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# Lab Report

## 4-bay UGREEN NAS System

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### Introduction

Network Attached Storage (NAS) systems are widely used by individuals, small businesses, and enterprises seeking reliable, centralized data storage. Beyond simply storing files, NAS systems help mitigate the risk of data loss caused by hardware failures, thanks to integrated redundancy mechanisms.

A key component of this reliability is RAID (Redundant Array of Independent Disks), which combines multiple physical drives into a single logical unit. Depending on the RAID level, users can benefit from enhanced performance, cost-efficiency, and fault tolerance. For example, RAID configurations typically use parity or mirroring to ensure data can be recovered even if one or more drives fail.

While single – and dual-bay NAS systems offer limited configuration options – usually a single drive or RAID 1 mirroring 4-bay NAS systems provide more flexible configurations. Users can choose from various RAID levels (e.g., RAID 0, 1, 5, 6, 10), each with trade-offs in terms of performance, redundancy, and usable capacity.

This report explores optimal RAID configurations for 4-bay NAS systems, focusing on practical considerations such as performance, reliability, and use-case alignment. Drawing on evaluation data from the Toshiba HDD Laboratory, it provides guidance for users seeking to maximize the potential of their NAS setup.

### UGREEN DXP4800 Plus

For this evaluation, our partner UGREEN provided a sample of the DXP4800 Plus NAS system. This 4-bay unit supports SATA drives with capacities of up to 30TB per bay, allowing for a total of 120TB in HDD storage. Additionally, the system includes two M.2 NVMe SSD slots, each supporting up to 8TB, which can be used for SSD caching or as high-speed storage. When fully populated, the system offers a maximum theoretical capacity of 136TB.

The DXP4800 Plus is equipped with dual high-speed network interfaces – 10GbE and 2.5GbE -capable of delivering data rates up to 1250 MB/s. This makes it well-suited for demanding workloads such as 4K video editing, large file transfers, and real-time data access.

For reference: We used the UGREEN DXP4800 Plus Model, Version 1.9.0.0075 with 8GB internal memory.

For this benchmarking study, we focused exclusively on the base performance of the HDD array under sustained data flow conditions. SSD caching was intentionally disabled to avoid skewing results, as caching primarily benefits random access patterns and short burst workloads. While SSD caching can


**Picture 1:** UGREEN DXP4800 Plus in the Toshiba HDD Lab

significantly improve responsiveness in scenarios involving frequent reads or small file operations, it does not affect sustained throughput, which is governed by HDD performance and RAID configuration.

In our test setup, two 256GB M.2 NVMe SSDs were installed and configured as Storage Pool 1 in RAID 1. This pool was dedicated to the operating system, ensuring that system-level disk activity did not interfere with the benchmarking of the HDD array. The HDDs were later installed and configured as Storage Pool 2, reserved exclusively for user data and performance testing.


**Picture 2:** 4 x Toshiba N300 NAS HDDs

## The HDDs

For the lab evaluation, we used the Toshiba NAS HDD model N300 with a popular capacity of 8TB (model number HDWG780 with firmware level 0501). These 3.5-inch N300 NAS Hard Drives are designed for NAS and other high-performance storage systems. They are optimized to meet the reliability, endurance, performance, and scalability requirements of 24/7 high-capacity storage for personal, home office, and small business use. The N300 is available in capacities of up to 22TB.

## Configurations

Four drives may be configured as:

