LOOMIA's current product offering and our current patented innovation.
- **The LOOMIA Tile** is a hardware device that acts as a user's "keychain" for multiple containing LELs. It stores the data gathered by LEL until it is synced into the LOOMIA Platform. It depends on fingerprint recognition to verify users' identity.
- **The LOOMIA Platform** is a P2P app which stores the data collected on the LOOMIA Tile, integrates it through a blockchain protocol to verify users' identities, and gives users the ability to sell their personal data to brands or third parties.
- **The LOOMIA Data Exchange** is an online marketplace through which brands and third parties (which, in time, might include restaurants, banks, or transit authorities) purchase data directly from users to study in aggregate for product and service improvement. This data is delivered in an anonymized manner, with no identifying information included in the exchange beyond the user's public key on the LOO-

MIA Platform. Companies and interested researchers gain data sets with unprecedented precision and volume, while users earn money in the form of LOOMIA tokens, which can be converted directly into other digital currencies or exchanged for special rewards with the companies on the LOOMIA Platform.

II. THE LOOMIA ELECTRONIC LAYER

The LOOMIA Electronic Layer (LEL) is a soft, flexible electronic layer that moves like a fabric, but works like a circuit board. LOOMIA specializes in producing soft, flexible circuits that integrate into textile products. These circuits can deliver heat and light and sense changes in adjacent materials. Their size, shape, and function can all be customized for many different use cases. Because the circuits are made from soft components which look and feel no different from fabric, they can survive frequent machine washing and exposure to the elements, which would destroy other mechanisms like flexible PCBs. LEL technology is explained further in Patent Filing USPA 20170086513.

All LELs come pre-assembled with a LOOMIA Interconnect, a hard-to-soft connection which can mount to various connectors, including USB and JST For use with the LOOMIA Tile, all LELs will come mounted with a magnetic pogo pin connector. The LOOMIA Interconnect houses all components that require logic, such as an Attiny85, as well as the LOOMIA Tag, where it can be read by the LOOMIA Tile once it is plugged in. The LOOMIA Tag is a pattern on the LOOMIA Interconnect that identifies each unique piece of clothing with information about the brand, SKU, material, size, and more. It can be read by the LOOMIA Tile when the user plugs it in, but it could also be read by other technology when the user enters or leaves a store, attends an event, or boards transportation, which would enable it to work in third party applications as a ticket or



an anti-theft device. The LOOMIA Tag could also be used during soft goods production to authenticate branding and ensure proper manufacturing processes all the way through the supply chain, while tracing the full lifecycle of the product from start to finish.

III. THE LOOMIA TILE

The LOOMIA Tile serves two different functions. In its first function, it acts like a “key-chain” with all your soft goods registered as “keys,” gathering all of the data collected through them in a single place. Each LOOMIA Electronic Layer will pass a specific resistance from its garment to the Tile, allowing it to identify that garment uniquely through a simple GPIO pin. Through its connection to the LEL, the Tile can collect data about the specifications of the garment (size, color, etc.), how many times the garment was used, how long it was used, where and when it was used, and more. In its second function, the LOOMIA Tile acts like a “MetroCard” which you can reload with

LOOMIA tokens in order to make purchases at LOOMIA Rewards locations, through an NFC chip which approves transactions and converts LOOMIA tokens seamlessly into other digital currencies.

LOOMIA-enabled garments have the capacity support “ring signature” identity verification schemes with three possible security thresholds. *Low security*: the presence of your registered garments. *Medium security*: the presence of your gait (accelerometer) and maybe some measurements of your usual conditions, bodily and environmental. *High security*: you place your finger on the fingerprint reader.

The LOOMIA Tile makes use of the “high security” option: it turns on and off with a fingerprint. Like the LOOMIA Electronic Layer, LOOMIA Tiles have a unique identifier on its integrated chip. The LOOMIA Tile uses a blockchain-friendly chip for identification, meaning it will have a device ID, a public key, and a private key. This could be a Chronicle Chip, or another chip with easy blockchain integration. LOOMIA is chain agnostic; in the

early stages of development, it will host private Ethereum blockchains on Azure, but in the future, it will support Rootstock and Hyperledger as well. (Figure 1 shows a code sample for a device ID and private Key set up through the Chronicled Chip.)

