# Application Performance Class:
# The new class of performance
# for applications on SD memory cards (SD 5.1)

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# Conditions for publication

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# Executive Summary

The SD Association (SDA) released the SD 5.1 specification to answer evolving market needs with Application Performance Class.

Most of today's smartphones and mobile computing devices, Win-Mobile and Android, allow application data to be saved on removable cards or run applications from cards.

Google released Android Marshmallow in 2015 and expanded microSD memory card support by offering "Adoptable Storage Devices," which helps users to run applications from the installed memory card.

There are some basic performance requirements based on a combination of random and sequential memory access that optimize user experiences when using memory cards as storage and/or to run applications.

Product manufacturers may use the Application Performance Class (App Performance) with its associated symbol to define a certain level of minimum performance for consumers, ensuring the SD memory card that may fit their products allows reasonable usage for their products. This also helps consumers choose the proper card for their product at the point of sale.

# Background on Market Situations

## General

The SD memory card is the most popular card in the world and is supported by a strong ecosystem. Even more significant, it is well-known to consumers around the world and enjoys unprecedented interoperability and backward compatibility.

The main use of SD memory cards until recently was for personal multimedia content storage for photos, videos, music, etc. With that legacy usage model, performance was driven mainly by either fast upload/download of content or assured video or burst-shooting images. Over time, the SDA evolved the SD specification with a focus on sequential performance and the related defined speed classes, including the recently introduced Video Speed Class.

In parallel to the legacy needs, new requirements driven by the mobile and mobile computing markets evolved. In the last few years a new usage model of storing applications and application data on removable cards emerged. Therefore, removable cards are now used as memory expansion of the internal embedded memory supplied within the mobile devices in a way that its usage model becomes somewhat similar to that of the embedded memory, or at least for application usage. This means that there is an increased need for SD memory cards to match embedded storage capabilities.

In short,
- It's not just about slow content-saving any more
- It's about application-running and new associated performance capabilities
- A combination of higher random + sequential performance is required

The SDA initiated new SD specification improvements to meet market requirements by:
- Standardizing a common language for consumers and product manufacturers, allowing best utilization of specific products with related best cost-effective card type
- Continually improving SD memory card protocol, enabling higher random and sequential performance.

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## Android Marshmallow introduces Adoptable Storage Devices

Google released Android Marshmallow in October 2015 and added microSD support as Adoptable Storage Devices, allowing users to run applications from their device's installed microSD memory card.

Android Marshmallow, and newer versions, run a benchmark test on the microSD memory card during its adoption process. The memory card's performance is tested against the internal embedded storage performance and, if the card's performance is found to be performing at less than 25 percent of the embedded memory, a pop-up message tells the user that the card appears to be slow.

This is a very positive initiative by Android and opens the door for real memory expansion of mobile devices while assuring satisfactory user experience for a given card.

However, two real-life problems appeared:

- Consumers do not have a means to determine which card they should purchase at the point of sale, and running the benchmark post-purchase is too late; it could cause product returns and customer dissatisfaction.
- For many currently available cards in the market, users may get a slow card warning message after running the benchmark.
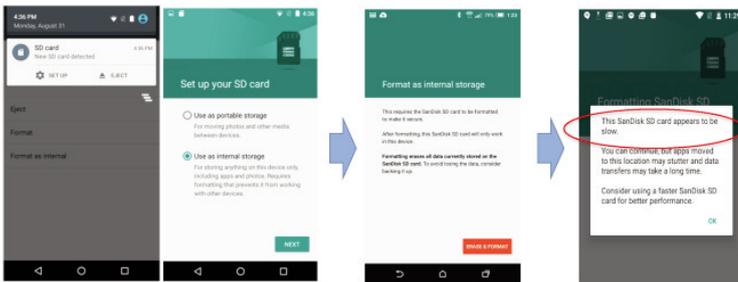


A common language between device and card manufacturers will guide consumers to the correct card for their device and improve satisfaction for both groups.

