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10 Yeas of Leading World-Class Innovation

- **SandForce**
  - 10x Flash Life
  - $20 → $3 / GB
  - SLC → MLC

- **skyera**
  - 100x Flash Life
  - $20 → $3 → $1 / GB
  - eMLC → MLC → TLC
  - Compression + Dedup.

- **Tachyum™**
  - 300x Flash Life
  - $20 → $3 → $1 / GB
  - TLC → QLC
  - Compression + Dedup.
  - Hyperscale-Out

Tachyum Confidential and Proprietary. Flash Memory Summit 2018, Santa Clara, CA.
Flash-Only Datacenter for Lower Cost & Power

- Flash is already cheaper than 10TB disk drive in hyperscale/Hadoop system
  - Disk 11¢/GB: 3 copies 10TB 3.5” $320 HDD = 9.6¢/GB + 1.4¢/GB system
  - Flash 9¢/GB: DRAMeXchange 32GB USB $2.5 mCOB = 7.8¢/GB + 1.2¢/GB system

- 1¢/GB effective achievable for flash
  - 5:1 compression + deduplication, 2:1 thin provisioning, zero overhead snapshots + clones

- 3 copies vs. RAID6 used to avoid 4x slowdown of slow HDD & high CPU cost
  - RAID6 for write requires 3 reads and 3 writes reduces 2x performance at 4:1 read/write ratio
  - If drive is failed then for 1/n drives (n-1) drives needs to be read leading to 2x slow down
Networking: 10x Bandwidth at Same Cost

Copper Rack → Edge → Fabric → Spine

Copper Rack → Fiber Spine

128 x 2x100GE PAM4 switch chip
12U 4K ports x 200GE switch front-connector-back cards

4096 x 200GE
Private Cloud Architecture

- **Prodigy T864-32A**
  - 1.6Tb/s
  - 32 x 128Gb/s
  - 32 x 16GB/s

- **2048 x 4x100GE switch**
  - 1.6Tb/s
  - 50M IOPS, 1-8PB
  - Max 16 EB 100B IOPS
  - 15 + 1 redundancy 6.7%
  - 250 + 4 redundancy 1.6%

- **32 x 16GB/s**
  - 50M IOPS, 1-8PB

- **50M IOPS, 1-8PB**

Tachyum Confidential and Proprietary. Flash Memory Summit 2018, Santa Clara, CA.
10x Effective Life Amplification

- 10x life amplification from compression
  - The compression has non-linear impact on life amplification
  - Example 2:1 compression and 5% overprovisioning giving 10x life amplification
  - SandForce with IBM proved 10x life amplification with 2:1 compression in real life applications
  - Speaker was founder and CTO of SandForce
  - No other SSD controller succeeded in implementing compression based life amplification
100x Effective Life Amplification

- **2.5x Deduplication and improved compression**
  - From 2:1 compression to 5:1 compression and deduplication
  - Invented by Skyera and Pure Storage for primary flash storage
  - Speaker was founder and CEO of Skyera

- **3x One write for protecting against 2 SSD failures instead 3 writes for RAID6**
  - It is not compatible with standard SSD use and requires a custom flash controller
  - Garbage collection and compression must be done on system and not SSD level as in SandForce
  - Data are written sequentially; flash of different drives and protections symbols are accumulated
  - Invented by Skyera and Pure Storage for primary flash storage
  - Speaker was founder and CEO of Skyera

- **1.33x Thin provisioning, zero overhead clones and snapshots**
  - Invented by Skyera and Pure Storage for primary flash storage

- **100 x life amplification = 2.5 x 3 x 1.33 x 10x from compression + recycling**
300x Effective Life Amplification

• Typical enterprise storage and private cloud storage uses 3-copy system
  • RAID6 reduces 2-3x performance and by another 2-3x factor during long rebuild times
  • RAID6 does not help when whole rack fails or part of the building get damaged (fire, ...)
  • That is why primary system has mirror system and also backup system

• 3x From system level failure tolerance without need for 3 copies
  • Write data and metadata sequentially across flash in different systems
  • Distributed processing allows for 2-4 complete system failures without data unavailability
  • Tachyon’s Prodigy chip has enough spare performance to not show slowdown during rebuilds
  • Processor and network cost is reduced to low enough level that entire solution is cost effective
QLC Flash Can Replace HDD in Datacenters

