

# epios

## Anonymous epidemic disease testing

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WHITEPAPER

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## 1. Overview

Epios is a project designed to provide a framework for providing anonymous testing for individuals during epidemics such as COVID-19. The project centers around a mobile application that serves as a hub for acquiring and submitting disease test kits for processing and for delivering the results of these tests in an anonymous manner that can provide useful epidemiological data to researchers and policy-makers. The Epios mobile app serves as a nexus between individuals seeking anonymous testing and test providers in various countries and regions that can supply and process test kits in accordance with local laws. By routing test kit processing through the Epios app and recording results on the Telos public blockchain, potential linkage between individual identities and test results can be eliminated.

### The Importance of Anonymous Testing

Many countries are home to individuals or populations who prefer to receive information about their health status anonymously. For some this may be related to immigration status or marginalization where a positive test result creates a reasonable fear of mistreatment or discrimination. Without the option for truly anonymous testing, individuals with concerns for their treatment by governments, employers, insurers or others due to receiving a positive test result for an epidemic disease are likely to go without testing and therefore pose increased risks of further transmission. Where large segments of the population share such concerns, significant numbers could present critical but unknown pockets of infection that are not accounted for in strategies for fighting the epidemic. By providing an option for anonymous testing with aggregate results available to researchers, more informed decisions are available to individuals and policy-makers.

### Goals

The Epios project has the following prioritized goals:

1. Epios will provide individual users with high quality disease testing that is anonymous.
2. Epios will provide researchers with the highest level of public reporting on test results that does not threaten anonymity.
3. Epios will create the simplest user interface and logistical process possible that does not compromise any of the above goals.
4. Epios will work with local groups in each country or region to work within local laws, structures, and supply chains, provided these groups do not compromise any of the above goals.
5. Epios will engage with governmental and non-governmental organizations with compatible missions to expand its reach, better serve populations, and provide testing at low cost to individuals, provided these

engagements do not compromise any of the above goals.

### Participants

The Epios project requires the participation of several groups:

**Individuals:** Human beings who seek anonymous test results for a given epidemic disease and who complete and submit testing kits for processing.

**Project Manager:** The person or group responsible for overall management of the Epios project including work with the software development and testing team, country and regional managers, and governmental and non-governmental organizations. The project manager selects country managers and region managers and arranges permissions for these to record results to the Epios blockchain database, and can revoke this permission. The initial project manager for Epios is Epios Ltd, a UK limited company.

**Country Managers:** The person or group in each country tasked with organizing the logistical process of working with test suppliers and processing labs within their country, and recording of results to the Telos blockchain.

**Region Managers:** The person or group who performs the duties of a country manager where practical or necessary due to fractionalization of a country's populace.

**Testing Kit Providers:** A group, whether corporation or governmental or non-governmental entity that provides and distributes physical testing kits under the direction of the country manager or regional manager.

**Testing Kit Labs:** A group, whether corporation, governmental or non-governmental entity that processes testing kits completed by individuals in order to determine results that will be reported to the country manager for recording to the Telos blockchain.

**Telos Blockchain:** A public blockchain used by Epios to record and report anonymous test results and for managing permissions that allow country managers and regional managers to record results.

**Software Development Team:** The group of system architects, developers, designers, project managers and others directly involved with the development of the Epios software.

**Researchers:** Anyone reading anonymous data about anonymous Epios test results to research the progress of the epidemic.

**App Stores:** A group managing a repository for the distribution of mobile device applications. These groups often provide some curation and testing to ensure the applications perform as described and within the accepted practices of the app store. In particular, Apple and Google operate leading app stores that are necessary to engage with in order to effectively distribute any mobile app.

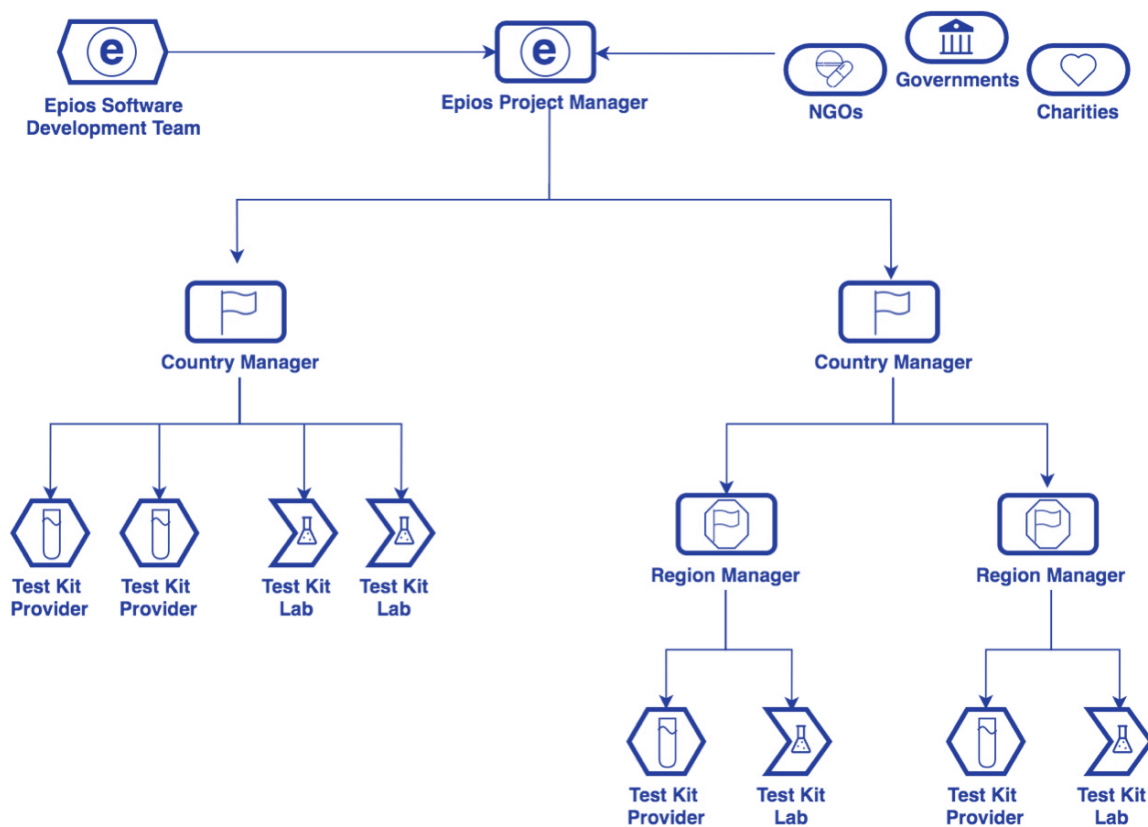


Figure 1. Epios Hierarchical Design Structure

## Etymology

Epios is named in honor of the goddess of Greek mythology Epione whose name derives from the word *epios*, ("soothing"). Epione was the wife of the god of medicine and the mother of goddesses of healing.