However, the unique identifier on a LOOMIA Tile's chip is not associated with a user until the Tile reads a fingerprint and associates the data on the tile with that user. When a user uploads data from a Tile, the data is associated with the account belonging to the owner of the fingerprint presented, not the owner of the Tile. Thus, the Tile is not a personalized item that can be stolen along with the data and tokens associated with it, but rather an interface that can be personalized to any user with the touch of a finger. Even if two users, Alice and Bob, share both a garment and a Tile, Alice can only access her data, and Bob can only access his, as illustrated in Figure 2.

Once a Tile recognizes a fingerprint for which it has collected data before, it can make decisions for the user based on their previous preferences and needs. In time, these decisions could become increasingly complex, such as setting the temperature of a garment based on the user's ideal body temperature or making payments automatically to the user's favorite coffee shop. All smart contracts involving the LOOMIA Tile will be open source, making it easy for third parties to use LOOMIA technology to support their own applications. In time, interface elements in garments or other soft goods could automate or expedite many interactions which currently require a smartphone, such as manually checking on apps like Yelp, Facebook, and Foursquare. (For more on third party integrations, see section VI.)

The LOOMIA Tile mates magnetically to a LOOMIA Dock, shown in Figure 3, in order to recharge its battery, recharge its' associated LEL's batteries, and connect to a computer with the LOOMIA Platform app. When the LOOMIA Tile recognizes the user's fingerprint inside of the LOOMIA Dock, they will be signed into the LOOMIA Platform app, where they can choose whether to transfer data between

their Tile and their account, sell data, or simply charge their batteries without any other action.

All data is visualized in the LOOMIA Platform's interface, where the user can view it before deciding which data to decrypt and sell. Data will only become available to interested parties once the user decides to sell it; the user will always retain the right to choose what data they will sell, as well as then they will sell it, and to whom. For example, a user might chooses to sell their biometric data for health and fitness rewards while keeping their location data confidential. Buyers can incentivize users to sell the kind of data they find most useful by providing different kinds of rewards, and users can incentivize brands to align with their lifestyle by selling their data for the rewards they value most.

Because the data on the LOOMIA Tile is automatically encrypted, it is useless to other parties until it is sold by the user. In order to view their own data, store it for future use, upload it to new Tile, or sell it on the LOOMIA Data Exchange, the user must first sync their Tile to the LOOMIA Platform.

IV. THE LOOMIA PLATFORM

The LOOMIA Platform is the P2P software that collects and manages data from the LOOMIA Tile and exchanges information with the network of LOOMIA users. The LOOMIA Platform is serverless; it is designed so that at no point does the app need to offload data or connect to a central server. Each instance of the app connects to other user instances. The first generation of the app is designed to run on desktops, but a mobile version of app is slated for future development.

The LOOMIA Platform's stack is made up of three distributed applications working together, as shown in Figure 4:

1. The **decentralized app** for user interactions and data collection
2. The **decentralized data storage** for long-term housing and retrieval of data

3. The **blockchain** for distributed, verifiable, universal record keeping

This section will describe the function of each of those applications separately. Taken together, they have an architecture similar to blockstack, and they use many blockstack protocols, modified to suit our needs. Blockstack's peer network, called Atlas, gives a global index for information discovery. In Atlas, every node maintains a full replica of the network's data, so the network needs no overhead to maintain a routing structure, and it is also very resilient against targeted node attacks, since every node has its own copy of data. The nodes in Atlas store data in the form of zone files, which are identical in structure to DNS zone files. The peer network accepts a zone file only if its hash has been pushed to the blockchain, which allows each peer to be confident that records have not been tampered with. At the moment, zone files are so small that each node is easily able to keep a full copy of the hash table. However, if this ceased to be true in the future, it would introduce only minor storage requirements.

Blockstack uses their own naming system known as BNS, Blockstack Naming System, which is meant to replicate the functionality of DNS without a central party. This system is a remarkable achievement, since it was long assumed that a decentralized system could not provide human-meaningful names, which is to say, it could not ensure that each user registered only one account. This seeming impossibility, often referred to as Zooko's triangle problem, has only recently become solvable with the advent of blockchains. When we move to run Atlas on Ethereum, we will use the ENS (Ethereum Name Service), which shares the ability of BNS to provide human-meaningful names.

i. The Decentralized App

The LOOMIA Platform app is responsible for the following functions.

- **Collecting the data from the LOOMIA**

Tile. At the end of the day, when a user syncs their LOOMIA Tile to their account through the LOOMIA Dock, their data transfers to the LOOMIA Platform app, where it can be aggregated and visualized. The LOOMIA app will also register new LOOMIA-enabled devices through the same process, via the LOOMIA Tile and the LOOMIA Dock.

