



High Performance SSD & Benefits for Server Applications

Sean In

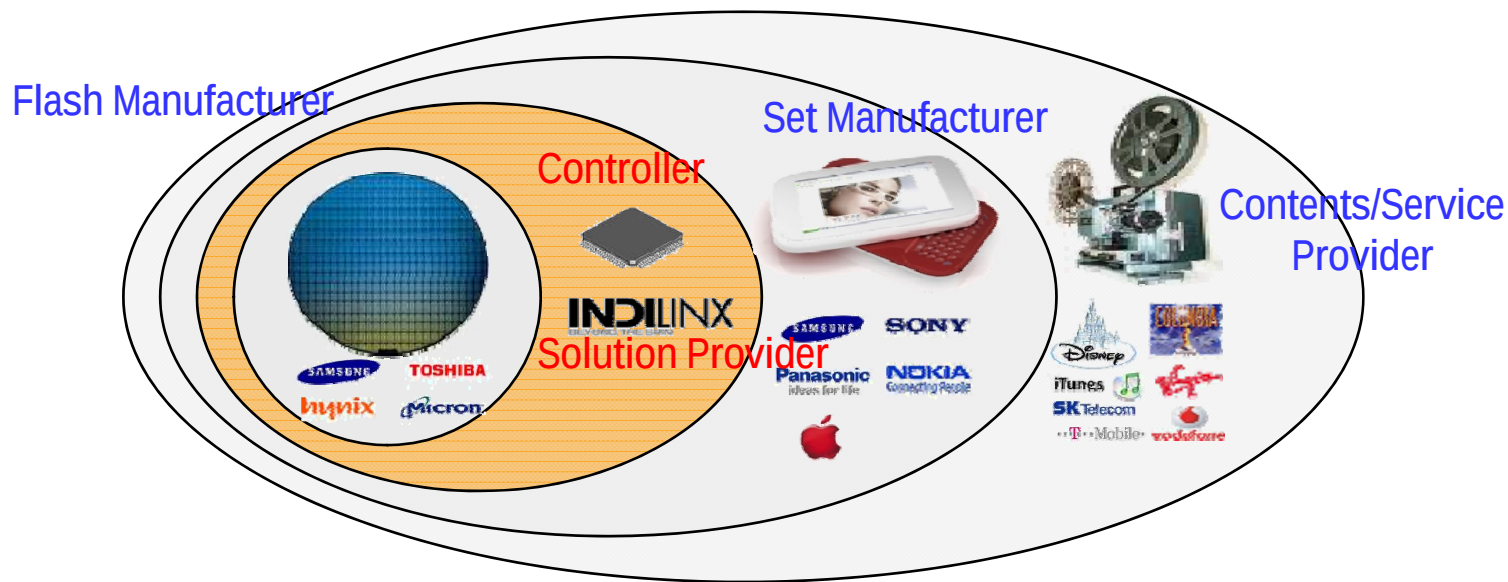
**Senior General Manager
Platform Marketing Group
INDILINX Co., Ltd.**

(The information contained herein is subject to change without notice)