## Ownership of Intellectual Property

All source code created for the Epios Project is provided for use under an open source software license. The ability to commit new code to the Epios software repository is controlled by the Epios software development team in conjunction with the Epios project manager. While any group may fork and further develop the Epios open source software, the name Epios and its logo are trademarks of Epios Ltd held for the benefit of the Epios project. In order to avoid confusion among participants, only country and regional managers selected by the project manager and in good standing may use the Epios name and marks.

The novel method for recording anonymous information within a system requiring disclosure of personally identifying information is patent-pending with the United States Patent and Trademark Office by the inventor, Douglas Horn and the Epios project has been granted an irrevocable, perpetual license worldwide to use the patent, if awarded.

## 2. Technical Architecture

Epios will pursue its goals and maximize their impact by creating a common set of software tools available to participants across the project coordinated with a set of country managers (and in some countries region managers) who coordinate logistics. The Epios approach to ensuring anonymity of results while still distributing and receiving physical test kits requires coordination across the logistics, software, and blockchain database. No element can be divorced from the others if anonymity is to be maintained. Epios presents a novel approach to solving this problem.

## The Challenge of Delivering Anonymous Results

There is a particular difficulty in designing a system that allows for the easy purchase and delivery of test kits to individuals seeking testing, while allowing no third party to possess information that can link the identity of the user with his or her results. This challenge is heightened when individuals must also pay for this lab processing to be performed in a way that ensures that labs will only process tests that have paid the necessary fees to prevent free-rider abuses in areas where fees are a part of the system. (Although sponsors may cover the cost of testing in some cases, there remains the need to properly account for and reimburse the tests performed by labs.) Until recently, there would be no way to ensure the anonymity of results without relying on some trusted party who could have access to enough information to deanonymize results.

Epios addresses this challenge by ensuring that no payment is made to the processing lab directly by the subject. Any lab that could possess both identity information for payment and results from the associated tests would present a potential threat to anonymity. While payment in an anonymous cryptocurrency instead of credit card or other more traditional payment systems could improve anonymity, this would present a significant difficulty to individuals that would hinder adoption and deeply limit the utility of the project. For the system to be broadly available, it must allow credit card payments to the test supplier directly or via a country manager.

Epios solves this conundrum through the use of a cryptographically protected physical payment coupon which is provided along with the test kit. This coupon can be verified by the lab prior to processing to ensure payment. Because these coupons will use cryptographic hashed values as unique but untraceable secret codes, the labs can verify that the coupons are valid and not previously used without knowing the codes or being able to trace them to the purchasers. Country managers will obtain proof-of-payment coupons from the Epios project manager team and these coupons will be pre-printed with their "private key" code numbers protected by tamper-evident measures to ensure individuals being tested that the coupons sent along with their purchased test kits remain secret and unused.

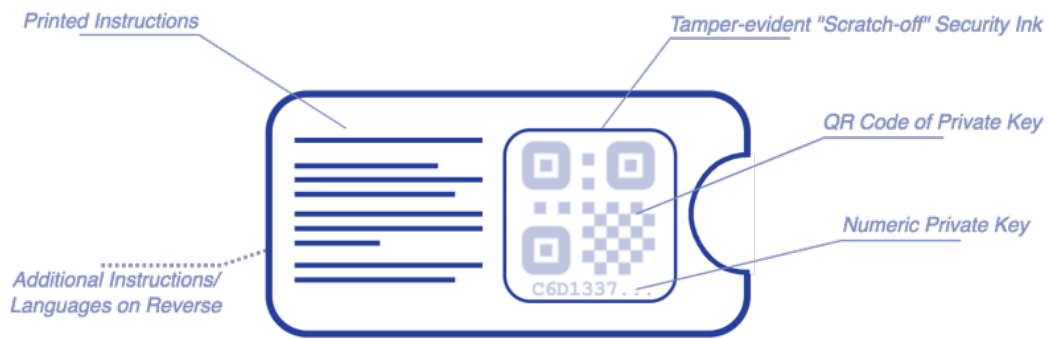


Figure 2. Epios Physical Coupon Features (Scratch-off Form Factor)

### Alternative Coupon Formats

In working with test kit processors and other participants within the Epios system, the design team will seek opportunities to align the form factor of the secret coupon with the needs of participants. Early research suggests that it may be more efficient to implement this system with testing labs if a removable sticker preprinted with the QR code is included

inside some form of tamper evident envelope such as a "Break-apart" used in some gambling games. This would allow the QR code to be directly transferred to the test kit specimen-collection vial. The Epios design team will continue researching the ideal form factor for the security coupons in terms of security, production and distribution costs, ease of use for test subjects, and streamlining of the test kit processing for labs.

