Miercom

Lab Testing Summary Report

September 2015

Report 150714C

Product Category:

Session Border Controller

Vendor Tested:

AudioCodes

Products Tested:

Mediant 9000 & Mediant VE

Session Border Controllers

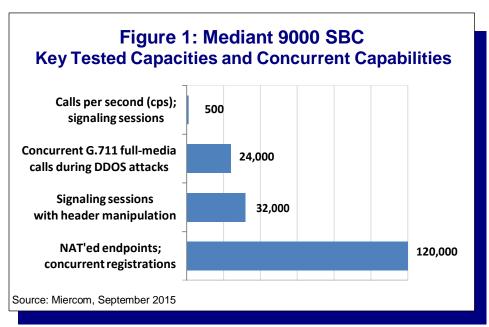**Miercom PERFORMANCE VERIFIED** ™

Key findings and conclusions

- AudioCodes' Mediant family of software-based Session Border Controllers (SBCs) exhibit rich interoperability along with impressive performance and resiliency. The Mediant 9000 ran on an HP server; the Mediant VE (Virtual Edition) ran on a VMware virtualized system.

- The Mediant 9000 and VE both handled 500 incoming calls per second, with header manipulation, while sustaining 32,000 signaling calls. In addition, both SBCs successfully completed an average of over 550cps during high call overload conditions of 2,000cps – four times the nominal call-processing rate.

- The Mediant 9000 can sustain 24,000, and the VE can sustain 6,000, G.711 20-ms calls with excellent Mean Opinion Score (MOS) ratings and with no failed or dropped calls.

- The Mediant 9000 and VE both proved fully resilient against Distributed Denial of Service (DDoS) attacks on both signaling and RTP/media ports, maintaining excellent MOS ratings and with no dropped calls or system degradation.

- The Mediant 9000 and VE supported a full capacity of 120,000 and 30,000 NAT'ed registered users, respectively, and successfully withstood a registration avalanche. Both SBCs supported a registration refresh rate of 6,000 registrations per second.

AudioCodes Ltd. engaged Miercom to conduct an independent performance assessment of its Mediant 9000 and Mediant VE (Virtual Edition) software-based Session Border Controllers. AudioCodes family of Mediant Software Session Border Controllers (SBC) are capable of being deployed as:

Server Edition (SE) running on dedicated Common Off-The Shelf servers.

Virtual Edition (VE) running on VMware, Hyper-V and KVM virtualized systems and in private and public clouds such as Openstack and Amazon Web Services (AWS). The results shown in this report relate to the Mediant VE running on VMware. The Virtual Edition can also be

Figure 1: Mediant 9000 SBC
Key Tested Capacities and Concurrent Capabilities

Category	Value
Calls per second (cps); signaling sessions	500
Concurrent G.711 full-media calls during DDOS attacks	24,000
Signaling sessions with header manipulation	32,000
NAT'ed endpoints; concurrent registrations	120,000

Source: Miercom, September 2015

Versatility. Miercom testing found the Mediant 9000 and the Mediant Virtual Edition (VE) to be highly interoperable, top-performing and resilient SBCs.

deployed as a Virtual Network Function (VNF) within an orchestrated Network Functions Virtualization (NFV) environment.

The Mediant 9000 is designed for large organizations, contact centers and service-provider core networks, providing reliable and secure connectivity between the service provider and the enterprise VoIP network. It is delivered on an HP ProLiant DL360p Gen 8 server platform, featuring 2 x Xeon E5, 2.8-GHz processors and 64 GB memory. The 1U appliance comes with 12 redundant 1-Gbit/s ports.

The Mediant Virtual Edition is aimed at enterprise and carrier virtualized environments, as well as software vendors looking to integrate applications with a rich, proven SBC software package. It was run in our testing on VMware on an 8-core, 2.5-GHz, COTS (commercial off-the-shelf) server. Four of the cores were dedicated to SBC processing and the other four to transcoding. Both the Mediant 9000 and the Mediant Virtual Edition run the same application code, which means they have uniform functionality and management. Version 7.00A.013.006 was used in this testing.

The adaptation and interoperability tools the Mediant SBCs support are impressive, efficiently handling SIP header manipulation, protocol interworking (IPv4-IPv6, UDP-TCP, etc.), encryption (UDP-TLS, RTP-SRTP), and transcoding of media streams between different voice coders.

