The Next Era of Precision Medicine

WhitePaper | v1.0

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SHIVOM

A global genomics ecosystem based on distributed ledger technology

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Abstract

In recent years, advanced technologies such as genomics, artificial intelligence and blockchain, have reached the potential to significantly improve global healthcare. At the same time, costs to sequence genomes have decreased considerably over the past twenty years. Genomic medicine, with considerable implications for understanding and treatment of many rare diseases, is perfectly suited for utilizing blockchain technology particularly for the secure and private storage of healthcare information. The Shivom ecosystem plans to offer an open a blockchain-based genomics database alongside a web-marketplace and innovation hub, which will allow providers and third-party vendors to add and market customized apps and precision medicine services.

Shivom intends to build such a platform using convergent technologies including genomics, blockchain and artificial intelligence; technologies identified by the European Commission as among today's most promising breakthrough innovations[1]. Upon establishing a highly scalable healthcare vertical, Shivom will extend its services to form a global network of genomic counselors and associated laboratories as well as establish a non-profit research and development (R&D) organization for a fully integrated healthcare service system. The research institute will be based on open-innovation that optimally connects patients, clinicians, researchers, insurers, clinical laboratories and other stakeholders. The Shivom platform works on the principles of open collaboration, transparency and integrity and provides patients with complete control over their own genomic data. Patients / donors via crypto keys will have full control over their sensitive personal health data and be able to donate or monetize on their genomes via Shivom's blockchain platform.

Every person on the planet, even those from low-income countries and rural areas where healthcare services are not readily available, will have the opportunity to have their genome sequenced and stored; and work with clinicians and genomic counselors to make educated decisions about personalized healthcare. By developing the world's largest genomic data-hub and healthcare services platform, Shivom plans to usher in a new era of healthcare and precision medicine. Shivom anticipates its massive genomics datahub and healthcare ecosystem will create value for all individuals, not-for-profit organizations, governments and for-profit entities worldwide.

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1 Introduction

1.1 Vision & Values

Shivom envisions a future when healthcare is auditable, authenticated by mass collaboration and powered by collective interest, guided by trust and transparency and all transactions are secure among all parties. Individuals will be empowered to manage their own health and have robust access to medical and scientific knowledge based on public health evidence and deep science. At the core of Shivom's vision of the future of healthcare will be society's deeper understanding of and the development of precision medicine based upon human genomics. By integrating various '*omics*' data with the genomic data stored in Shivom's blockchain-based ecosystem and by applying latest technologies to include artificial intelligence (AI) technology (e.g. certain deep learning algorithms), Shivom through its healthcare services platform intends to provide deep scientific insights, boost therapeutic development, advance molecular diagnostics, biomarker discovery and disease risks assessment; and ultimately serve to improve people's quality of life by working to prevent, alleviate and treat thousands of rare diseases worldwide.

Shivom plans to work with as many global players as possible to accomplish its goals and develop a world class healthcare services platform for the benefit all people globally. To these ends, Shivom intends to collect clinical and population data to assess the utility of genome sequencing in healthy and diseased individuals, and explore ethical, policy and infrastructure issues related to responsible adoption of its genome technology. Shivom will strive to educate consumers to better understand test results in order to make informed decisions; support human rights approach of data sharing, as stated in the GA4GH *Framework for the Responsible Sharing of Genomic and Health-Related Data*, such that data sharing should be conducted "with a view towards minimizing harms and maximizing benefits to not just those who contribute their data, but also to society and healthcare systems as a whole"[50]. Ultimately, Shivom plans to build a new genomics ecosystem based on the strong belief that all people should:

- own their genomic and health data
- have free access to its platform
- have easy access to all their data
- have confidence that their genome is safely stored
- be able to improve their health with their data
- be able to use the platform effectively
- be able to control who accesses their data
- be able to economically benefit from third party use of their genome
- have the option to anonymously donate their data for the public good

1.2 Fixing a Broken Healthcare System

Healthcare data, when siloed and stored in a variety formats and in disparate databases, is not readily available for society's maximum utility, benefit and medical needs. Compartmentalized information, especially for genomics data, significantly limits healthcare providers from being able to conduct effective research and drug development. According to the U.S. Food & Drug Administration (FDA), an estimated nine out of ten drugs/biologics tested in humans are never

submitted to FDA for approval. If individuals and medical centers around the world fully shared their genomic data, then the collective data and consequently R&D and clinical trials, would likely be more profoundly valuable and useful; and healthcare costs would likely significantly decrease.

In addition to considerably higher costs and relatively poor economies of scale, siloed data often leads to limited patient stratification or variation of genomic data pools. Including the sequenced genomes of patients worldwide among various geographies and ethnicities with unusual mutations and phenotypes, or individuals with disease-resistant mutations, would significantly improve clinical trial outcomes and further advance development and adoption of precision medicines. By combining genomic sequencing data with health records, researchers and clinicians will have a vast resource that can be interpreted to improve patient outcomes and be used to investigate the causes and treatments of a disease. Ultimately, for big data approaches to thrive, historical barriers dividing research groups and institutions need to be broken down to usher in a new era of open collaboration and more effective data-driven drug discovery approaches.

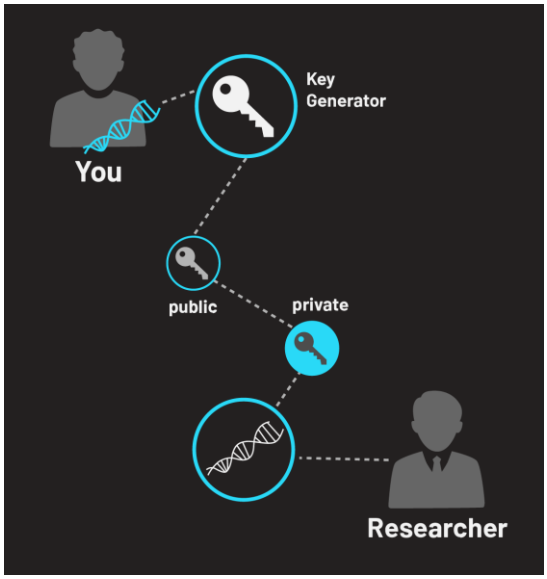
Moreover, today's centralized databases continue to allow for multiple points of access and failure as evidenced by routine reports of data hacks and breaches worldwide. New platform architecture and technology solutions, while still publicly accessible and searchable, are required to more effectively store data in a secure, anonymized manner considerably more resistant to malicious attacks or unauthorized access. Such a platform must be accessible on a global scale, offer data provenance and auditing features, be easily accessible and understood by all users and stakeholders, and easily allow for the upload / addition of new genomic data.

In addition to relatively poor security practices and protocols, participants continue to lack sufficient access and control to their own sensitive personal data and electronic healthcare records. Beyond lack of transparency, patients also continue to be discouraged and lack incentives to participate in studies and share data, which is known to be routinely monetized by third parties. Based on these and other persistent healthcare system deficiencies, people worldwide increasingly demand not only new practices, technologies, methodologies, business models and innovative approaches to the drug discovery and therapeutic remedies, but also greater oversight, management and control over their personal data and wellness / healthcare.

1.3 Shivom Genomics Datahub & Healthcare Services Platform

To tackle the numerous challenges associated with today's healthcare system, Shivom plans to develop **the world's largest genomics datahub and healthcare services platform on the blockchain**. Why the blockchain? Blockchains offer superior security and privacy relative to today's prevailing centralized solutions. A blockchain is a distributed tamperproof database, shared and maintained by multiple parties that secures all records (e.g. a link to private genomic data) that are added to it.

Each record contains a timestamp and secure links to the previous record. Records can only be added to the database, never removed with each new record cryptographically linked to all previous records in time. New records can only be added based on synchronous agreement or "distributed consensus" of the parties maintaining the database. By cryptographically linking the records it is virtually impossible for one party to manipulate previous records. Such a process eliminates the need for trust because participants in the blockchain can have mathematical certainty for every digital asset that constitutes the system you want to protect.



Second,

Public Key Cryptography. A cryptographic key generator is used to begin generation of a pair of keys suitable for use by an asymmetric key algorithm. Anyone can encrypt data (e.g. private genomic- or health data) using the public key, but only the holder of the paired private key, for example a researcher or the patient's physician, after consent by the patient can decrypt and hence access to the genomic data.

When storing healthcare data in a blockchain, cryptography is used for encrypting the contents of a message or transaction, so that only intended users can open and read its contents. The encryption process works via 'Public Key Cryptography' or asymmetric cryptography, an encryption system that uses pairs of keys. For example, a "public key" may be disseminated widely to everyone, while a "private key" is known only to its holder.

Either key may be used to encrypt a message, but the other key must decrypt the message. Practically speaking, a patient can encode their genomic data with a public key and be sure that only the holder of the private key can decrypt it. the data can be encrypted with a private key. If the data, e.g. a hospital discharge letter, makes sense when it is decrypted using the corresponding public key, it is evident that the holder of the private key is the party that encrypted the data. Such a process is equivalent to "signing" a message because it is analogous to someone putting their unique signature on a document.

Overall, the blockchain solution provides significant improvement and value over standard centralized databases in multiple areas to include:

- **Security** – Data cannot be revised or tampered with
- **Disintermediation** – No more costly middlemen
- **Privacy** – Blockchain helps to keep identities private
- **Global** – Platform operates across borders
- **Permanent ledger** – Everybody has structured, time-stamped data
- **New Economies** – Users can operate everywhere, serving underserved markets
- **Decentralization** – No hacker access point, no central authority
- **Smart Contracts** – Real-time transactions occur automatically via pre-defined agreements
- **Accurate Tracking** – Consensus mechanisms allow transactions to occur error-free
- **Digitized Assets** – Makes assets securely available globally.

With a blockchain-based platform, Shivom envisions developing a world class and transparent healthcare services platform that is highly secure, auditable and all donors, patients, and stakeholders will trust and be able to rely upon with a high degree of confidence. Shivom will be able to leverage smart contracts to effect transactions and power its platform with its OmiX (the currency of the Shivom ecosystem) utility token, which must be used for any product, service and action conducted on the Shivom blockchain platform. Shivom's advanced protocols and technology platform will also be able to aggregate and unlock disparate siloed data from centralized databases

around the world thereby resulting in significantly more efficient drug discovery and research and development efforts. Ultimately, the platform will service to usher in the next industrial revolution and a new era of open, collaborative and data-driven science that will open new ways for the advancement of precision medicine.

1.4 Advanced Protocols and Architecture

The Shivom platform is designed to be blockchain agnostic and will utilize best-of-breed technologies depending on network and community requirements. Shivom plans to deploy a sophisticated cryptographic identity layer and the main components of the platform will be based on distributed ledger technology derived from advanced technologies to include the Hyperledger Fabric, the BigchainDB framework (Decentralized Data Exchange; Ocean protocol) and potentially the IOTA Tangle (for streaming and collecting medical data via medical/IoT devices). Majority of the data collected will *not* be stored on an immutable blockchain ledger. Data sets or bundles of data sets will be stored off-chain. To prove integrity of data, all data stored on the Shivom platform will be hashed. The hashes will be stored on an immutable ledger or blockchain database (i.e. BigchainDB, and others) based on two hashing approaches: hash of an individual data set and anchor hashes of bundles of data sets. Shivom will also develop its own unique protocols, which will perform a variety of key functions to include key management and encryption; role-based access management; storage of data set hashes and anchor hashes; and data management (where to write which data in which structure for DNA data sharing or processing use cases).

1.5 Democratizing Genomic Sequencing

In contrast to other potential competitors or other direct to consumer genetic services, Shivom will not only focus on the classical target regions (US, central Europe) but also on the transitional economies (i.e. Middle-East, Asia, and South America). Emerging and lower-income countries are expected to predominantly drive the rise in healthcare expenditures through 2020 as well as the expansion of services in developed countries. The most promising countries include India, China, Brazil, Turkey, and states in the MENA region (e.g. United Arab Emirates, Saudi Arabia, Qatar, Israel, and Egypt). Shivom intends to work closely with governments, local stakeholders and genetic and precision medicine initiatives in those countries to drive adoption of Shivom and procurement of its production and services.

1.6 Governance & Foundation

Shivom's genomics datahub and healthcare platform will not be governed by nation states, state-based institutions or corporations; rather it must be distributed around the world and operated by trusted institutions in multiple countries on a decentralized basis free from government interference and subjugation. Building this foundation will mitigate some of the strong legal uncertainty surrounding emergent technologies such as genomics and blockchain thereby helping the genomics ecosystem and partners alike to move beyond the proof-of-concept stage. The foundation will work on legal and regulatory frameworks to ensure a long-term, sustainable and technically sound healthcare service. Accordingly, Shivom plans to form a not-for-profit, global foundation that will ensure security, sustainability and proper ethical conduct of the system. As a global initiative focused on the greater good, Shivom will be governed by a private-sector, international, non-profit consortium and led by a Board of Trustees and an Executive Director. The

Board of Trustees will establish key domain networks to include a Policy Network, Advocacy Network and Knowledge Network; collectively which will serve to fulfill the day-to-day operations of the business and to effectively implement and advance Shivom's global mission and vision.

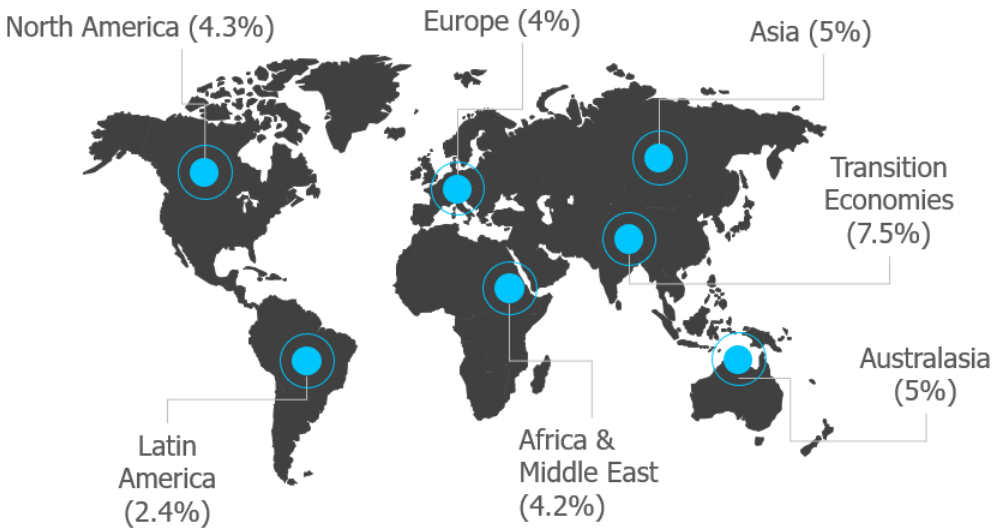
2 Market Overview

2.1 Global Healthcare Market

Global healthcare spending is projected to reach
$8.7 trillion by 2020[a]

According to Deloitte, the average percentage of GDP spent on healthcare should rise to 10.5% in 2020. Emerging and lower-income countries will drive this rise in healthcare expenditures as well as the expansion of services in developed countries[9]:

Healthcare growth rates through 2020

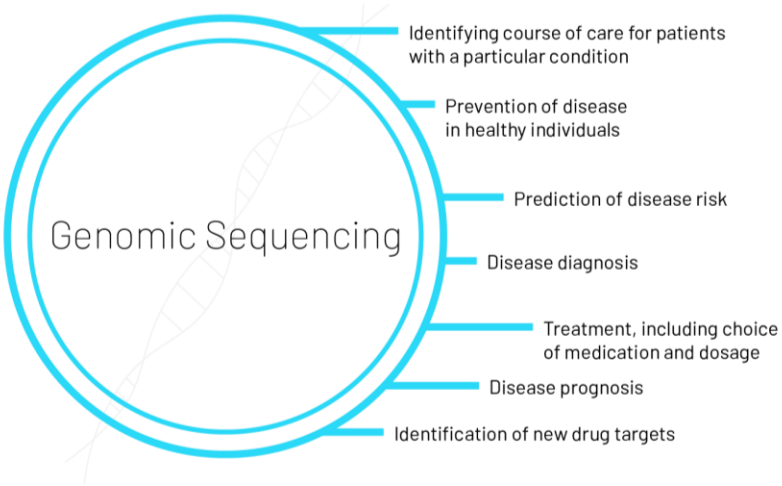


[a] World Bank Group and the Institute for Health Metrics and Evaluation (IHME), The Lancet "National spending on health by source for 184 countries between 2013 and 2040"

2.2 Genomics Market & Data Privacy Concerns

Genomic sequencing is a one-time investment that will help to manage the health of people for their whole lifetime.