- **Matching data against models of realistic, genuine data.** For example, if a user uploads more data points than can feasibly be gathered in a single day, then the LOOMIA app will ignore that data. The app's models are calibrated among peers and adjusted over time.
- **Encrypting data and backing it up** to the decentralized data storage in the LOOMIA Platform stack, or to other external storage venues chosen by the user.
- **Giving users the option to decrypt the data and sell it** by pushing it to the DHT (distributed hash table), where it can be accessed and viewed by all users. If a user chooses to do this, then they will get paid for their data. Users will have the option to set the payment thresholds to meet before releasing the data.

Eventually, prices will be set by users as data creators and data buyers interact and compete in the LOOMIA Data Exchange. The process of receiving payments in the form of LOOMIA tokens and spending those tokens to get rewards is managed by the user's wallet inside of the app.

ii. The Decentralized Data Storage

Data which the LOOMIA app has approved for long-term storage will be transferred to the LOOMIA Platform's distributed data storage system. If a user's Tile or app gets lost or corrupted, everything can be reclaimed from this distributed storage. The user's private

key is all that's needed to decrypt their data capsule.

The LOOMIA Platform is storage agnostic. In the early stages of development, it will integrate with Swarm for convenience in working with the Ethereum platform, which means it will use Swarm's DPA (distributed preimage archive) protocol for storage as well as the bzz protocol for sending and retrieving data. In the long term, we envision using multiple storage platforms simultaneously, including Storj, Sia, and Filecoin in addition to Swarm. We also leave open the option for users to connect to their personal cloud storage accounts and upload their encrypted data there, which is similar to the way that blockstack operates.

Swarm's DPA protocol stores information in strings of bytes according to their hash value, which are assumed to be collision-free, just like ethereum addresses. The repository of data stored through the DPA is the Distributed Hash Table (DHT), in which each node has an address that is within a short distance of the hashes of the data it has contributed. Nodes will store only the data whose hashes are closest to itself, and once a node reaches storage capacity, it will discard the data whose hashes are furthest away. Thus, each node has the ability to add new data to the DPA, retrieve data which it has previously stored, and provide routing information to nodes which are closer to the data being retrieved. Each node also breaks large chunks of data into a tree of smaller blocks, in which the key of each root block can be used to retrieve its children until the whole data chunk is reassembled.

iii. The Blockchain

The blockchain provides the constant backbone to ensure data authenticity, so that individual nodes can join and leave the network with no impact on the network's integrity and operations. The blockchain ensures that zone files are correct by matching the hash for the file stored on the blockchain with the hash retrieved from distributed storage. This allows users to connect and get correct routing in-

formation for communicating with the rest of the network. (The routing algorithm LOOMIA uses is based on Kadmelia routing.)

- **A directory of every registered LOOMIA device.** This directory of SKUs is updated every time new LOOMIA-enabled products are manufactured. When a new device is authenticated by the LOOMIA app, it checks this registry to ensure that it is an authentic LOOMIA-enabled product.
- **Aggregated user data,** which is periodically hashed and written to the blockchain, creating a history that is verified in time. The length of this time series of hashes impacts a user's identity score. This will act as a cryptographic secure tagging of IDs.
- **Payment rails,** which enable the user to transfer tokens to other users inside of LOOMIA and to other integrated distributed storage platforms such as Storj, Sia, or Filecoin.

Device registration:

All LOOMIA products will be registered on the blockchain. In the post-manufacturing phase a public/private pair is generated for the device and the public address is written to the blockchain with that item's ID. This address represents the owner of that device.

Purchasers receive the private key of the item's blockchain address when they purchase the product. The buyer can then choose to update the owner address to one of their choosing or to keep the address generated for them (which is less secure, but more convenient). The update method will naturally only be invokable by the owner.

```
function updateDeviceOwner(string
    deviceId, address newOwner) {
    if ( msg.sender == devices[deviceId] )
        devices[deviceId] = newOwner;
}
```

Writing data to the blockchain and proving its authenticity

When updating the blockchain with a new record, the client will create a hash of that record and store that. The smart contract will verify the addition is valid e.g. that this device record has not been updated within 24 hours (we throttle the number of records added to prevent false record entries).

```
function addNewRecord(string deviceId,
    address deviceOwner,
    bytes32 newDataHash)
{
    uint lastEntryTime =
        records[deviceId].entryTime;
    if (now >= lastEntryTime + 24 hours
        && records[deviceId].owner ==
            deviceOwner) {
        records[deviceId].entryTime = now;
        records[deviceId].dataHash =
            newDataHash;
    }
}
```

When data is transferred to a buyer the record is produced along with the transaction showing that hash of that data written to the contract. In this way data cannot be falsified after the fact.