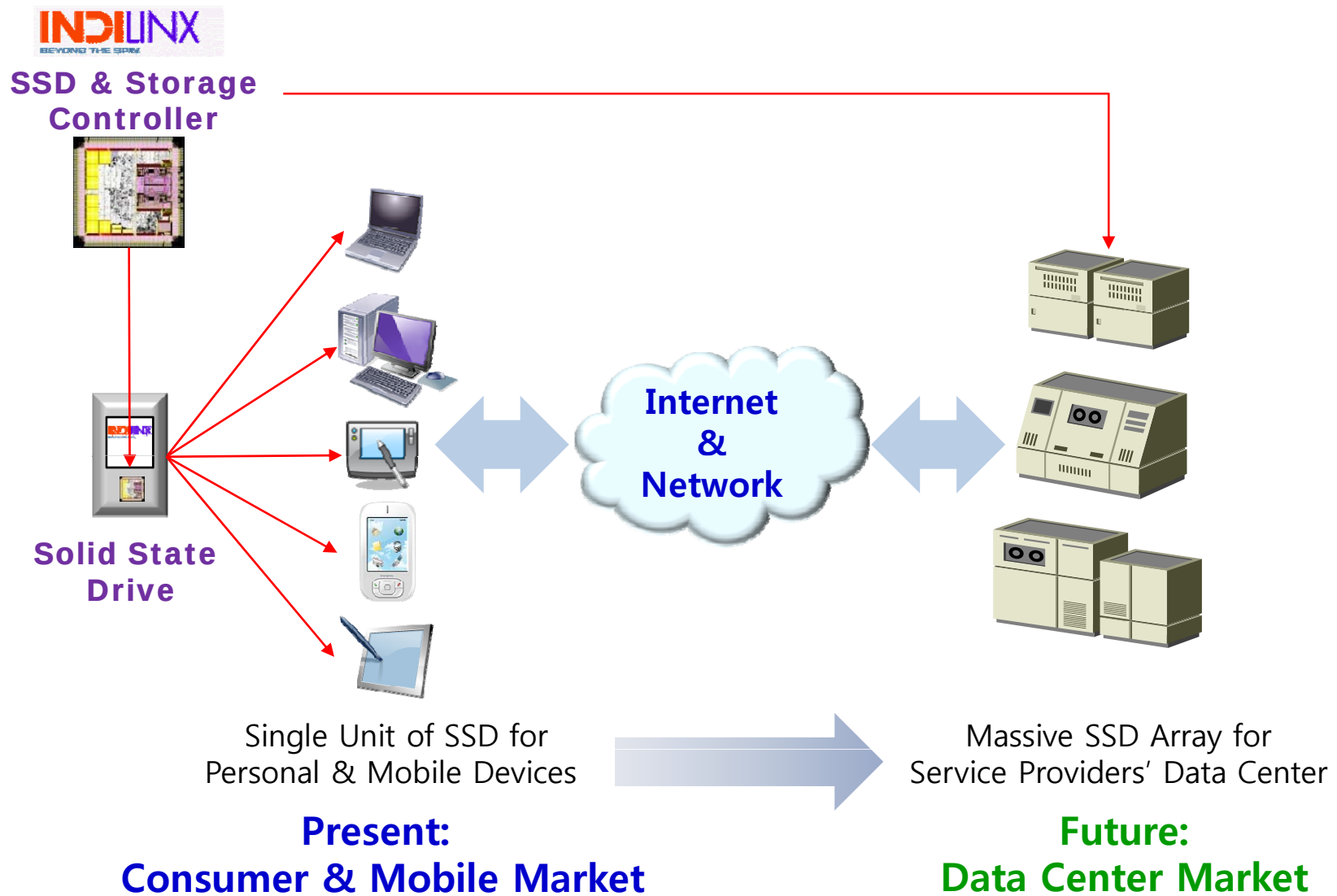
What is INDILINX

INDI = Independent **INXINX** = Link

- We create value by linking flash vendors to set the manufactures and service providers
- INDILINX is a fabless semiconductor company that specializes in the development of SSD Solutions
 - Controllers
 - S/W
 - SSD based Platforms
 - SSD based Solution



Our Mission



Company Overview

Company	INDILINX Co., Ltd.
Established	October 19, 2006
Location	Business HQ : Milpitas, California R&D Head Office : Bundang (South of Seoul), KOREA
Main Business	Fabless Semiconductor Design and Software Development Storage System Design and Development
Capital	\$ 4.5 Million (Total Equity)
Total Members	44 (23 Engineers)

Company Overview

World best Team Organization

– Engineering

- Possess 5~16 years' experience at Samsung, LG, Cisco, AT&T, Bell Lab & AMD
- Consists of highly educated & well experienced workforces
- Retains strong expertise in various fields of flash memory applications & systems e.g. ASIC, F/W, OS, H/W & Application S/W
- Boasts excellent product development, smooth team play and strong cooperative corporate culture

