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| Project | **IEEE 802.16 Broadband Wireless Access Working Group <**<http://ieee802.org/16>**>** |
| Title | ***Proposed Draft IEEE 802.16.3*** ***Architecture and Requirements for Mobile Broadband Network Performance Measurements*** |
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| Re: | *Call for Contributions: IEEE Project P802.16.3 – Mobile Broadband Network Performance Measurements* (IEEE 802.16-12-0594-01) for IEEE 802.16’s Session #82 of 12-15 November 2012 |
| Abstract | This document provides the content supporting a proposal to develop a draft document on *Architecture and Requirements for Mobile Broadband Network Performance Measurements* to underlie the development of the P802.16.3 draft. The proposed draft would replace the current *[Draft] Applications and Requirements for Mobile Broadband Network Performance Measurements.* |
| Purpose | This contribution proposes that the text be adopted as an initial architecture and requirements document to serve as the basis of the P802.16.3 draft. |
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[Proposed Draft] IEEE 802.16.3 Architecture and Requirements for Mobile Broadband Network Performance Measurements

Table of Contents

1 Scope 4

2 References 5

3 Definitions and Abbreviations 5

3.1 Definitions 5

3.2 Abbreviations 5

4 Applications 6

5 Mobile-Specific Considerations 7

6 Architecture 7

6.1 Architectural Reference Model 7

6.2 Expanded Architectural Reference Model showing Public and Private Entities 8

6.3 Functional Entities 8

7 Communication Links 10

7.1 Summary of Communication Links 10

8 Data elements and messaging 11

8.1 Client to Controller – Registration 11

8.2 Public Server to Controller – Registration 11

8.3 Controller to Client – Configuration 11

8.4 Controller to Controller – Configuration 11

8.5 Client to Public Server – Measurement Execution 11

8.6 Client to Private Server – Measurement Execution 11

8.7 Public Server to Client – Measurement Execution 12

8.8 Private Server to Client – Measurement Execution 12

8.9 Client to Public Data Collector – Storage 12

8.10 Client to Private Data Collector – Storage 12

9 Requirements 13

**List of Figures**

Figure 1: Architectural Reference Model 8

Figure 2: Application of Architectural Reference Model 8

List of Tables

Table 1: Assessment of key measurement applications per stakeholder role 6

Table 2: Functional Entities 10

Table 3: Communication links among Functional Entities 10

Table 4: Communication links: Client to Controller 11

Table 5: Communication links: Public Server to Controller 11

Table 6: Communication links: Controller to Client 11

Table 7: Communication links: Controller to Controller 11

Table 8: Communication links: Client to Public Server 11

Table 9: Communication links: Client to Private Server 11

Table 10: Communication links: Public Server to Client 12

Table 11: Communication links: Private Server to Client 12

Table 12: Communication links: Public Server to Controller 12

Table 13: Communication links: Client to Public Data Collector 13

[Draft] IEEE 802.16.3 Architecture and Requirements for Mobile Broadband Network Performance Measurements

# Scope

The IEEE P802.16.3 draft standard shall be developed in accordance with the P802.16.3 project authorization request (PAR) and Five Criteria Statement (IEEE 802.16-12-0489-01-Gdoc), as approved on 30 August 2012 [1]. According to the PAR, the scope of the resulting standard shall be:

*This standard specifies procedures for characterizing the performance of deployed mobile broadband networks from a user perspective. It specifies metrics and test procedures as well as communication protocols and data formats allowing a network-based server to coordinate and manage test operation and data collection.*

The standard will address the following purpose:

*By standardizing the metrics and methods, the standard provides a framework for characterizing and assessing the performance of various mobile broadband networks. By standardizing the protocols and data formats, it allows for a measurement server to collect information from a disparate set of devices on the network.*

and the following need:

