

4E Framework for Mobile Network Variability Testing

Mobile phone communication standards have advanced from the basic analog communication channel to high-speed fourth generation (4G) today. Today a smartphone/tablet user enjoys a ubiquitous status, thanks to advancements in wireless network technology. Figure 1 depicts the evolution of wireless networks over the years and the impact it has on the phones we use:

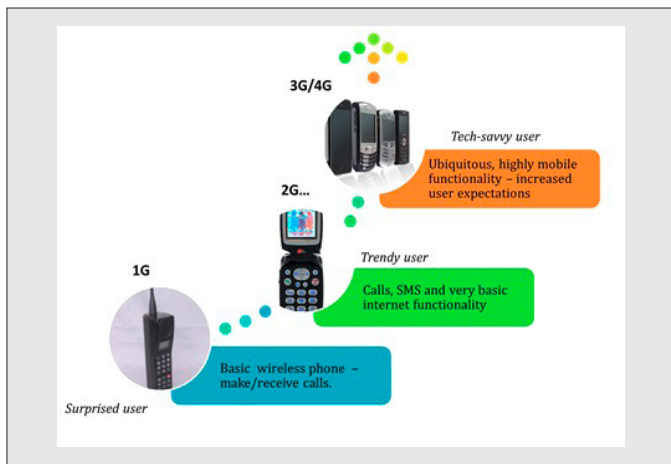


Figure 1: Evolution of mobile networks over the years

Why network performance is key?

With advancements in technology, there has been a radical shift in the way we communicate. From being surprised users awed by the first mobile phone, today's users have become extremely tech-savvy, expecting their mobile applications to perform 'like' their desktop or laptop. Excerpts from a survey conducted by Compuware for tablet users reported (1):

- Almost 70 percent of tablet users expect a website to load in two seconds or less. More than two thirds of tablet users expect websites to load just as quickly, or quicker, than on a desktop/laptop computer.
- Nearly half of tablet users will retry a website only once or twice if it did not work initially.
- A bad website experience will also drive 46 percent of tablet users to competitors' web sites
- 35 percent are less likely to visit the problematic website on any platform, and 33 percent are less likely to purchase from that company.
- Customers expect transactions that are fast and work flawlessly. Failure to deliver quality web experiences to tablet users through slow or malfunctioning sites will result in lost business. Nearly half of tablet users would only retry a website twice if it did not work initially, while 24 percent would retry it only once, and six percent would not retry it at all.

At the end of 2011 there were 6 billion mobile subscriptions, according to an estimate by the International Telecommunications Union (2011) (2). That is equivalent to 87 percent of the world's population, and is a huge increase from 5.4 billion in 2010 and 4.7 billion in 2009(3). Many exogenous

and endogenous factors influence an application's performance when it is hosted on a mobile device. Network is one such example of an exogenous factor. Incomplete and improper testing of network parameters can result in a bad user experience. Table 1 below provides four such real-life scenarios of mobile network issues leading to bad user experience:

#	Scenario	Consequence
1	<ul style="list-style-type: none"> • User places an order for items from an online retail store through his 3G mobile phone on his way back home. • Upon reaching home, the mobile device is configured to pick up the home Wi-Fi signal automatically and switch over. • However, the online transaction fails when this switch occurs. 	<p>Outcome: bad user experience</p> <p>User may not be aware of the background network switch but all he sees is that his transaction has not been processed.</p>
2	<ul style="list-style-type: none"> • User is performing a critical banking transaction onboard a NY subway train. • Application hangs frequently due to variation in signal strength. • This results in intended transaction not being processed. 	<p>Outcome: application unable to perform a graceful exit from the scenario.</p> <p>Application to build in capability to keep the user informed about the lack of signal.</p>
3	<ul style="list-style-type: none"> • User is uploading a soft copy of mediclaim bills to the insurance website for claim initiation. • Due to packet loss, the image gets corrupted and the application throws an unrelated exception error and closes automatically. 	<p>Outcome: application fails to perform a graceful exit.</p> <p>Irrelevant error message provided by application (out of context with the actual problem).</p>
4	<ul style="list-style-type: none"> • While doing an online fund transfer, a bandwidth issue and packet loss were noticed. • Application reported a false transfer even though transfer didn't go through. 	<p>Outcome: application is not robust enough to handle a low bandwidth/packet loss scenario.</p> <p>Result is an erroneous status report (false transfer) which leads to a bad user experience</p>

Table 1: Real-life scenarios of mobile network issues

Network variability testing – the difficult way

Various components/factors can affect network performance:

- Signal strength – varying signal strength leading to occasional disconnect of the network
- Bandwidth – constrained network bandwidth due to heavy traffic (GPRS/3G/Wi-Fi)
- Packet loss/packet duplication – dropping of data packets due to signal degradation or data congestion. Duplication of data packets resulting in corrupted data transmission.
- Delay/jitter – latency of data originating from mobile application and the related variance.
- Network hopping – switching from 3G/4G to Wi-Fi or vice versa