– Marketing & Sales

- Consists of highly experienced marketing members in the field of flash memory area and storage from Samsung, PQI, HP USA, and DELL USA
- Upgraded Samsung Electronics' flash memory division ranking from 7th place to 1st place ('99-'06)
- Expanded Samsung's flash memory business to mobile phone, MP3, Web Phone, DTV, Notebook PC, DSC, DVC and memory card markets
- Built up global platform strategy for SSD, Hybrid HDD market

INDILINX SoC Projects

BAREFOOT™

Code name for Flash SSD controller which has SATA2.0 interface and max. 230MB/s read speed, targeted high-end notebook PC and storage systems with a high reliability.

AMIGOS™

Code name for SSD controller which has SATA2.0 interface and optimized for low cost PC and mobile computing platforms e.g. Ultra Mobile PC, and WiBro terminals. It gives maximum cost performance.

JET STREAM™

Code name for next generation SSD controller which is targeting 600MB/s read speed with a SATA3.0 and new flash technology e.g ONFI and DDR Flash.



Under Planning

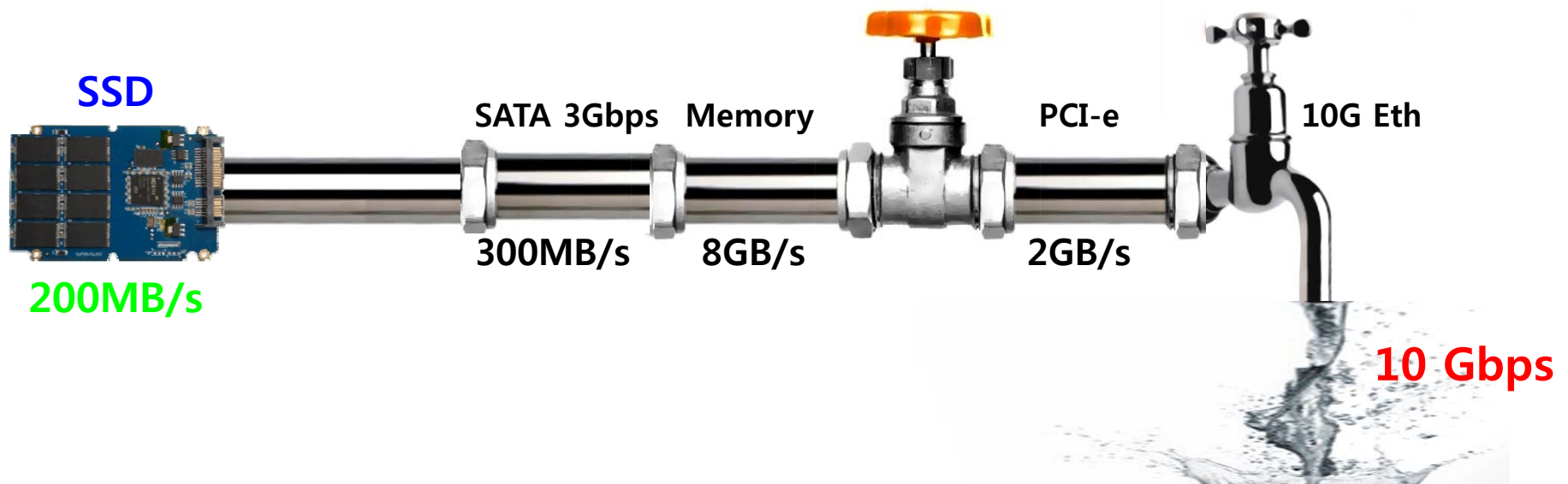
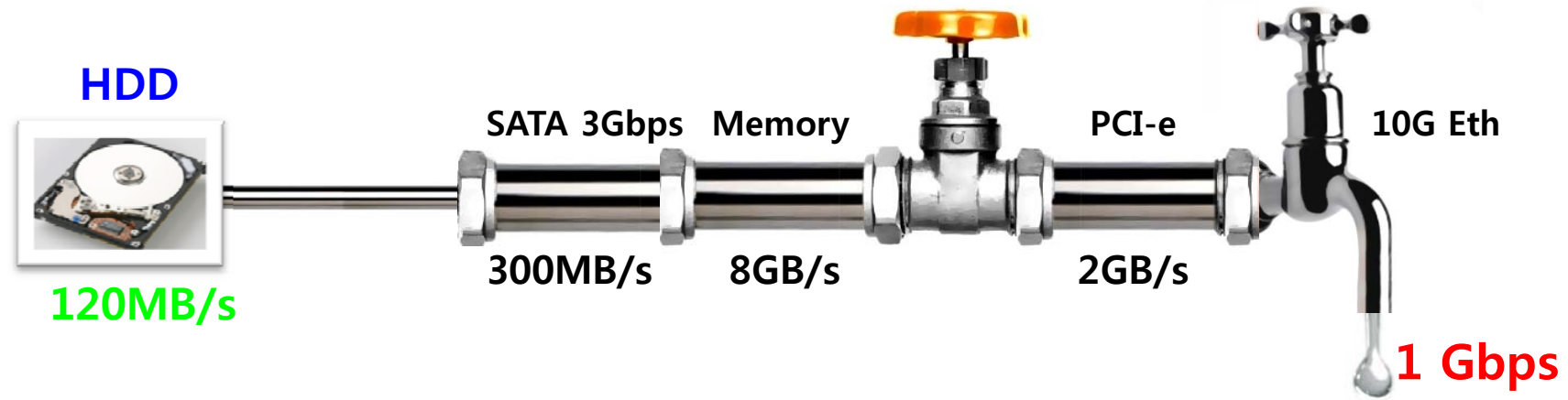
INDILINX Platform Projects