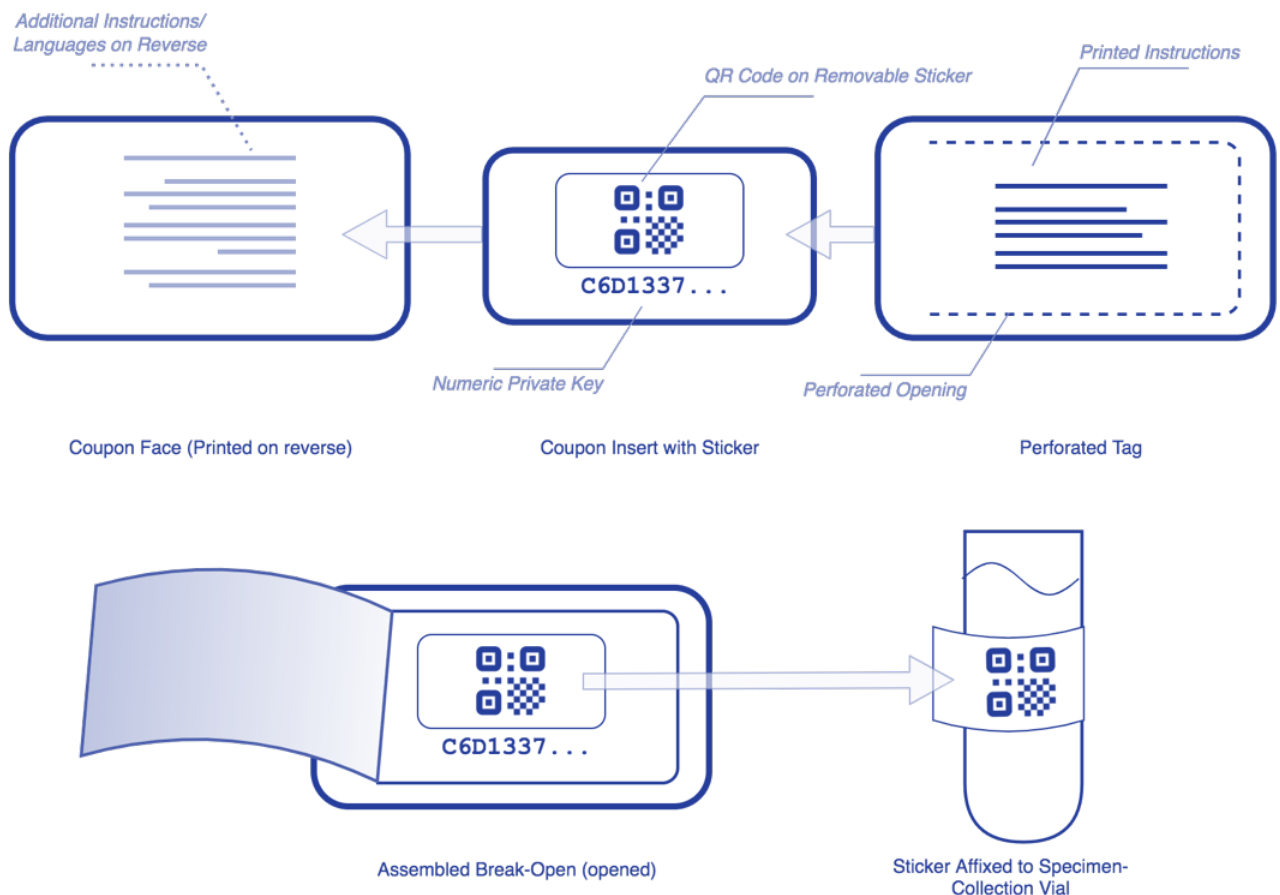


Figure 3. Epios Physical Coupon Features (Break-apart Form Factor)

## Preserving Anonymity with Physical Coupons

The process for using tamper-evident secret keys to ensure anonymity of testing results is as follows:

1. The Epios project manager creates printed coupons that each include a unique private key (secret code) in the form of a QR code that is secured under opaque, tamper-evident "scratch-off" security ink. These are sent to country managers to meet the needs of their testing.
  - a. A public key (the private key processed by a hashing algorithm) is written to a data table on the Telos blockchain along with the status of the code (initially unused) and the country to which it is being sent. Because the public key is a hashed value of the private key, it is easy to derive the public key from the private key but impossible to derive the private key from the public key. This facilitates checking and avoiding forgeries.
2. The country manager of a given country sends these coupons to testing kit suppliers to be included, unaltered, in the kits sent to individuals ordering them. (In some countries the country manager may also serve as the test kit supplier.) As long as the test kits are not altered the country managers or testing kit suppliers will not have access to the private keys and the Epios project manager will not know to whom individual coupons were distributed.
3. The test kit provider distributes a package including the test, instructions, a mailing envelope for sending the completed test to the lab, and an unaltered coupon as proof of payment. The test provider also does not have access to the private key as long as the coupon remains unaltered.
4. The individual to be tested receives the kit for themselves or a family member or friend who is accessing testing through the Epios app.
  - a. If the tamper-evident coupon has already been revealed, the recipient should return the testing kit or just the coupon to the provider in exchange for a new one.
  - b. Removing the protective (scratch-off) covering from the coupon will reveal the QR code of the private key. The individual can scan this QR code with the mobile app, which will compare the associated public key on the data table on the Telos blockchain to ensure that it is a valid code that has not already been used. This ensures a unique result amongst all tests performed and also that the lab will process the order because the coupon is valid. If the coupon is not valid or already used, the individual should return the testing kit or just request a new coupon.
  - c. The mobile app will record the private key to be used as a record locator associated with the individual's test results. The individual will also have the option to record the numeric version of this record locator in another way as a backup to ensure access to the records in case their mobile device is lost or destroyed.
  - d. The individual returns the completed testing kit (with sample) in the provided envelope along with the coupon.
5. When the lab receives the individual's testing kit, it associates the private key/record locator with the testing sample. The lab will also verify that the payment coupon is valid in the same manner as the individual did. In some countries the country manager may be the lab or may aggregate results for the lab. Because the country manager does not have any way to associate the record number with the address or payment information the individual being tested sent in, the process provides secure anonymity even if the country manager provides testing kits and lab processing services.

6. The lab sends the country manager a data file including for each test, the private key from the coupon as a unique record locator and the test results to be written to the blockchain. The information about what country the coupon was originally sent to by the Epios project manager will already exist on the blockchain without the individual being tested needing to provide any level of personal data.
  - a. The lab can send reference coupon codes along with its lab identifier recorded on the blockchain to prove its tests were performed and invoice the country manager and/or testing kit provider to receive payment for tests performed.