Even without any provision for buying and selling data, the LOOMIA Platform would have some value for consumers simply by collecting all of the data about their soft goods in one system, from which they can easily retrieve it to provide proof of purchase or to claim support under warranties and get replacements or repairs for their damaged goods. But the main value in the LOOMIA Platform's massive aggregation of data comes from the rewards that users can earn with it, when they sell their own data on the LOOMIA Data Exchange.

V. THE LOOMIA DATA EXCHANGE

Before a user chooses whether or not to sell their data, the LOOMIA app sorts it into many different categories, which allows both users and buyers to be selective about what kind of

data they want to sell and acquire. Some categories will be defined according to the World Economics Forum's conventions for classifying personal data.

- *Volunteered data*: completed survey forms, profiles, and other attestations written by users explicitly for the use of researchers
- *Observed data*: recordings of the action or condition of the user, which can be captured by researchers without any conscious effort or declaration by the user
- *Inferred data*: Inferred data: conclusions about the user drawn from statistical analysis of volunteered or observed data, similar to credit scores

Other categories will sort data by its structure, rather than its content:

- *Independent data points*: how often a user is doing a given activity or interacting with a given product (e.g. wearing a given jacket, or going outside in cold weather).
- *Related data points*: how often two independent data points correlate (e.g. wearing a given jacket while going outside in cold weather).
- *Static data points*: identity parameters which broadly define the marketing demographic and basic persona of the user, independent of their product use behaviors.

In the LOOMIA Data Exchange, buyers can broadcast their interest in and price point for buying specific kinds of data. In time, those buyers could include a wide range of third parties like delivery services and city planners, in addition to product brands. In response, users can sell each kind of data manually, or set it to be released automatically at a certain price point or to a certain buyer. In exchange for their data, users get LOOMIA tokens deposited into their wallet in the LOOMIA app.

The LOOMIA token is the currency unit which provides access to the LOOMIA Platform. One LOOMIA token is the cost of one API call to the system. For example, if a brand

wanted to determine how many users wear their jacket, it would spend tokens to query the LOOMIA Platform to get usage data. If a smart contract wanted to verify the identity of a user before it transferred funds, it would spend tokens to query the user's associated registry entry and get their identity score.

The original LOOMIA token is an Ethereum ERC20 token. During a LOOMIA token generation event, 1000-1200 LOOMIA tokens will be created per ether contributed, plus an additional 20 percent at the conclusion of the generation event. The value chosen from that 1000-1200 range depends on the time of the contribution and the bonuses assigned at that time. LOOMIA tokens have a small annual inflation of 1% every 6 months, which is in line with USD inflation. As a result of this inflation, there will always be small supply of tokens available for new brands and users who join the network as the LOOMIA Platform grows. Each new account will contain a small amount of tokens as a courtesy to help new users get started. The new supply of tokens is minted every 6 months by a minting function.

LOOMIA tokens can be used just like any Ethereum token and transferred freely between users directly on the blockchain, with no reliance on the LOOMIA app in any way. In future stages of development, we also plan to ask our users for payment in tokens in exchange for the opportunity to vote on product developments to the LOOMIA platform. Aragon and Status have already expanded their token systems to include this voting feature, which gives users a direct say in future developments while ensuring that these important decisions cannot be gamed or influenced by people who do not have a stake in the system.

In essence, LOOMIA tokens pay users passively for things they do everyday. In order to generate valuable data, users don't need to change their behavior or build any new habits besides syncing their Tile to the LOOMIA platform at the end of the day. The market research data which they passively provide – collected by LOOMIA from a large population of users than ever before, with a much richer, more pre-

cise, and more reliable array of details – will allow brands to match their customers' demands, minimize their excess inventory, and provide tailored options for individual users. Armed with what they've learned from this data, companies in the LOOMIA community can attract and retain customers with rewards, discounts, suggestions, and exclusive opportunities. Beyond the direct rewards which users receive in the form of LOOMIA tokens, LOOMIA-enabled clothes can act like credit cards to provide others benefits like miles, access to special events, and consumer-focused experiences which users couldn't get otherwise.