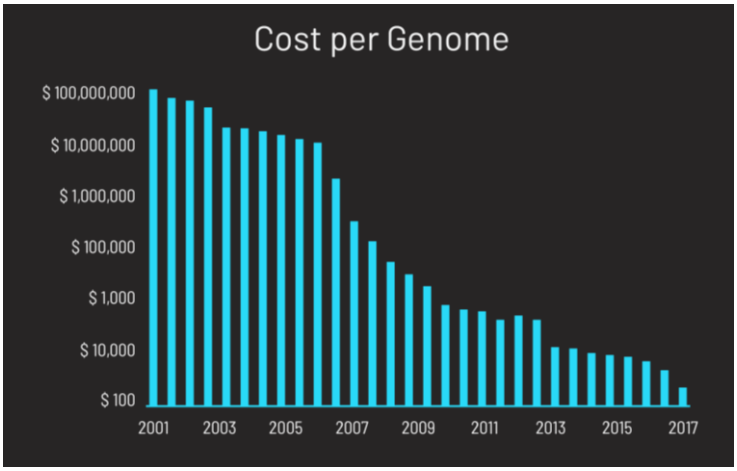
According to several market analyst companies[b], the global genomics market is estimated to reach over USD $22 billion by 2020, growing at an expected compound annual growth rate (CAGR) of 10-11%. The global genomics market has undergone an increase in its market potential due to technological developments. Factors including growing prevalence of fetal disorders such as diabetes and cancer and an increase in partial or full compensation by the government of certain countries add to the market's growth globally. The genomics-based personalized medicine segment is projected to have the highest growth rate at an anticipated CAGR of over 12-15% to 2020. Eventually, sequencing is expected to become so affordable and routine that nearly all individuals will be sequenced.



In many countries, there is an increasing number of companies that offer direct-to-consumer (DTC) DNA tests where anyone can order a test from home for genealogy, health or fitness advice, and ancestry insights. The growth in personal genomics has occurred mainly because DTC genetics is now relatively frictionless. One can purchase a genetic test online, receive a test kit by mail, and collect a sample (usually saliva) in one's own home[2]. Usually the customer can then get information about their family tree or health-related lifestyle help, e.g. nutritional advice. Some but not all companies also offer information about disease susceptibility or inform couples whether they are at risk of having children with a range of inherited diseases, such as cystic fibrosis, Tay-Sachs, or spinal muscular atrophy; other service providers offer information on potential drug response (pharmacogenomics) of their customers. Significantly lower costs have also driven demand for genomic sequencing. In recent years, costs for DNA sequencing have plummeted and it is now

[b] Deloitte, Data Bridge Market Research, Research and Markets, MarketsandMarkets, Research Cosmos, & Grand View Research

probable that in a year or two it will be possible to generate a person's entire genome for less than $500. In the coming years, dramatically lower costs will make it accessible for almost all individuals globally to sequence their genomes.



DNA sequencing costs tracked by the National Human Genome Research Institute (NHGRI) until 2015. The figure uses a logarithmic scale on the Y axis. The sudden and profound drop in prices beginning in 2008 represents the time when the sequencing centers transitioned from Sanger-based (dideoxy chain termination sequencing) to 'next-generation' DNA sequencing technologies.

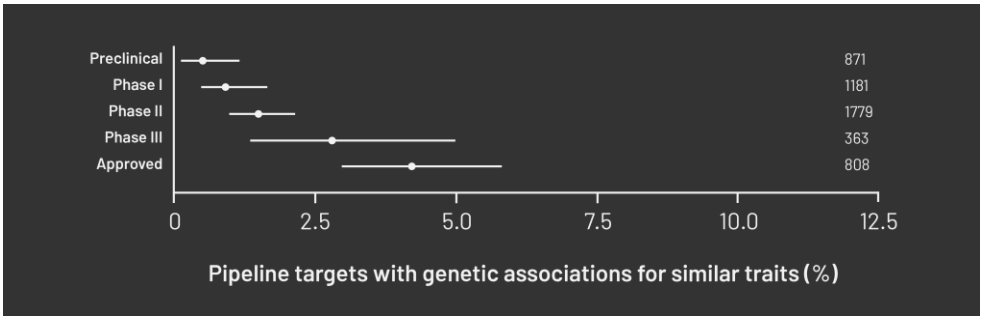
Several of the DTC companies have already amassed significant databases, which are being or could be used for ongoing health research. However, many of the existing companies in the space currently rely upon centralized databases, which poses data security risks and controversially monetize and treat customers' personal data as a commodity. By submitting DNA to DTC companies, the customers usually grant the DTC companies a perpetual, royalty-free, world-wide, transferable license to use their DNA and to sublicense and distribute the resulting analysis. The license usually continues even if the customer stops using the website or the service. A detailed review describing the privacy policies of the leading DCT companies was published in *Gizmodo*[3]. Shivom aims to provide a new kind of global and transparent genomics ecosystem that will allow data donors to completely own and securely store / manage access to their data from all available platforms and sources.

2.3 Pharmaceutical Companies & Healthcare Providers

With recent technological advancements, evolving patient needs and increasingly outdated business models, both the pharmaceutical industry and global healthcare systems are under intense

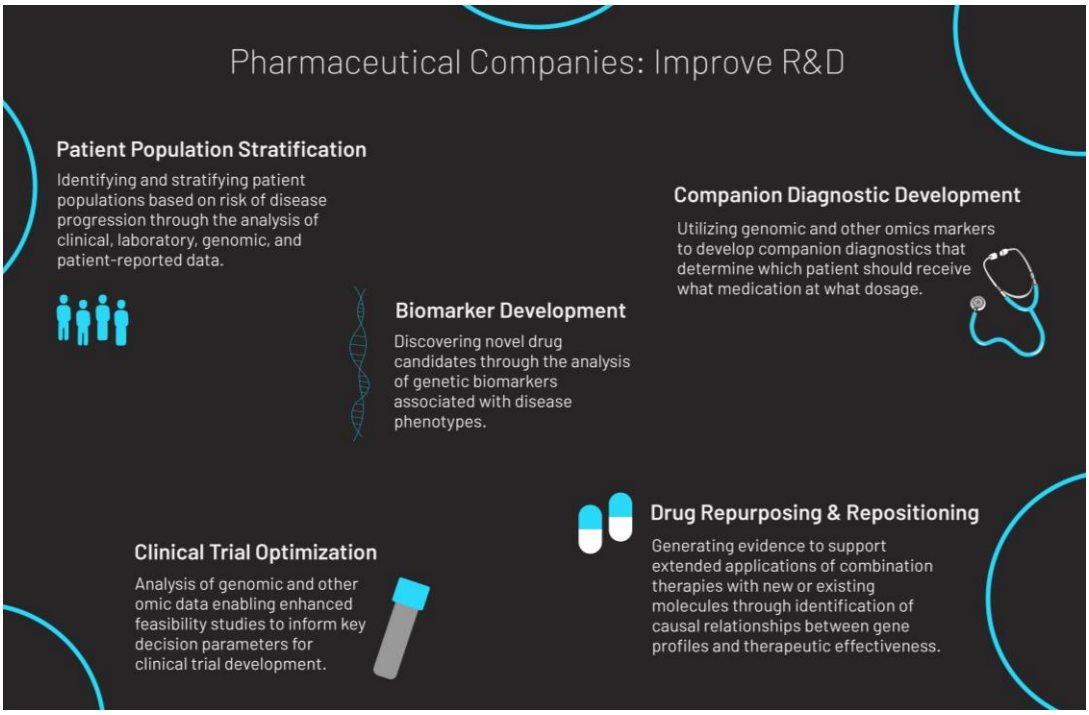
pressure to innovate via increased R&D efforts, acquisitions and / or new partnerships with cutting-edge companies. Public and private healthcare systems have already been facing revenue pressures and declining margins for years. Accordingly, healthcare providers are focused on establishing new partnerships and collaborations to keep or gain competitive advantages.

Drugs with human genetic information are more than 2 times more likely to be successful.



Percent overlap for all target-indication pairs at the latest stage reached in the development pipeline[11].

Genomic and other 'omic' data are essential for new drug development and the currently evolving regulatory landscape. For example, the impact of R&D integrated with genomic data is emerging throughout the drug development pipeline. Since the FDA started tracking pharmacogenomic information for all approved drugs in 2009, the number of FDA approved drugs with pharmacogenomics information in their labeling has grown to over 160 drug / biomarker pairs[10]. Of the 41 novel new drugs approved by the FDA in 2014, 9 (22%) are classified as a personalized medicine treatment that uses biological markers to guide prescribing practices. A platform that provides the necessary data & privacy plays a pivotal role in the following areas:


Pharmaceutical Companies: Improve R&D
Patient Population Stratification
Identifying and stratifying patient populations based on risk of disease progression through the analysis of clinical, laboratory, genomic, and patient-reported data.
Biomarker Development
Discovering novel drug candidates through the analysis of genetic biomarkers associated with disease phenotypes.
Companion Diagnostic Development
Utilizing genomic and other omics markers to develop companion diagnostics that determine which patient should receive what medication at what dosage.
Clinical Trial Optimization
Analysis of genomic and other omic data enabling enhanced feasibility studies to inform key decision parameters for clinical trial development.
Drug Repurposing & Repositioning
Generating evidence to support extended applications of combination therapies with new or existing molecules through identification of causal relationships between gene profiles and therapeutic effectiveness.

Patient Stratification

Problem

Usually, only small groups of people are studied in clinical trials

Without a lot of genomic data, it is hard to know who will respond to a certain treatment...

And when they don't respond well, it is hard to know why

This wastes time and resources

Solution

Use genomic data to inform clinical trials

Researchers and clinicians can use genomic data to figure out which patients are likely to be unresponsive to a treatment

patient stratification

Then, they can target a subgroup of patients that will benefit the most

This allows effective treatments to be available more quickly

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For public health, genomics matters significantly. In addition to helping to identify rare diseases, more importantly, genomics also plays a role in 9 of the 10 leading causes of death including heart disease, cancer, Alzheimer's disease, diabetes and stroke[12]. These are complex diseases with potentially multiple genetic interplays taking place alongside significant epigenetic risk factors. Treatments for these diseases have been elusive and many patients are non-responders. With genome sequencing, it will be possible to tailor treatments for patients based on their genetic backgrounds thereby allowing for more targeted treatment options and increased success rates. Routine genome sequencing of sick and healthy individuals will lead to the discovery of clinically relevant and actionable information. In the future, the number of conditions which have treatments or can be prevented based on genomic data will increase dramatically. The importance of genome-based companion diagnostics or Companion diagnostic tests (CoDx), which define the subset of patients who are most likely to benefit from a therapy or who should not receive the therapy because of ineffectiveness or predicted adverse effects, will increase significantly too.

3 Offerings & Solutions

3.1 Genomics for Everybody

In many countries, genomic and health services remain unaffordable and inaccessible. Shivom plans to democratize genomic sequencing for all people worldwide. There will be several ways by which partially or fully subsidized genomic testing will be available to people. People who already have access to their genome can upload it to Shivom's database to monetize this information as well and to use their genome to gain access to information that will support their health and longevity. Together with partner labs around the world that have access to the best state of the art DNA sequencing technologies, Shivom intends to offer two affordable kits: one exome kit and one whole genome sequencing (WGS) kit as follows:

Exome sequencing is a test for identifying disease-causing DNA variants within the 1% of the genome which codes for proteins (exons) or flanks the regions which code for proteins (splice junctions).

~30 million DNA base pairs

Whole genome sequencing is a test for determining the complete DNA sequence of an individual. This entails sequencing all the chromosomal DNA as well as DNA contained in the mitochondria.

~3 billion DNA base pairs

Any participant or their physician will be able to order a DNA collection kit which will be mailed to her / him worldwide. After providing a saliva sample, the kit can be shipped back or picked up by Shivom. When available, Shivom would notify the user of the availability of their report and raw data in their secure account. Shivom intends to provide patients with more informed choices that include such health determinants as environmental exposures and socio-economic status based on real-world data. The basic idea of the Shivom genomics ecosystem is that people are encouraged to contribute their unique datasets, which could be used for the common good. To circumvent adoption challenges, Shivom intends to collaborate with hospitals, doctors and governments all around the world to make it as easy as possible for people to donate their genomic and health data. In turn, participants should benefit from the collective data sharing by getting access to better healthcare and precision medicine opportunities. Consent, which must be verifiable, can be withdrawn at any time and must be given by a child's parent or custodian, would be a foundational condition of care at these genomic centers. Valid consent must be explicit for all data collected and used for intended patient purpose.

3.2 Open Source Platform & Innovation Hub

The Shivom modular platform will connect its components using open standards, open source tools, APIs and other interoperability measures; and utilize a decentralized development model that encourages open collaboration.

- ***Open Marketplace***: Shivom aims to provide an open marketplace for new ideas and applications that enhance the well-being of Shivom's members. Potential services in the Shivom marketplace include health apps, nutritional & fitness advice, ancestry information, treatment plans, genealogy, disease predisposition, high throughput data analytics, pharmacogenomics, and lifestyle management, among others. Such applications and services built on top of the Shivom marketplace form an important part of the genomics ecosystem. Shivom's partners will offer existing / modified or newly developed apps for the Shivom ecosystem. Looking into the future, additional apps and services will be added as science / technology further advances and as the community grows and attracts more projects and applications.

- ***Healthcare Providers***: Shivom's open marketplace intends to offer several partnership opportunities for the healthcare sector. For example, pharmacies could offer Shivom-genomic tests in their stores. Personalized genomics has now advanced to the stage where one simple test can reveal how your body will uniquely respond to the medicines you take. For example, a simple DNA test could allow a pharmacist to determine how patients will respond to different medications and what dosages will be most effective for individuals based on their genetic profile. At the same time, with access to the Shivom database, customers could be incentivized to use those services (and the pharmacy would get a detailed pharmacogenetic picture of the customer, avoiding adverse events). For the pharmacy, it would be a considerable advantage to be able to find out which medications, nutraceuticals, and various supplements would work best for a customer. In turn, the store could then offer those products to the users of the Shivom ecosystem.