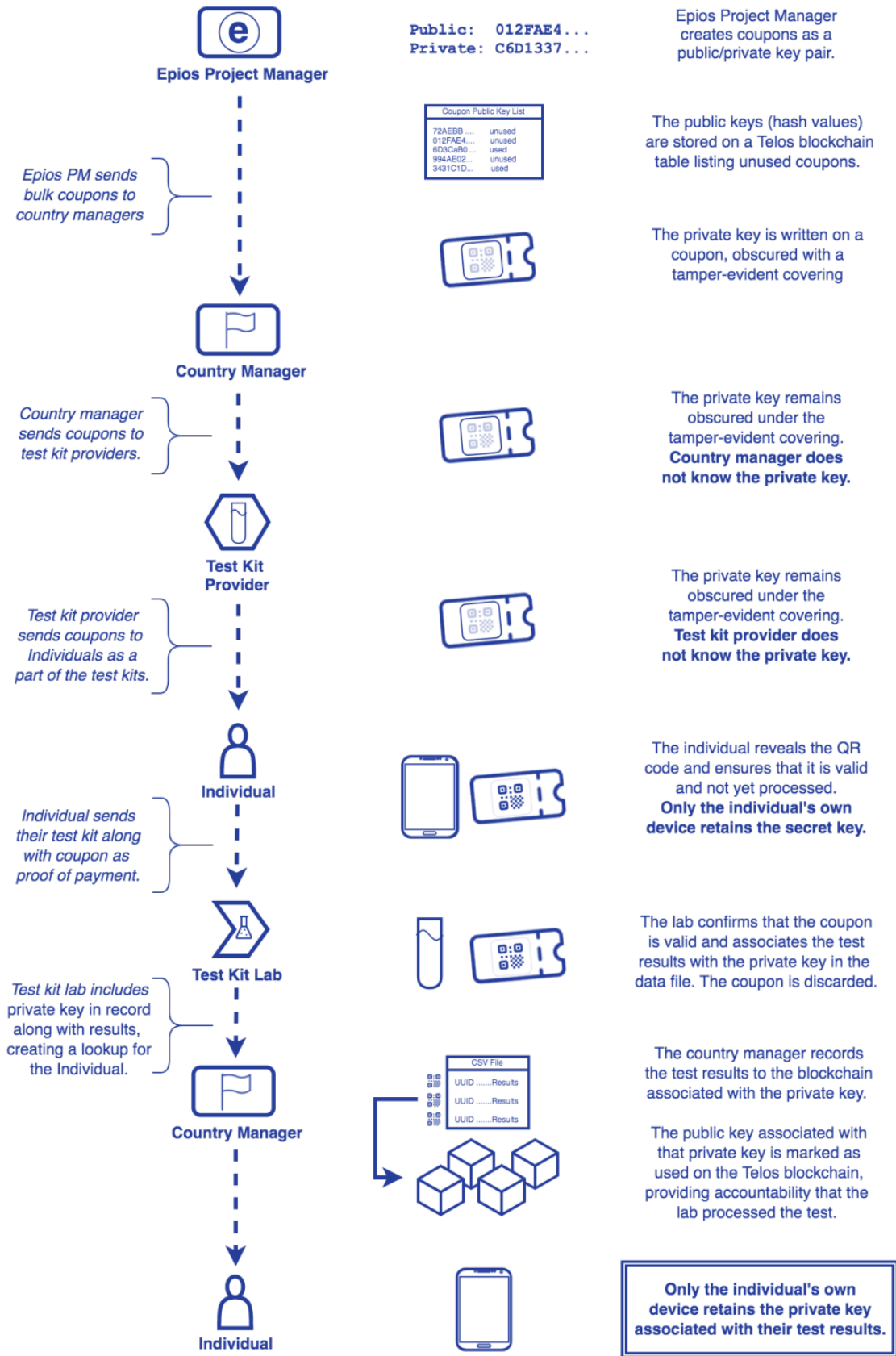


Figure 4. Assuring Anonymity Through Secret Key Coupons

To deliver anonymous test results to individuals, Epios employs twelve distinct steps:

1. The individual desiring testing downloads the Epios mobile app from an app store.
2. The individual sets up their account, determines the country they are in and can add additional people to track their tests independently through the same instance of the app (though these results will not be anonymous to other users of the same instance of the app). Individuals may use the app to track multiple tests for multiple people as desired. Once set up, the app directs the individual to an external web page that allows the ordering of the test kit with pre-paid lab processing.
3. The individual orders the number of testing kits desired. The actual ordering is performed via an external web page approved by relevant country managers so payment and delivery information can be entered without associating this information with the app.
4. The test kit provider sends a testing kit consisting of the sample collection vial, instructions for use, a pre-addressed mailer to the test processing lab, and an unaltered coupon.
5. The individual ensures that the test coupon is unaltered and scans it to ensure it is still valid (meaning it has not been listed as already having provided test results. The mobile app will record the unique record locator for future access.
6. The individual performs the test by providing a sample in accordance with the instructions.
7. The individual sends the test sample and coupon to the testing lab in the pre-printed mailer provided.
8. The lab receives the sample, ensures its accompanying coupon is valid for payment and if so, performs the test with the record locator number (private key) associated with the sample to be tested.
9. The lab aggregates test results and provides these as a data file to the country manager via email or secure file transfer as soon as testing has been performed (ideally as part of an automated process).
10. The country manager records the data file to the Telos blockchain with additional data such as the lab that performed the test.
11. The individual can check with their mobile app to see when the data associated with their coupon's private keys to track their test results anonymously from the mobile app or a Telos blockchain explorer.
12. Researchers can look at the entirety of the Epios data to learn the number of tests taken, their aggregate results, and when tests were performed in each country. Multiple tests associated with an individual or grouped by family/friend/or community groups so it is apparent when an individual has had results on subsequent tests.

