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**SAMKNOWS SMARTPHONE-BASED TESTING
SamKnows App for iOS
White Paper**

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1 **Important Notice**

IMPORTANT NOTICE

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2 Introduction

2.1 Background

SamKnows has developed a Smartphone App for measuring mobile broadband performance. The SamKnows Smartphone App conducts measurement tests which have been built to the same specification as those used in the SamKnows Whiteboxes, but are designed to run in software on a smartphone.

The most recent iterations of the SamKnows App can be run on Android devices running Android 4.0.3 or later, and on Apple devices running iOS 7.0 or later.

The purpose of this document is to provide an overview of the SamKnows Smartphone App for iOS. For information about the Android app, please refer to the 'Android Smartphone App Whitepaper' which can be found on the Whitepapers section of www.samknows.com.

The SamKnows Smartphone App for iOS has the following key features:

- Measures a user's mobile broadband performance, providing an in-depth view into different parameters that affect user experience.
- All tests are user initiated on iOS ('push-to-test').
- Optimised for efficient network usage, however data used by the apps may still be too high for some data plans. If that is the case, the user can configure a monthly data cap in the settings menu. There is a default data cap of 100MB, meaning the app will use no more than 100MB per month if the user takes no action.
- Automatic warnings if user is approaching, or has exceeded, the data cap.
- Users can view real-time performance data as well as historical results accessed via the 'Results' tab of the application. Results can also be viewed in graph format over different periods of time in the 'Summary' tab.
- Measurement results are transmitted back to SamKnows for aggregation and analysis.
- Performance results can be easily shared by the user via social media and email (optional).
- No personally identifiable information is collected.

3 The Architecture

The SamKnows Smartphone App for iOS can be downloaded and installed on a user's iPhone or iPad via Apple's App Store. The application is available without cost to end-users. All tests are initiated by the end-user.

3.1 Determining the best measurement server

The Smartphone App for iOS targets dedicated servers (test nodes) that are configured as the end point for the various performance measurements. The test nodes are located either on the ISP network or at major international peering points.

When starting a measurement cycle, the Smartphone App runs a brief latency test to all measurement servers hosted by SamKnows. This process allows the app to determine the nearest measurement server (in terms of latency). The measurement server with the lowest round-trip latency is selected as the target for all subsequent measurements (throughput, latency, packet loss and jitter). Target selection is performed before every test batch. The list of servers used by the app can be configured on a per-project basis.

3.2 Capturing location, carrier and network data

The approximate location of the client is determined by using the smartphone's internal geolocation APIs. These typically use a combination of nearby cell towers, nearby Wi-Fi access points and GPS (if available).

The carrier in use, bearer in use, and the carrier country code is determined by making calls to the iOS APIs. These metrics are recorded before, during and after every active measurement. Other network characteristics (such as signal strength data, among others) are not obtainable due to the restrictive nature of iOS.

3.3 Communications

All communications between the Smartphone App and the Data Collection Service are initiated by the application over HTTP.

The Smartphone App communicates with the measurement servers over a variety of TCP and UDP ports.

3.4 Configuration updates

The Smartphone App will not automatically upgrade to new app versions released via the App Store unless the user enables this feature via their iPhone settings. The testing configuration of the App is built into the app, and can only be updated if a new app version is released and installed by the user. This configuration describes parameters the tests should use and includes the list of

measurement servers. The test data that SamKnows receives includes which version of the app is in use for each individual test result.

3.5 **Removing the application**

End users will be able to uninstall the Smartphone App at any time via their smartphone's normal application uninstallation procedure.

3.6 **Privacy**

SamKnows respects user privacy over all else and therefore adheres to a very strict privacy policy. The Smartphone App has been developed to allow maximum privacy for all users.

The following information is NEVER monitored, recorded or transmitted:

- Web sites visited
- Any 3rd party software or applications loaded
- User internet activity or any other internet-related actions performed

Users are not required to register or sign up to the App.

The SamKnows Smartphone App can be configured to operate in two different data collection modes as described below:

(1) Completely anonymously - No personally identifiable information (such as IMEI, IMSI, name, email address) is collected by the App and users are not required to register or sign up to the App and therefore the information we collect about broadband performance is totally anonymous.

(2) Semi-anonymously – As above but the IMEI and IMSI are collected for the purposes of aggregating measurements together from a single handset.

4 Metrics

4.1 Active Performance Tests

The following key active test metrics are included in the Smartphone App.

Metric	Primary Measure(s)
Download speed	Throughput in Megabits per second utilising one or more concurrent TCP connections
Upload speed	Throughput in Megabits per second utilising one or more concurrent TCP connections
UDP latency	Average round trip time of a series of evenly spaced transmitted UDP packets.
UDP packet loss	Percentage of UDP packets lost from latency test
UDP Jitter	The interval between the minimum round trip time and the average round trip time of transmitted UDP packets.

SamKnows has designed and developed its performance tests in house, ensuring adherence to relevant RFCs. All times are measured in microseconds and all speeds in bytes per second.

Speed Tests

Measures the download and upload speed of the broadband connection in bits per second. The transfer is conducted over one or more concurrent HTTP connections (using the GET verb of download and the POST verb for uploads).