- ***Additional 'Omics' Services***: In the future, Shivom aims to offer services that are based not only on genomic data but also other 'omics' information. Genomics is an entry point for looking at the other 'omics' sciences. When combining genomic data with other molecular data types, such as epigenome, transcriptomes, microbiomes, and clinical information, the resulting uniquely rich dataset enables integrative analyses to be carried out at unprecedented depth and scale and facilitates new insights into molecular disease processes. Integrating data from different technologies is a rare case where 1+1 equals more than 2; the more data is combined, the more valuable the scientific insight. Linkage of multiple data sets at the individual person level is needed for Big Data to become truly transformative[33]. Combining experimental results from multiple 'omic' platforms is an emerging approach, which aims to help identify latent biological relationships that may become evident only through holistic analyses integrating measurements across multiple biochemical domains.

Shivom long-term vision: *To understand biological systems, in addition to genomic and health data, other digitized molecular and environmental information must be integrated into a holistic view, consisting of various omics data and environmental information:* ***Epigenome*** *(i.e. DNA methylation and histone modification),* ***regulome*** *(DNA binding regions),* ***transcriptome*** *(gene expression incl. isoforms),* ***spliceome*** *(alternative splicing),* ***miRNome*** *(miRNAs),* ***proteome*** *(protein expression with isoforms),* ***autoantibodyome*** *(antibodies targeted against one's own proteins),* ***metabolome*** *(small molecules such as nucleotides, amino acids or vitamins), and* ***microbiome*** *(microbial characterization). In addition to these layers, bio-sensors data, e.g. from mobile devices to capture the individual's* ***physiome****, imaging (e.g. MRI data), are also important to depict the anatomy, nutrition, social demographic & environmental exposure data (****exposome****).*

- **Third Party Health Apps:** Once people have their genome sequenced and uploaded on the Shivom platform, they will have access to various customized, health-related apps developed by Shivom and third parties. A growing collection of health and lifestyle applications, ancestry information and other genome-based material will either be directly accessible in exchange for tokens from the users' dashboard or will be made accessible via partner programs. The Shivom platform will be open for other service providers to add their genomics apps and services to the platform. Typical apps will relate to nutritional advice, taste perception, drug metabolism, caffeine or alcohol tolerance, behavior, physical appearance, ethnicity, ancestry and many more.

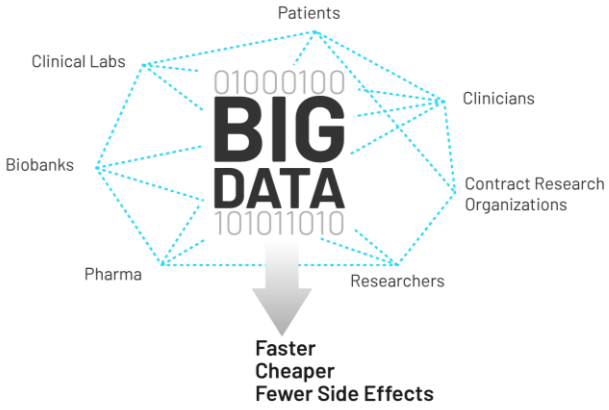
Example of healthcare apps available in the Genomics Marketplace.

3.3 Genomic Counselors

Shivom strives to build a large global network of its own and connected genetic counselors which can also form a telemedicine ecosystem (in case people in rural areas have no direct access). With the rising interests in common and complex diseases genetic testing, Shivom anticipates that there will be a growing need for genetic counselors to evaluate complex diseases in the coming years[37]. This reflects rapid advancements in the scope and cost of genetic test, the knowledge of how genetics contributes to common and complex diseases such and diabetes or Alzheimer's disease, and the enormous complexity of genome science in medicine today. Genetic counselors will be responsible to provide education and risk interpretation for consumers as well as supporting health promotion models.

3.4 Research & Development / Clinical Trials

The Shivom genomics ecosystem can promote participants with long-term participation in and commitment to medical research. Donating a genome and health data to science is a great way to enable advances in the understanding of disease origin, human genetics, biology and health. Data sharing ensures that precision medicine is brought to patients and healthy individuals faster, cheaper and with significantly less severe adverse effects, leveraging information from the interaction between labs, biobanks, business management, CROs, investigators, patients and a variety of other stakeholders.



- **Pharmaceutical Companies**: By providing value at multiple points throughout the design, implementation and analysis of clinical trials, Shivom plans to provide pharmaceutical companies will opportunities to:

  - **Support feasibility studies** by affording analysis of patient populations, study sites and clinical trial design. Using this information, clinical trial study parameters can be adjusted to maximize the trial's speed and cost effectiveness.

  - **Help establish patient cohorts** and inclusion/exclusion criteria to further support clinical trial optimization. For drugs that are designed to target a specific molecular pathway or gene variant, omics data can provide valuable information to guide the selection of patients for all study cohorts.

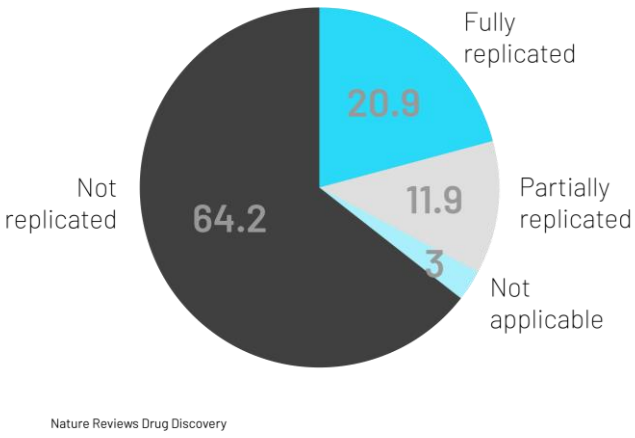
  - **Provide insight to further classify the clinical trial population** based on molecular signatures to ensure more targeted inclusion/exclusion criteria,

which will lead to smaller study populations, thereby reducing costs dramatically.

- **Enable adaptive clinical trials** by characterizing study cohorts, providing insights on drug safety and efficacy. This information will determine pharmacogenomic effects to support modifications to the drug dosage, patient inclusion criteria or clinical trial sample size.

- **Patient Recruitment**: By some estimates, patient enrollment for clinical trials is responsible for 30% of the time it takes to conduct clinical trials; some sites never enroll enough patients. Shivom's databases will have the potential to dramatically improve the recruitment process by connecting patients with trials in an anonymous fashion. Pharmaceutical or CRO organizations would have access to a treasure trove of information about potential participants and the users of associated investigative sites who are likely to be motivated to join a study.

- **Data Quality & Reproducibility**: Multiple reports and studies are fueling discussions about reproducibility of results especially in the biomedical sciences. These discussions raise concerns about the level of trust in results in the scientific literature, in public databases, within organizations, and from clinical studies. The Shivom genomics ecosystem will be updated with new data, curated for the quality of records and made compliant with local regulations for genomic data handling. It is essential to maintain integrity, provenance, security and privacy of all sensitive information along the processes of data uploading, processing, analysis, and sharing. Systematizing this process will be essential for Shivom to dynamically accommodate and manage changes to the workflow.



3.5 Disease Prevention

The Shivom anticipates it will become a dominant force in the future of disease prevention. In most countries, the funding for preventive medicine and public health is relatively small compared to the overall health care budget; for example, in the US, only 0.8% of the physician workforce works in disease prevention. Genomic-medicine is an important component of disease prevention. Affordable gene sequencing used in conjunction with complementary technologies such as artificial intelligence will significantly advance efforts to better understand the link between genes and medicine and to offer meaningful predictions about the risk associations between genetic alterations and probabilities of disease.

Multiple large-scale initiatives are already poised to bring whole-genome analysis into routine medical care. Iceland was the first to launch a large-scale genomic analysis of its population and many nations have followed suit with the explicit goal of linking health care and genomics[13]. Forerunner the United Kingdom in 2012 took a giant leap into genomic medicine with its 100,000 Genomes Project, which is already 50% complete. The project's aims are to gain scientific insight by linking disorders with precise genetic signatures, obtain better diagnoses and to tailor treatments to individual patients. In the U.S., the Precision Medicine Initiative plans to sequence the genomes of one million volunteers.

China has even bigger plans. Fueling the drive is a multibillion-dollar, 15-year precision-medicine initiative, which China announced in March 2016[7]. Similar projects are under way in Canada, Singapore, Australia, Japan, South Korea, Thailand, Kuwait, Qatar, Israel, Belgium, Luxembourg and Estonia. To make all these stored genomes actionable and comparable, they need to be stored in a safe and anonymized way. Shivom aims to collaborate with international groups and to provide information and raise awareness within the global healthcare community, governments and the wider public on the health challenges and opportunities within the rapidly developing science of human genomics. Utilizing blockchain technology, Shivom intends to make it possible for large population studies and private citizens from around the world to share their genomic information without compromising control and identity.

Moreover, by focusing on the development of a global genomic data-hub, Shivom also anticipates it will be well-positioned to support drug development efforts with ethnically- and geographically-variable genomic datasets. Genomics is failing on diversity. Despite being extremely valuable for research, current genomic databases typically lack a diverse representation of ethnic groups from around the globe[17]. The molecular biology of various common disorders is significantly different across race and ethnicities. Faced with such heterogeneity, it is important for researchers and physicians to have enough data across races and ethnicities to identify moderately common genomic alterations. The representation of racial minorities in large genomic sequencing efforts would have a huge impact on the better understanding of healthcare disparities and disorders.

Notably, patients of African and Asian ancestry are currently more likely than those of European ancestry to receive ambiguous genetic test results after exome sequencing or be told that they have variants of unknown significance[18]. This lack of coverage suggests that some populations today continue to be left behind and lack access to precision medicine solutions; and geneticists are likely missing out on important disease biology information.

> Ethnic minorities may run the risk of being misdiagnosed because of the lack of diversity in genomic databases.

Shivom, in collaboration with local doctors, medical centers, and governments, plans to conduct large-scale healthcare projects in various developing / emerging economies and to sequence population subgroups that are typically underrepresented in prevailing genomics databases. The study cohort will primarily be comprised of underprivileged / poor individuals in both remote rural area and urban regions (those that have no housing and/or medical support) as well as patients in local hospitals, e.g., those with severe inborn diseases. By including and sharing underrepresented anonymized genomic information globally, Shivom expects to make genome sequencing more useful and actionable for researchers and healthcare professionals — to the benefit of all people globally.

3.6 Unique Global ID

Shivom will add a unique encrypted ID to every genome, linked to the owner of the DNA sequence (i.e. CRAM, VCF and BED-files)[29], which is entered into the blockchain. Having a unique, yet anonymous genome ID will empower researchers to avoid redundant analysis of genomes across multiple genomic databases thereby avoiding bias and false positives. The Shivom platform and database is expected to consistently deliver value and filter redundant genomes uploaded from external genomics service providers and databases. Researchers will have the opportunity to filter genomes according to origin and previously analyzed IDs. If a certain genome is re-sequenced, e.g. when an individual wants to upgrade their exome sequence to a complete whole genome, the unique ID would remain the same with only the version changing. Similarly, should an individual upload a sequence from service provider 'A' and after some time from alternate service provider 'B', the DNA sequence would continue to maintain its unique ID – only the metadata of the sequence would change. Within its QC processing pipeline, Shivom intends to apply algorithms to detect re-uploads of data. Accordingly, Shivom expects to be able to filter and minimize the possibility of fraudulent uploads, e.g. by people who upload sequences that they downloaded from external databases, platforms, or genetics sequencing service providers. In short, Shivom will solve these and other existing redundancy / fraudulent / inaccuracy problems by providing a unique global ID for each sequence on the platform. Shivom will develop interfaces for raw and processed data including prediction / classification data, as well as metadata (e.g. a trail of how raw data contributed to processed data) that will make it easier for customers to work with Shivom's curated datasets.

3.7 Smart Contracts

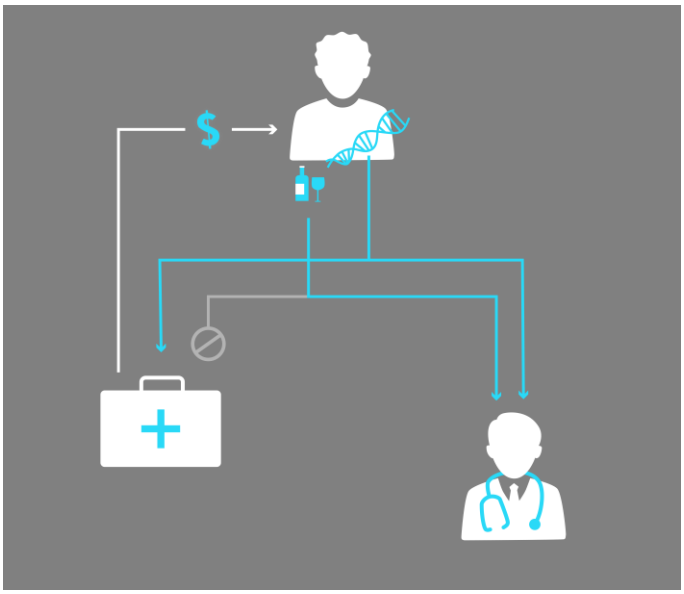
Shivom plans to utilize a variety of easy to understand smart contract templates. Users will be able to easily manage their genomes / accounts and seamlessly navigate within the Shivom platform even without knowledge about blockchain technology or genome science. Individuals will have the choice to only learn what they want about their genomes and any corresponding health implications. Sometimes, people want to know only aspects of their potential future, i.e. information that has actionable consequences rather than information related to certain incurable and unpreventable diseases (e.g. Huntington's disease). It is this type of information that some healthy, high-risk individuals prefer not to know. By using smart contracts on the Shivom platform, people can be

guided in their learning process and easily decide if they want to learn about their risk of developing certain curable (or incurable) diseases. By using smart contracts, people from all over the world will be able to easily use Shivom's platform to securely:

- store and easily access all genome data in one place
- control who can access the data in a fine-grained matter
- manage how researchers, their physicians or family members can use the data
- find health and lifestyle information
- identify and remove potential health roadblocks before they get serious

3.8 Data Management & Monetization

The Shivom platform will ensure each user is able to maintain full control over his / her sensitive genomic and healthcare data. Each person has their own idea of what should be private and what could be shared. While some organizations currently provide the means to share in-depth information about a patient's health status and help to identify research opportunities for motivated individuals, Shivom is unaware of any existing platform that currently protects data privacy and provides the means for the secure sharing of data. Blockchain provides the ideal method of sharing genomic data among multiple stakeholders while protecting patient privacy and ensuring data integrity. The Shivom platform provides a way for people to securely use their genomic data (either via using Shivom DNA kits, or via their healthcare providers or from personal genetic testing services), empowering them to take control of their health by improving access to actionable information and by making more healthy lifestyle choices, particularly to modify their disease risk. Shivom plans to allow every individual to share their genome. Blockchain technology will help patients keep sensitive information, such as disease predispositions, mental health or substance abuse data from certain parties (e.g. insurances), while ensuring that R&D efforts and treatments are still possible and engage in more shared decision-making with their caregivers of their choosing. Each interaction with the genomics database is expected to be auditable, transparent, and secure, and will be recorded as a transaction on the distributed ledger.