HILLVIEW™	SSD optimized server / workstation. SSD server validation, optimization, LINUX tuning, RAID configuration, application – OLTP, OLAP, Search Engine, Virtualization.
NIAGARA™	Code name for streaming engine solution: RTP/HTTP/FTP protocol media delivery solution. 10Gbps / 20Gbps.
PACIFIC™	Code name for special designed INDILINX's Flash SSD RAID (ROC) for maximizing SSD storage server system performance.
SKYVIEW™	Code name for next generation SSD storage.
GREENVIEW™	Code name for low power (green) IDC solution.

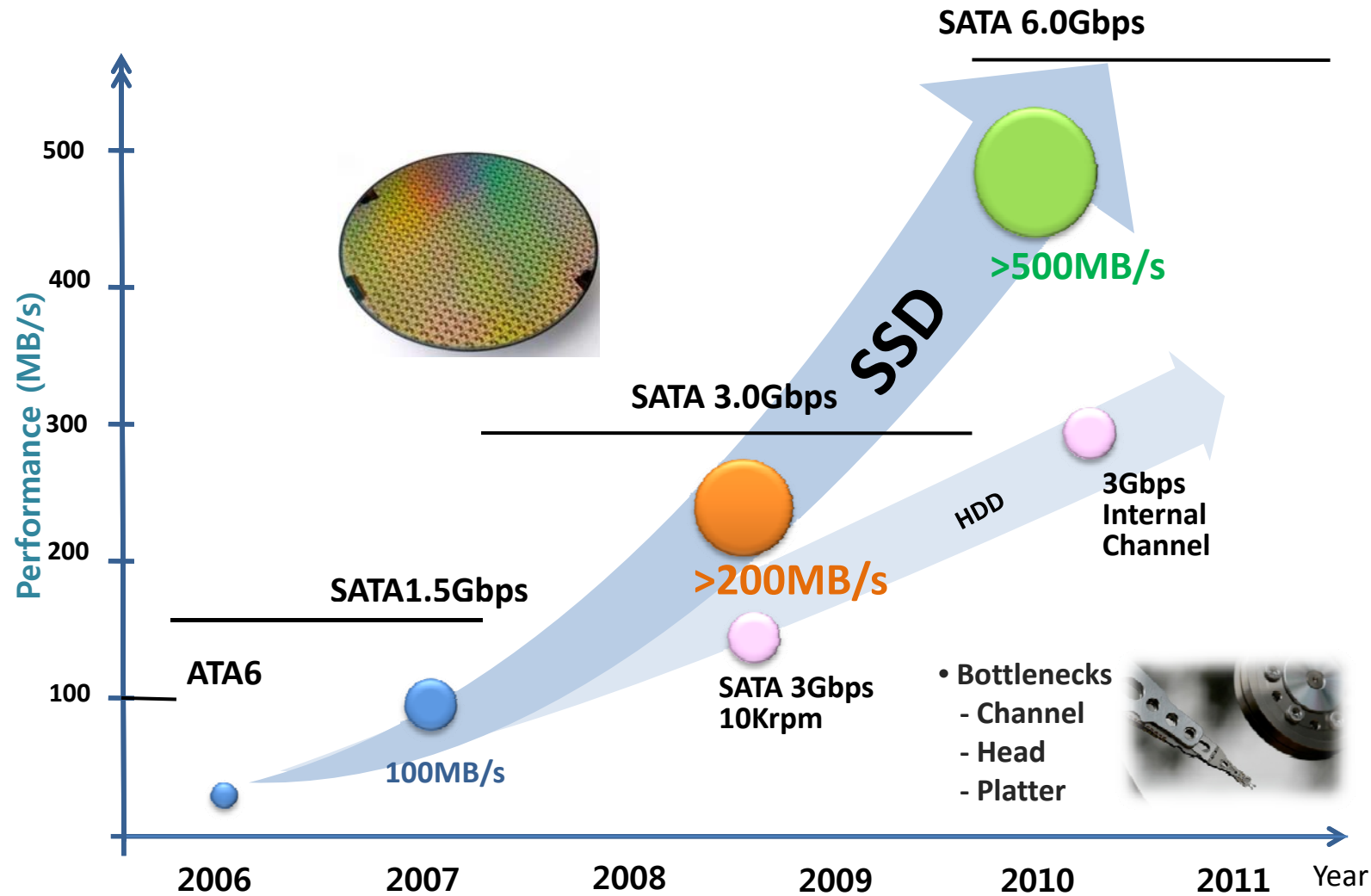


Under Planning

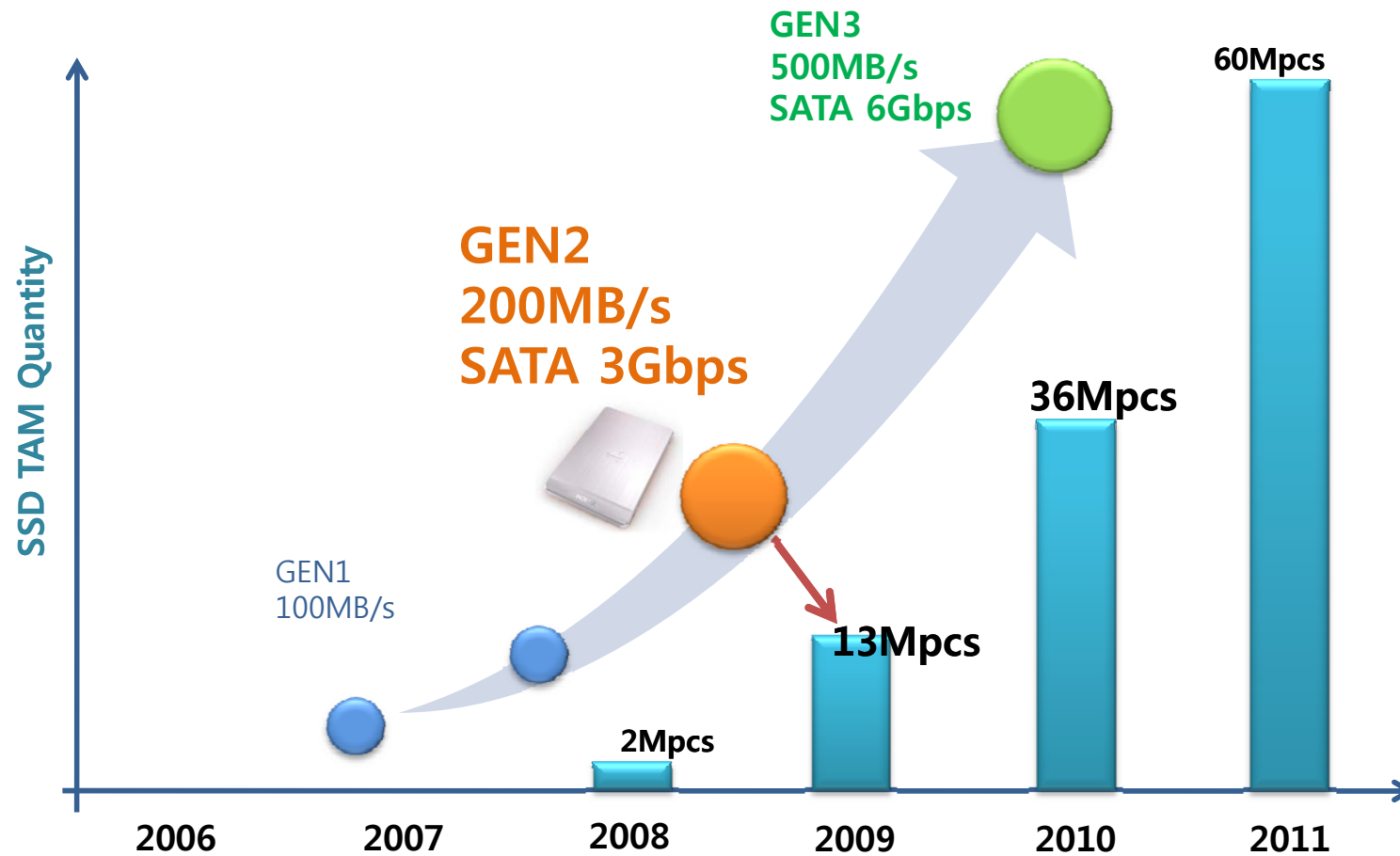
See the Difference!



Only SSD is the Solution!