**RAID 5**

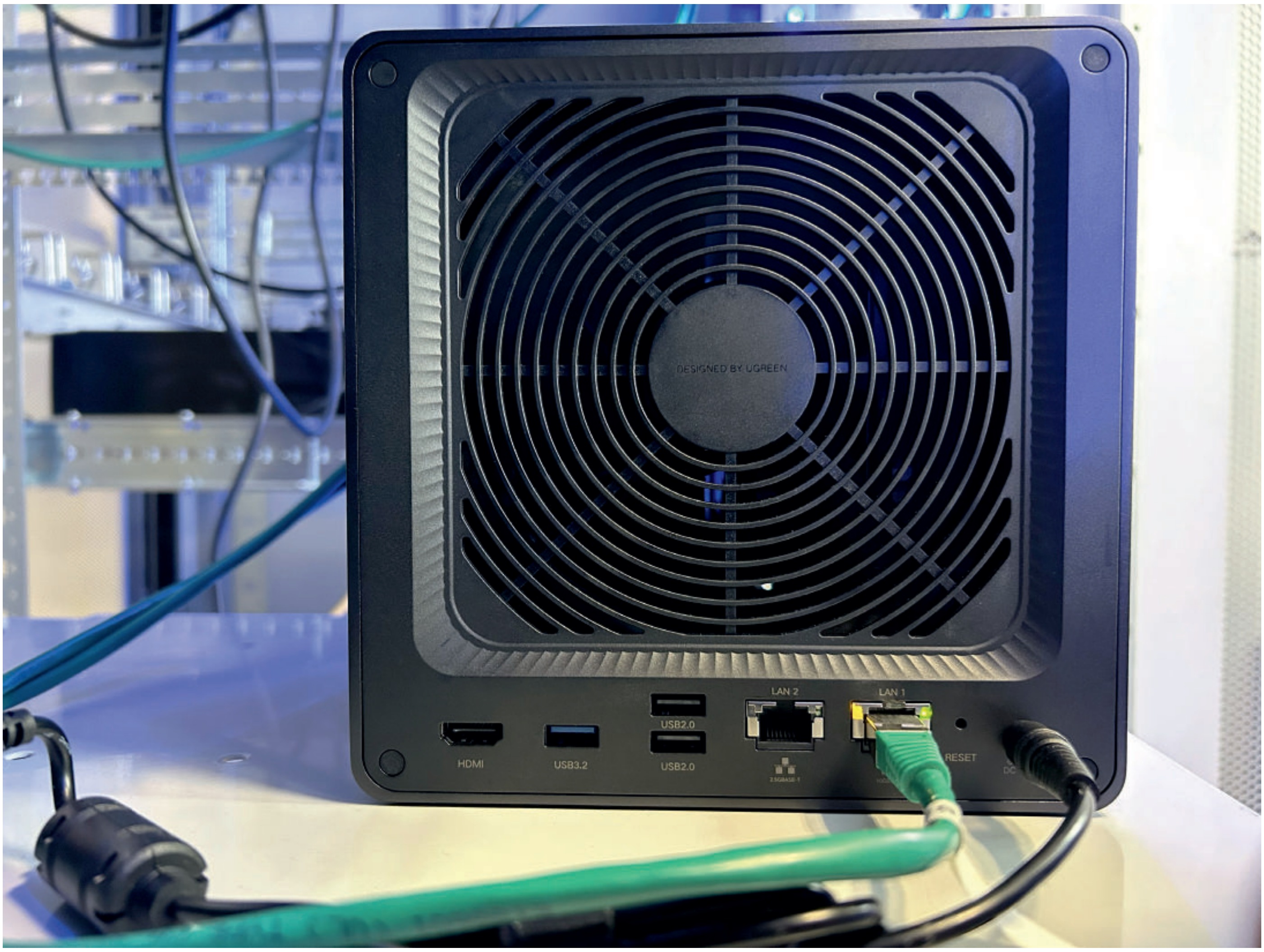
Incoming data is distributed and stored in stripes across three disks, with a fourth stripe carrying the parity information. In the event of a drive failure, data can be reconstructed using the parity. This RAID 5 configuration offers 75% storage efficiency, as the four 8TB drives provide 24TB of usable data space. Data can be read from 3 or 4 disks in parallel, resulting in fast read speeds. Writing is also performed in parallel, but the parity must be calculated and written, which can reduce write speed. During a rebuild, all parity must be recalculated, which is a resource-intensive process.

**RAID 10**

This configuration is considered an alternative to RAID 5. Instead of using parity for redundancy, RAID 10 mirrors data across two disks while striping it. This avoids the resource-consuming parity calculations required by RAID 5 during writes and rebuilds. Data can still be read from all four drives, but is written to only two drives at a time. The trade-off is reduced storage efficiency – only 50% – due to mirroring.

**RAID 6**

RAID 6 uses a parity concept similar to RAID 5, but stores two parity stripes, allowing it to tolerate two drive failures. This is advantageous in worst-case scenarios where a second drive fails during the rebuild of a previously failed drive. RAID10 also tolerates two drive failures, but only if they are not from the same mirrored pair. RAID 6 allows any two drives to fail. However, because two drives are used for parity, RAID 6 is typically used in systems with more than four drives. With only four drives, storage efficiency is 50%, the same as RAID10. The




**Picture 3:** 10GbE connection

added tolerance for random drive failures may justify choosing RAID 6 over RAID 10, so we evaluated this configuration as well.