Blockchain technology may help users to transmit genomic data or quantifiable lifestyle information to other stakeholders. At the same time, the patient can keep sensitive information, such as substance abuse data, hidden from certain stakeholders. As a result, outcomes research and precision medicine initiatives can be better supported. In addition, this framework allows stakeholders, e.g. employers or insurers to incentivize their client's lifestyle change (e.g. by paying for the genome sequencing).

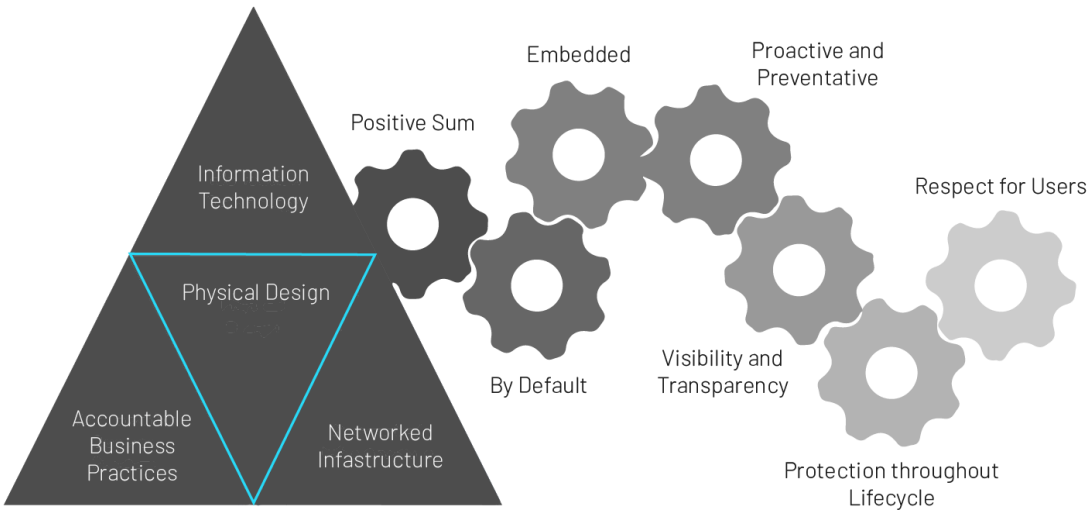
The Shivom platform will also facilitate the ability of individuals to monetize their genome and to support scientific research. Sharing data generated from human research participants must be

done in a manner that appropriately protects participant interests[15]. Here, smart contracts are revolutionizing how data can be managed, taking up the role of classical 'honest brokers' which ensure the appropriate use of genetic information and effectiveness, accessibility, and quality of genetic services.

3.9 Regulatory & Compliance Considerations

Healthcare systems worldwide share overarching health policy and regulatory goals – ensuring patient safety, mitigating fraud and cyber threats. Similarly, Shivom will be focused on delivering better diagnostics and more personalized therapeutic tools while providing full data security and protection from cyber threats. The storage of genomic information raises significant concerns regarding data privacy. Current medical research studies and databases continue to harbor potential vulnerabilities given existing methods and approaches for securing and protecting participant identities[19]. News of high-profile cyber-attacks have become common in recent years. In such cases, cyber attackers gained unauthorized access to companies' IT systems and obtained customers' personal information to include their names, birthdays, medical IDs, social security numbers, street addresses, email addresses and employment information including income data. Blockchain technology will help to reconcile the often-competing values of privacy and innovation. Developments in artificial intelligence and sophisticated re-identification algorithms have led to an increasing concern about the effectiveness of existing data protection laws[20].

To address these issues, the European Union (EU) as a global forerunner in personal data protection worked out the **General Data Protection Regulation (GDPR)**[21] (Regulation (EU) 2016/679), intended to strengthen and unify data protection for all individuals within the EU. GDPR, which becomes effective on May 25, 2018, also addresses the export of personal data outside the EU. Shivom intends to adopt and outperform GDPR rules on a global level, aiming to give control back to citizens over their personal data and to simplify global data sharing for the common good. For its ecosystem, Shivom plans to apply a **Privacy by Design** approach such that data protection measures are



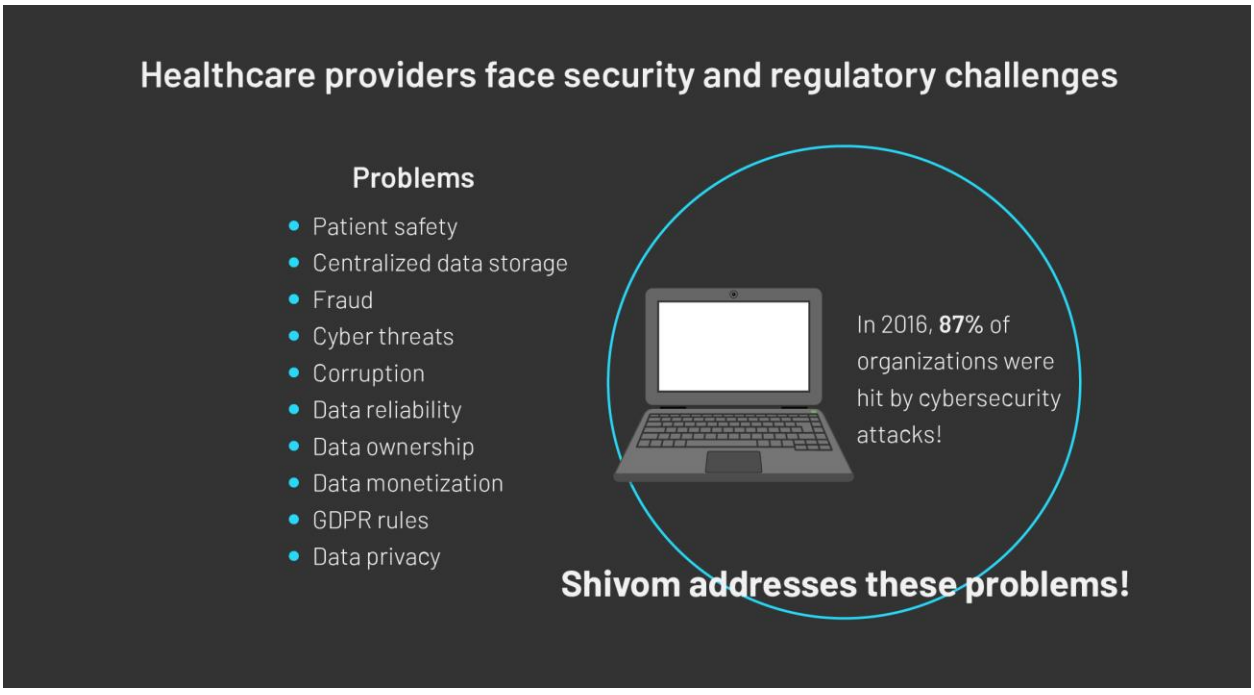
Privacy by Design

designed into the development throughout Shivom's entire core business and research processes for products and services.

The Shivom platform will also be developed and managed in accordance with HIPAA rules. The HIPAA Security Rule requires covered entities to maintain reasonable and appropriate administrative, technical, and physical safeguards for protecting electronic protected health information (e-PHI). Specifically, covered entities must:

- ensure confidentiality, integrity and availability of all e-PHI they create, receive, maintain or transmit;
- identify and protect against reasonably anticipated threats to the security or integrity of the information;
- protect against reasonably anticipated, impermissible uses or disclosures; and
- ensure compliance by their workforce

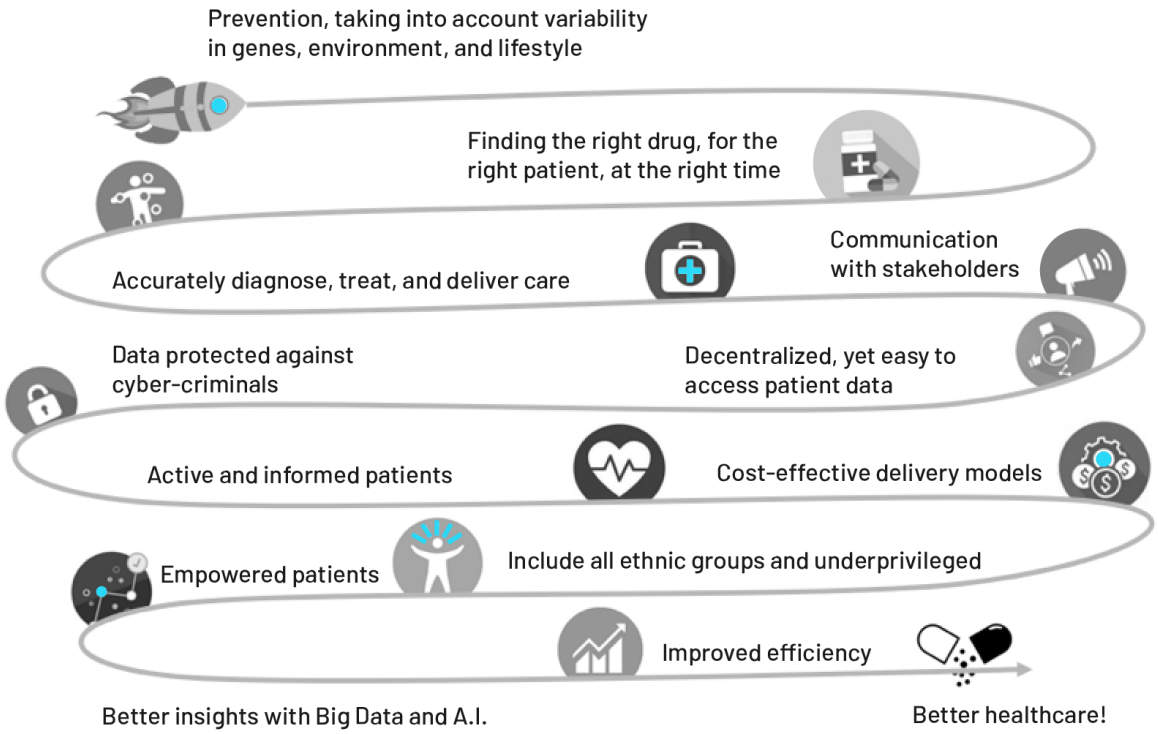
The Security Rule defines "confidentiality" to mean that e-PHI is not available or disclosed to unauthorized persons. The Security Rule's confidentiality requirements support the Privacy Rule's prohibitions against improper uses and disclosures of PHI. The Security Rule also promotes the two additional goals of maintaining the integrity and availability of e-PHI. Under the Security Rule, "integrity" means that e-PHI is not altered or destroyed in an unauthorized manner. "Availability" means that e-PHI is accessible and usable on demand by an authorized person.



Shivom plans to outsource the storage of its genomic and healthcare data on secure federated remote cloud infrastructures; only the data owner, not the cloud service or participants of the Shivom ecosystem, will hold the decryption key. This setup resolves discussions about the limits to be drawn when using sensitive personal data in medical research[22]. Blockchain technology will make sure that data privacy is not violated and that all participants are able to prove "consent" (opt-in),

whereby any consent may be withdrawn at any time. Other important data management tools / applications that are planned to be partly represented in Shivom are cognitive computing, cloud-based, interoperable electronic health records, and Internet of Things (IoT).

3.10 Smarter Healthcare with Shivom



Overall, the Shivom genomics datahub and healthcare services platform offers a smarter healthcare platform solution and will be designed to:

- Assure the privacy and confidentiality of genomic information on a global scale
- Create & evaluate scientific evidence to support valid and useful genetic tests and family health history tools
- Reduce health disparities & better disease prevention
- Develop evidence-based practice recommendations that evaluate the net health benefit of genetic tests
- Improvement of care coordination
- Support research on how to translate recommendations into practice
- Facilitate the use of valid and useful genetic tests to guide clinical practice and policy

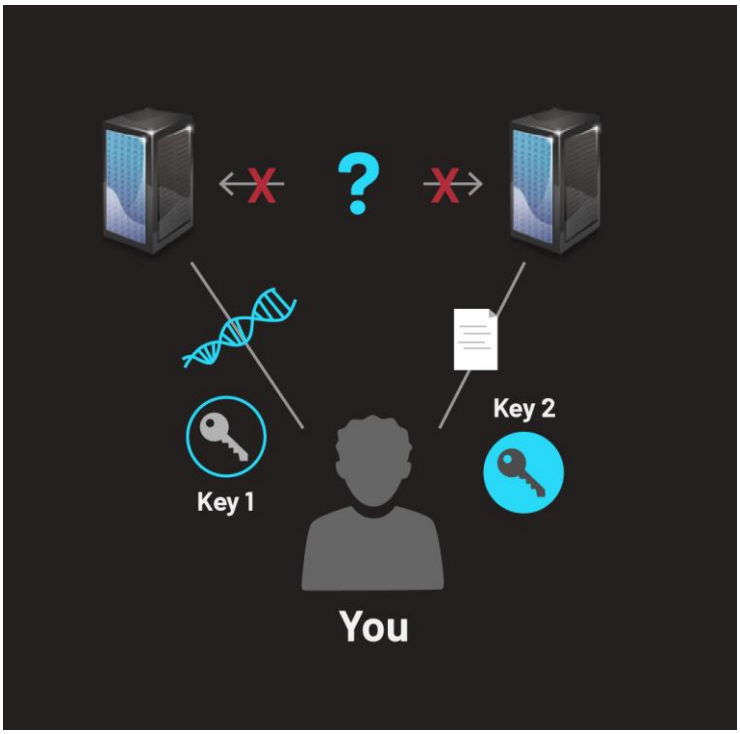
- Facilitate public programs to identify individuals at risk for disease, make diagnoses, and provide appropriate interventions
- Reduce research silos
- Monitor the use of genetic tests in populations, the health outcomes related to their use, and disparities in their use and outcomes
- Add/link genomic information to electronic health records
- Promote genomic literacy
- Increase medical record usability
- Better and cheaper patient enrollments
- More precise precision pharmacogenomics
- More informative non-invasive pre-natal testing
- Improved preimplantation genetic screening
- Engage patients and families
- Avoid obsolete and costly middlemen in healthcare
- Improvement of public and population health
- Enhanced oncogenomics
- Enhanced privacy and security for personal health information

4 Platform Protocols & Architecture

Shivom intends to operate at the forefront of data security and cryptography and work in close collaboration with leading cryptographers to add additional security layers to the Shivom platform that go beyond the use of blockchain for decentralization purposes. Via a '**Security-by-Design**' approach, preventive security is implemented in the system from the beginning in a way such that there is far less dependence on internet and cloud service providers own security.

Shivom plans to implement several layers of security and data provenance to ensure that:

- there must be security for all parties of a transaction
- stored information about the user is not to be ascribed directly to their physical identity unless it is strictly necessary and negotiated; therefore, virtual identities/pseudonyms rather than identified keys such as social security numbers will be utilized
- the user's data is not to be linkable even if more external parties work together on extracting more information than the user originally explicitly approved
- service providers using the platform must only receive valid user-approved information without disclosing / divulging the user's identity
- Shivom will work on algorithms to implement so-called 'proof of liability' that makes it possible to identify a user who does not follow the playing rules e.g. by attempting to commit fraud (e.g. uploading data from another person)
- the consequences of security breach in one system or for one user are limited to the local context and, thus, do not scale to other systems or other users



A user can apply different credentials and hence cannot be traced across service providers on the platform. Data can be coupled to virtual identities (e.g. pseudonyms), which are subject to validation (i.e. the user can prove that he represents a pseudonym via a secret key). The user can choose a new virtual identity for each transaction if desired.

