Impact Factor:					
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	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science
p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)
Year: 2024 **Issue:** 12 **Volume:** 140
Published: 26.12.2024 **http://T-Science.org**

Issue Article

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OPTIMIZATION OF MOBILE APPLICATION PERFORMANCE: MODERN APPROACHES AND METHODS

Abstract: *The article explores modern approaches to optimizing the performance of mobile applications (MA), including code optimization, the use of advanced technologies, and continuous monitoring. It analyzes key factors affecting performance, such as hardware limitations of devices, characteristics of mobile networks, and architectural solutions. The significance of methods such as resource compression, data caching, and lazy loading is emphasized for enhancing the stability of MA. The successful experiences of companies like Uber, LinkedIn, and Airbnb are examined. The conclusion is made that optimizing MA plays a crucial role in ensuring their competitiveness and user satisfaction.*

Key words: *optimization, performance, mobile applications, MA, code, technologies, monitoring.*
Language: *English*
Citation: Blazhkovskii, A. (2024). Optimization of mobile application performance: modern approaches and methods. *ISJ Theoretical & Applied Science, 12 (140),* 290-294.
Soi: http://s-o-i.org/1.1/TAS-12-140-35 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2024.12.140.35
Scopus ASCC: *1700.*

Introduction

Mobile applications (MA) have become an integral part of modern society's daily life. They encompass a wide range of tasks, from communication and entertainment to financial management and professional activities. With more people using mobile devices due to continuous development, performance is one critical area nowadays that determines whether this type of application will become a successful one or not. Slow performance, delayed responses, or using too many resources are not only frustrating for the users but result in losing customers and degrading the developer's brand.

The relevance of this topic is that competition in the market of MA has noticeably increased. All this stimulates developers not only to actively introduce new functionality into the applications but also to conduct optimization work so that it can run even on a device with a modest system. The goal of the article was to review contemporary approaches to optimizing MA performance, such as code optimization, advanced technologies adoption, and performance monitoring.

Main part. Factors influencing the performance of MA

Many factors affect the performance of a MA. The most crucial of these are hardware limitations of mobile devices, which include **random access memory** (RAM), processor power, and **graphics processing unit (GPU)**, among others; while battery capacity is a serious concern as well. Resource-intensive applications might bring lower-end-spec devices to a crawl-especially if the application developers didn't take the proper care to make good use of that hardware. As it happened, low RAM crashes the application and drops running tasks in the background, but with high CPU and GPU, it overheats, leads to power consumption, hence reducing the battery life. Recent research of 2023 showed the iOS application reached an average of 99,93%, and Android applications 99,81% [1]. More critical, the average memory warning rate of Android applications is 12,94%, more than twice that of iOS applications, standing at 5,49%.

Such are the **peculiarities of mobile networks**, which also provide for the smooth execution of applications, especially those bound with unceasing data exchange with servers. Therefore, it depends on

a user's geographical position, signal strength, and network load. As an example, some applications can be characterized with a longer loading time, a response delay in weak or unstable connectivity, because some important feature cannot be accessed. This is particularly critical in real-time applications, such as messaging platforms or streaming services, where each second of delay contributes to poor user experience.

Architectural and software decisions made by developers significantly affect application performance, too: poorly optimized code, extra server requests, and not handled asynchronously may result in superfluous resource usage and big delays. Besides, the choice of technologies and libraries used in the development process makes a serious impact on the quality of the end product. For instance, dependencies on obsolete or resource-intensive libraries can make the application slower; modern frameworks that allow for adaptation to a wide range of platforms and devices contribute to more effective software development.

Optimization techniques for MA

Optimization of a MA is a multilayer process; this requires the implication of both conventional and modern technologies. The efficiency of an application largely depends on **code optimization**, which begins during the development stage. Compact and clean code will contribute to lesser consumption of device resources, including the processor and RAM (table 1).