## Methodology

To evaluate the performance of various RAID configurations on the UGREEN DXP4800 Plus NAS, we followed a structured benchmarking approach focused on sustained throughput and realistic workload simulation.

For each RAID level tested, a dedicated HDD storage pool was created within the NAS. After allowing full initialization of the array, we provisioned a thick iSCSI block storage target using 80% of the pool's usable capacity. This target was connected to an application server via the 10GbE network interface. On the Windows server, a 15TB logical drive was created, populated with 2TB of test data, and subjected to performance benchmarking.

The following workloads were benchmarked:

- Sequential write of 1MB blocks
- Sequential read of 1MB blocks
- Random read/write operations using mixed block sizes

Note: While most NAS systems are typically used for shared file access via protocols like SMB, benchmarking SMB performance is often inconsistent due to caching and protocol overhead. To ensure reproducibility and determinism, we opted for iSCSI block-level testing. Although iSCSI and SMB differ in

**These are the “FIO” (flexible IO tester) command lines:**

```
fio --filename=test --size=2T --direct=1 --rw=write --bs=1m --iodepth=32 --time_based --runtime=20m --group_reporting
--name=job1 --ioengine=windowsaio --thread --numjobs=16 --group_reporting --output=write.txt --norandommap --randre-
peat=0

fio --filename=test --size=2T --direct=1 --rw=read --bs=1m --iodepth=32 --time_based --runtime=20m --group_reporting
--name=job1 --ioengine=windowsaio --thread --numjobs=16 --group_reporting --norandommap --randrepeat=0

fio --filename=test --size=2T --direct=1 --rw=randrw --bssplit=4k/20:64k/50:256k/20:2M/10 --iodepth=8 --time_based --runt-
ime=20m --group_reporting --name=job1 --ioengine=windowsaio --thread --numjobs=32 --group_reporting --output=mixed.
txt --norandommap --randrepeat=0
```

**Table 1:** FIO measurement scripts

implementation, the performance results obtained here are expected to approximate real-world shared file storage behaviour under similar conditions.

To discuss and understand the results for a multi-drive configuration, the performance of a single drive was evaluated with the reference scripts as well:

| Disk Model | Capacity | Single Disk Performance | | |
|---|---|---|---|---|
| | | SeqWrite | SeqRead | Mixed |
| N300 8TB (HDWG780) | 8TB | 281 | 283 | 68 |

**Table 1:** FIO performance results for a single HDD

## Results: Single HDD Pool with 10GbE Connection

The following table summarizes the performance of the UGREEN DXP4800 Plus NAS using a single HDD storage pool configured in RAID 5, RAID 6, and RAID 10. All tests were conducted over a single 10GbE connection.

## Analysis

The benchmark tests were designed to simulate realistic NAS workloads using iSCSI block storage over a 10GbE connection. Three RAID configurations – RAID 5, RAID 6, and RAID 10 – were evaluated using sequential and mixed I/O patterns.

Sequential Write & Read (1MB blocks)

- RAID 5 delivered the highest sequential write throughput (1068 MB/s), closely followed by RAID 10 (1034 MB/s) and RAID 6 (958 MB/s).

- Sequential read performance was nearly identical across all configurations (~1150-1170 MB/s), indicating that the 10GbE link was saturated and the RAID level had minimal impact on read throughput.

Mixed Workload (Random Read/Write with varied block sizes)

- RAID 5: 68 MB/s
- RAID 10: 40 MB/s
- RAID 6: 32 MB/s

| Manufacturer | Model | Disk Model | Capacity | Number | Config | Capacity | Performance | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | SeqWrite | SeqRead | Mixed |
| UGREEN | DXP4800 Plus | N300 8TB (HDWG780) | 8TB | 4 | RAID5 | 24TB | 1068 MB/s | 1170 MB/s | 68 MB/s |
| | | | | | RAID6 | 16TB | 1010 MB/s | 1152 MB/s | 32 MB/s |
| | | | | | RAID10 | 16TB | 954 MB/s | 1165 MB/s | 40 MB/s |

**Table 1:** FIO Benchmark Results (Single 10GbE Link)

Surprisingly, RAID 10 underperformed compared to RAID 5 in mixed workloads. This is atypical, as RAID 10 is generally expected to excel in random I/O due to its mirrored structure and lack of parity overhead.