All these parameters are applicable to any real-time network signal and, so, it has become imperative for organizations to focus on in-field testing of mobile applications/devices under real-time network conditions. In-field network testing can be cumbersome, as it is difficult to reproduce scenarios due to varying signal parameters in a specific location. Figure 2 shows some of the typical limitations of in-field network performance testing of a mobile application:

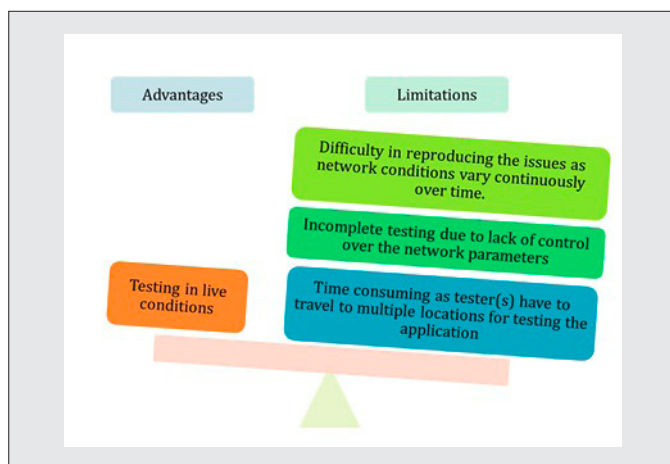


Figure 2: In-field network testing – advantages and limitations

Characteristics of an ideal mobile network testing setup

Since in-field network performance testing has its own limitations, testing of network parameters in a controlled lab environment is another solution. Listed below are some of the characteristics of an ideal mobile network testing setup:

1. Real-time simulation: although testing happens in a controlled way, the test data should mimic or resemble the real-time network signal as close as possible.
2. Location-based pre-calibration: the system should be able to store pre-calibrated network data from various locations and ‘feed’ it to the mobile device under test.
3. Integrated view of dynamic network state: system should have the ability to monitor the network parameters (signal strength, delay, packet loss etc.). It should also provide an option to ‘manipulate’ these parameters in order to identify the response from the mobile application under changing network conditions.

4. System should be able to support end-to-end mobile network testing

4E framework for mobile network variability testing

Evaluate:

This is the discovery phase of the entire QA framework. When collecting requirements for testing the mobile application, extensive profiling of the possible locations from which the mobile application can be accessed is required.

Almost all smartphones have the ability to record signal parameters, such as signal strength, bandwidth, packet loss, jitters, etc., and so it is possible to make a live recording of the network at various locations for various carriers. Over a period of time, the database of live signal parameters will keep growing into a comprehensive list. Ad hoc locations can always be added to this database, based on individual requirements. The key part in the Evaluate phase is to prioritize the test scenarios based on business criticality and impact.

To give an example, consider a banking application which serves customers in New York state. In this scenario, we would ensure that we include the following locations:

- Signal strength and characteristics in Manhattan high-rise for various carriers (Verizon, AT-T, T-Mobile, etc.)
- Signal strength and characteristics near Niagara Falls for various carriers
- Signal strength and characteristics in NY subway and tunnel systems
- Signal characteristics in the countryside

Enhance

These recorded signal parameters should be fed to the network variability QA setup to evolve into a framework. The framework should be able to perform the following functions:

- Advisory role – for a given mobile application based on input parameters (location of use, carrier information), the system should be able to generate test cases/test data from pre-existing signal data.
- Configurability – apart from pre-existing signal parameters, the framework should have the ability to test manually, i.e. testers should be empowered to change the input values for network parameters and verify the behavior of mobile applications when subjected to those parameters.
- Integration with the test management system – the framework should be integrated with test management systems (such as Quality Center). Exporting/importing of test cases, test results and defects should be possible in order to maintain the test artifacts at a centralized location.

Experience

The mobile application should be subjected to network variability testing based on test scenarios derived from the QA framework. The signal parameters should be simulated by a network simulator to:

- Integrate with the network variability QA framework to run pre-calibrated scenarios.