Shivom aims to develop an architecture, which will move from a single digital key or credential to a nuanced identity model, where different security considerations are dealt with by specific mechanisms. Here, identity is broken down into logically separate components each of which can be made non-invasive and purpose-specific. Examples of the underlying cryptographic techniques are so-called blinded signatures, secret sharing and zero knowledge protocols[26–28]. The attribute-based credential can be used together with a virtual identity (pseudonym), which is detached from the physical person and it is possible to use many different identities to keep different transactions separate. Also, an user may use different attribute-based credentials with different platform service providers without the possibility to determine that it was the same user (details see platform architecture).

It should be possible for a user to send encrypted data (e.g. patient data) to a service provider, and subsequently prove properties about them without revealing the content, so-called verifiable encryption. The proposed security model makes it possible to design applications giving the users control over their data, providing the user with liberty of choice in relation to when to become actively involved in the orchestration of identities and credentials.

By strengthening and increasing access to existing rights, Shivom aims to more effectively protect individuals' data and put them in control of their personal information rights. The idea is simple. Contributors will decide how their genomic data will be used.

In summary, Shivom's security architecture will be designed so that:

- only the necessary information about the user is disclosed
- disclosure is done under the users control
- the users may perform transactions under a virtual identity including not being identified unless strictly necessary/wished by the user

4.1 Blockchain Agnostic

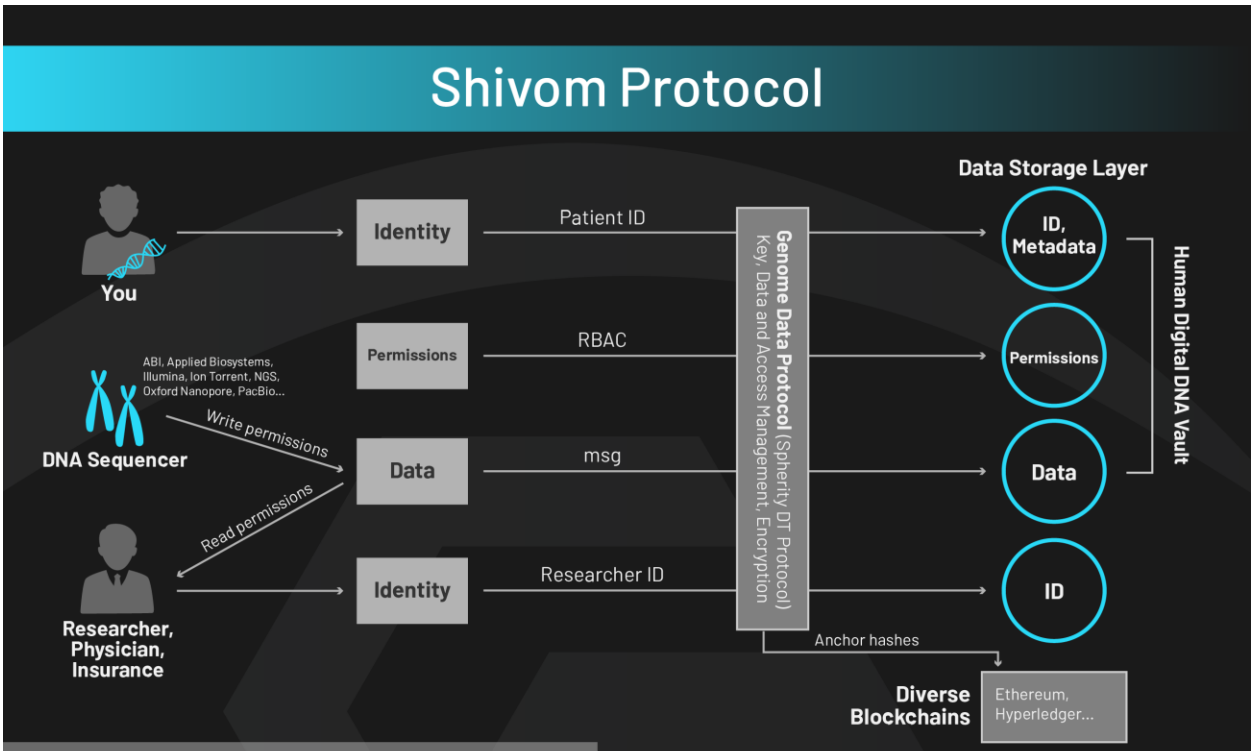
The Shivom platform is designed to be blockchain agnostic and will utilize best-of-breed technologies depending on network requirements. Shivom plans to deploy a sophisticated cryptographic identity layer and the main components of the platform is expected to be based upon distributed ledger technology derived from the Hyperledger Fabric, the BigchainDB framework (Decentralized Data Exchange; Ocean protocol) and the IOTA Tangle (for streaming and collecting medical data via medical/IoT devices) as follows below. The platform will consist of:

- an identity layer utilizing modern cryptography eg zero knowledge proof systems or secure multi-party computing
- identity registry, adopting the Decentral ID (DID) standards laid out by Decentralized Identity Foundation
- data management, starting from on-boarding and data import
- Digital DNA Vault – combining ID, metadata, and DNA, under user control
- research and development activities of Spherity GmbH for digital twins on BigchainDB technology to ensure PII data sets are secure
- right to be forgotten implemented by using proxy re-encryption

Majority of the data (especially personal data or PII) will not be stored on an immutable blockchain ledger. Data sets or a bundles of data sets are stored off-chain. To prove integrity of data, all data stored on the Shivom platform will be hashed. The hashes will be stored on an immutable ledger or blockchain database (eg BigchainDB, and others). Shivom is using two hashing approaches: hash of an individual data set and anchor hashes of bundles of data sets.

4.2 Shivom Protocol & Human Digital DNA Vault

Shivom will also develop its own unique protocols, which will perform a variety of key functions to include key management and encryption; role-based access management; storage of data set hashes and anchor hashes; and data management (where to write which data in which structure for DNA data sharing or processing use cases). Summary of the Shivom Protocol, permissions and Human Digital DNA Vault follows:



Write Access

- Authentication and matching of MedTech or DNA Sequencing Devices or DNA raw data locations or streams
- Push write or pull MedTech query management to defined storage locations and blockchains, authenticated encryption
- Anchor hashing for off-chain data integrity stored on multiple blockchains

Read Access

- Read management based on temporary RBAC permissions, data retrieval and decryption
- Validation of data integrity

Authentication, Encryption, and Permissions

- Decentral n-Factor authentication key management (no central storage of private keys), personal n-Factor key retrieval
- Secure computing
- Integration with other healthcare data, health records

Identity

- Decentral Identities (DID) on BigchainDB in accordance to Standards of the Decentral Identity Foundation (DIF)
- Authentication via n-Factor approach, preferably including biometry data

Identity Meta Data

- General patient master data (e.g. validated passport NFC chip data, demographics claims/proofs)
- RBAC configuration data (on-chain permissions, access to personal encrypted data stores, smart contracts)
- Data subscription and data control configuration data (EX/WGS data structure, data availability requirements, data/hash storage locations)

Permissions

- Role-based access control (RBAC) for write and read permissions in accordance to GDPR
- RBAC configuration customised by the patient, access tokens with temporary access to individual data

Genome Data

- Encrypted data and their hashes stored on different data storage solutions
- Data with immutability requirements: BigchainDB
- Data with integrity requirements only: encrypted AWS databases, personal health records, etc.

SHIVOM

4.3 Human Genome Sequencing & Processing

After human genome data has been sequenced, a *sequencing processing* process commences. Raw DNA data are extracted and processed in a DNA correlation engine in order to produce refined sequence alignment, store individual DNA data in a DNA data model and identity variants[55,56]. Alignment refinement using tools such as duplicate marking, local realignment and base quality recalibration as well as Variant Calling, Filtering and Reporting will be either integrated by using 3rd party sequencing systems or might be optionally built as a Shivom DNA sequencing service[57]. As an alternative sequenced data can be uploaded to the platform as well. This is a simpler approach for the first version of the Shivom protocol and does not require any system integration with DNA sequencing services. A typical data model is the OMICS data model[58] that works with a define set of tables to manage input for reference data, sequencing processing and sequencing output/variant reporting include:

1. Reference data are loaded into a reference table
2. Set of tables to provide the genome-features metadata required to link sample specimen results to specific portions of the genome
3. Set of tables used to capture the sample specimen results and link each result to some object in the human genome reference model and are also linked back to the patient
4. Results data tables (gene expressions, sequencing result).

There are alternative data models for DNA data storage. Design of the data model and its alignment with the small data principle and cryptographic models being used while handling very large amounts of data (in the order of terabytes, human genome with around 3 billion bases in each strand, individual genes have many different variants) is still subject to additional research by Shivom.

- **Human Genome Secure Data Sharing:** Shivom intends to establish a DNA data sharing marketplace that incentivizes users to provide a supply of individual DNA (WGS or DNA extracts for a special purpose) for medical evaluations or pharmaceutical research purposes. Shivom initially plans to provide a proxy-service that decouples the identity of the user from the human genome data for 3rd party research purposes. Individual sequences or the whole genome (if the data owner agrees) will be shared with a third party. Data access logging and payment mechanism will be established. Such a data sharing transaction may be conducted in accordance with a previously generated data sharing transaction agreement about the evaluation or analysis of individual human genome data by a third party relating to a Shivom user. In such an agreement, an incentive can be specified to either send a cryptocurrency to the Shivom user or to release payments depending on the research outcome in a fair way. For further developments, Shivom is evaluating data market exchange protocols, particularly the Ocean protocol[59], a decentralized data exchange protocol that lets people share and monetize data while guaranteeing control.

- **Human Genome Proof System:** Recent advances in modern cryptography enable developers to build zero knowledge (zk) proof systems[60]. Zk proof systems are a cryptographic method by which one party (the prover) can prove to another party (the verifier) that a given statement is true without disclosing any information apart from the

fact that the statement is indeed true. Zk proof systems are of value in doing DNA comparisons or forensics without disclosing the DNA (DNA profile matching). Shivom intends to do further research on this topic to implement such a proof system. Cryptographic alternatives such as secure MPC will be considered in the research roadmap as well.

- **Trusted Human Genome Computation / Analytics:** A significant amount of research regarding high performance Human Genome Computation and Analysis technologies has been done[62–71]. However, privacy-preserving for third party computation and analysis was not considered in this research as a non-functional requirement. Shivom plans to develop a platform that enables trusted, privacy-preserving computation for genome sequencing processing, healthcare analytics and pharmaceutical research.

4.4 Blockchain Architecture, Features & Components

Shivom is a B2B and B2C platform providing services primarily for the storage, process and analysis of genomics sequence data using cutting edge Blockchain and other frontier technologies.

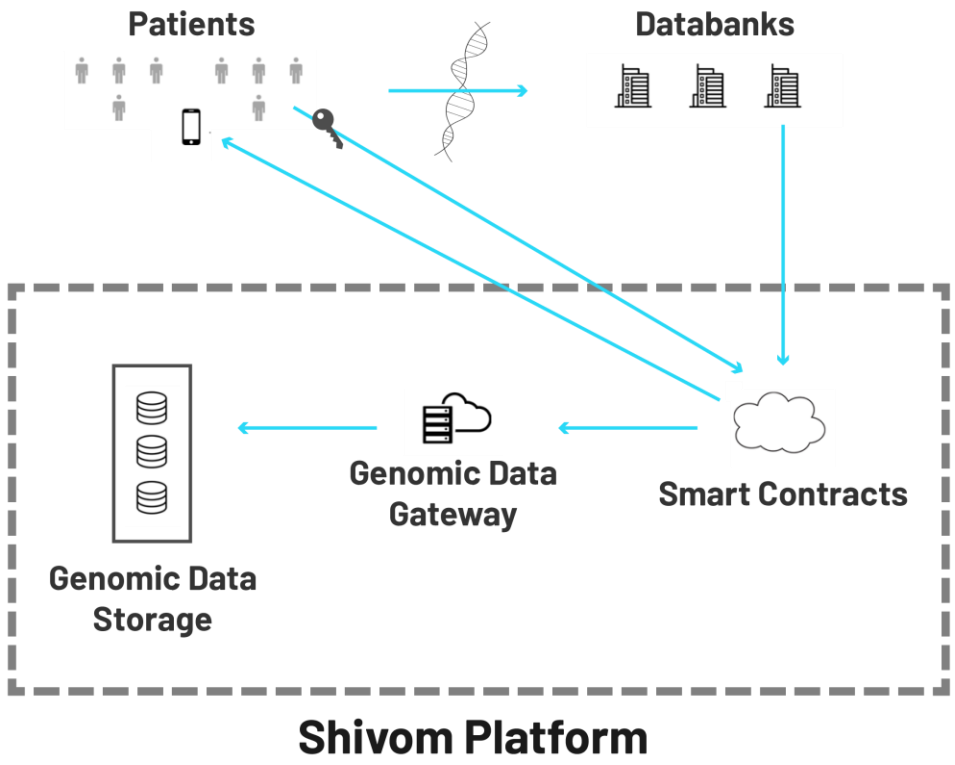
Two key problems the Shivom platform intends to solve are genomic data aggregation and sharing. For example, a data owner may be paid every time her data is shared for querying and analyzing. In this case, a researcher requests computation access to the whole genome sequence from the owner, and every time this data owner will paid again. For better usability, Shivom will provide mobile apps with dashboards, allowing data owners and researches to easily utilize these services. Since Shivom is based on blockchain technology, there will be no lost payments or shared data without the owner's approval. The data owner will be able to see which companies his genomic data was shared with, and how much he earned from this. All the payments on the platform will be made with the Ethereum-based ERC20 token OmiX (OMX; see token section).

- **Smart Contracts:** Shivom will utilize smart contracts to facilitate all transactions on the blockchain platform to include:
  - Storage of user information
  - Storage of metadata of genomic sequence data
  - Circle of trust with access control lists (ACL), providing secure access to genomic data, queuing and analyzing
  - Storage of access logs
  - ERC20 Token

- **Blockchain-agnostic platform:** Shivom's blockchain can be run on Hyperledger Fabric, Ethereum, Qtum or other blockchains. Hyperledger Fabric will be shown in this white paper as an example. The main components of Shivom's Blockchain part are:
  - Decentralized Apps (DApp): Interface to communicate with decentralized Shivom platform

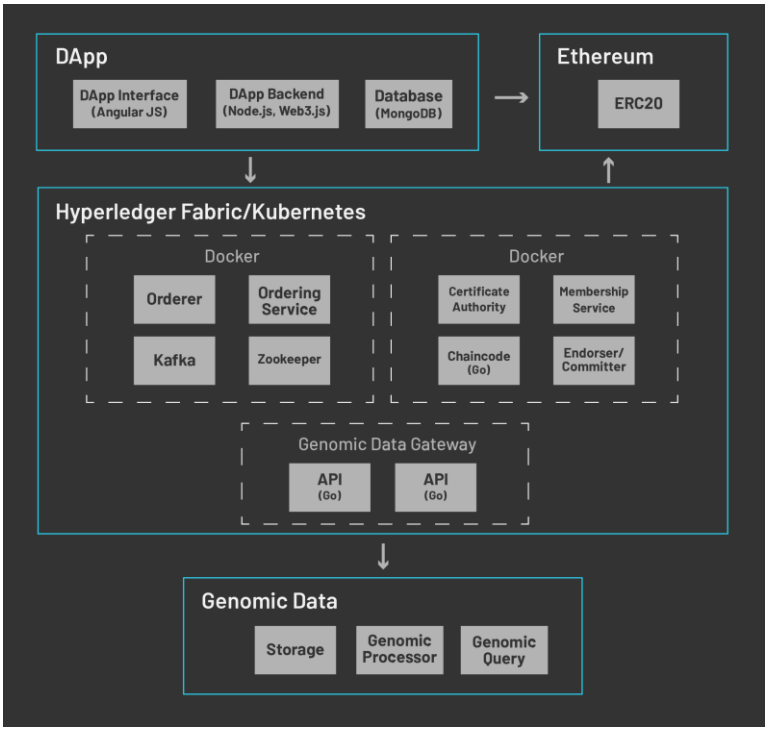
- Ethereum Blockchain: The main purpose of Ethereum is to handle ERC20 token
- Hyperledger Fabric: It contains multiple parts with the main purpose of having smart contracts, storing metadata and providing access to genomic data in a decentralized way

- **BigchainBD & Ocean Protocol:** To scale long-term and to add AI capabilities, the Shivom platform will be designed to work with BigchainDB and the Ocean protocol. BigchainDB fills a gap in the decentralization ecosystem: a decentralized database, at scale. It points to performance of 1 million writes per second throughput, storing petabytes of data, and sub-second latency. The BigchainDB design starts with a distributed database (DB) and through a set of innovations adds blockchain characteristics: decentralized control, immutability, and creation & movement of digital assets.