- Several factors may explain this anomaly:
- Mirrored Write Overhead – RAID 10 duplicates every write operation across mirrored pairs. With 32 concurrent threads and a mix of small blocks, this can introduce latency and reduce throughput.
- Controller Optimization Bias – The RAID controller may be optimized for RAID 5/6, handling parity calculations efficiently while not fully leveraging RAID 10's parallelism.
- FIO Configuration Impact – The mixed test used iodepth=8, which may not have been sufficient to fully exploit RAID 10's parallelism. The block size distribution (bssplit) was dominated by 64k blocks (50%), which may favour RAID 5's striping over RAID 10's mirroring.
- No SSD Caching – With caching disabled, the raw disk performance becomes the bottleneck. RAID 10's advantage in handling frequent random reads may be less pronounced without cache acceleration.

## Recommendations

**RAID 5 –** Best Overall Balance

Use Case: General-purpose NAS with high capacity and good performance.

Pros: Highest usable capacity (24TB), strong sequential and mixed performance.

Cons: Can only tolerate one drive failure.

**RAID 6 –** Best for Data Protection

Use Case: Archival or mission-critical storage where fault tolerance is key.

Pros: Can survive two simultaneous drive failures.

Cons: Lowest mixed performance and usable capacity (16TB).

**RAID 10 –** Use with caution

Use Case: Workloads with high random read/write demand, ideally with SSD caching.

Pros: Simple recovery, good sequential performance.

Cons: Mixed performance lower than expected; only 50% usable capacity.

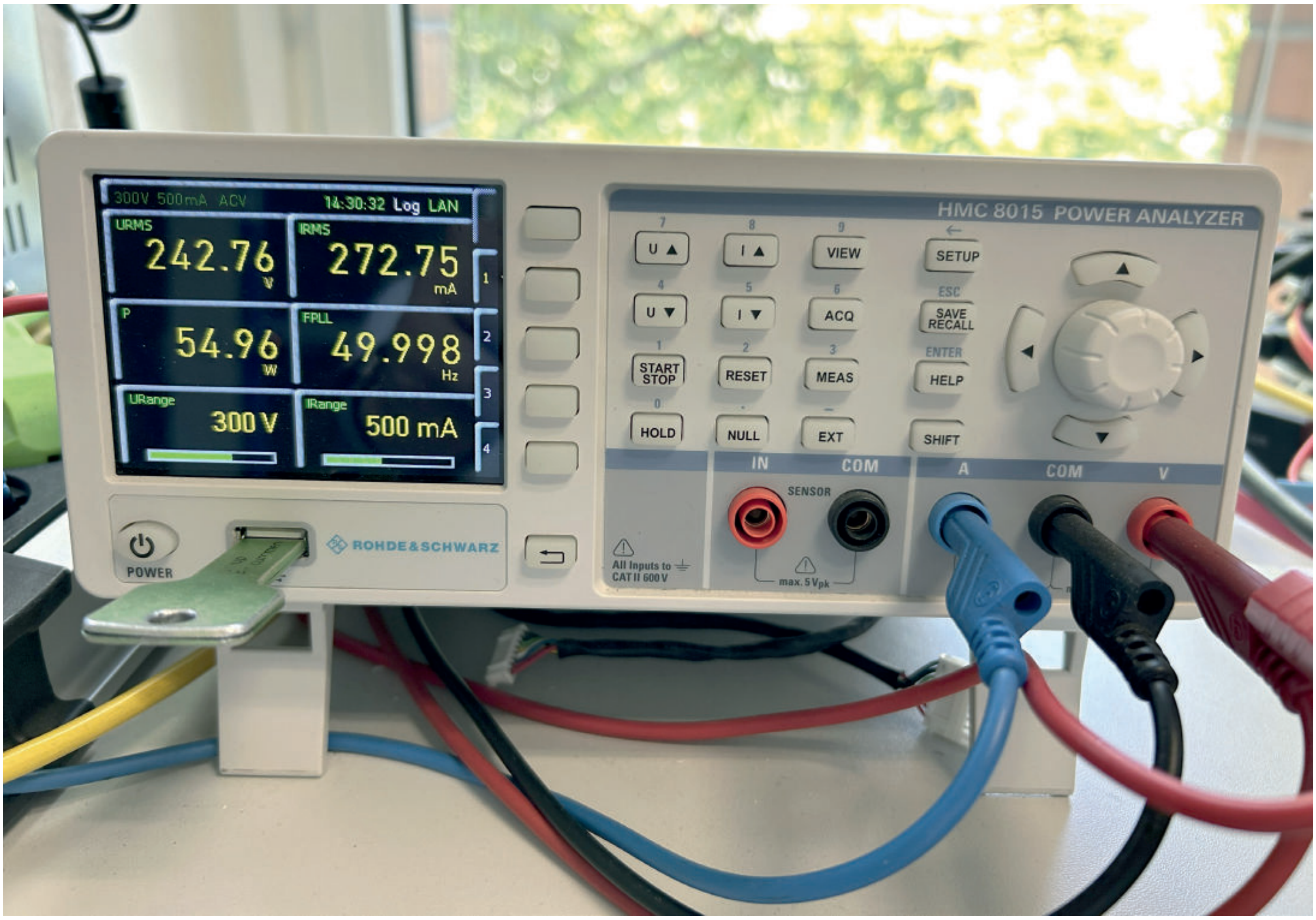
**Note:** On networks limited to 1GbE, RAID performance differences are masked by the bandwidth ceiling (~110 MB/s). In such cases, RAID selection should prioritize redundancy and capacity over speed.