*Users of broadband mobile networks, including enterprises such as corporations and governments, lack reliable, comparable data on which to base their assessment of network performance. Such data can be valuable to determine overall network quality and to pinpoint specific weaknesses, including limitations in deployment. Improved knowledge of system performance will lead the market toward more effective networks and therefore encourage the redeployment of scarce spectrum using the most efficient technologies and implementations. Also, policy makers seeking information on performance of available networks will directly benefit by the opportunity to apply the standardized metrics and methods. Researchers will also gain by the ability to compare measured performance data to simulated results and thereby assess the theoretical models. One application of such information is the assessment of technology elements proposed during standards development.*

This document specifies, in addition, the requirements to be satisfied by the IEEE P802.16.3 draft standard. In order to explain and specify those requirements, it also indicates suitable applications, and it details the architecture, functional entities, and communication links to be specified, along with a list of data to be exchanged among the entities.

# References

 [1] IEEE 802.16-12-0489-01, “Approved PAR P802.16.3, with Five Criteria: *Mobile Broadband Network Performance Measurements*” ([link](http://doc.wirelessman.org/16-12-0489-01))

[2] Steven Bauer, David Clark, and William Lehr, “Understanding Broadband Speed Measurements,” MITAS Working Paper, June 2010 ([link](http://mitas.csail.mit.edu/papers/Bauer_Clark_Lehr_Broadband_Speed_Measurements.pdf))

[3] William Lehr, Steven Bauer, and David D. Clark, “Measuring Internet Performance when Broadband is the New PSTN,” *The End of the Phone System: A by-invitation Experts’ Workshop*, The Wharton School, University of Pennsylvania Philadelphia, PA, May 16-18, 2012 ([link](http://mitas.csail.mit.edu/papers/lehr_bauer_clark_pstn_transition_6_2012.pdf))

[4] “Next-Generation Measurement Architecture Standardization and Outreach Group (NMASOG) – Architecture Standards and Specifications,” Federal Communications Commission, 2012 ([link](http://apps.fcc.gov/ecfs/document/view?id=7022008017))

[5] Henning Schulzrinne, Walter Johnston, and James Miller, “Large-Scale Measurement of Broadband Performance: Use Cases, Architecture and Protocol Requirements,” September 21, 2012 ([link](http://datatracker.ietf.org/doc/draft-schulzrinne-lmap-requirements/))

# Definitions and Abbreviations

## Definitions

1. **[Term**: definition]

## Abbreviations

MBNPM Mobile Broadband Network Performance Measurements

PII Personally Identifiable Information

# Applications

In Table 1, we have listed key applications in tabular form, along with a list of various stakeholder roles, drawn significantly from PAR Item 5.6 (“Stakeholders for the Standard”). Table 1 also indicates an assessment of the applications of greatest interest to each stakeholder role.

|  |  |
| --- | --- |
|  | **Stakeholder role** |
| **Measurement application** | **Governmental policy maker** | **User (individual or enterprise)** | **cell tower operator** | **wireless carrier** | **researcher** | **standards developer** | **User device vendor** | **Application developer** |
| Overall data on Quality of Experience of set of networks available to consumers | x | x | x | x | x |  | x | x |
| Quality of Experience of a specific network |  | x | x | x | x |  | x | x |
| Identify limitations in deployment of a specific network |  | x | x | x |  |  |  | x |
| Monitor for changes in operation of a specific network |  | x |  | x |  |  |  |  |
| Diagnose problems in a specific network |  |  | x | x |  |  |  |  |
| improve knowledge of system performance |  |  |  | x | x |  |  |  |
| lead the market toward more effective networks | x |  |  |  |  |  |  |  |
| encourage the redeployment of scarce spectrum using efficient technologies and implementations | x |  | x | x |  |  |  |  |
| compare measured performance data to simulated results |  |  |  |  | x | x |  |  |
| assess theoretical models |  |  |  |  | x | x |  |  |
| assess technology elements proposed during standards development |  |  |  |  |  | x |  |  |