Table 1. Key methods for MA code optimization [2]

Method	Description	Advantages
Eliminating redundancy	Removing duplicate code fragments and unnecessary operations.	Reduces code volume and resource usage.
Asynchronous programming	Implementing operations that do not block the main application thread.	Ensures smooth UI performance and reduces delays in task execution.
Algorithm optimization	Selecting the most efficient algorithms for tasks.	Speeds up operations and reduces CPU load.
Resource compression	Reducing the size of images, videos, and other static resources.	Decreases loading times and data transfer volume.
Data caching	Storing frequently used data in local device memory.	Speeds up data access and reduces network load.

In 2023, a study was presented on the arXiv platform that focused on the GIDroid tool, using genetic programming methods for automated optimization of Android application performance [3]. Experimental data showed that the use of GIDroid reduced the execution time of applications by 35% and their memory consumption by 33%, which allows judging the very high efficiency of this approach under modern demands on mobile products.

Another research analyzed the effect of decreasing JavaScript code volume on application performance. Based on the results, in projects developed with React Native, reducing the code volume by 20% resulted in a 15% decrease in load time [4]. Also, for applications developed on the Flutter platform, the use of «Skia Shader Language» contributed to a 25% decrease in central processing unit (CPU) load during operations with complex graphics.

Thus, this research confirms the necessity of applying up-to-date code optimization methods and using tools that enhance the performance of MA. It is highly important in general for developing high-quality products that can work well under high user demands combined with hardware resource constraints.

Another important point of optimization is the **time of loading the application**. Such techniques as compression of static resources, allowance of data caching, and minimization of network requests allow for speeding up the access to functionality and reduction of volume in transmission, especially under poor conditions of internet connectivity (table 2).

Table 2. Methods for reducing MA loading time [5, 6]

Method	Description	Advantages
Image and video compression	Reducing the size of multimedia files before loading.	Decreases data transfer volume, speeds up loading.
Data caching	Storing frequently used data on the device.	Reduces the number of network requests, speeds up access to information.

Lazy loading	Loading data only when necessary (e.g., during scrolling).	Reduces initial loading time of the application.
Content Delivery Network (CDN)	Distributing static content through a network of servers worldwide.	Improves loading speed for users across different regions.
Network request optimization	Reducing the number and size of network requests.	Decreases delays in data loading.

Thus, by employing these methods for reducing the application load, it develops great optimization concerning users and resource use. In such a way, data access speeding and latency minimization will help the developers to provide applications performing seamlessly even with poorer connections, bringing users' satisfaction more.

Also, the contribution of **modern technologies** to optimization is great. Multithreading allows doing several things simultaneously: data loading, treatment of user events, and rendering of the interface-all this provides smooth work of the application. Adaptive interfaces, depending on screen size and performance of the device, allow the user to feel comfortable working with a wide range of devices.

Cloud technologies are helpful in reducing the workload of a device by shifting most computation-intensive operations to a remote server. In particular, this refers to a wide range of data treatment applications, such as games or some analytical platform. Thus, in September 2024, the most widespread cloud software development kit (SDK) for Android applications around the world was Amazon AWS (fig. 1).

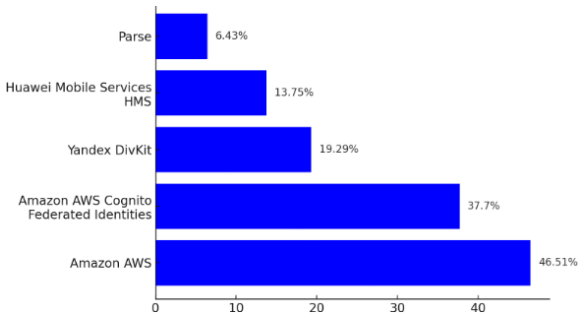

Figure 1. Popular cloud solutions for Android application development [7]

High performance requires continual assessment concerning the quality of an application. Testing tools like Firebase Performance Monitoring and Appium help in finding out the bottlenecks that affect performance. Metrics such as response time, FPS (frames per second), and energy consumption give data to the developers for necessary tuning. Continuous testing enhances overall stability and real-world performance of the application.

Thus, the ways of optimization of a MA include thorough code refinement, the use of modern technologies, and continuous testing. This ensures not only stable application operation but also enhances the user experience, providing a substantial competitive advantage in the saturated mobile product market.