## Power consumption and HDD temperature

Power consumption was measured across various operational states of the UGREEN DXP4800 Plus NAS system equipped with four Toshiba N300 8TB HDDs. The results are summarized below:

| Power Consumtion | Disk | Number | Power | | | | |
|---|---|---|---|---|---|---|---|
| | | | Off | Sleep | Idle | Operating 1x10GbE | Startup Max |
| UGREEN DXP4800 Plus | N300 8TB | 4 | W | W | W | W | W |
| | | | 0 | 27 | 50 | 55 | 60 |

**Table 1:** Power consumption




**Picture 4:** Power measurement equipment

Sleep Mode (27W): In sleep mode – where no storage access or GUI interaction occurs – the system consumes approximately 27W. This reflects the baseline power draw of the NAS processing unit. The HDDs enter standby mode, consuming minimal power (~0.57W per drive as per Toshiba datasheet), which confirms that disk impact is negligible in this state.

Idle and Operating States (50–55W): During idle and active data transfer over a 10GbE link, power consumption rises to 50–55W. This includes the operating power of all four HDDs, each rated at ~8.19W under load. The system remains energy-efficient even during sustained operation.

Startup Peak (60W): The highest power draw occurs during startup, when all drives spin up simultaneously. This peak is brief and within expected limits for a 4-bay NAS with enterprise-grade HDDs.

The DXP4800 Plus demonstrates excellent energy efficiency across all operational states. Its low power footprint in sleep and idle modes supports sustainable 24/7 operation, while peak consumption remains well within acceptable limits for a high-performance NAS. These characteristics make it suitable for both home and business environments where energy cost and thermal management are important considerations.

| Temperature | | Disk | Power | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | | | Ambient | Sleep | Idle | Loaded |
| | | | degC | degC | degC | degC |
| UGREEN | DXP4800 Plus | N300 8TB | 23 | 21-24 | 35-40 | 38-44 |

**Table 4:** HDD temperature

Sleep & Idle: HDDs remain cool during low activity, with temperatures ranging from 21°C to 40°C depending on ambient conditions.

Loaded (38-44°C): Even under sustained data transfer, the DXP4800 Plus cooling system effectively keeps HDD temperatures below 45°C – a critical threshold for long-term reliability.

## Conclusion

The UGREEN DXP4800 Plus is a well-balanced NAS solution offering high capacity, strong performance, and excellent energy efficiency. RAID 5 is recommended for general use, while RAID 6 suits critical data protection scenarios. RAID 10 may require further tuning or caching to reach its full potential in mixed workloads.

## Note of thanks to our partners

"Important to the success of this lab report has been the collaboration. I would like to thank our partner UGREEN for the support on this project, as they contributed with the DXP4800 Plus NAS unit and valuable support and advice. Together with our Toshiba NAS Hard Disk Drive models, we were able to evaluate all aspects of the different RAID levels and provide valuable guidance for NAS users and administrators."

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Interested in performing a test in our lab yourself or planning a visit? We'd be happy to support you.

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