Table 1: Assessment of key measurement applications per stakeholder role

# Mobile-Specific Considerations

The standard shall take into consideration the specific circumstances relevant to mobility and the resultant implications on measurements. In the mobile case:

1. measurements will typically be related to a specific user device, rather than to a router on a LAN
2. a single user device can typically operate with multiple disparate network technologies
3. a single user device may connect with multiple operators
4. a user device experiences widely varying signal and network conditions
5. due to variability, far larger statistical samples may be required to draw generalized conclusions
6. significantly more metadata (including, for example, location information) is required to characterize the scenario of a specific sample
7. it may be necessary to trigger testing based on a set of environmental circumstances, such as location, rather than relying upon scenarios such as LAN quiescence as a trigger
8. active testing may be relatively more constrained due to practical issues, including data plan limits and battery consumption
9. underlying software on many mobile devices is relatively closed, and underlying network data is often relatively difficult to access

# Architecture

## Architectural Reference Model

Figure 1 illustrates the architectural reference model. The reference model refers to five Functional Entities: Controller, Client, Server, Data Collector, and Network Parameter Host. The Functional Entities are described in more detail in subclause 4.3.

Note that the architectural reference model is similar to those described in other documents, such as [3], [4], and [5], but with a simplified set of communication links.



Figure 1: Architectural Reference Model

## Expanded Architectural Reference Model showing Public and Private Entities

The expanded architectural reference model illustrated in Figure 2 indicates that the Measurement Client is able to communicate with two distinct forms of Measurement Server: Public and Private. Likewise, the Measurement Client is able to communicate with two distinct forms of Data Collector: Public and Private.



Figure 2: Application of Architectural Reference Model

## Functional Entities

Table 1 specifies the Functional Entities of the Architectural Reference Model.

|  |  |  |
| --- | --- | --- |
| **Functional Entity** | **Type** | **Description** |
| Client |  | The Client is the central element of the Architectural Reference Model. It is typically embodied as software executing on the user edge device (the Client Device), typically a mobile terminal. The measurement process is intended to collect data representative of the performance of the network from the perspective of the user edge device. In the case of passive measurements, the Client will collect performance data characterizing communications to and from the Client Device. In the case of active measurements, the Client will initiate communications, for measurement purposes, with the Server. The Client posts resultant measurement data to one or more Data Collectors. |
| Controller |  | The Controller provides information to the Client governing the measurement process. This information includes the measurement triggers (which may include day/time information as well as other specific triggering details, such as location conditions). The Controller also provides the Client with the Server and Data Collector addresses. The Client registers with the Controller to indicate its address and availability to conduct measurements. It updates its registration status as needed.Note: Inter-controller communications for configuration sharing may be specified. |
| Server | Public | The Server serves as a communication termination, providing a data source and data recipient for active measurements initiated by the Client. The Public Server registers with the Controller to indicate its address and availability to conduct measurements. It updates its registration status as needed. The address of the Public Server is specified to the Client by the Controller.The results of measurements collected by a wide range of Clients using the Public Server should be readily comparable. Therefore, the characteristics of the Public Server should be well known and consistent, with minimal congestion and minimal variability.Note: A drawback to the use of the Public Server is that network operators could prioritize traffic to and from this server so that measurements would overestimate real network performance. |
| Server | Private | The Server serves as a communication termination, providing a data source and data recipient for active measurements initiated by the Client. The Private Server is typically hosted in a network of primary interest to the user, so that measurement of communications between the Client and the Private Server are reflective of communications conducted by the Client device outside the measurement scenario.The address of the Private Server is specified to the Client as a result of Client configuration controlled by the user.Note: The tests conducted with the Private server need not be identical to those conducted with the Public server. |
| Data Collector | Public | The Data Collector receives measurement results from the Client. The Client transmits to the Public Data Collector only results that are intended for public use, with appropriate controls to prevent release of personally identifiable information (PII). In the case of active measurements, such data is limited to that collected from the Public Server. |
| Data Collector | Private | The Data Collector receives measurement results from the Client. The Client transmits to the Private Data Collector results that are intended for private use as well as those intended for public use.The address of the Private Data Collector is specified to the Client as a result of Client configuration controlled by the user. |
| Network Parameter Host |  | The Network Parameter Host is not used.Note: The Network Parameter Host is included in the Architectural Reference Model for information only, since such a functional entity is described in other documents ([3],[4],[5]). Those documents are primarily oriented toward fixed networks. In those cases, this entity (also known as a “Network Information Subscription Server” or “Network Parameter Server”) stores information and provides such information about the “nominal” network performance, such as the nominal service characteristics as specified in a network subscription. Such information may be available to a network operator but is generally not publicly available, so accessing this information without violating privacy concerns is problematic. Also, in the mobile case, the active network access provider depends on circumstances; for example, the link may be to a wireless LAN or a roaming cellular provider, so that subscription information may be of little relevance. Furthermore, such information is of little value in the mobile environment generally, since performance is highly dependent on many environmental parameters that vary significantly with respect to nominal performance, and information about these environmental conditions can be obtained directly through observations collected by the Client. |