- Assume 300 P/E (Program/Erase) cycles for QLC flash
  - 90,000 effective cycles = 300 x life amplification x 300 P/E cycles
- We need conventional SSD with flash with 90,000 P/E cycles
  - If we place them into existing RAID6 system
  - If we use snapshots, cloned and thick provisioning
  - If we make 3 copies for protecting against system failures
- HAMR disk drives write endurance is limited by laser active lifetime
  - Seagate proved single-head HAMR data writes of over 2PB (20TB drive has 16 heads)
  - So 2PB * 16 heads / 20TB = 1,600 full drive writes during lifetime, equivalent to 1,600 P/E cycles
- QLC is lower cost than disk drive in the datacenter with Tachyum chips
  - Disk 11¢/GB: 3 copies 10TB 3.5” $320 HDD = 9.6¢/GB + 1.4¢/GB system
  - Flash 9¢/GB: DRAMeXchange 32GB USB $2.5 mCOB = 7.8¢/GB + 1.2¢/GB system
- QLC endurance is sufficient for datacenters with Tachyum chips
  - 300 P/E cycles QLC with Tachyum chips has similar effective endurance as existing conventional datacenter using systems with SSDs with flash endurance 90,000 P/E cycles for typical
Software Model for Prodigy Chip Customers

• Tachyum does not build systems or software
  • But provides compiler and operating systems
  • Provides IP and libraries to builders of storage systems
  • Provides know-how how to build storage systems

• Tachyum-ported software
  • GCC with Tachyum backend, LLVM in 2019
  • Porting Linux and Free BSD in 2019
  • Device drivers, Boot-loader and Java JIT

• Existing Applications Recompiled
  • Hardware supports strong or relaxed memory ordering
  • Recompiled applications run faster than on Xeon
  • Apache, MySQL, Hadoop, Spark, TensorFlow, ...

• Existing binaries supported via emulators
  • QEMU and emulators transparently launched by Linux
  • Deployment of processor before all applications ported
  • Port CPU intensive application first, other later
Prodigy: Universal Processor / AI Chip

• Prodigy is a Server/AI/Supercomputer Chip
  • For hyperscale datacenters, HPC and AI markets

• First time humanity can simulate human brain-sized neural networks in real-time
  • Critical for the Human Brain Project

• Prodigy: a Tachyum Architecture

• Outperforms CPU, GPU and TPU
  • CPU: easy to program, costly & power hungry
  • GPU: much faster but very hard to program
  • TPU: faster but more limited apps than GPU
Prodigy: Big AI for Datacenters CAPEX Free

- Universal Processor / AI chip: 10x more AI using idle servers

- Avg. over 24 hours: 60-80% of servers are idle
  <5% of servers have AI GPUs
  Prodigy enables idle servers to be seamlessly and dynamically reconfigured into HPC/AI systems

- Existing Processors - too slow for AI therefore, GPU or TPUs are used
Brain Simulation In Hyperscale Datacenter

• From Rat Brain to Human Brain real-time simulation
  • SpiNNaker system 518,400 processors simulates rat brain
  • Human brain simulation requires 1,000x more performance
  • The NNSA 20 Pflops Sequoia is 1,542x slower than real-time

• How a system can be built in 2020
  • 256K servers, each 4 x 2x100GE with no oversubscription
  • Partner’s 128 x 2x100GE PAM4 switch chip
  • Copper 64 nodes to rack switch, fiber to central switches
  • 12U 4K ports x 200GE switch, front-connector-back cards
  • Only 1 set of fibers 256 x 2x100 GE vs. 3 to central switches

• 100+ brain-capable datacenters
  • Facebook: 100MW datacenter with 442,368 servers
  • 40% utilization means 265,420 idle servers
  • Use $100B of underutilized equipment in the world
Prodigy Delivers Low Power Flash Cloud

- Datacenters today consume 2% total electricity
  - Consume 40% more power than UK
  - Emit more CO2 than world’s airliners

- 10% of planet energy by 2030
  - 15% growth: is 2x every 5 years
  - 40% of planet energy by 2040

- New Technology is needed
  - 10x lower power to continue growth
**Tachyum**  $10+B Semiconductor Company

**Product**  Faster & 10x more efficient processor than Xeon

**Disruption**  Flash only datacenters below disk drive cost

**Status**  Tape-out 2019, production 2020

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2018 Winner

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**HPCwire**  silicon startup coming onto the HPC/hyperscale scene with some intriguing and bold claims

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**451 Research**  attractive proposition for hyperscale cloud providers, which could potentially build a single architecture that could be repurposed

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**Microprocessor Report**  new 64-bit architecture that combines elements of RISC, CISC, and VLIW

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Hyperscale/Al/HPC  3x Lower Capex

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$24B market

10x less power

1st real-time human brain sized neural network sim