Concurrent session and call-rate capacities were verified in various demanding scenarios, including during high-call-rate loads, with DDoS attacks delivering traffic 100 times greater than normal, and with device failover in a High Availability (HA) configuration.

The primary test tool we employed was Tektronix Communications' Spectra2, running software version 8.5.0.1. The Spectra2 can simulate all of the key processing elements in today's advanced service-provider networks. In this testing the load test functions of Spectra2 were used to generate thousands of call set-ups, registrations and media streams; while capturing media QoS measurements for the calls.

Call Performance

A battery of tests measured the Mediant 9000's and Mediant VE's call-handling performance. The

first set, with results shown in Figure 2, measured call- handling performance without media, but with added processing applied by the Mediant SBC to each SIP signaling session. These included:

- **Header Manipulation**: The SBC was configured to add a new header, delete an existing header and modify the content of a third header, for each SIP message.
- **UDP-TCP Interworking**: The SBC was configured to convert each message's transport between connectionless UDP and connection-oriented TCP.
- **UDP-TLS Interworking**: The SBC was configured to convert each call set-up message flow between an open, unsecure UDP stream and an encrypted Transport Layer Secure (TLS) connection.

The results confirmed that the Mediant 9000 and VE both accepted and successfully processed 500 cps while sustaining 32,000 signaling sessions, with no calls dropped or rejected.
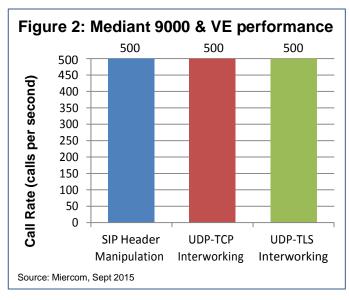
Call Admission Control (CAC). The Mediant 9000 and Mediant VE SBCs allow the administrator to set limits on the call capacity available to specified SIP users or user groups. This way one busy SIP "entity", such as a call center, can't consume all available capacity, leaving none for other users.

To test this feature we defined a CAC policy that allotted a maximum of 300cps to a particular source IP address – the Spectra2. We then had the Spectra2 initiate calls at a rate of 400cps to the Mediant SBC – 100cps more than the CAC limit would allow.

The result: The SBC successfully limited the call capacity allotted the Spectra2 to 300cps, rejecting the rest of the SIP INVITEs.

Call Overload Performance. The Mediant 9000 and VE could both readily handle a load of 500 calls per second (cps) in normal call environments, and in some cases even when performing considerable additional processing (Figure 2).

We also performed tests to see how the SBCs react when inundated with call overloads. We delivered 2,000cps – four times the nominal call-handling capacity of the Mediant 9000 and VE, for a duration of 5 minutes. The results: while CPU load was high, the SBCs continued to successfully process an average of over 550cps during the overload.

Figure 2: Mediant 9000 & VE performance

Source: Miercom, Sept 2015

Heavy loads. Shown above are the calls-per-second (cps) rates achieved during heavy added processing, in each scenario with no lost or dropped calls.
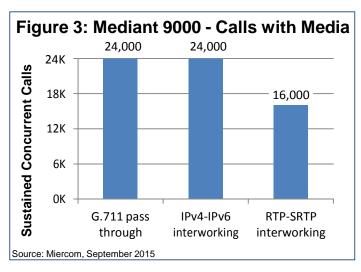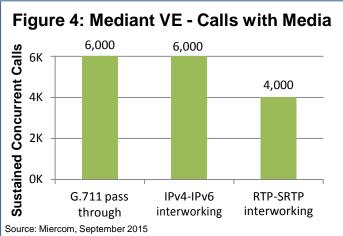
Media Handling Performance

Measuring calls with media examines the SBC's handling of both call-control signaling and the corresponding bi-directional media streams, which together make up each call.

In the VoIP world, media streams can be exchanged directly between SIP endpoint clients, bypassing the call controller (IP-PBX or SBC typically) completely. However, to perform any special handling on the media streams, the media streams have to pass through the SBC, which then acts as a relay point. This naturally imposes more load on the SBC than if media streams bypassed the SBC altogether.