CY2009 SSD

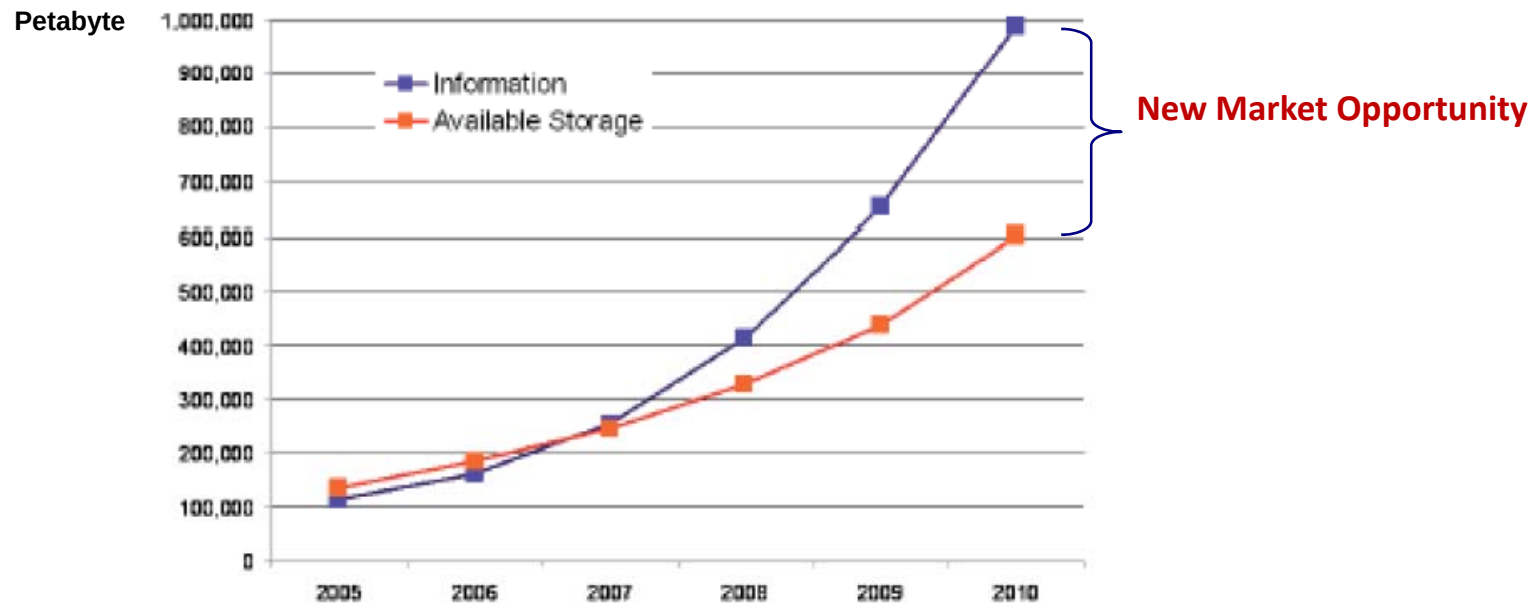


Source: isupply 2008

Storage Market Opportunity

In 2007, for the first time, the amount of information created surpassed the storage capacity available (255 EB vs. 246 EB)

Information vs. Available Storage

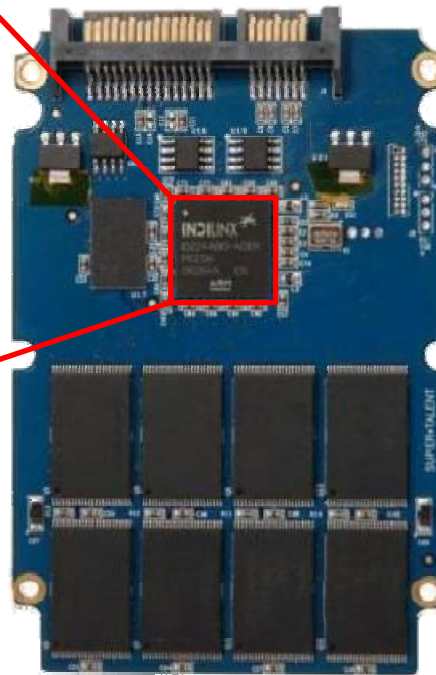


Source: IDC, 2007

- ✓ Average person's data storage growth = 250 megabytes per year
- ✓ The average company's data storage needs triple every 18 to 24 months with 75% of all IT spending dedicated to data storage

INDILINX GEN2 SSD Solution

Barefoot™



What is GEN2 SSD?

Requirements:

- Native SATA 3Gbps and Backward Compatibility
- Buffer/Cache Memory
- 200MB/s and up to 300MB/s Throughput
- Steady Performance under Fragmentation
- SLC/MLC Support
- More than 12bit/sector ECC
- 256GB and More Capacity
- Enhanced Power Management