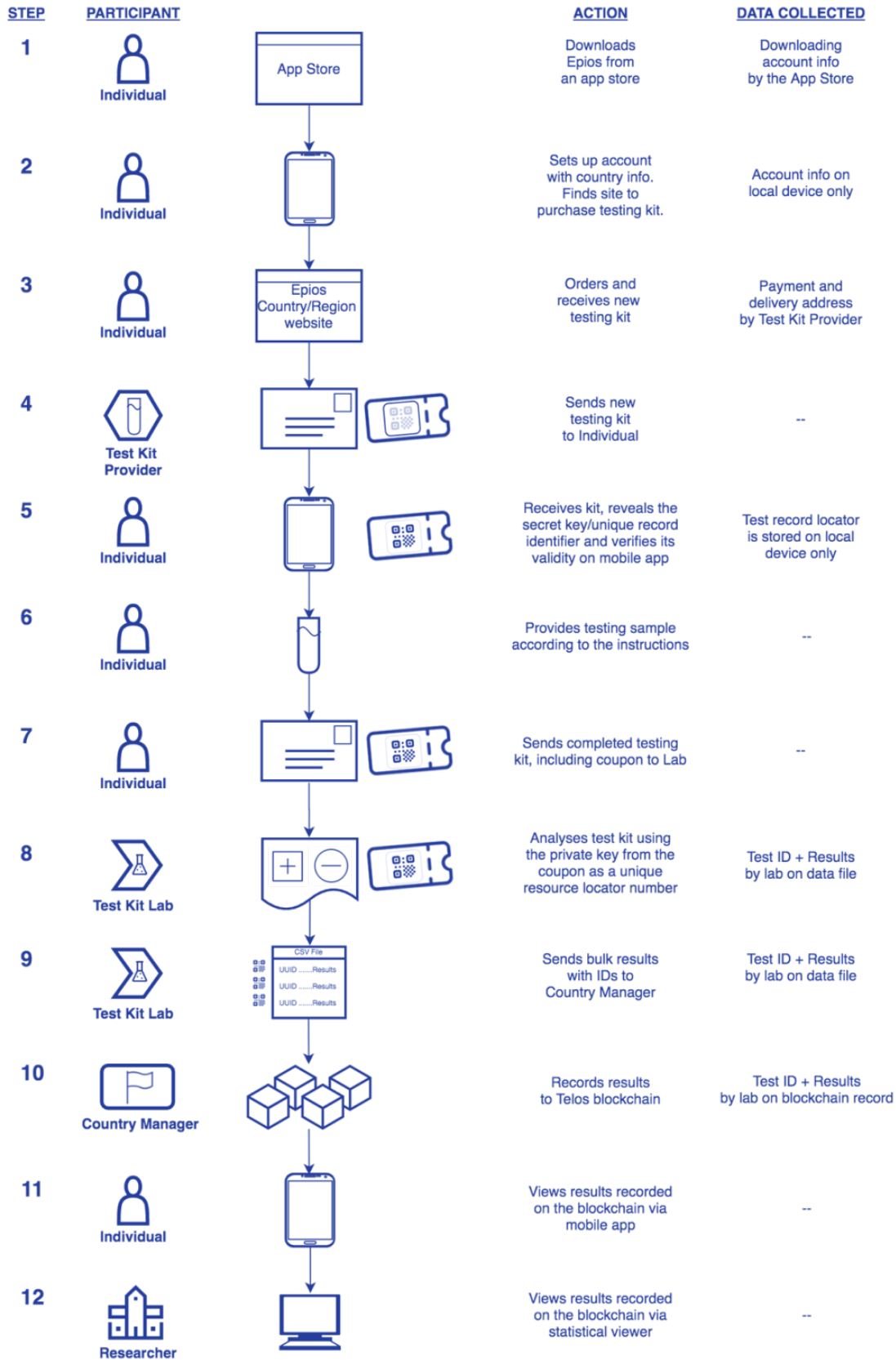


Figure 5. Epios Process Flowchart with Data Collection

## Coupon-less Version Was Considered

Naturally, a design that does not require the creation and distribution of physical coupons would be preferable if it could achieve the same goals. The design team put considerable thought into exploring such an approach. However, no other approach sufficiently addressed all needs for secure anonymity, payment to labs, and associating an individual's unique record identifier code with the sample. To better illustrate the user-experience and data integrity challenge presented by this last point, consider if no pre-printed coupon is employed in the system. The mobile app could create a unique record identifier which it alone retains. However, these would still need to be associated with the test sample, meaning that the individual submitting the test would need to print or write the record locator number themselves, presenting an opportunity for data corruption through inaccurately transcribing a long string of characters comprising the unique record identifier code. Users will also have different abilities to print from mobile devices (still a problem for many). Similarly, pre-printing the unique record identifier code on the test specimen collection kit itself without any form of tamper-evident obfuscation would allow test kit providers or country managers to break anonymity.

It may be possible in the future to eliminate coupons from the system by printing the QR code directly onto the sample collection tube in a secret, tamper-evident manner which would essentially turn the collection tube into the coupon as well. However, such an approach has drawbacks: primarily that sample collection tubes are a sterile component of the test kit and the Epios project managers are not equipped to provide such goods. Therefore, the low-tech approach of including the described coupon is deemed the most practical by the design team.

## Approach to App Stores

Any mobile application that hopes to reach a broad section of the population must be represented on the leading app stores from Apple and Google, and this naturally applies to the Epios mobile app. App stores have some sensitivities about in-app purchases and particularly about apps that involve cryptocurrencies. These considerations and the desire to have an app that would not be excluded by large app stores helped drive the decisions to externalize the test kit purchase process from the app and further minimized the exposure to any form of cryptocurrency within the design. The Epios mobile app will use the Telos blockchain as a data recording device only, not employing any sort of payment.

## Participant Functions and Onboarding

Epios requires a number of participants to function. These fall into five groups:

- Design and development
- Operations
- Test supply and processing
- Funding and governmental support
- End users

This section will describe the needs of each of these groups.

