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AirCloud Desktop vs Amazon WorkSpaces Remote Control Comparison Results

1.1 Comparison Conditions*

Link to the video: https://aircloud.org/aircloud-vs-amazon/.

During the preparation for the comparison, our main aim wasn't just to make the same conditions for both sides, **but to put AirCloud in conditions that are obviously worse than those of Amazon.**

Table 1.1: Conditions of the experiment

Name	AirCloud	Amazon
Server Location	**Frankfurt**, Germany	
Network Connection (From Belarus To Frankfurt)**	PING: **44ms** Down/Up Speed: **18.12 Mbps | 20.91 Mbps**	
Client Device Info	Display: **3840x2160 (4K, 32bpp)** Ubuntu Desktop 20.04 (**4 Cores, 4GB of RAM**)	
Server CPU Type	Intel Xeon Silver 4210 2.20Ghz (10C, 20T, **$511.00**)	Intel Xeon Platinum 8259CL 2.50Ghz (24C, 48T, **$7705.00**)
Number of vCPU and RAM of VM	**2 vCPU | 3.82GB**	**2 vCPU | 7.90GB**
Guest Operating System	**Windows 10 Home** (Not optimized for remote)	**Windows Server 2016** (Optimized for remote by MS)

* *All these conditions were demonstrated in the video.*

** *Link to the network test: https://www.speedtest.net/result/9958532407*

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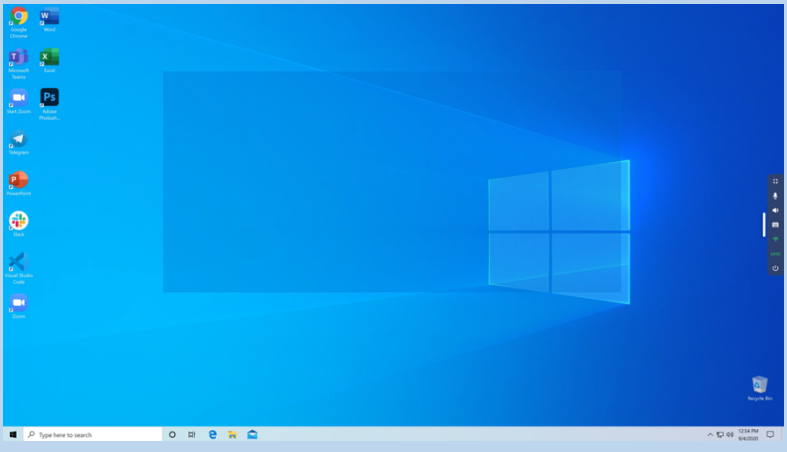
1.2 Comparison methods

To make this comparison, we used the methods of the OpenCV library. In particular, we decomposed RAW 60 FPS video into separate frames and used delta rendering to detect changes in two adjacent frames. We also calibrated the frame comparison so that minor changes such as moving the mouse cursor were ignored. To minimize the statistical error, we used a sample of more than 1000 measurements and calculated the arithmetic mean.

2.1.1 Test №1.1: **Selection of the screen area**

In this test we compared response time and FPS while doing a selection of the screen area. This test is the simplest one, but very important as according to statistics users spend most of their time doing such simple graphics operations.

Table 2.1.1: Selection of the screen area test results

Name	AirCloud	Amazon
Test illustration		
Average FPS: **More is better**	**29.96 FPS**	**19.37 FPS**
Average response time in milliseconds (From the cursor move): **Less is better**	**66.05ms**	**97.16ms**
Test Conclusion	Pretty fast selection speed without freezes and with acceptable frame rate.	Normal selection speed with some freezes and missed frames.