- **Internet of Things Data (IOTA Tangle):** IOTA is different from how a classical global blockchain works given its use of a directed acyclic graph (DAG), aka a Tangle. The transactions issued by nodes (entities that issue transactions) constitute the site set of the tangle (i.e., the tangle graph is the ledger for storing transactions). Sites are transactions represented on the tangle graph. To send an IOTA transaction, a user's device must simply confirm two other transactions on the Tangle (the network) via low

difficulty "proof of work" math problem computations. This removes the need to waste large quantities of energy on mining or risk inevitable validation centralization.



4.5 Sequenced Data Files

The genomics ecosystem is a living ecosystem, which means many people and organizations can help shape its future. In the beginning, in agreement with foremost experts in the field of genomics and Bio-IT, the platform will store only CRAM, VCF (structural genetic variants) and BED-files (a tab-delimited text file that defines a feature track). CRAM (compression algorithm) is able to shrink 'normal' sequence files such as BAM files by ~30 % without any data loss and by more if compression is allowed to lose some information, typically in the quality scores. CRAM only records the reference genome and applies so called Huffman coding to the result. Shivom will work with data analytics companies, genomics scientists and the Shivom Foundation Genomics Steering committee to develop and adopt newer and better compression algorithms once they become available. As such, the storage will adapt in time balancing between usability and compression.

The metadata structure will be developed by a customer driven approach as well as by an international working-group which will be part of the Shivom Foundation. In general, the metadata should include some demographic data, indexed data to be used for research purposes, the protocols and assays performed on these samples, the data files generated from the results and the computational methods used to analyze the data. A data framework that emphasizes data reproducibility will be an essential part of the database governance. To avoid interoperability issues and redundancies, we will closely follow the recommendations from the Metadata Task Team of the Global Alliance for Genomics & Health, as well as Pistoia Alliance, the Clinical Data Interchange Standards Consortium (CDISC) and the EBI Ontology service.

DNA samples will be sequenced with ≥30x coverage; for special projects, e.g. sequencing of samples from tumor tissues or from patients with rare diseases, Shivom will try to target at least 50x coverage. Shivom will provide the highest quality sequencing services available and strive to have a sequencing quality score of over Q30 in at least 80% of the bases. Here, the sequencing quality score of a given base, Q is defined by $Q = -10\log_{10}(e)$, where e is the estimated probability of the base call being wrong. In practical terms, this means that a higher Q score indicates a smaller probability of error. A quality score of Q30 represents an error rate of 1 in 1000, with a corresponding call accuracy of 99.9%. This value is an average across the whole read length, and error rate increases towards the end of the reads.

Sequencing and analysis pipeline.

4.6 Cloud Data Storage

The raw genomic data and processed data files will be stored anonymously in the cloud. Under HIPAA guidelines in the US and other rules in various jurisdictions, organizations can transmit, and store protected health information (PHI) in the cloud, made even more secure by adopting another blockchain layer. Genomic cloud computing is a scalable service where genetic sequence information is stored and processed virtually usually via networked, large-scale data centers accessible remotely through various clients and platforms over the internet. As a genomic ecosystem relies on data contributed by participants and is bound to abide by laws and ethical guidelines, Shivom's ecosystem will ensure that all raw and processed genome data are kept safe during their full life-cycle and cannot be linked to the data-owner; there should be no way to trace a genome back to other metadata which is stored decentralized on the blockchain. Most commercial cloud infrastructures that typically process data transnationally have built-in security mechanisms and can handle the large-scale data generated by genomic sequencing projects. Genomic data is by default uploaded only to encrypted objects leveraging server-side encryption. Regarding data transfers, all user data is transferred exclusively through encrypted TLS/ SSL channels throughout

for all data flows. The leading public cloud vendors provide security mechanisms that equal or surpass those utilized in traditional in-house data centers. Most vendors provide documented best practices for securing systems and data. Genomic cloud storage (and computing) provides other benefits. First, it is relatively low-cost in terms of allowing access to resources due to its 'elasticity'—an on-demand service wherein one pays for what one needs. This shifts the need from purchasing many IT-resources in-house. Also, cloud computing may provide greater data security, as large-scale cloud-based infrastructure typically have the capacity to invest in and implement state-of-the-art encryption, firewalls and auditing capabilities. In addition, genomic cloud solutions also offers increased data storage capacity and efficient processing, and 'scaled up' genomic analysis through increased computing power, which can accelerate discovery and innovation[22].

5 Business Model

5.1 Shivom Products & Services

Shivom is a B2B and B2C platform providing services primarily for the storage, process and analysis of genomics sequence data using cutting edge blockchain and other frontier technologies. Shivom's core business will be comprised primarily of Shivom products & data aggregation and analytical services; genomic counseling network of services; and third-party applications / products. Initially, genomic and other 'omics' services will be primarily paid by consumers via classical B2C / D2C channels. By disintermediating the "middlemen" in the system, Shivom will be able to offer genomic sequencing and other healthcare-related services at a discount relative to today's prices. Similarly, data buyers will be able to acquire or move data on the platform without all the middlemen that plague many healthcare systems.

For any such services, Shivom will receive a small transactional fee for each genomic sequencing service performed or analytical product / insights delivered. Receipts would be utilized in part to pay for any direct or outsourcing expenses and overhead as needed; Shivom intends to direct net token proceeds back into Shivom platform as warranted to further expand the platform and enable more robust and efficient delivery of products and services. As the cost to sequence genomes becomes cheaper, Shivom anticipates employers and healthcare providers (i.e. healthcare insurance companies) to sponsor / subsidize or even offer genomic sequencing for free as such insights help people to better manage their health; thereby presumably leading to the overall reduction of healthcare costs and insurance premiums. Today, many insurers are interested but do not know how to offer preventive healthcare services to their customers. Shivom's platform and suite of products and services will make it easy for people to purchase and better manage their health and companies to benefit from and / or offer preventative care services.

5.2 Applications, Service Providers & Network Effects

Beyond its product and service offerings, Shivom customers will be able to purchase apps that are of interest to them from external parties such as genomic counselors and third-party service providers, whom, benefiting from an ever-growing knowledge base of anonymized genomics data, will collectively serve to further help customers to manage their health. In addition, customers who participate in public health research projects or consent to clinical studies will also be able to receive, subject to compliance to applicable law, OmiX tokens as part of an integrated program to

incentivize preventive health. For any such transactions, Shivom anticipates taking a modest service fee in the form of OmiX tokens.

Shivom encourages and invites all stakeholders to join and work together in one robust ecosystem. Shivom champions solutions and innovations within the genomics space and encourages competing teams including startups, innovators, genomic counselors, technology providers, researchers, investors and established healthcare services to combine efforts and collaborate within a personal healthcare ecosystem. Doing so helps to realize a common marketplace and to contribute towards rapidly building a network effect and economies of scale while using Shivom's OmiX token and simultaneously giving each partner the freedom to explore their own development paths, e.g. using their own compatible token or blockchain technology. Shivom intends to build a powerful center of gravity that brings the rest of the ecosystem into Shivom's orbit. Its genomics ecosystem will ultimately be totally self-sustained and will increase in adoption and utility through collaboration and network effects. From an economic perspective, some of the advantages of Shivom's open marketplace include larger overall economy by combining markets; higher utility value due to early bundling of services; greater network effects and combined cross-marketing effects.

Starting the Shivom genomics ecosystem is just the first step in a much bigger mission to win over an entire market to join a new digital healthcare economy. The value of the network grows as the square of the number of network nodes (or applications, or users, etc.) while costs generally decrease in a linear function. Every time someone joins the genomics ecosystem, as partner, service provider or as user, the network becomes markedly more effective. Networking effects will increase dramatically in the coming years as sequencing becomes a mainstream business. As the price of sequencing becomes more affordable and the usefulness of the data increases as more genetic changes are linked to diseases and other traits, doctors will increasingly order whole genome and exome sequencing; thereby further driving the velocity of transactions on platforms like Shivom.

5.3 Platform Growth & Sustainability

For most DTC genomics companies, customers do not have direct access to their data, cannot monetize it, and must pay for all services. Additionally, the data is not secured by blockchain technology. Companies simply sequence customers' genomic data and store it centrally (making it a target for hackers). The emergence of genetics companies, as well as the race for blue chip companies like Amazon or Google to collect and store peoples' DNA in the cloud underscores the prospects of a booming consumer genetics market. While most patients will only sequence their genomes once, limiting the long-term prospects of sequencing companies, Shivom will instead offer a sustainable economic ecosystem and business model with its end-to-end healthcare services platform. Doctors and researchers will routinely look at a patient's genomic data multiple times over the life of the patient.

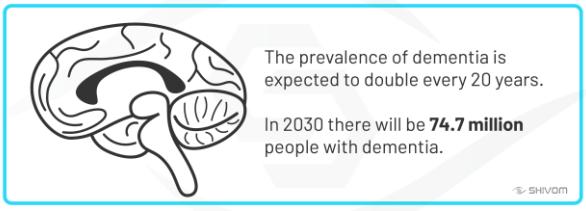
Shivom's marketplace is a healthcare-specific ecosystem, which will not be limited to a specific ledger technology; rather, the platform will be comprised of a combination of technologies. Siloed platforms and databases can be merged onto Shivom's platform to rapidly kickstart a new economy via network effects and spur the growth of the Shivom ecosystem. The Shivom ecosystem and its OmiX token are being designed to bring contributors together and align efforts towards a common goal – better healthcare for everybody. The economic alignment of the OmiX token with contributors, users and all stakeholders within the Shivom genomics ecosystem will collectively

serve to realize decentralized data sharing and a variety of healthcare services. This provides a way for independent companies within the wider Shivom community to compete whilst still being aligned to the mission of the overall success of the genomics ecosystem. In short, Shivom will develop and introduce a new token-based platform and innovative business model, which will not only help to reduce drug development costs but will also help to promote the secure sharing of resources and ideas; and more efficiently provide better genomics-based healthcare services for all.

5.4 Research & Drug Discovery Institute

A central part of Shivom's long-term plan is the establishment of a highly scalable 'open-source' research and drug development organization for the development of more effective, less costly, and safer therapeutics and precision medicine. Shivom envisions establishing a pharmaceutical ecosystem on top of blockchain technology, paving the way to trusted and open R&D processes & trusted transactions between parties, powered by collective self-interest of a global community of independent investors and stakeholders. This pharma ecosystem is anticipated to be immune to exorbitant drug prices, tampering, fraud or political control; all of which are serving to destroying the healthcare system in many countries worldwide. Shivom will concentrate on the biggest cost drivers in healthcare, particularly age-related diseases such as Alzheimer's, diabetes and cardiovascular disorders. Shivom aims to also work with its partners in the field of cancer research.

With the prevalence of type 2 diabetes (T2D) rising rapidly worldwide, Shivom anticipates focusing on diabetes and other related disorders. Diabetes is the most expensive condition in terms of total dollars spent in the world, costing approximately $120 billion in diagnosis and treatment yearly in the U.S. alone. Diabetes-related costs have grown 36-times faster than those for ischemic heart disease, which kills more people than any other condition. Shivom intends to study diabetes in the developing economies where diabetes rates are rising sharply. One of the largest absolute increases is expected to occur in India; the International Diabetes Federation estimates that India alone will have 100 million people with diabetes by 2030 with approximately 90% of these individuals suffering from T2D.



A special focus of the Shivom's R&D efforts will be on Alzheimer's diseases and other dementias. Someone in the world develops dementia every 3 seconds. There were an estimated 46.8 million people worldwide living with dementia in 2015 and this number is believed to be close to 50 million people in 2017. This number will almost double every 20 years, reaching 75 million in 2030 and 131.5 million in 2050. Much of these anticipated statistical increases and trends are expected to occur in developing countries. It is expected that individuals currently living with dementia live in low and middle-income countries is expected to rise from 58% to 68% by 2050. Geographic areas of

particular concern include countries such as China, India, and others in South Asia / Asia Pacific, which collectively are experiencing the fastest growth in elderly population.

Demographic ageing is indicative worldwide given considerable advances in healthcare over the last century. Many are now living longer and healthier lives and so the world population has a greater proportion of older people. Dementia mainly affects older people, although there is a growing awareness of cases that start before the age of 65. There are over 9.9 million new cases of dementia each year worldwide, implying one new case every 3.2 seconds.

Research shows that most people currently living with dementia have not received a formal diagnosis[c]. In high income countries, only 20-50% of dementia cases are recognized and documented in primary care. This 'treatment gap' is certainly much greater in low and middle-income countries, with one study in India suggesting 90% remain undiagnosed. If these statistics are extrapolated to other countries worldwide, it suggests that approximately three quarters of people with dementia have not received a diagnosis, and therefore do not have access to treatment, care and organized support that getting a formal diagnosis can provide.

5.5 Big Data- & Artificial Intelligence-Driven Solutions

Data within the Shivom platform will be used for:

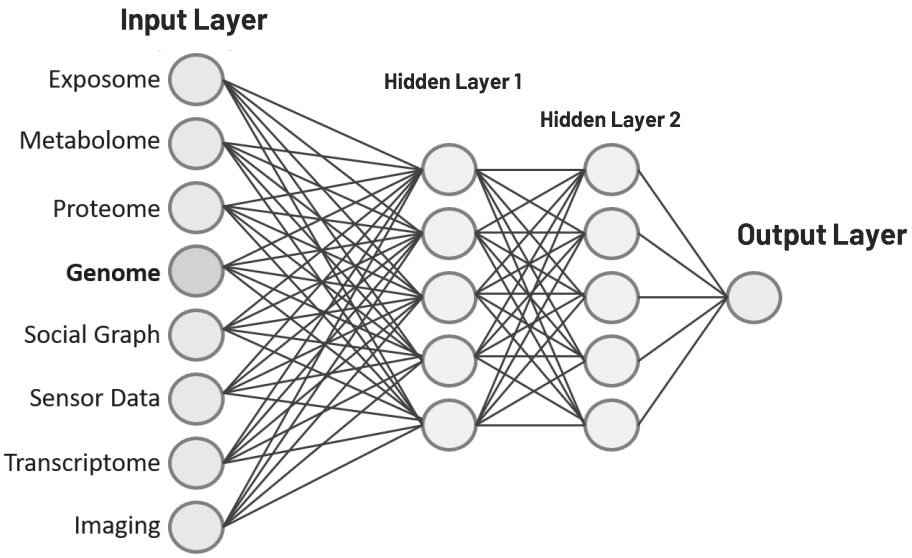
- **Companion Diagnostic Development.** A companion diagnostic is any test that provides additional information to guide the safe and effective use of a treatment. Such tests can be used to identify patient populations that will beneficially respond to a particular drug or to identify sub-populations of patients that have an increased risk for adverse drug events.

