QLC Flash: Meeting the Challenges of the New Data Economy

Derek D. Dicker
Micron Corporate Vice President, Storage Business Unit
Micron Technology, Inc. is founded
1978

Micron Technology, Inc. is founded
The New Data Economy is accelerating data creation

2017-Now

22,000 billion GB created in 2017

62,000 billion GB to be created in 2021

Client PC

- >80% PC SSD adoption anticipated
- >2X expected average capacity increase

Source: Micron, 2021 data from IDC WW 2017-2022 SSD Market Forecast Update
Mobile PC

- >80% SSD adoption anticipated with 5G
- >2X expected average capacity increase and >3X NAND per phone anticipated

Source: 2021 data from Micron
Mobile

- 100X network bandwidth increase with 5G
- 1.7X increase in DRAM and >3X NAND per phone anticipated

Automotive

- Vehicle sensors projected to increase to 200 per car
- 22 billion sensors generating automotive data a year

Automotive Things

- Vehicle data growing projected business data to 200 per car
- 3 image sensors
- 22 billion sensors anticipated

Source: 2020 data from equalum.io: "The Future of Big Data is Here"
Sensor data growing at 50X business data
3 image sensors for every human anticipated
AI requires memory and storage to deliver results

Harvesting Big Data to Create Immense Value
AI Workloads Unleash the Need For More Memory & Storage

AI Training Impact in 2021 vs. Standard Server Config

<table>
<thead>
<tr>
<th></th>
<th>DRAM (per server)</th>
<th>NAND (per server)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>145GB</td>
<td>2TB</td>
</tr>
<tr>
<td>2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>366GB</td>
<td>11TB</td>
</tr>
<tr>
<td>2021</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AI Training</td>
<td>2.5TB</td>
<td>20TB</td>
</tr>
<tr>
<td>2021</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Micron
AI Workloads Unleash the Need For More Memory & Storage

Systems are already capable:

1.5TB DRAM
30TB NAND
AI & DL Are Changing the IO Patterns of the Data Center

Traditional Data Center IO VS. IO pattern, Deep Learning for AI

4:1 read-to-write ratio VS. 5000:1 read-to-write ratio

Source: EnterpriseStorageforum.com: "Data Storage, AI, and IO Patterns"
Accelerating Intelligence
Spanning the Memory & Storage Continuum

- DRAM
- NVDIMM
- 3D XPoint™
- NVMe™ SSD
- SATA SSD

Real-time
In-memory
Processing

Storage Applications

NAND
NAND
NAND
CMOS under the Array (CuA)

NAND with CUA
- Metal
- Array Structure
- CMOS Circuits

Top Down View
CMOS under Array
- Enabled Cost Reduction & Performance Improvements
Array Stacking

- 50% increase in layers
- Sets write bandwidth benchmarks
- Array stacking for the 2nd time
- Uses CMOS under array for the 3rd time
Russ Meyer
Micron Corporate VP of Non-Volatile Memory Integration
4th Gen 3D NAND: Optimized for performance and scaling.

- Micron Developed
  - Micron’s solely developing Replacement Gate (RG) technology

- Uniquely Designed
  - Incorporates unique combination of CMOS under array with novel charge trap cell technology

- Performance Driven
  - Targets industry-leading die size & performance
4th Gen 3D NAND:
Optimized for performance and scaling.

Significant Improvements Optimized To Meet Future Needs Of Multiple End Markets

- Performance Improvement:
  - 96 Layer
  - Gen. 4

- Lower Power:
  - 96 Layer
  - Gen. 4

- Write Bandwidth: >30% increase
- Energy/Bit: >40% decrease
Micron Innovation in NAND

4 bits per cell

SLC
1 bit/cell

MLC
2 bits/cell

TLC
3 bits/cell

QLC
4 bits/cell
Now Shipping the Industry’s First QLC SSD
Read-Intensive Enterprise Workloads at 7X lower TCO

QLC refers to 4 bits per cell. TCO vs. 7200 RPM HDD for same performance
Right-sized, cost-effective performance for the top workloads of today & tomorrow

Real-time analytics & read-centric data stores

Content delivery & distribution
The QLC Workload Advantage

BI/DSS with MS SQL: Get more out of less

25% fewer drives to achieve 4.6x better query results

5210 QLC TLC (x4) vs. 2.4TB 10K HDD (x8) x86 (x1)

Source: Micron
TPC-H testing performed by Micron.
No SQL Cassandra
Get nearly 4x the IO performance with a fourth of the drives

Source: Micron
YCSB testing performed by Micron
The QLC Workload Advantage

Ceph Object Store:
Ceph with QLC is a cost-effective media streaming solution.

3 Node Ceph Cluster
24X 8TB 5210 ION SSDs can produce:
70Gbps object read output

Source: Micron
RADOS Bench object storage benchmark performed by Micron.
Unleashing NAND with Software

Increasing QLC NAND throughput & endurance

2X better throughput

4.5X reduction in write amp

Source: Micron
Unleashing NAND with Software

Micron storage stack: Designed to optimize database application

- Reduced Latency: 95%+ latency reduction
- Lower System Write Amplification: More than 8X improvement
- Reduced Power Consumption: 7X improvement
- Increased Operations per Second: More than 8X improvement

Source: Micron
Researchers accelerated speeds on our weather sampling database by more than 2X ... which will enable more comprehensive and fine-grained understanding of climate conditions and natural hazards.
Transforming how the world uses information to enrich life.
Join Micron at FMS 2018:

Booth 407

Breakout sessions:

- QLC Is the Best Way to Replace Enterprise HDDs
  Today | 3:40-4:45 p.m. | Great America Ballroom J

- Meeting the Storage Needs of 5G Networks
  Today | 4:55-6:00 p.m. | Great America Ballroom J

- QLC and Mixed Mode SSDs Require Deep FTL-Tuning
  Today | 3:40-6:05 p.m. | Great America Meeting Room 1

- New Flexible Form Factors for Enterprise and Data Center SSDs
  Tomorrow | 8:30-10:50 a.m. | Great America Ballroom K

Reception: 7 p.m. tonight in the Terra Courtyard
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