In the download speed test the client will fetch a portion of a 1GB binary (non-zero, randomly generated) payload hosted on an HTTP server on the target test node. The content is discarded as soon as it is received.

In the upload test the client will generate the payload itself (using /dev/urandom as a non-blocking source of random content) to send to the server. The measure of throughput may be optionally carried out on the server side (the receiver) in the upload test.

The speed tests (both download and upload) operate for either a fixed-duration (specified in seconds) or a fixed-volume (specified in MB). A fixed duration test caters well for all broadband access speeds, including LTE. However, a fixed volume test allows for better predictability of bandwidth usage. The speed test configuration is decided on a per-project basis, and SamKnows can make recommendations based on project aims, characteristics and requirements.

Four separate variations of the test are supported:

- Single TCP connection download speed test
- Multiple TCP connection download speed test
- Single TCP connection upload speed test
- Multiple TCP connection upload speed test

For multiple TCP connection tests we typically recommend that three concurrent connections are used. In some cases (e.g. where the round-trip time between client and server is very high) it may be necessary to increase this.

Factors such as TCP slow start are accounted for through the use of a “warm-up” period. This period begins as soon as the test starts and seeks to establish that the throughput has reached stable rate before starting the real test (which will continue over the same TCP connection(s)). It is important to note that the data transferred in the warm-up period is excluded from the main test results, but it is still recorded separately as a supplementary metric.

The speed test client will record the throughput, bytes transferred and time taken at the end of the test. It may also record these values at multiple intervals during the test. This is commonly used to help characterise the difference between ‘burst’ and ‘sustained’ throughput (where transfer speeds may be inflated at the start of a TCP connection).

UDP Latency and Packet Loss

Measures the round trip time of small UDP packets between the handset and a target test node. Each packet consists of an 8-byte sequence number and an 8-byte timestamp. If a packet is not received back within two seconds of sending, it is treated as lost. The test records the number of packets sent, the mean, minimum and maximum round trip time, and the total number of packets sent and received. Sixty packets are used by default, but this is configurable and can be changed. This test uses a very small amount of data, less than 1MB.

Jitter

The Smartphone App extrapolates a jitter measurement from the results of the UDP latency test. The jitter reported is the round trip time jitter, which is calculated as the average time difference for each packet sent from the minimum round trip time recorded during the test. This test uses a very small amount of data, less than 1MB.

4.2 Passive Network Indicators

The SamKnows Smartphone App passively captures cellular network and handset information before, during and after the active measurements, including:

Cellular Network Information

Bearer	The connected mobile bearer, or network type (eg. HSDPA, HSUPA, CDMA, LTE, Wi-Fi, etc)
MCC	The Mobile Country Code of the connected mobile network.
MNC	The Mobile Network Operator Code associated with the Mobile Operator the handset is connected to.

Location Information

Location Fix Type	The type of location fix captured, i.e. GPS, Cell Triangulation or from visible Wi-Fi networks.
Longitude	Geographic coordinate captured using GPS, Cell Triangulation or from visible Wi-Fi networks.
Latitude	Geographic coordinate captured using GPS, Cell Triangulation or from visible Wi-Fi networks.

Handset Information

Handset Manufacturer	The manufacturer of the handset being used.
Handset Model	The model of the handset being used.
OS Version	The version of the OS running on the handset.
Handset IMEI*	The IMEI number (International Mobile Equipment Identity) of the handset being used.
SIM IMSI*	The SIM IMSI number (International mobile Subscriber Identity) of the SIM being used.

** Please see section 3.6 in relation to our privacy policy and data collection modes.*

Availability of passive network indicators will vary by operator, device and territory. The above list details what is available under optimum conditions.

4.3 Test Schedules

By virtue of our ability to geo-locate each test, and assuming a large panel of volunteers, SamKnows anticipates a vast and comprehensive dataset, both in terms of the volume of data points and the geographic spread.

This dataset can then be used as the basis for analysing performance across each of the networks and filtered by the standard parameters of geography, network operator, specific location (hotspot), cell tower, etc.

Sample Test Schedule and Estimated Data Consumption

The table below provides an example of the expected data usage if a user runs the standard test schedule once per day. Please note that there is no automated or background testing from the iOS App and all tests must be initiated by the user.

Test	Target(s)	Frequency	Duration*	Est. Daily Volume**
Download speed, 3 TCP connections	1 test node	Once per day	20MB fixed size, up to max 20s	20MB max
Upload speed, 3 TCP connections	1 test node	Once per day	20MB fixed size, up to max 20s	20MB max
UDP latency	1 test node	Once per day	30 seconds	0.1MB
UDP packet loss	1 test node	Once per day	30 seconds	N/A (uses above)
UDP Jitter	1 test node	Once per day	30 seconds	N/A (uses above)

Please note that by default the app contains a monthly 100MB limit (this can be adjusted up or down to suit the user's preference).

*These settings (test duration and file size) are configurable on a per app basis. The configurations shown here are currently used by the FCC and EAQ apps.

**The app only controls how much data is used by the application layer. Other overheads may apply. Users can configure a monthly data cap in the settings menu accessible via the Settings key.

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