Testing and performance monitoring

Effective testing and performance monitoring of MA are critical for their stable work and high level of user satisfaction [8]. Specialized tools allow developers to timely detect and resolve performance-related issues. Popular solutions include such tools as Firebase Performance Monitoring, which gives data on load times, delays, and other aspects of application performance to developers, and Appium, which is used for automated testing of MA on multiple platforms.

Various metrics applied to the performance objectively enable the measurement of key application performance parameters (table 3).

Table 3. Key performance metrics for MA

Metric	Description	Optimal value
FPS	Frames per second, indicating the smoothness of the user interface.	≥ 30 FPS
Response time	The time required to perform an action or load data.	< 1 second
Energy consumption	The amount of energy consumed by the application over a specific period.	Minimal, especially in background mode.

Equally important for maintaining MA is real-time performance monitoring. Crashlytics and New Relic are some of the tools that allow tracking the performance of an application once it is released and enable observation of its behavior under real conditions of usage. Gathering data on crashes, delays, and other issues enables not only rapid problem-solving but also strategy building in order to avoid such issues in the future.

User feedback is a very good source of monitoring data. Reviews in app stores or those provided through mechanisms built into the app allow the identification of problems that were not obvious during testing. When coupled with real-time monitoring tools, this forms a complete view for the developers about application performance and enables them to maintain high standards of user experience.

Examples of successful MA performance optimization by companies

Many American companies have achieved significant improvements in the performance of their MA by applying various optimization methods. For example, **LinkedIn** has successfully undertaken a major overhaul of its MA by abandoning the use of HTML5 in favor of native development. Initially this application was made using HTML5 to enable compatibility between different platforms with less time consumption. However, users suffered from poor performance, slow content loading, and crippled functionality. The shift toward native application development-regularly developed for iOS and then for Android-increased the speeds manifold and totally renovated the user experience. By consequence, it started to get the performance of the application up ten times faster because of faster loading and easier navigation. Moreover, increased engagement was reflected in more time spent in the app, with more engagement rates within the app itself. As of April 2024, LinkedIn's USA audience reached 230 million users. That experience taught me how the choice of proper technology in development will lead to great performance and satisfaction for end-users.

Other successes include the work done by **Uber** in 2023 to update its MA for better performance by reducing the launch time of its app. The company introduced a new architecture in measuring latency at launch, taking into account features of iOS 15, such as the pre-warming function for applications. This greatly helped them accurately measure and optimize the app's cold start time to provide quicker access for end-users to the service.

Airbnb implemented an all-encompassing strategy for the optimization of MA for enhancing user experience and performance on their portal. The main objective was to decrease the load times for the applications. For that, the authors redesigned the application architecture and introduced such a «lazy loading» principle of content loading. That means the application loaded only those interface elements and data which were needed for the user at this very moment. It reduced many times the time of the initial loading. The team also worked on optimization of rendering algorithms in order not to make excessive computations and enhance multimedia content processing. To speed up the handling of data, more efficient caching mechanisms were introduced that would reduce network overload and delay the creation of queries on the server. Further, it started using the CDN for the swift delivery of all static resources like images and fonts, irrespective of the geographical location of the users. According to AppFigures, the monthly downloads of Airbnb increased from 8 to 16 million from 2018 to 2024. This underlines how effective use of optimization technologies, in a strategic manner, may not only enhance application performance but also extend its audience dramatically.

The examples above show that targeted optimization efforts can bring profound improvements in the performance of a MA by enhancing user satisfaction and efficiency in service delivery.

Conclusion

Mobile performance optimization is such a complex process that embraces technical and architectural solutions of various kinds. The application of such practices as code optimization, resources compression, lazy loading, and adoption of the newest technologies may bring significant improvements to application performance. Examples of such companies as LinkedIn, Uber, and Airbnb prove that a systematic approach to performance improvement not only reduces load times and resource consumption but also increases user satisfaction. It is especially important in a highly competitive MA market, where stability and speed are crucial in terms of maintaining an audience. In this regard, comprehensive optimization strategies can allow developers not just to create qualitative products but also guarantee their successful continuation.

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