## Solution: Application Performance Class

The Application Performance Class standard defines:

- App Performance symbol for use on cards, packaging and manuals
- Assured combination of minimum random + sustained Sequential performance levels under specified conditions

The SD 5.1 Physical specification introduced the first and most basic App Performance level, which sets the absolute minimum requirement bar named A1 or App Performance Class 1. Higher App Performance Class levels will be introduced to meet market needs.

## App Performance Class 1 (A1) memory cards

App Performance Class A1 SD memory cards shall meet the performance measures as given in Table 1.

| RD IOPS* | WR IOPS | Sequential |
|----------|---------|------------|
| 1500 | 500 | 10MB/s |

*Table 1 Application Performance Class 1 (A1)*
*\*Input-Output access Per Second (IOPS) Minimums*

Note that the given performance levels are assured under the conditions defined in SD Physical Spec v5.1. Any SD memory card that introduces itself as an A1 card (by the logo and in the internal SD Card Status register) shall meet the defined spec requirements. Please refer to the SD 5.1 Spec for further details.

Figure 1 shows the new App Performance symbols in both short and long forms.
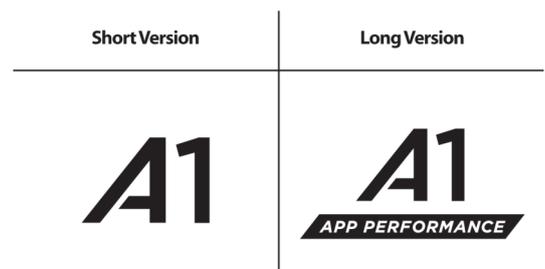


*Figure 1 App Performance Symbol*

## What is expected from product manufacturers?

Product manufacturers that support SD memory cards and need certain minimum random and sequential performance levels that can be satisfied by App Performance Class 1 minimum levels may include A1 SD memory card recommendations in manuals and product packaging to help customers choose the best SD memory card for that device.

Manufacturers that recommend usage of App Performance Class SD memory cards should check for the desired Application Performance Class level as follows:

1. Check the Application Performance Class type of the SD memory card in the SD Card Status and confirm whether it matches its requirement level.
2. In addition, or in cases where the Application Performance Class is not indicated by the card, the host may perform an internal benchmark test and check for the absolute execution time to qualify the memory card. If it matches or exceeds the execution time expected from the corresponding Application Performance Class expected by the host, the card should be accepted for use.

In November 2016, Google updated its benchmark test and uploaded it to the Android Open Source Program (AOSP) for review. Per the new update, which is expected to be included in the pending platform release, Google relaxed the benchmark to be a static threshold value instead of comparing it against the relative speed of internal storage.

The updated version, anticipated in a forthcoming periodic update for Android Nougat, does not test the removable card against the embedded performance. It tests it against a fixed level (as recommended in Item 2 above).

IMPORTANT: The performance level that SD memory cards are tested against allows A1 SD memory cards to pass, but they cannot be *guaranteed* by Google. The reason is that the Android benchmark test is dependent on the device environment (i.e. clock speed, background apps, etc.), not only the memory card. Therefore, the SDA highly recommends the product manufacturers first test their devices with A1 SD memory cards using the new Android benchmark mentioned above before they recommend their customers use A1 cards.

Note that in any case SD memory cards that indicate Application Performance Class support shall meet the SD standard specification for Application Performance Class conditions as defined in SD Physical Spec v5.1.

## Test Equipment

There are several approved test equipment options in the market that implement the SD Specification Test guidelines and are used for self-compliance tests of SD memory cards and host devices.

The App Performance Class tester, for both host side and card emulator, is expected to be ready by leading test equipment manufacturers soon after the SD 5.1 Specification is introduced.

# Summary

With the expanded usage of SD memory cards for storing applications and application data, there is a growing need for a combination of Random and Sequential performance levels. This demand becomes even stronger with the introduction of Android's Adopted Storage Device capability. The Application Performance Class was introduced by SD 5.1 Physical specification with the first App Performance Class, A1, to address these new market demands. The new class assures minimum performance under given conditions and the new App Performance symbol enables a new method of communication in the SD memory card market, giving manufacturers a method to communicate device requirements and allowing their customers the means of choosing the right card for their device at the point of sale.