Our testing of calls with media examined several real-world scenarios where the media streams went through the SBC. Tests were performed with separation on the SBC of trusted and untrusted network interfaces, both with 1+1, redundant Ethernet ports for increased resiliency. All MOS measurements were done based on PESQ methodology, which is currently considered the most reliable and complete media-quality rating in the industry. Results are shown in Figures 3 and 4 for these scenarios:

- **G.711 call pass through**, where basic G.711 20-ms (per packet) calls are relayed through the SBC, with no additional special processing.

- **IPv4-IPv6 interworking,** where the SBC converts every packet of the signaling messages *and* media streams of every call between IPv4 and IPv6 transports.

Figure 3: Mediant 9000 - Calls with Media

Source: Miercom, September 2015

Figure 4: Mediant VE - Calls with Media

Source: Miercom, September 2015

With no calls failed, rejected or dropped.

Add'l call handling	G.711 RTP media traffic passes through the SBC	Signaling *and* media converted between IPv4 & IPv6	Media is translated between RTP & encrypted, Secure RTP
MOS	4.2	4.2	4.2
CPU load	44% (9000) 13% (VE)	47% (9000) 13% (VE)	35% (9000) 11% (VE)

- **RTP-SRTP interworking**, where the SBC converts the media streams bi-directionally between basic Real-time Transport Protocol (RTP) and encrypted, Secure RTP (SRTP), including the corresponding RTP Control Protocol (RTCP) and Secure RTCP (SRTCP).

As shown in the figures, the Mediant 9000 readily handles the signaling and media pass-through of 24,000 regular G.711-based calls (tested with typical 20-ms voice samples per packet) on a sustained basis. The Mediant VE can handle 6,000 such concurrent pass-through calls.

Tests also found that the Mediant 9000 can handle the real-time conversion of 24,000 concurrent calls between IPv4 and IPv6 transports – signaling-message flows and all RTP media packets, on a sustained basis. The Mediant VE concurrently handles 6,000 such converted calls.
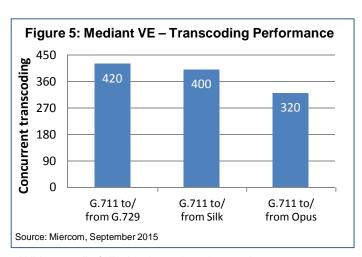
The Mediant 9000 also handles the bi-directional translation of 16,000 calls' media streams between the basic RTP media transport and the encrypted Secure RTP, on a sustained basis. The Mediant VE could handle 4,000 such concurrent media-stream conversions.

In all of these calls-with-media scenarios, call quality remained high (4.2 average MOS).

Transcoding. We tested the ability of the Mediant Virtual Edition (VE) to handle the conversion of media streams, bi-directionally and in real-time, from one vocoder format to another. This is complex processing, but necessary when one SIP client sends media based on one vocoder and the other SIP client uses or requires another.

The Mediant VE performs transcoding in software. Still, our tests found that the VE is able to sustain hundreds of concurrent transcoded media sessions.

The Mediant VE was configured for carrier peering and the Spectra2 test system launched G.711 calls with a 180-second call hold time. In the first test the VE converted all media streams between G.711 and

Figure 5: Mediant VE – Transcoding Performance

With no calls failed, rejected or dropped.

Media handling	G.711 converted to/from G.729	G.711 converted to/from Silk	G.711 converted to/from Opus
Call hold time (sec)	180	180	180
MOS	4.2 (G.711) 3.88 (G.729)	4.2	4.2

the low-bit-rate G.729 vocoder, which is very popular in bandwidth-limited environments. As shown below, the VE can handle 420 concurrent G.711-G.729 transcoding sessions, with no calls failed and with excellent call quality.

In other transcoding tests, the VE converted between G.711 and two relatively new wideband vocoders – Silk and Opus. These are two very complex, open-source vocoders, which deliver excellent voice quality at reduced bit rates. Silk is currently used by Microsoft in Skype for Business. Opus was standardized by the IETF as an RFC in 2012 and is the primary coder for Internet-based communications such as WebRTC.

As shown in Figure 5, testing found that the Mediant VE can sustain 400 concurrent media-transcoding sessions between G.711 and the Silk vocoder, or 320 transcodings between G.711 and Opus – in all cases with no call failures or drops and with excellent call quality for both transcoded media streams.