These benefits can expand and evolve in even more creative ways as third parties harness the power to build on top of the LOOMIA Platform.

VI. THIRD PARTY INTEGRATIONS

Since the LOOMIA Platform P2P protocol provides an API endpoint, it is very easy for third parties to build applications on top of it, using LOOMIA technology to verify users' identity and facilitate the transfer of payments.

The sophistication of the LOOMIA Tile intelligence for transferring payments will grow over time. In the early stages of development, the Tile will require manual authorization for all payments. The Tile will use its indicator light to display a signal about the payment, and the user will validate it with their thumbprint. Future developments might allow the Tile to make small automatic payments below a certain threshold, or larger automatic payments to users with strong reputations and well-verified identities, which could allow for checkout-free shopping and dining. The LOOMIA Platform also could provide service opportunities by allowing users to assign a certain percentage of their rewards on the LOOMIA Data Exchange to the factory worker who made their clothes, or to other causes which they support.

Even without any payment transactions, the LOOMIA Tile's ability to confirm a user's identity reliably through their fingerprint has many interesting third party applications on its own.

Other web services can query a user's LOOMIA address to get their identity attestations, as well as a score describing the probability that each attestation is true. For example, it is highly likely that someone who has worn LOOMIA garments for 20 years is over 20, someone who has entered bars and casinos is over 21, and someone whose immediate social circle is over 21 is also over 21 themselves. Each user builds an identity profile through the course of their interaction with LOOMIA; as the user contribute more data, their identity profile grows, and other users can verify them with greater confidence. Thus, it would be very feasible for third parties to use the LOOMIA Tile to check whether a user has clearance to enter schools or secure facilities, to unlock the user's car or home, to inform them of severe weather conditions in their area, or to share their location with other members of their social network, among many other examples.

VII. CONCLUSION

You get the picture: Users wear LOOMIA-enabled garments made by brands they love which collect data about their use patterns, their location, their body temperature, their body motions, and their environmental conditions, all tied to the garment's SKU. LOOMIA-enabled garments store data points during the day and transfer them to the LOOMIA Tile when they recharge at night. Simply by going about their day, with no extra effort, users create very valuable data sets which provide brands with meaningful insights about how their products are really being used. The only "work" required from the user is getting dressed in the morning and recharging the LOOMIA Tile at night. All the rest is passive.

On the LOOMIA Platform, users can sell the data on their LOOMIA Tile to researchers in an anonymized fashion in exchange for LOOMIA tokens. These tokens can be converted to other digital currencies or used across businesses on the LOOMIA platform, offering a wide economy in which the LOOMIA token has value. Participating business can develop

reward plans based on LOOMIA tokens to incentivize users to buy and wear their products. The more you wear a certain brand, the more brand-specific rewards you could get. A brand could even try to drive sales patterns by making limited-edition "high token value" items and promising to pay a higher price for data collected through those items than through others, which would naturally incentivize users to buy those items and use them more often.

The basic technology in the LOOMIA Tile system has the power serve a wide variety of functions for different enterprises. Researchers with no interest in product development might still want to make use of LOOMIA's temperature, motion, and location data to study the safety conditions of industrial workers, to report in real time about the population-level effects of accidents and severe weather patterns, or to determine the best place in town to build a new housing development or franchise. If multiple third parties want to buy the same datasets collected from the same population of users, those users could receive royalties for each additional purchase. And as third parties harness the ability to build their own applications on top of the LOOMIA Platform, the use-cases for enterprises could become even more creative and complex.

The LOOMIA Tile sits at the intersection of two new, fast-growing industries: smart apparel and personal data. As such, it is uniquely well-positioned to unite these two burgeoning fields in service of each other. Smart apparel needs better data in order to drive product development, and personal data needs better smart apparel in order to track a larger number of internal and environmental variables in a more consistent, ongoing, and non-invasive way. Personal data is already a hot commodity for businesses in many spaces, but it will become even hotter over the decades ahead as developments in data science lead to cheaper, faster, and more revelatory forms of analysis on larger datasets than ever before. LOOMIA's Tile is a proactive, ethical plan for providing the the high-volume, high-precision data sets that companies will seek while eliminating the

middlemen, closing the feedback loop, and ensuring that individuals will retain the right own the data that they [**dirac**] create.