Table 2: Functional Entities

# Communication Links

## Summary of Communication Links

Table 2 summarizes the communication links among Functional Entities of the Architectural Reference Model.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| To=>From⇓ | Client | Controller | Server-Public | Server-Private | Data Collector-Public | Data Collector-Private |
| Client | - | registration (including updates) | measurement execution(initiator)  | measurement execution(initiator) | storage(measured data and metadata, public) | storage(measured data and metadata, public) |
| Controller | configuration(schedules/triggers)(including updates) | configuration | - | - | - | - |
| Server-Public | measurement execution(responder) | registration(including updates) | - | - | - | - |
| Server-Private | measurement execution(responder) | - | - | - | - | - |
| Data Collector-Public | - | - | - | - | - | - |
| Data Collector-Private | - | - | - | - | - | - |

Table 3: Communication links among Functional Entities

# Data elements and messaging

## Client to Controller – Registration

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Type/Units** | **Description** |
| tbd |  |  |
|  |  |  |

Table 4: Communication links: Client to Controller

## Public Server to Controller – Registration

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Type/Units** | **Description** |
| tbd |  |  |
|  |  |  |

Table 5: Communication links: Public Server to Controller

## Controller to Client – Configuration

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Type/Units** | **Description** |
| Server Address - Public | IP address | path to Public Server |
| Collector Address - Public | IP address | path to Public Data Collector |
| Configuration Expiry | hours | How often Client should check Controller for config changes |
| Data Usage Limit | kilobytes | The maximum number of bytes the Client will transfer in one month |
| Distance Threshold | meters | Land distance from previous test a Client must exceed to perform its next test set |
| Time Threshold | minutes | Time since previous test a Client must exceed to perform its next test set |
| Location Threshold | meters | Accuracy threshold above which Client will not initiate test set |
| Test Set | Array of integer | List of indexes of tests to conduct |
| Test Parameters | Array of string | List of test-specific parameters |
| Registration Interval | seconds | How often Client should re-register with Controller |
| Battery Threshold | percentage | The battery level below which the Client will not submit to Data Collector |

Table 6: Communication links: Controller to Client

## Controller to Controller – Configuration

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Type/Units** | **Description** |
| tbd |  |  |
|  |  |  |

Table 7: Communication links: Controller to Controller

## Client to Public Server – Measurement Execution

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Type/Units** | **Description** |
| tbd |  |  |
|  |  |  |

Table 8: Communication links: Client to Public Server

## Client to Private Server – Measurement Execution

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Type/Units** | **Description** |
| tbd |  |  |
|  |  |  |

Table 9: Communication links: Client to Private Server

## Public Server to Client – Measurement Execution

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Type/Units** | **Description** |
| tbd |  |  |
|  |  |  |