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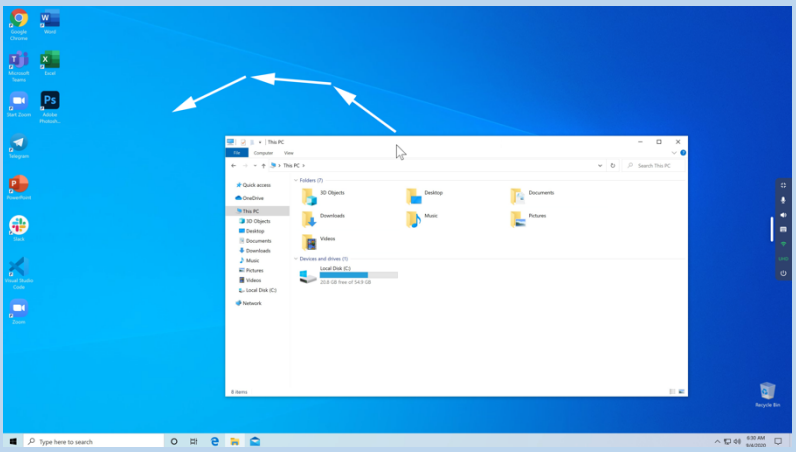
2.1.2 Test №1.2: **Window dragging**

Here we decided to make a more complicated test and compared FPS and response time of window dragging. This test is an advanced one because many pixels change simultaneously in a short period of time during a window movement.

Table 2.1.2: Windows dragging test results

Name	AirCloud	Amazon
Test illustration		
Average FPS: **More is better**	**39.45 FPS**	**9.10 FPS**
Average response time in milliseconds (From the cursor move): **Less is better**	**11.78ms**	**125.13ms**
Test Conclusion	Smoothness and response rate are as close as possible to a real computer use.	A large number of freezes and dropped frames. Unacceptable for use.

In this test, AirCloud transmits the content of the moving window only once, and then this window attaches to the cursor position. However, Amazon transmits the content of the window each time when it moves. It increases the amount of transmitted data by several tens of times and increases the delay by the same amount.

AirCloud uses a recognition system based on machine learning algorithms to identify static elements of a dynamic scene. Also, it uses motion interpolation algorithms to achieve maximum smoothness.

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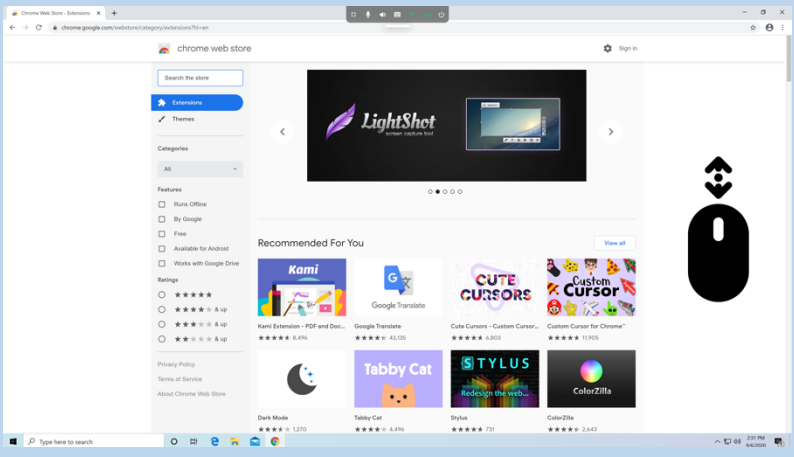
2.2.1 Test №2.1: **Web browsing (Simple content)**

These tests check response time and FPS during web browsing. The first part of the web browsing test was made on the Chrome Web Store Website. Also, this test emulates work with simple documents in programs like Word, Excel, etc.

Table 2.2.1: Web browsing scroll test results (Simple content)

Name	AirCloud	Amazon
Test illustration		
Average FPS: **More is better**	**33.14 FPS**	**8.02 FPS**
Average response time in milliseconds (From the scroll event): **Less is better**	**71.89ms**	**372.31ms**
Test Conclusion	Scroll response rate and smoothness aren't different from a real computer use.	Huge response time, what is felt every time user scrolls. Another problem is a lot of freezes and artifacts.