### Design and Development

The Epios design & development team exists and has accomplished a significant amount of the initial work leading up to the publication of this document. The primary tasks of this group will be to design, test and implement the various software functions needed to operate the Epios system. These software applications include:

*(following page)*

	Software Application	Users	Functions
1	Educational/Promo Website	Anyone	Project information hub
2	Coupon Code Generator & Recorder	Project Manager	<ul style="list-style-type: none"> <li>Creates public/private keypairs</li> <li>Writes private keys on physical coupons</li> <li>Writes public keys to blockchain via Participant Management Contract</li> </ul>
3	Participant Management Contract	Project Manager, Country Managers	<ul style="list-style-type: none"> <li>Manages permissions for CMs</li> <li>Manages permissions for test providers and labs</li> </ul>
4	Blockchain API History Server	Mobile App, Website	<ul style="list-style-type: none"> <li>Listens to all blockchain activity related to Epios smart contract</li> <li>Provides rapid information lookup via API calls</li> </ul>
5	Mobile App	Individual User	<ul style="list-style-type: none"> <li>Directs users to test kit providers approved by country manager for their country</li> <li>Provides test instructions/help</li> <li>Scans and validates coupon</li> <li>Stores test private keys &amp; subject information</li> <li>Checks API history for status of any test</li> <li>Provides statistics and news related to the epidemic and Epios</li> </ul>
6	Coupon Code Verification & Input	Test Kit Lab	<ul style="list-style-type: none"> <li>Scans and validates coupon</li> <li>Associates private key from coupon with test sample</li> </ul>
7	Test Result Recording to Data File	Test Kit Lab	<ul style="list-style-type: none"> <li>Batch records test results and metadata (private key) to CSV file</li> </ul>
8	Test Result Recording to Blockchain	Country Manager	<ul style="list-style-type: none"> <li>Validates each private key on CSV file</li> <li>For tests with valid keys, submits test results and metadata from CSV file to blockchain via the Test Result Record Contract</li> </ul>
9	Result Record Contract	Country Manager	<ul style="list-style-type: none"> <li>Adds records to the Epios blockchain database</li> </ul>

Of these, the mobile app (5) and blockchain contracts for recording test data (3) and managing the permissions for who can record that information (9) form the core of the development effort.

The Blockchain API History Server (4) continuously monitors the Telos blockchain and duplicates all actions on the Epios smart contracts into a database that holds no other blockchain records and can

therefore be accessed very quickly via API calls from the mobile app, block explorers and applications developed by outside researchers.

Aside from the project website, the remaining software applications are utilities allowing participants to validate and record data and interact with these project smart contracts in specific and limited ways.

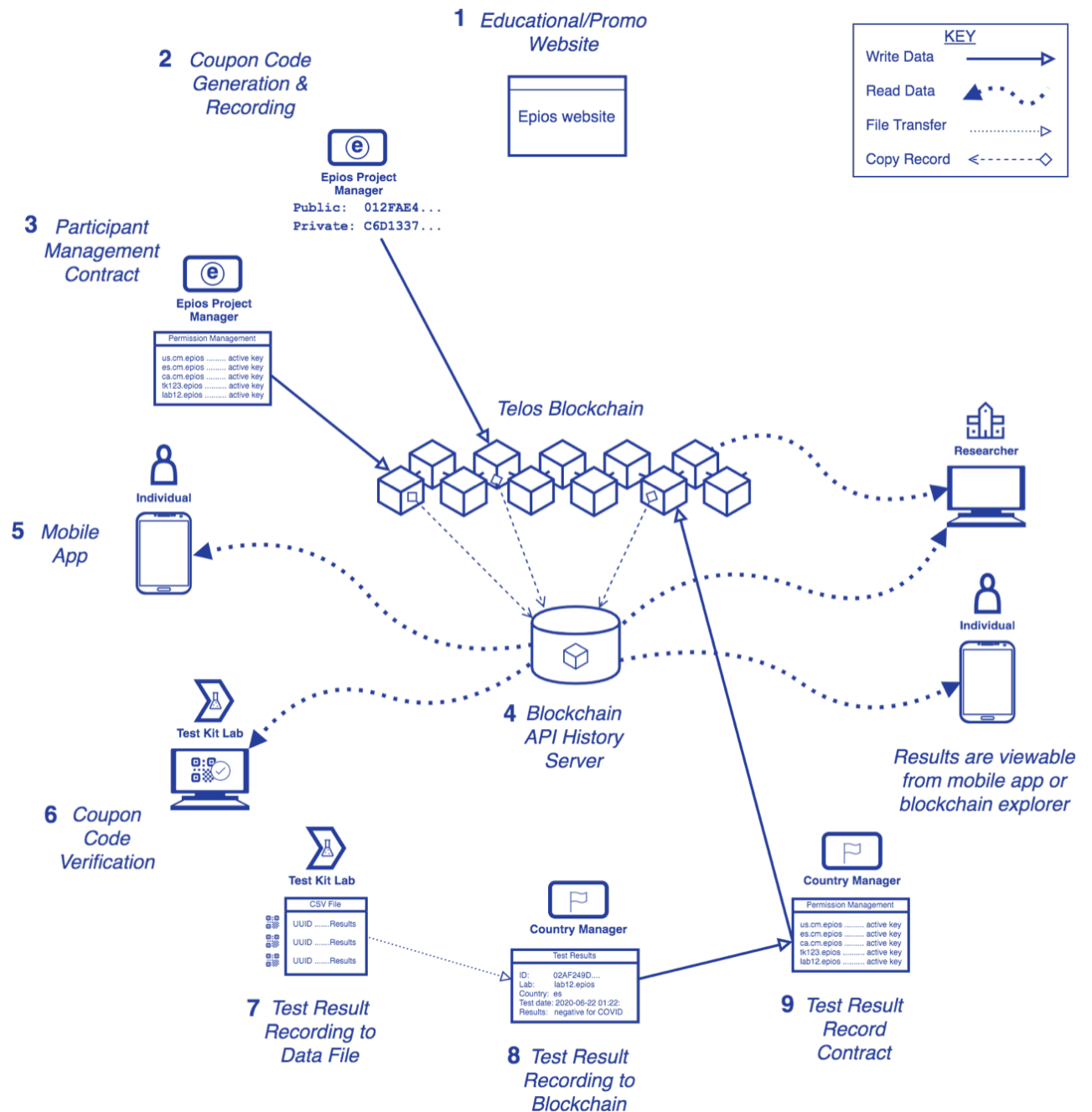


Figure 6. Epios Project Software Applications

The design and development team currently consists of a small number of contributors focused on creating the initial software product needed to launch Epios. As the project grows in impact, there will, no doubt, be need for onboarding additional contributors in these teams.