Registration Performance

To test registration performance, the Spectra2 tester issued conventional SIP registration requests at various rates in separate tests to the Mediant 9000 and VE:

Maximum Endpoint Registrations: The Mediant 9000 and VE were configured in an access role, accepting calls directly from the user endpoints. Result**:** The Mediant 9000 handled and sustained 120,000 registrations and the Mediant VE handled 30,000 registrations –with no rejections or dropped registrations by either SBC.

Registration Avalanche: The Mediant 9000 and Mediant VE were inundated with near-simultaneous registration requests from all clients (as might be the case after a campus- or city-wide power loss/restoral). Result**:** The Mediant 9000 processed and sustained 120,000 registrations within 75 seconds, and the Mediant VE handled 30,000 registrations within 20 seconds, in both cases at a rate of 1,600 registrations per second (rps).

NAT'ed clients: When SIP clients communicate via a NAT/firewall, "fast registration" or "re-registration" is used to update the SBC of clients' status and network address. Result**:** With a 30-second refresh interval set, the Mediant 9000 could process and maintain 120,000 re-registrations, and the Mediant VE 30,000, on a sustained basis. The Mediant 9000 and VE both achieved a maximum registration-refresh rate of 6,000rps per second.

Registrations with TLS. A registration rate for encrypted, TLS (Transport Layer Security)-based registrations (including the setup of the TLS connection) of 160 TLS registrations per second was measured for both the Mediant 9000 and VE.

Surviving Malicious Attacks

Tests were also run to determine the susceptibility of the Mediant 9000 and Mediant VE to malicious network attacks. To do this we employed an Ixia test system, the Ixia 400T chassis, running IxNetwork v5.30 software.

A total of 15 different malicious attacks were launched against each SBC while they were handling a heavy load of calls. Some of the attacks were directed at the SIP signaling interface of the SBC, Port 5060. Others were directed at the media ports, during which we checked to see if the attack had any damaging effect on call quality.

The attacks were DoS (Denial of Service) in nature – very common in today's private and public networks – in which the target system, the Mediant 9000 or VE, is flooded with bogus traffic to disrupt or shut down normal traffic flow and operations. What's more, the Ixia system launched each attack from multiple simulated sources. Ten different IP sources were used, making these Distributed DoS attacks – much harder for target systems to suppress than DoS attacks from a single source.

The Ixia test system launched these DDoS attacks:

- ARP Flood
- SYN Flood
- Evasive UDP
- UDP Scan
- Land Attack
- Ping-of-Death
- Ping Sweep
- RST Flood
- TCP Scan
- TearDrop
- Surf Attack
- UDP Flood
- Unreachable Host
- Xmas Tree Attack

In addition, PROTOS, a sophisticated open-source tool that generates malformed SIP packets, was used to deliver flood attacks.

Results**:** None of the malicious attacks, including PROTOS, had any damaging impact on either SBC's operations – either to the incoming call load of 500 cps being handled **or** to the 32,000 concurrent signaling sessions (6,000 for the Mediant VE).

Highlights of DDoS Attacks

Attack	Target	Result
SYN Flood	44,000 TCP SYN packets per second (pps) directed at signaling port 5060	No effect on Mediant 9000 or Mediant VE while handling 32,000 sustained no-media calls at 500cps
UDP Flood	50,000 UDP pps (400 Mbps) directed at the Mediant 9000 and Mediant VE media ports to consume all bandwidth	No effect on Mediant 9000 or Mediant VE while sustaining 24,000 G.711 calls (6,000 calls on Mediant VE); call MOS was rated at 4.2 during the attack
Unknown Source	56,000 bad SIP INVITES per sec from unknown sources directed at port 5060	No effect on Mediant 9000 or Mediant VE while handling 32,000 sustained no-media calls at 500cps
SIP Fuzzing	18,000 malformed SIP messages per sec (200 Mbps) directed at port 5060	No effect on Mediant 9000 or Mediant VE while handling 32,000 sustained no-media calls at 500cps
ICMP Flood	52,000 ICMP pps (200 Mbps) directed at the Mediant 9000 and Mediant VE media ports	No effect on Mediant 9000 or Mediant VE while sustaining 24,000 G.711 calls (6,000 calls on Mediant VE); call MOS was rated at 4.2 during the attack

Notes: All attacks were issued from 10 different IP-address sources. All attacks lasted 5 minutes.