- **Drug Repurposing and Repositioning**. Various drugs are designed to act within a certain molecular pathway to treat disease. By integrating information on how the drug acts on a disease target, a disease's mechanism of action and the structural similarity of drug compounds, new treatment paradigms emerge. The added insight afforded on novel therapeutic applications can be applied to investigational compounds, approved drugs on the market or innovative combinations of both.

- **A.I.-driven Research:** With the highly complex and intricate human genomic machinery, advanced computers, machine learning algorithms and other frontier technologies area required to process, analyze, identify and classify the extremely large anonymized datasets. Already, these algorithms can capture discriminative patterns from genomic data, which can be used for prediction purposes and the ability to extract actionable information via data integration[48]. Machine learning is by far most effective and essential for analyzing large, complex datasets. The most powerful form of machine learning

[c] Dementia Statistics. https://www.alz.co.uk/research/statistics

approaches used today is called "deep-learning", designed to be analogous in function and performance as a human brain. Based on vast quantities of data, deep learning enables the developments of a complex mathematical structure or neural network. These deep-learning methods use multiple processing layers to discover patterns. The higher the level, the more abstract the concepts that are learned. As the platform grows, Shivom plans to increasingly incorporate machine / deep learning methods and technologies to process large datasets.



Multi-level artificial neural network to support genomics research. At the input layer, multi-omics and demographic data are fed into the network. Each circular node represents an artificial neuron, and each line represents a connection from the output of one neuron to the input of another. Machine learning enables data-driven decision systems to continuously learn from new epigenetic data and adapt itself to deliver **reliable and repeatable** *results.*

6 Sponsorships & Partnerships

The precision medicine ecosystem will be built largely upon collaborations and partnerships to develop and collect the large volumes of genomics data required to generate new and more precise insights. Accordingly, Shivom intends to partner with a variety of organizations to promote a large genomics ecosystem. A central part of this ecosystem is genome sponsoring. In this model, governments, pharmaceutical collaborators, academic labs, patient organizations, or private sponsors are able to support sequencing initiatives, e.g. for clinical trials, population genomics (also in underdeveloped rural areas) or for the identification of interesting phenotypes such as disease resistant variants in the population.

- **Strategic Alliances & Partnerships**: Shivom to date has established strategic alliances and signed MOUs with a variety of partners (e.g. service providers joining Shivom's healthcare marketplace). These partnerships range from blockchain and AI partners such as Spherity GmbH, Ocean Protocol; various medical centers and labs such as Australia-based Genetic Technologies Limited; to various governments. Additional partnership and strategic alliance announcements are forthcoming.

- **Pharmaceutical & Biotech Companies**: To remain competitive, pharmaceutical companies need to dramatically drive drug development efficiencies. Genomics and artificial intelligence present a real opportunity to revolutionize R&D programs, especially in screening for potential drug targets and corresponding drug candidates to address diseases or conditions with a dire unmet medical need. The significant cost associated with drug development is linked to the ability to get high-quality and validated data sets from patients. These processes can be improved and done more cost effectively. Shivom intends to partner with pharmaceutical / biotech companies and clinical research organizations (CROs) to allow access to Shivom's services, as well as offer the opportunity to sponsor genomic testing on a mass level. The data will not be owned by any company and most of the revenues from pharmaceutical companies produced by using genomic data are passed on to the owners of the data, patients and healthy individuals.

- **Group Sponsorship**: There will be several options for private or corporate sponsors to support the platform, patient groups, research projects or specific individuals:

    - **Employee sponsorship**: Shivom will offer special employer programs. Already, many companies offer various forms of wellness incentives or financial rewards to employees who work towards getting healthier. Companies can also use the data to figure out what their workers' health needs are, without getting access to their personal information. A comprehensive, incentive-based program is most effective in improving employee productivity, engagement and overall health.

    - **Private sponsorship**: There are many underprivileged individuals, especially children, around the globe who don't have access to standard health care on a regular basis. To address this need, Shivom aims to provide a special private sponsoring program that will offer people the opportunity to sponsor those who cannot afford to purchase a sequencing kit for themselves. A smart contract can be invoked which can either (partly of fully) reimburse those who paid for the test, after the genomic information was used in a scientific study or gives rewards to the recipient.

- **Patient support group sponsorship**: Support groups have been a component of medicine for years, and several studies indicate that these groups can be beneficial for patients. When confronted by illness, patients seek professional help and advice from their doctors are able to rely on support from peers and fellow patients. Patients with genetic diseases are a significant part of this patient group, as they often require support and counseling following diagnosis of their condition. It is our goal to partner with such patient support groups to enable those groups to provide patients and their families with information on their disease, encourage and fund research, treatment and education, and act as advocates for those affected by illness. For example, a cancer support group might want to sponsor the genetic test for its members, supporting larger scientific studies. In case of rare diseases, they can sponsor individuals that may harbor unknown genotypes. In addition, patient support groups are increasingly important partners for the pharmaceutical industry. Using smart contracts, the support groups may demand that all the money invested by them is going only in R&D efforts related to a specific indication. For example, a major diabetes patient group may want to make sure that their money is directly used for the development of a new drug against diabetes. The contract can then specify that any drug or companion diagnostic developed in this process is 'open-source', meaning not protected by patents, or that the price for the drug is limited to the lowest possible price to the public.

- **Governments for population health**: Governments have an important influence on the emergence and progress of genomic medicine. Shivom expects to see an increasing role for public health in providing policy frameworks for protecting consumers and minimizing costly and unnecessary healthcare expenditures, ensuring the success of genomic medicine. Shivom with its partners aims to attain the global adoption of evidence-based preventive healthcare. Such projects are highly relevant; for example, in the US alone, about 1-2% of the population carries genetic mutations with high risk of preventable common conditions such as cancer and heart disease. If undetected, many affected people and their at-risk relatives are not undergoing recommended interventions that can prevent early deaths from common diseases.

- **Governments & International Genomics Groups**: Shivom also aims to work together with **international genomics working groups** to support the design of a framework that will provide the evidence for the implementation of large-scale genomic sequencing programs in healthy adult populations. Together we intend to address the ethical and regulatory issues arising from genomic research and its clinical applications(e.g. analytic challenges, return of results to participants, workforce and education needs), and sharing of human genomic information. Already several countries recognized the huge chance that is presented by pairing blockchain with healthcare. The governments of several

countries, for example Estonia, the United Arab Emirates and others are already working on solutions in the blockchain space; others such as Australia, China or the UK are also looking into healthcare blockchain solutions. Shivom anticipates that most countries in time will join the 'global genome' movement.

- **Global genetic counselor network**: Shivom plans to build a large global network of its own and connected genetic counselors, which can also form a telemedicine ecosystem (in case people in rural areas have no direct access). Eventually, most people will undergo genetic testing and counseling, not only those with clearly elevated genetic risks. With the rising interests in common and complex diseases genetic testing, it is certain that there will be an exploding need for genetic counselors in complex diseases in the coming few years[37]. This reflects rapid advancements in the scope and cost of genetic test, the knowledge of how genetics contributes to common and complex diseases such and diabetes or Alzheimer's disease, and the enormous complexity of genome science in medicine today. Genetic counselors will be responsible to provide education and risk interpretation for consumers as well as supporting health promotion models.

A global network of genomic/health counselors and laboratories.

- **Pharmacogenomics Services**: Shivom also plans to provide sophisticated, state-of-the-art pharmacogenomics services for healthcare providers. Shivom will enable physicians and pharmacies across the healthcare landscape to select the most appropriate therapies based on how people metabolize drugs. In the era of evidence-based medicine, drug therapy was rather nonspecific, meaning patients diagnosed with the same disease were commonly given standard drugs[43]. Using pharmacogenetic information, physicians will be able to ensure that drugs have on average higher efficacy while adverse events can be minimized. Sharing of genotypic and phenotypic data within the Shivom genomics ecosystem will accelerate the determination of causality for novel genes or variants. Thus, a deeper understanding of disease will be realized that will allow its targeting with much greater therapeutic precision. As evidence builds up, the use of pharmacogenetics may become a common practice in hospitals and pharmacies around the world[37].

7 OmiX: The Global Genomics Token

The OmiX token will be the fuel of the Shivom ecosystem and necessary for all transactions that occur on the platform. Users will use the OmiX token to access and procure healthcare related

products and services. All parties on the Shivom platform including individuals, pharmaceutical companies, research organizations, insurance companies, universities, employers, etc. will be required to utilize OmiX tokens to settle any activities and transactions to include the procurement of products and services. OmiX tokens also ensure that the identity of genome owners as well as genome data remains anonymous and secure, even across borders.

OmiX token holders have numerous benefits and advantages.

As more service providers enter the Shivom ecosystem, the platform scales and community demand are better understood, more services and products will be available to platform users in exchange for OmiX tokens[d], which will be linked directly to smart contracts, a mechanism that is not easily done by FIAT currencies. Another reason to use tokens instead of FIAT is that transactions are generally orders of magnitude faster (i.e., seconds vs. days).

Customers signing up to use the platform will have a wallet with an OmiX balance, which will eventually be reduced by the tokens being used on the platform. Shivom will take great effort to provide a variety of opportunities for users to utilize the token balances for a variety of use cases ranging from D2C sequencing services, genomic counseling to donation of tokens for philanthropic purposes.

Tokens are digital and cannot be counterfeited or reversed arbitrarily by the sender as is the case with credit card charge-backs. Tokens use a "push" mechanism that allows the token holder to send exactly what he or she wants to the healthcare provider with no further information; lowering the chance of identity theft. Also, the strong encryption techniques employed throughout the distributed ledger are a safeguard against fraud and account tampering, and guarantors of consumer privacy.

7.1 Token Utility

Below is a short list of potential uses on the Shivom platform:

Examples of ways to spending OmiX include:

[d] At the start, only a subset of services and products will be available. In time we will add more and more products.

Users

- Buy genome sequencing kits to get your genome sequenced
- Get access to health/fitness apps from 3rd party providers
- Buy health insurance
- Redeem for health-related products (partner pharmacy or online shop)
- Buy other 'omics' kits (e.g. get your metabolome, transcriptome, microbiome, or epigenome tested)
- Obtain your ancestry or genealogy profile
- Analyze information on your pharmacogenetic profile (which drugs work for you and which do not)
- Get personalized lifestyle, diet, and nutraceuticals advice
- Understand evidence-based information on susceptibility to diseases and associated therapies

Organization

- Sponsor sequencing projects
- Access the genome database and analytics
- Pay donors for data & participation in research studies
- Upload sequences to the ecosystem
- Obtain secure cloud storage space for Omics data
- Support rare disease projects
- Find participants for research studies
- Optimize patient stratification in clinical trials
- Add apps and services to the platform
- Store your proprietary DNA sequences for tamper-proof IP protection
- Optimize patient stratification in clinical trials
- Add apps and services to the platform
- Store your proprietary DNA sequences for tamper-proof IP protection

Everyone who participates in the Shivom ecosystem is helping to not only enhance individual wellness but also to revolutionize healthcare. It's a form of collaboration; a partnership to build a global ecosystem for all people. To the extent possible, Shivom aims to provide incentives and opportunities to reward all those that participate in the ecosystem. Rewards (in the form of OmiX tokens) will be obtained through several mechanisms.

Examples of opportunities to earning OmiX include:

- Referring other users to the Shivom ecosystem
- Updating health information, adding health data/fitness data and supporting community projects
- Participation in healthcare projects (e.g. surveys, clinical trials, population health initiatives) that Shivom or partner organizations fund
- Proper ID verification (you will stay 100% anonymous)
- Sharing data for medical research purposes and giving consent to be contacted anonymously by researchers
- Donating health data for non-profit research programs

- Filling out health questionnaires
- Supporting the Shivom healthcare revolution by writing articles, reviews or creating YouTube videos

Platform incentives and rewards (including tokens, cryptocurrency, free health apps or discounts) can also be earned based on level of engagement to include, for example, users' creation of original social media content, social promotions, sharing research campaigns, or using apps, or encouraging use of Shivom via viral marketing.

7.2 Token Circulation

Within a few years, Shivom envisions becoming the largest genomic datahub and ecosystem in the world. To achieve this feat, Shivom understands the importance of the timely development of its secure platform that will allow for the routine adoption and robust usage of the OmiX token for any product or service transaction conducted on the Shivom platform. Increased global adoption, velocity and sustained usage of the OmiX token will serve to significantly drive the utility and long-term value of the Shivom platform. With network effects and increased adoption of the platform, the utility of and demand for the Shivom platform and related products / services and circulation of OmiX should increase exponentially.