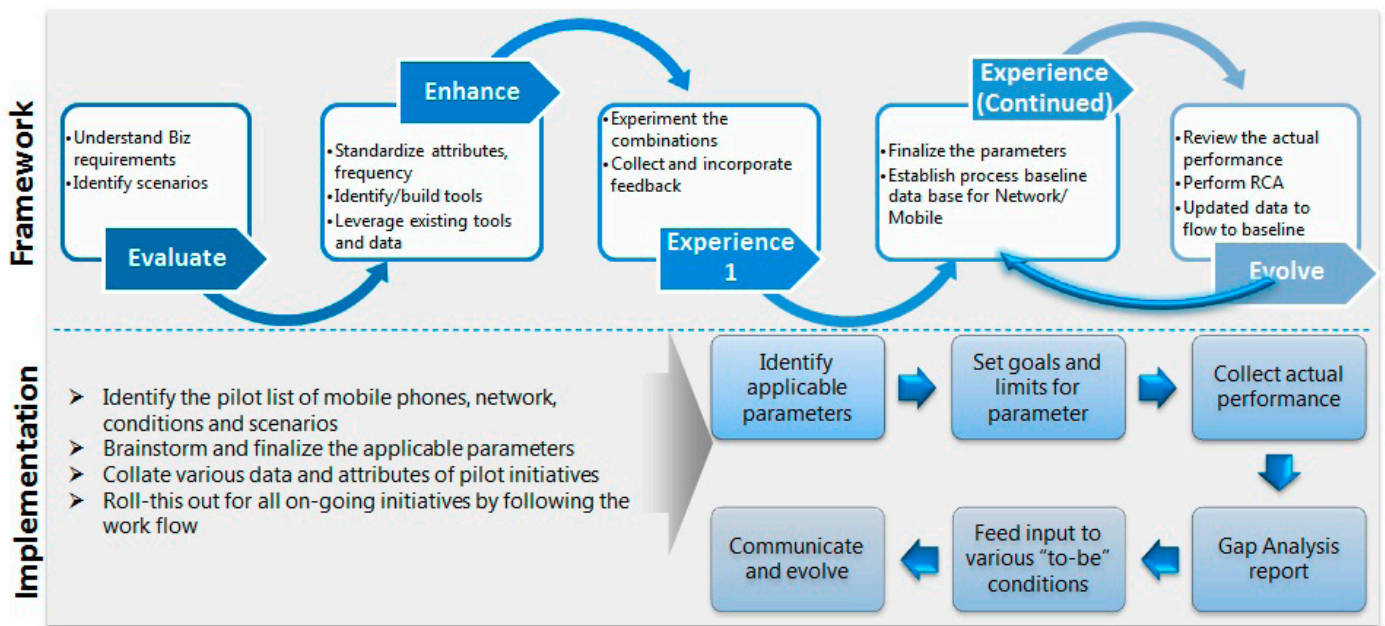


Figure 3: 4E Framework for Mobile Network Variability QA

- Connect to the mobile application/device in a non-intrusive way, i.e. device or application under test should not be altered or modified to accommodate network simulator.
- Simulate all types of signal – 3G, GPRS, or Wi-Fi, depending on the type of testing.
- Enable signal change or hopping, i.e. 3G to Wi-Fi and vice versa.

The measurable outcomes would be the user experience and behavior of application based on the network variability.

Evolve

The network variability QA framework has to keep evolving continuously to add new scenarios. It could be enhanced to include:

- Key city and carrier trend verification – to verify mobile application response in selected cities for key carriers under various scenarios (day, night, evening, Christmas, New Year's Eve, etc.).
- Simulation of abnormal network scenarios to see how the application responds to these (e.g. 10% bandwidth or 90% packet loss).
- Mobile platform-specific network variability testing – how network variability QA affects an Android phone/tablet vs. iOS phone/tablet vs. other operating systems.
- Custom and on-demand test packages for network variability QA based on ad hoc or one-time requests.
- Continuous improvement of test conditions based on best practice and lessons learnt.

Afterthought

The underlying thought behind developing the 4E framework for network variability QA is to subject the mobile application to various possible real-time scenarios in a controlled environment. The errors/exceptions thrown up by the mobile application when subjected to varying network signal strengths will help developers debug the application and make it as robust as possible. This framework can also be extended to desktop application testing. At the same time, the application has to ensure that the user is kept informed in the event of a network outage (e.g. 'signal

strength is low', 'upload is not successful due to network issues') and that the app performs a graceful exit from such exceptions. The 4E framework will also minimize the need for in-field testing, as most of the scenarios would have already been validated in-house. ■

> about the authors



Kiran Marri, BE MS, is currently working as a delivery manager at Infosys Limited, Bangalore (NASDAQ: Infy, www.infosys.com). He has 16 years of IT experience in project management, client relations and developer roles. He has published and presented several papers at conferences in the field of project management, software testing, clinical data management and biomedical engineering. He has also conducted workshops, and tutorials on creativity, thought leadership, risk management, test management and defect prediction methods. His current research interest and publications are primarily in specialized testing, test maturity practices and innovation strategies. He received his bachelor's in Electronics & Communication Engineering from Madras University in 1993 and his master's by research in Biomedical Engineering from the Indian Institute of Technology Madras, Chennai in 1996. Kiran is also PMP certified. Kiran Marri can be contacted at kiranmrr@infosys.com.



Sundaresa Subramanian has 11 years of experience in software testing, embedded systems testing, and digital signal processing research and development. Currently he is a senior project manager with Infosys Limited (NASDAQ: Infy www.infosys.com) and part of the Independent Validation and Testing Services unit. Before Infosys, he was involved in strategizing and delivery of testing projects in the automotive multimedia domain, and also in research and development of digital signal processor-based embedded applications. He has authored and presented papers at national and international conferences on the topics of risk identification, data warehouse test strategizing, mobile QA, specialized QA services and project management. He earned his Bachelor of Engineering degree from Manonmanium Sundaranar University, India. Sundar can be contacted at ssubramanian_gv@infosys.com.