Attacks against the SBCs' media ports caused no call drops or failures, and call quality during the attacks remained excellent.

The Mediant 9000 and Mediant VE have a built-in IDS (Intrusion Detection System) feature that detects and suppresses malicious attacks directed at the SBC. Reactions can include blacklisting the assaulting IP addresses/ports for a user-defined period of time and/or sending alerts (SNMP traps) with full details of the suspected malicious activity.

Resiliency, High-Availability Testing

Two tests were performed on the SBCs' resiliency to failure modes. In the first test, the resilience of 24,000 active G.711 pass-through media sessions was checked after the fail-over of the primary media link. The Mediant 9000 was first configured for carrier peering. A shutdown command was then issued through the Mediant

9000 command line interface to disable the active 1-Gigabit/s port that was carrying the bi-directional media traffic to and from the Mediant 9000.

All media packets were then redirected to a standby 1-Gbit/s port on the same Mediant 9000. Using the Spectra2 call generator, we determined that it took only 10.2 milliseconds for the traffic to re-route and the media streams to re-establish. This near instantaneous failover would not even be noticeable to callers on an active call.

High Availability. The ability to deploy two Mediant SBCs in a high-availability, fail-over pair was also tested. For this test, two Mediant 9000's and two VE's were configured for carrier peering. In each pair one was deployed in the role of primary; the other as its hot standby.

A full load of 24,000 calls was delivered to the primary Mediant 9000. The primary Mediant 9000 was then shut down. The standby Mediant 9000 immediately took over as the primary, taking over the media of all calls in progress and the handling of new SIP INVITE call requests.

As a result of the fail-over, calls in progress remained connected and the brief delay for re-directing their media streams was imperceptible to callers. There was some loss of transient calls that were being set up at the moment of fail-over, but all new calls were again successfully handled after a brief transition. Calls in progress during the failover were MOS-rated an excellent 4.2.

The same test was conducted with the Mediant VE pair. With 6,000 concurrent calls in progress, the primary VE was shut down. The standby VE immediately took over, media streams switched over and all new calls were successfully processed.

Network Function Virtualization (NFV)

Mediant VE can run as a Virtualized Network Function (VNF), in a VNF infrastructure and directed by a VNF "orchestrator." It is one of the first SBC Virtual Network Functions (VNF) proven by Miercom to deliver effective protection against DDoS attacks, sustaining high performance while under heavy attack without sacrificing call quality.

Mediant VE reportedly operates with all leading hypervisors now on the market, as well as in private and public clouds.

AudioCodes offers pool licensing that gives service providers the architecture flexibility to choose between multi-tenant and multi-instance approaches (A multi-instance approach means that

each tenant gets its own SBC instance and is therefore provided with full tenant isolation).
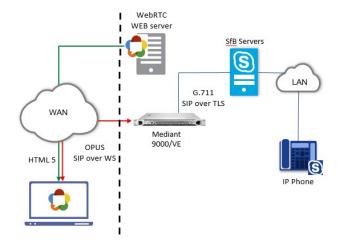
Testing WebRTC

The Mediant 9000 and VE, our testing showed, are fully supportive of WebRTC – an increasingly popular, free and open project that provides browsers and mobile applications with real-time communications via simple APIs (application programming interfaces). Support for WebRTC is already integrated in Google Chrome, Android Chrome and Mozilla Firefox browsers.

Service providers can use the integrated WebRTC support in the Mediant 9000 and VE to offer business customers an integrated calling service directly from the customer's Web site.
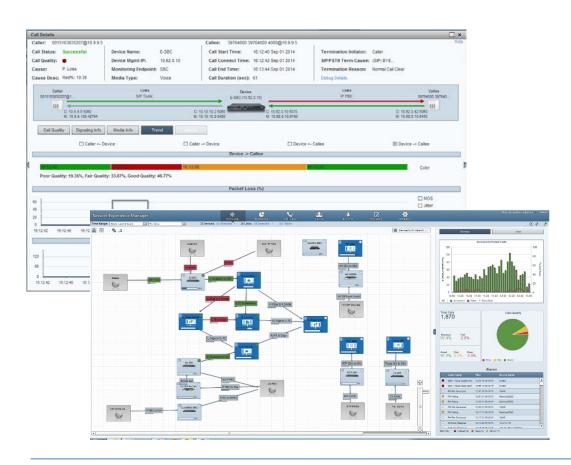
In the first scenario tested (see figure below), the Mediant SBC connected to Microsoft Skype for Business (SfB) through the SfB Mediation server, which allows calls into the user's VoIP network.