Table 10: Communication links: Public Server to Client

## Private Server to Client – Measurement Execution

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Type/Units** | **Description** |
| tbd |  |  |
|  |  |  |

Table 11: Communication links: Private Server to Client

## Client to Public Data Collector – Storage

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Type/Units** | **Description** |
| Test Set – Public | Array of floating | Test Set measurement report |
| Metadata Set – Public | Array of floating | Test Set measurement condition report – Public, including:Public ServerCellular carrierNetwork typeNetwork technologyNetwork identifierBase station identifierCell identifierCell location codeNetwork Mobile County CodeNetwork Mobile Network CodeRoaming stateSignal strength (RSSI)Wi-Fi radio stateWi-Fi connection state |

Table 12: Communication links: Public Server to Controller

## Client to Private Data Collector – Storage

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Type/Units** | **Description** |
| Test Set – Public | Array of floating | Test Set measurement report - Public |
| Metadata Set – Public | Array of floating | Test Set measurement condition report – Public |
| Test Set – Private | Array of floating | Test Set measurement report - Private |
| Metadata Set – Private | Array of floating | Test Set measurement condition report – Private, including:Enterprise identifier LatitudeLongitudeAltitudeSpeed of travelDirection of travelLocation AccuracyLocation data providerSIM Mobile County CodeSIM Mobile Network CodeSIM providerPower adapter stateBattery stateBattery charge levelBattery temperatureBattery voltageDevice unique identifier Device manufacturerDevice brandDevice modelDevice operating system type/versionBIOS IdentifierCPU informationCPU activity/loadScreen resolutionFree disk/RAM spaceFree memory card storage spaceNumber of running apps |

Table 13: Communication links: Client to Public Data Collector

# Requirements

1. The standard shall specify procedures for characterizing and assessing the performance of deployed mobile broadband networks from a user perspective.
2. The standard shall specify metrics broadly applicable to all IP-based mobile broadband networks.
3. The standard should reference metrics specified by IETF (particularly from the IP Performance Metrics (IPPM) Working Group) whenever feasible.
4. The standard shall specify test procedures.
5. The standard shall specify procedures for a measurement server to collect information from a disparate set of user devices on the network.
6. The standard shall specify communication and data exchange protocols and data formats allowing a network-based server to coordinate and manage test operation and data collection.
7. The standard shall be implementable in software.
8. The standard should be compatible with implementation by any IP-based server in conjunction with any IP-based user device.
9. The standard should consider how to minimize (consistent with an overall optimized solution) the cost burden on the user device due to the extent that data transfer may be subject to a fee from the carrier, may interfere with other active user device processes, and may drain the user device power.
10. The standard shall specify procedures for measuring including uplink throughput rate, downlink throughput rate, latency, and jitter.
11. The standard shall specify procedures for quantifying packet loss and timeouts.
12. The standard shall specify procedures for collecting and transmitting various types of metadata, to include carrier network, network type, cell ID, user device make/model, network policy information, and radio resource control parameters, if available.
13. The standard shall specify procedures for collecting and transmitting user device location and location accuracy associated with measurement events.
14. The standard shall specify procedures for reducing user device location accuracy for privacy protection.
15. The standard shall specify procedures to ensure that Personally Identifiable Information (PII) is treated sensitively and protected from unauthorized disclosure.
16. The standard shall specify procedures to manage and respond to user consent authorization with regard to PII.
17. The standard shall specify anonymization procedures.
18. The standard shall provide for control of the tradeoff between cost and performance, so that cost-driven users can reduce the number of measurements and the thoroughness of measurements to obtain lower-cost operation, albeit with less complete information. The standard should recommend means of estimating and reporting the statistical validity of a set of measurement data.
19. The standard shall specify procedures based on active probing.
20. The standard should specify procedures based on passive measurements.
21. The standard shall support the needs of the public and research communities for collection of openly accessible anonymized data.
22. [addition requirements (tbd)]