2.2.2 Test №2.2: **Web browsing (Heavy content)**

The second test of a web browsing is aimed to emulate the hardest conditions of heavy content web browsing and to emulate work with large PDF documents. This test was performed on the Apple Inc. Website.

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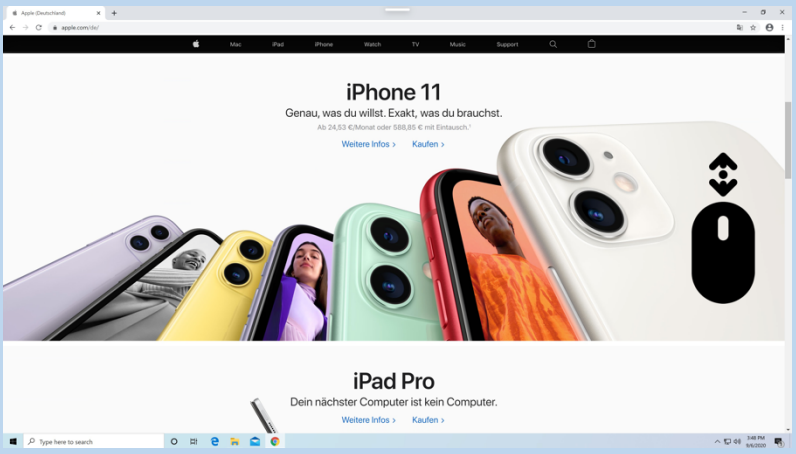
Table 2.2.2: Web browsing scroll test results (Heavy content)

Name	AirCloud	Amazon
Test illustration		
Average FPS: **More is better**	**26.91 FPS**	**7.12 FPS**
Average response time in milliseconds (From the scroll event): **Less is better**	**75.72ms**	**401.45ms**
Test Conclusion	Smoothness and response rate of scrolling are still as close as possible to a real computer use. But average FPS is lower due to a bigger size of "shadow" pixels.	It still has huge response time and in some places Amazon fells down to 1-2 FPS with artifacts. It makes Amazon unusable for work with heavy websites and docs.

While scrolling, AirCloud transfers whole window's content only once, and then it transfers only "shadow" pixels and motion vectors which are interpolated on the client side. On the other hand, Amazon transmits whole window's content part each time when a user scrolls. It increases the amount of transmitted data by several tens of times and increases the delay by the same amount.

2.3 Test №3: **Video Playback Test**

Our final test is a video playback on YouTube. Official Extended Aquaman trailer was used as a test video due to the large amount of heavy graphic scenes.

The results of this test depend on the compression efficiency, as well as the compression/decompression time on the server and client side, respectively. **As a test**

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result, the average FPS was calculated over a 75 seconds video playback. Also, time periods when the FPS fell below 10 were calculated, considering 10 FPS as unacceptable for a regular user.

Table 2.3: Video Playback Test

Name	AirCloud	Amazon
Test illustration		
Test video duration	**75 seconds**	
Average FPS: **More is better**	**24.19 FPS**	**15.78 FPS**
Duration in seconds of the video with FPS below 10: **Less is better**	**4.40s** of 75s	**31.10s** of 75s
Test Conclusion	High enough FPS for comfortable watching without audio lag. Visible reductions in the quality of the transmitted video were not observed.	Significant drops in FPS are noticeable, in some places FPS dropped to 1-2 frames per second. Also, in some fragments the image quality was greatly lowered.

During a video playback streaming, AirCloud uses an intelligent system for automatic selection of compression algorithms and their parameters. This system uses machine learning models that are retrained during the actual work.

It is important to note that AirCloud developers have created a system for direct forwarding of a compressed video stream from the guest operating system directly to the client device. However, in this test it was disabled for equal conditions.