The process for onboarding new members of the design and development team includes continuously assessing needs for additional or replacement developers by the team's project manager and soliciting new team members as needed or anticipated. Because the project is open source software, new contributors are likely to emerge through examining the code repositories and suggesting new issues, comments, and pull requests.

## Operations

Operational participants include the Epios project managers, and a country manager (and, as appropriate, region managers within diverse countries) for each country where Epios will operate.

### Epios Project Managers

Epios project management is by Epios Ltd. The Epios project manager group is responsible for onboarding new country managers and training them in the necessary functions and tools necessary to succeed in a given country. The project managers also have the task of receiving and evaluating complaints about country managers suspected of acting in ways that do not support the stated priorities of the Epios project. Where this occurs, the project managers will have the responsibility of determining the best course of action, whether to retrain or replace the existing country managers.

The task of the Epios project management is expected to grow quickly as the project scales up. It is likely that its demands will soon overwhelm the availability of the current staff unless additional human resources can be onboarded. This is likely to be an early funding need for the project.

### Country Managers

In the interest of "thinking globally and acting locally," Epios is organized to rely on country managers in each country where it operates. In fact, the Epios project is primarily about providing powerful tools to empower local organizations to serve the needs of their local populace for anonymous testing services. Because each country has its own laws and customs surrounding health care services, it is crucial that Epios engage closely with local organizations that can solicit and manage test kit providers and processing labs. The Epios project does not assume that the testing practices, tools or expectations will be uniform across countries, nor does it intend to impose a prefabricated list of standard practices that country managers must adopt regardless of suitability. In fact, we assume that there will be broad differences. Therefore, as long as country

managers can act in ways that support the anonymous epidemic disease testing priorities of Epios, the project will work with them to support their efforts.

The primary tasks of country managers will be to onboard and manage test kit providers and processing labs, and to ensure that payments flow from test kit providers to other participants including the test kit processing labs and the country and region managers, as appropriate. In some countries, the country managers will take on the bulk of the processing functions by acquiring tests and contracting with labs, and then managing all monies directly. In other countries, the various vendors will be fully independent of one another, and in some countries, official government agencies may take on these duties, where Epios provides a more structured framework for delivering testing services than previously exist or are manageable. Regardless of structure, the Epios framework ensures robust anonymity for individuals seeking testing.

It is crucial to onboard country managers in order for the Epios project to have impact. The current participants will use a strategy of open outreach, promotion of the project within the international press, and providing a desirable toolset and project "brand" in order to attract and retain strong partners in countries around the world. The Epios team understands that country managers in different countries may have different motives for their participation, from humanitarian to profit motive. The Epios project manager team will assess the available partners in each country best able to deliver services overall in accordance with the project priorities regardless of whether that group is a governmental agency, NGO, non-profit, or for-profit entity.

### Test supply & processing labs

Test suppliers and processing labs will be solicited by the country managers in accordance with local laws and customs. (Good access to such vendors is likely to be a core consideration in selecting country managers.) There are no preconceived ideas about the nature of tests and processing provided, since Epios anticipates the possibility of addressing current and future unknown epidemics where the most

appropriate or feasible testing (due to costs, patent status, local considerations, and other considerations) cannot be known at this time. Therefore, country managers are encouraged to find providers who best serve the needs of their populace in terms of cost efficiency, time efficiency, reliability, and other factors.

## Funding & governmental support

Funding and governmental support is crucial in order to rapidly provide services to all who are in need of testing. As a testing and reporting platform, Epios may offer services more efficiently than traditional centralized medical services. It is conceivable that some countries will find that employing the Epios framework may be better aligned with local priorities than alternative options. The Epios project managers and development team will engage with governments, NGOs, charities, and others in the interest of finding the funding needed to expand the project's reach.

### Use of funds

The Epios project was launched by a number of designers and developers working without the expectation of being paid in order to rapidly build a framework and platform for providing high quality anonymous testing for epidemic diseases. It is our belief that the most challenging step in such an endeavor is to provide the first meaningful tools, and doing this was the intention of the initial core team of Epios. However, while the software component of Epios can scale easily to any size, as the project gains momentum it will encounter needs in a variety of areas. The design & development team is likely to be a small cost, although there is no guarantee that the initial team, having provided a solid and functional version 1 of the software will necessarily remain involved in the project. It may become necessary to provide some funding for future versions to attract new developers to the project on an ongoing basis. This is the nature of such open source projects.

There are limited costs associated with the development and operations of the Epios software. The functions on the Telos blockchain require only a small amount of staked resources. The project website and dedicated API history server are similarly inexpensive, especially as the project scales.

Likely the largest ongoing operational costs associated with Epios will be:

- Providing free or reduced cost test kits and processing to expand availability across the economic spectrum
- Promoting the system to inform more potential participants about its existence
- Expanding the capacity of the Epios project managers to keep up with growing demand
- Engaging with researchers to provide better epidemiological tools for viewing the results data.

The Epios project manager team will seek to onboard additional funding and governmental participants through promoting the project's aims and vision and engaging with organizations with aligned principles and aims.

## Individual end users

The most important group of participants to engage with Epios will be the individual end users who seek testing and provide aggregate data about the populace that would otherwise go untested. Without these participants, the project has no value or meaning. Epios seeks to serve these individuals by providing an easy to use, intuitive interface and rock-solid anonymity protection, along with high ease of use and cost reductions in acquiring and processing test kits, wherever partnerships with government agencies, charities, and NGOs make this possible.

The primary method of onboarding individual end users for testing will be through education and promotion needed to reach a broad base of potential users and address their questions and concerns surrounding anonymous testing. The project's web site and public relations/promotional contributors are expected to be strong components of this push.