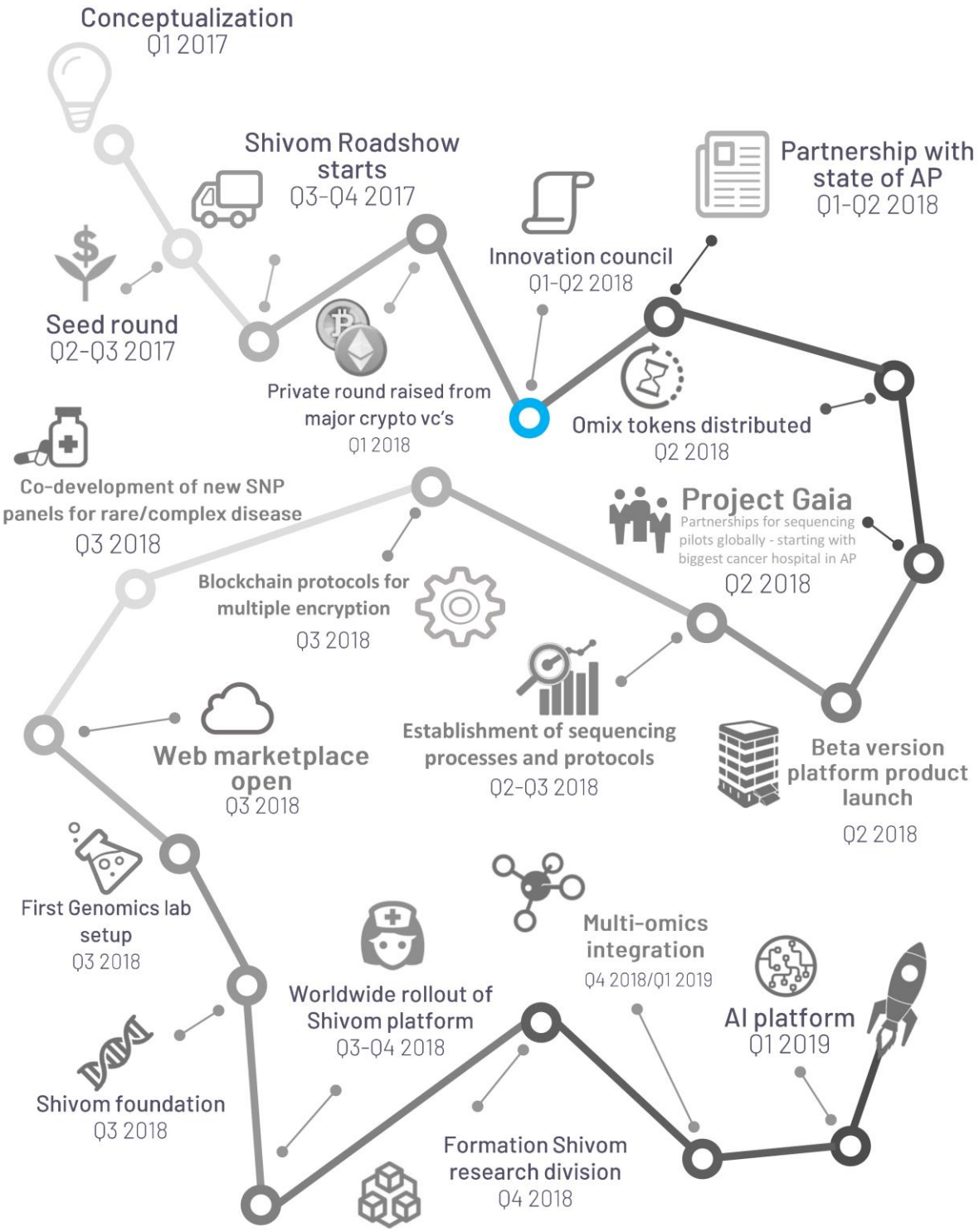
Initially, Shivom plans to pursue a D2C model, which will be comprised of customers setting up an account and wallet on the Shivom platform and converting FIAT to OmiX to procure genomic sequencing services directly from Shivom. On-site sequencing at partner facilities will also be pursued. In parallel, Shivom plans to encourage those, whom have already had their genome sequenced to upload their genomes; and thereby benefit by gaining control over their genomes / healthcare data and access to the Shivom platform. Such users would require OmiX to procure products & services and / or could earn OmiX via sponsored projects. Beyond the initial conversion process, users are expected to have ongoing opportunities to earn tokens by participating in various Shivom engagement & reward activities. For those that lack the resources and access to healthcare, i.e. impoverished individuals, Shivom, in the absence of any sponsors or charitable contributors, anticipates subsidizing such individuals to the extent possible with existing Shivom reserves. Users will be able to use tokens to procure any of the anticipated healthcare products and services to be offered on the Shivom healthcare ecosystem; or could donate OmiX for social / philanthropic purposes. OmiX holders are expected to serve as a source of supply for those in need of tokens.

Pharmaceutical companies, employers, CROs and other sponsors would need to convert FIAT into OmiX to reward users for participating in any sponsored R&D, clinical trials, etc. projects. For any such programs, donors would receive OmiX tokens, which could subsequently be utilized for any products and services on the Shivom platform. Depending on the level of demand, variation of genome, donor profile and other factors would dictate the total amount of OmiX, which a donor may be rewarded for participating in a sponsored program. Genomic counselors and other providers will receive OmiX in exchange for any service offered. Similarly, third party vendors would also be able to earn tokens via the offering of any custom healthcare and wellness applications to be procured by members on Shivom's platform. Service providers would be able to use the tokens on the Shivom platform and are also expected to be a resource for tokens.

For any OmiX earned by Shivom, either via modest transaction fees or directly via the procurement of any Shivom product or service, Shivom envisions utilizing the token for platform / community development and other uses as outlined herein and here. Shivom plans to employ effective strategies to manage its token holdings and those in circulation. Ultimately, Shivom strives to develop a platform that will realize a virtuous supply & demand cycle and token circulation system among pharmaceutical companies, CROs, employers, R&D organizations, etc. (i.e., sponsors); genomic counselors and third-party vendors (i.e., service providers); users / donors; and any other party holding and utilizing OmiX within the Shivom ecosystem.

8 Roadmap

The following roadmap information provided below is non-binding, shared for information purposes only and offered to provide insight on current and anticipated future Shivom platform development plans to include Shivom's envisioned products and services as outlined herein, which collectively are subject to discontinuation or change at any time without advance notice.


Conceptualization
Q1 2017
Shivom Roadshow starts
Q3-Q4 2017
Partnership with state of AP
Q1-Q2 2018
Seed round
Q2-Q3 2017
Innovation council
Q1-Q2 2018
Private round raised from major crypto vc's
Q1 2018
Omix tokens distributed
Q2 2018
Co-development of new SNP panels for rare/complex disease
Q3 2018
Project Gaia
Partnerships for sequencing pilots globally - starting with biggest cancer hospital in AP
Q2 2018
Blockchain protocols for multiple encryption
Q3 2018
Establishment of sequencing processes and protocols
Q2-Q3 2018
Web marketplace open
Q3 2018
Beta version platform product launch
Q2 2018
First Genomics lab setup
Q3 2018
Multi-omics integration
Q4 2018/Q1 2019
Worldwide rollout of Shivom platform
Q3-Q4 2018
AI platform
Q1 2019
Shivom foundation
Q3 2018
Formation Shivom research division
Q4 2018

9 Global Leadership

Shivom's international team harnesses a wealth of cross-sector experience, skills and perspectives that come together around a common vision for Shivom and the democratization of the healthcare industry. The team shares a genuine optimism for the future, entrepreneurial drive and the passionate belief that Shivom will herald the next era of genomics and precision medicine and be a powerful force for positive social impact and good globally.

9.1 Founding Members

Axel Schumacher, PhD
Co-Founder & CEO

Axel has over 20 years of R&D leadership experience in genomics, epigenetics, biomarker discovery, Bio-IT, and aging & longevity. He is the Author of the 'Blockchain & Healthcare Strategy Guide', the standard compendium for the healthcare industry. Axel translates scientific discoveries into practical applications to help understand, diagnose, and treat complex disorders, but also to promote cutting-edge technologies that could transform precision medicine and the way we age. Axel is a Faculty-Member of the Blockchain Research Institute in Toronto. He holds a PhD in Human Genetics from the University of Cologne.

Gourish Singla
Co-Founder & COO

With a background in investment banking and wealth management, Gourish is an accomplished business leader, angel investor and social entrepreneur with a focus on performance, growth and innovation. He drove $30MM+ revenue in his last venture within a highly competitive marketplace and has founded three successful companies in the digital health space. Through Project Shivom, Gourish combines his deep interest in this sector alongside advocacy for blockchain and distributed ledger technology that can make a transformational difference both for business and for wider society.

Sally Eaves, PhD
Co-founder & CMO

Sally combines a depth of experience as a Chief Technology Officer, Practicing Professor of FinTech and Global Strategic Advisor, consulting on the application of disruptive technologies for both business and societal benefits. She is an award-winning thought leader in innovation, digital transformation and emergent technology, notably blockchain, artificial intelligence, machine learning and robotics. A member of the Forbes Technology Council, Sally is an accomplished author with regular contributions to leading business, technology and academic publications. She is an international keynote speaker and respected online influencer across multiple social media channels and consistently rated in the top 10 for blockchain and social media influencers worldwide.

Akash Gaurav
Co-Founder & CTO

Akash is a blockchain expert. He started India's first blockchain company, Auxesis Group during his undergraduate course at IIT Bombay. Auxesis today is counted among the Top 100 blockchain companies in the world. Backed by various state governments of India, Auxexis' Auxledger enables organizations to quickly deploy a blockchain network and build their business logic on top of it. Akash also started Blockchain Lab, India and is an advisor to the hot blockchain startup Cashaa.

9.2 Management Team & Advisors

Henry L. Ines
Chief Innovation Officer

Henry is a global executive with extensive VC, advisory, and corporate finance experiences. As an investor, he has focused on fintech and frontier tech investments based on his collective years of experience at DragonVenture, DFJ Dragon Fund, and DraperDragon Fund in Silicon Valley. Henry has also advised on multiple blockchain and tech startups; and serves as a mentor for accelerators worldwide. Henry also co-founded the SF Bay Area chapter of the Global Chamber® and is an instructor at Nanyang Technological University (NTU) in Singapore. Henry began his career as a management consultant for Fortune 500 companies. Later, he focused on M&A and other corporate finance transactions before transitioning to direct investments. Henry holds a BS in Finance from Pennsylvania State University in University Park, PA and an MBA from Duke University Fuqua School of Business in Durham, NC.

Natalie Pankova, PhD
Chief Scientific Officer

As an experienced Director in 2 early stage health tech companies, Natalie is skilled in operations, business development, investor relations and R&D. She holds a Ph.D. from the Faculty of Medicine at the University of Toronto, with a research focus on ophthalmology, inflammatory disease, diagnostics and precision medicine. She is also the Healthcare Lead for the Government Blockchain Association European Strategic Conference. Natalie further combines a breadth of experience with 8+ years of teaching at University of Toronto & Trent University in Canada, and holding multiple board, management & consulting roles in the non-profit sector.

Agam Kansal
Marketing Lead

Marketing expert who loves to challenge boundaries, an independent learner who is always excited about new technological developments happening around the world. Agam co-founded a funded startup in an IoT space named POCKEY NEXTA. Agam wants to make a meaningful difference to the society through technology and aid to the poor. With a certificate course in Entrepreneurship from Stanford, Agam has extensive experience in developing and implementing communication strategies across organizations.

Dr. Rashad Ibrahim
Middle East Head

A Blockchain Enthusiast, Technology Imagineer and a Technical Advisor of Smart Government transformation at Dubai Corporation for Ambulance Services - United Arab Emirates. A hybrid Profile of being a medical Consultant and an IT Specialist with huge passion for Information Technology, Cryptography, Post Quantum Cryptography and Blockchain Technology. Worked for several international agencies in United Nations and, NGOs and Government Agencies. Designing and implementing Smart Medical projects integrating Predictive AI and learning Algorithms, Big Data Analysis, IoT and most recently DLT Technology.

Stephane Laurent
Chinese Subcontinent Head

A world citizen, Stephane started his career in the field of conflict resolution, working for UN-backed projects in the Middle East. His strengths are in international business analysis and development, supported by strategic and project management skills. He can also speak 5 languages. Passionate about technology, global development, and entrepreneurship, Stephane currently manages a community of social entrepreneurs out of Shanghai.

Pierre Maarek
Investment Lead

Currently head of the Equity Derivatives activities of Exane America. With 15 years in the industry working for the biggest players (JP Morgan in London, Natixis in Paris and now Exane in New York), he will bring his deep knowledge of the financial industry and his extensive network to the team.

Charles Leslie
Investment Lead

Charles has a degree in Computer Science and a minor in Mathematics from the University of Alabama. He has been in technology for 20 years. One of the veterans from the internet boom era in the late 1990's. He has been in 4 startup companies, including the first high-speed Internet broadband cable modem company, Excite@Home, now Comcast network in the US. He has also worked in technology for financial companies like UBS Hong Kong, UBS Tokyo, JPMorgan Hong Kong, JPMorgan Tokyo, JPMorgan US and Citibank Tokyo.

Kayleen Schreiber, PhD
Design Lead

Kayleen communicates complex concepts to the general public through anima on, infographics, and writing. She displays the value of science and technology by highlighting wonder, process, challenges, and storytelling.

Ting Peng
PR Manager

Associate professor with demonstrated experience in higher education in Busan, South Korea. Background in International Relations and business anthropology. Consultant and translator for businesses and international education conferences. Radio show guest host. A truly passionate communicator.

Azam Shaghaghi
Head of Public Relations

Azam is an entrepreneur and blockchain consultant. She has the passion for innovation and disruptive technology to bring positive global change.

Ajit Singh Kular
Head of Digital Marketing

With over 8 years of experience in the Digital Marketing and SEO Industry, Ajit has handled various E-Commerce Sales and Product-based clients, including Fortune 500 companies. He is a resourceful and ambitious person who seeks challenges and growth by empowering organizations through SEO and Digital Marketing to drive results.

9.3 Shivom Innovation Council

Shivom is aiming to create the best innovation ecosystem in the world and to disrupt the global healthcare ecosystem. To achieve these goals, Shivom will assemble the Shivom Innovation Council, which will function as an internal think thank and support and inform Shivom's senior management team about future technology and industry trends and other strategic considerations; and help to prioritize investments, resources and initiatives. The Council is comprised of world-class experts and thought leaders in a variety of key areas and domains ranging from AI, Genomics, Business Strategy, Cryptography, Computer Science, Cyber Security, Telemedicine, IoT, Futurology, to Precision Medicine.

Dr. Jay Sanders

Father of Telemedicine, Dr. Jay Sanders is a graduate of Harvard Medical School, Dr. Sanders directs the U.S. telemedicine initiatives to the G-8 nations and is a founding member of the American Telemedicine Association. As a pioneer advocate and activist in the field of telemedicine, Dr. Sanders has trail-blazed a new frontier for physicians and the medical profession.

Antanas Guoga

Lithuanian representative at the European Parliament, Antanas Guoga (TonyG) is an entrepreneur, venture capitalist investing in start-ups in the digital area, and philanthropist. Known for his efforts to promote a better climate for entrepreneurship and improving conditions for business opportunities. He is a well-known promoter and advocate of blockchain technology and crypto-currencies.

David Orban

Founder and Managing Partner of Network Society Ventures, David Orban's entrepreneurial accomplishments span several companies founded and grown over more than twenty years. An early adopter of blockchain technologies since 2010, he was the first to own Ether during the Ethereum launch. He also led the adoption of Bitcoin and blockchain in start-ups and is an advisor and investor in numerous blockchain companies and funds.

Geoff Hancock

Founder of Advanced Cybersecurity Group, Geoff Hancock has spent 27 years in cybersecurity from Department of Defense and Intelligence community to other governments and global corporations. Over the last ten years, his work has been applying cybersecurity concepts and challenges to Blockchain, Artificial Intelligence, Genetics and Cybersecurity.

Dr. William Yasnoff

Known for his groundbreaking work leading to the creation of the Office of the National Coordinator for Health Information Technology in 2004 in the U.S.A. Dr. William Yasnoff accomplished consultant and national leader in health informatics, his focus is developing and implementing practical, real-world solutions to the most complex and difficult unsolved problems.

Dr. Irshaad Ebrahim

Fellow of the Royal College of Psychiatrists, Dr Irshaad Ebrahim Neuropsychiatrist and Sleep Medicine Specialist, is actively involved in clinical research for new treatments for Insomnia, Depression and Anxiety Disorders. He is an early adopter of Blockchain Technology for Healthcare and has recently been appointed to advise several Crypto Funds on their Blockchain Healthcare Strategy.

Dr. Kamala K Maddali

Dr. Kamala K Maddali holds a DVM Ph.D., in Pharmacology from the University of Missouri-Columbia and a DVM Veterinary Medicine from Acharya N.G. Ranga Agricultural University in India. With over 12 years of experience in global P&L scientific and companion diagnostics (CDx) services covering personalized medicine strategies. She was Global Director Scientific Development - Biomarkers & Companion Diagnostics for Q2 Solutions. Currently Vice President at Cancer Genetics Inc, Rutherford, NJ.

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