The Mediant SBC acts as a WebRTC gateway in the process – terminating signaling and connectivity protocols such as DTLS, ICE light, SIP over Secure WebSocket, RTP and RTCP multiplexing, transcoding where necessary between the Opus wideband codec of WebRTC and G.711, and validating the calls with the Active Directory.

In another test we connected from a Google Chrome browser, via the WAN, to AudioCodes IP phones (which natively support the Opus coder) in a simulated call center. In our test bed, high-quality wideband voice media streams passed through the Mediant SBCs unchanged, since the WebRTC and AudioCodes endpoints both natively support the Opus codec.

The result: straightforward WebRTC setup with the Mediant 9000/VE, and excellent call quality.
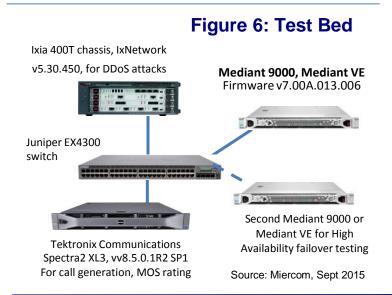
AudioCodes' Sessions Experience Manager (SEM). The Mediant SBC family, including the 9000 and VE are monitored by the SEM for Call Control and Voice Quality network analysis. The SEM shows both a high-level quality NOC view, as well as drill-down capabilities into intimate call details such as MOS trends over the call. The SEM also provides powerful reports to detect abnormal user behavior such as call theft and misused user

Voice Quality Management

A noteworthy aspect of the Mediant SBCs we observed in testing was its QoE monitoring system – the Sessions Experience Manager (SEM) – which lets the Mediant 9000 or VE administrator quickly isolate and remediate real-time problems throughout the VoIP infrastructure. The Mediant 9000 and VE have an integrated session-quality probe; therefore no external probes are needed.

The package includes many key management tools:

- **Network**: A NOC view designed for proactive monitoring from the top down.

- **Alarms**: Easily configurable alarms are issued via e-mail, SMS, syslog and SNMP.
- **Statistics**: Trends over time for KPIs such as network usage and network Voice Quality.
- **Users**: An Active Directory integration to monitor and assess users' QoE satisfaction.
- **Call details**: Drill down into both call control and voice quality metrics of any call.

Bottom Line

The AudioCodes Mediant 9000 and Mediant VE delivered impressive performance. The SBC is ideally suited for its role as controller and mediator of VoIP traffic for large enterprise and service provider networks.

The tests in this report are intended to be reproducible for current or prospective customers who want to recreate them with the appropriate test and measurement equipment. Readers interested in repeating these results can contact reviews@miercom.com for details on the configurations applied to the equipment and test tools used in this evaluation. Miercom recommends that current and prospective customers conduct their own needs analysis study and test specifically for the expected environment for product deployment before making a product selection.

Figure 6: Test Bed

Ixia 400T chassis, IxNetwork v5.30.450, for DDoS attacks

Mediant 9000, Mediant VE
Firmware v7.00A.013.006

Juniper EX4300 switch

Tektronix Communications Spectra2 XL3, vv8.5.0.1R2 SP1 For call generation, MOS rating

Second Mediant 9000 or Mediant VE for High Availability failover testing

Source: Miercom, Sept 2015

Miercom Performance Verified

Based on the results of this testing, we present AudioCodes with the Miercom Performance Verified Certification for the Mediant 9000 and Mediant Virtual Edition (VE) Session Border Controllers. The SBCs excel at mediating between different VoIP media, protocol, transport and security environments, and reliably handle thousands of calls concurrently, at high traffic rates, on a sustained basis.

The 1U Mediant 9000 appliance, and the Mediant VE, a software product tested on a VMware COTS server, also exhibit exceptional resiliency and survivability – able to instantly redirect traffic to redundant 1-Gbit/s ports, and to fail-over in seconds to a hot-standby SBC. We compliment AudioCodes on the versatility of these SBCs.

AudioCodes Mediant 9000, Mediant VE

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