## Software and Logistics Flow Model

### Participant Management Contract

The participant management contract is a smart contract deployed on the Telos blockchain based on EOSIO code implemented in the C++ programming language. A table of records maintained in Telos system RAM tracks the names of country managers, test kit sellers and test kit processing labs. These records keep track of what Telos accounts will be able to record what types of data to the blockchain under the Epios smart contracts. Because only approved country managers may write data to the blockchain based on the permissions controlled by this contract, no unapproved results will be written to the system by those who are not country managers or region managers.

The participant management contract maintains the following variable inputs:

- Country name (*text*)
- Country code (*uint8*)
- Manager account (*account name*)

The participant management contract provides the following actions:

- Country Manager Signup – interested parties may nominate themselves for approval by the Epios project managers as country managers in their home country
- Country Manager Approval – the Epios project manager approves a nominated country manager to serve (including recording test date to the blockchain in their country)
- Country Manager Removal – The Epios project manager removes an existing country manager from the ability to serve (including recording test date to the blockchain in their country)
- Seller Signup – interested parties may nominate themselves for approval in their country as test kit providers by the country manager
- Seller Approval – the country manager approves a nominated test kit provider

- Lab Signup – interested parties may nominate themselves for approval in their country by the country manager
- Lab Approval – the country manager approves a nominated test processing lab

The permissions management system takes advantage of the permission management tools on Telos that allow accounts to be assigned the ability to perform specific actions as well as to have these permissions removed by the controlling entity.

### Test Results Record Contract

One of the ultimate aims of the Epios project is to record test results on the Telos blockchain where they can be viewed by the subjects or researchers with strong anonymity of the results. The test result record contract is a smart contract deployed on the Telos blockchain based on EOSIO code implemented in the C++ programming language. These records may only be recorded by previously approved/permissioned country managers (via the participant management contract) in the country where the test coupon is expected to reside. The test results record contract is a fairly simple smart contract with a single action that accepts various inputs and writes them to a block on the chain. The inputs consist of:

- Private key/unique record identifier (*uint64*)
- Country code (*uint8*)
- Test processing lab (*account name*)
- Test processing date/time (*time\_t*)
- Test results (*text*)

The test results record contract requires just one action:

- Record – inputs are passed to the record() action and if valid, written to a block on the blockchain.

### API History Server

The API history server monitors all contract actions on the designated accounts associated with Epios and record these alone to a database such as PostgreSQL in order to recreate indexable records of blockchain transactions and provide extremely fast

query responses to the server's API. This serves as the primary interface for the Epios mobile app due to the speed and scalability as well as reduced blockchain resource costs of this approach over searching the blockchain directly for each request.

## Mobile App

The Epios mobile app is the primary interface of individual end users. It is programmed in a mobile development environment and performs the following functions:

- Directs users to test kit providers approved by country manager for their country
- Provides test instructions/help
- Scans and validates coupon
- Stores test private keys & subject information
- Checks API history for status of any test
- Provides statistics and news related to the epidemic and Epios

## Coupon Code Generation & Recording

A script generates a public key private key pair through a standard hashing algorithm of sufficient security. A list of key pairs is generated. The public keys are written to a data table in Telos RAM with the following variable attributes:

- Public key (*key*) – the hashed value of the secret private key
- Country (*uint8*) – the identifier for the country where coupon will be delivered and used
- Status (*uint8*) – whether the code is valid or has been used

Records are expected to require very small amounts of RAM per code, however, at scale the amount of RAM used could become unwieldy. Because the records of available and used public identifiers only needs to persist until a public identifier has been used (marked as no longer valid by a test kit processing lab) and the lab has proven its work and been paid, records no longer needed can be periodically eliminated to conserve and reclaim Telos blockchain RAM resources.

## Coupon Code Verification & Input

This utility, written in a simple scripting language, provides an interface for test kit processing labs to scan the coupon's private key code, calculate the hashed value (the corresponding public key), check the contract data table in RAM on the Telos blockchain to determine its validity, and if valid, record it as associated with the testing sample to be processed.

## Test Result Recording to Data File

This utility, written in a simple scripting language such as BASH, allows test kit processing labs to record the results and metadata associated with a particular test and writes them to a CSV (comma separated values) text file. Particularly, the values recorded are:

- Name or identifier of the testing lab (probably once in a file header)
- Private key associated with the test
- Time the test was processed
- Test results

This CSV data file is then transmitted to the appropriate country manager for recording on the blockchain. (Note: a version of this system could allow test kit labs to record results to the blockchain directly, however, research into the time constraints on laboratories suggest that this function is better pushed to the country managers who are also better equipped to manage blockchain permissions and keys for writing the data files. Testing labs are generally comfortable providing results as automated data files.

## Test Result Data File Recording to Blockchain

This utility is written in a simple scripting language such as BASH and used in conjunction with the Telos/EOSIO command line interface, [cleos](#). The utility is executed by country managers and ingests CSV data files delivered to them by test kit processing

labs. The program first seeks to validate the private key provided against a valid public key existing in the blockchain contract's RAM data table. If the key pair is valid, the program uses cleos commands to write the following parameters to the blockchain using the Test Result Record Contract's record() action:

- Private key/unique record identifier (*uint64*)
- Country code (*uint8*)
- Test processing lab (*account name*)
- Test processing date/time (*time\_t*)
- Test results (*text*)

## Powering Anonymous Health Testing

People have the right to control the disclosure of their own personal information. No one should have to surrender this information as the price of receiving testing for epidemic illnesses. That erodes personal liberty and for populations in some areas of the world, could lead to potential outcomes more

frightening than the disease itself. Disease testing without the option of anonymity will ultimately have negative impacts on controlling epidemics. Epios builds a new technology to ease concerns about the disclosure of test results by providing a novel approach to structurally-ensured anonymity. This creates an atmosphere where more people can get tested without fear of repercussions and therefore, make better choices to protect themselves and others.

The Epios project aims to partner with country and regional managers, governments and NGOs, funding organizations, test providers and processors, funding organizations and developers who wish to contribute to reaching these goals. The project is off to a strong start, but the cause of fighting epidemics while preserving personal choice, liberty and anonymity can always use more champions. Together, we can deploy this highly malleable framework and set of tools to fit the local needs, customs and laws of people around the world.

## Disclaimer

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