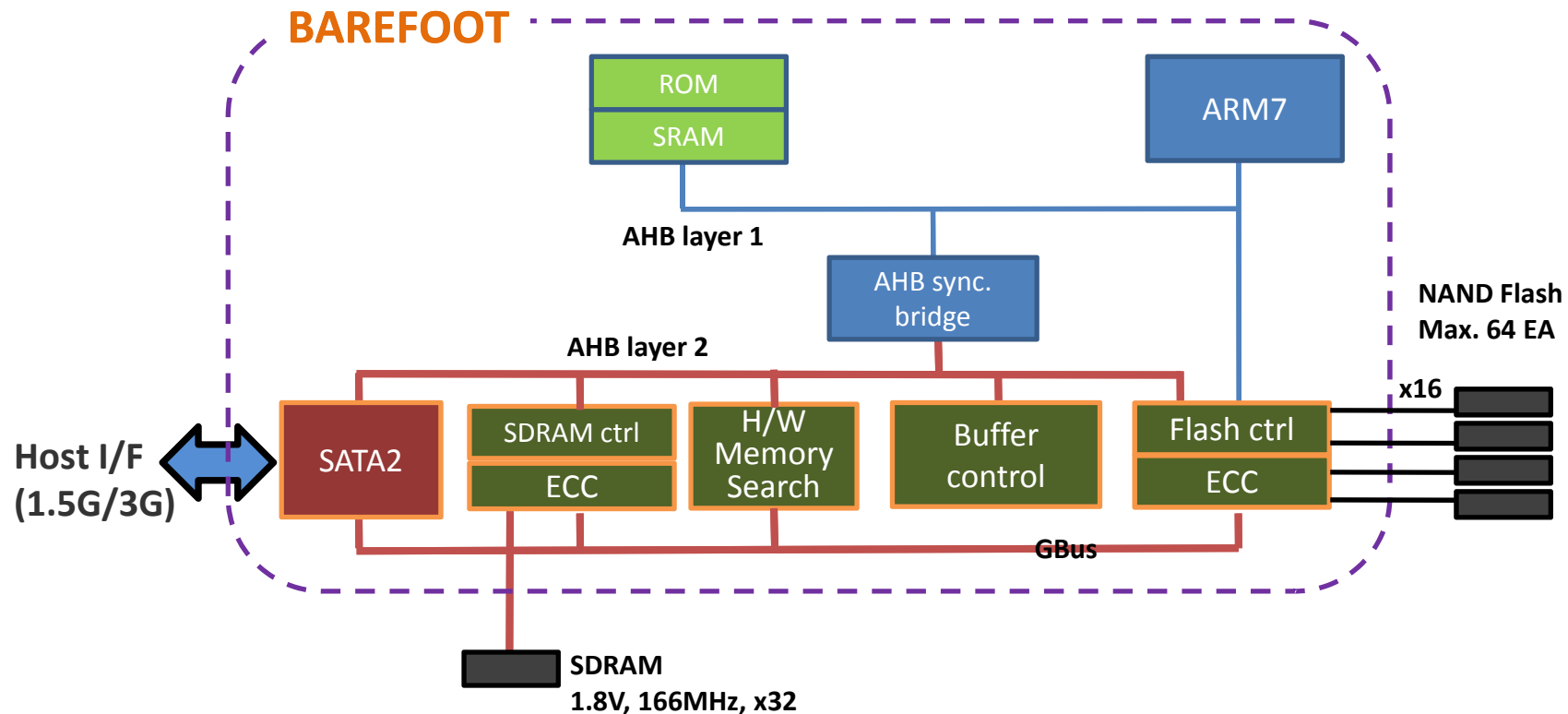
SSD Controller Product: Barefoot™

Items	Specifications
Host Interface	▪ SATA2 3Gbps
Process Technology	▪ 90nm
Operating Power	▪ 1.0V for Core, 1.8V for LP SDRAM, 3.3V for I/O
Density	▪ MLC : max. 512GByte, min. 16GByte (with 32Gb MLC NAND Flash) ▪ SLC : max. 128GByte, min. 4GByte (with 8Gb SLC NAND Flash)
Target Performance	▪ Sustained Read & Write with SLC : max. 230MB/s, max. 170MB/s ▪ Sustained Read & Write with MLC : max. 200MB/s, max. 160MB/s ▪ IOPS with SLC : target 20,000 (4K random read)
Operating / Standby Power / Slumber Mode	▪ 2 Watt / 0.5Watt / 0.1 Watt
Package	▪ 0.75 pitch 324 FBGA (14x14mm)



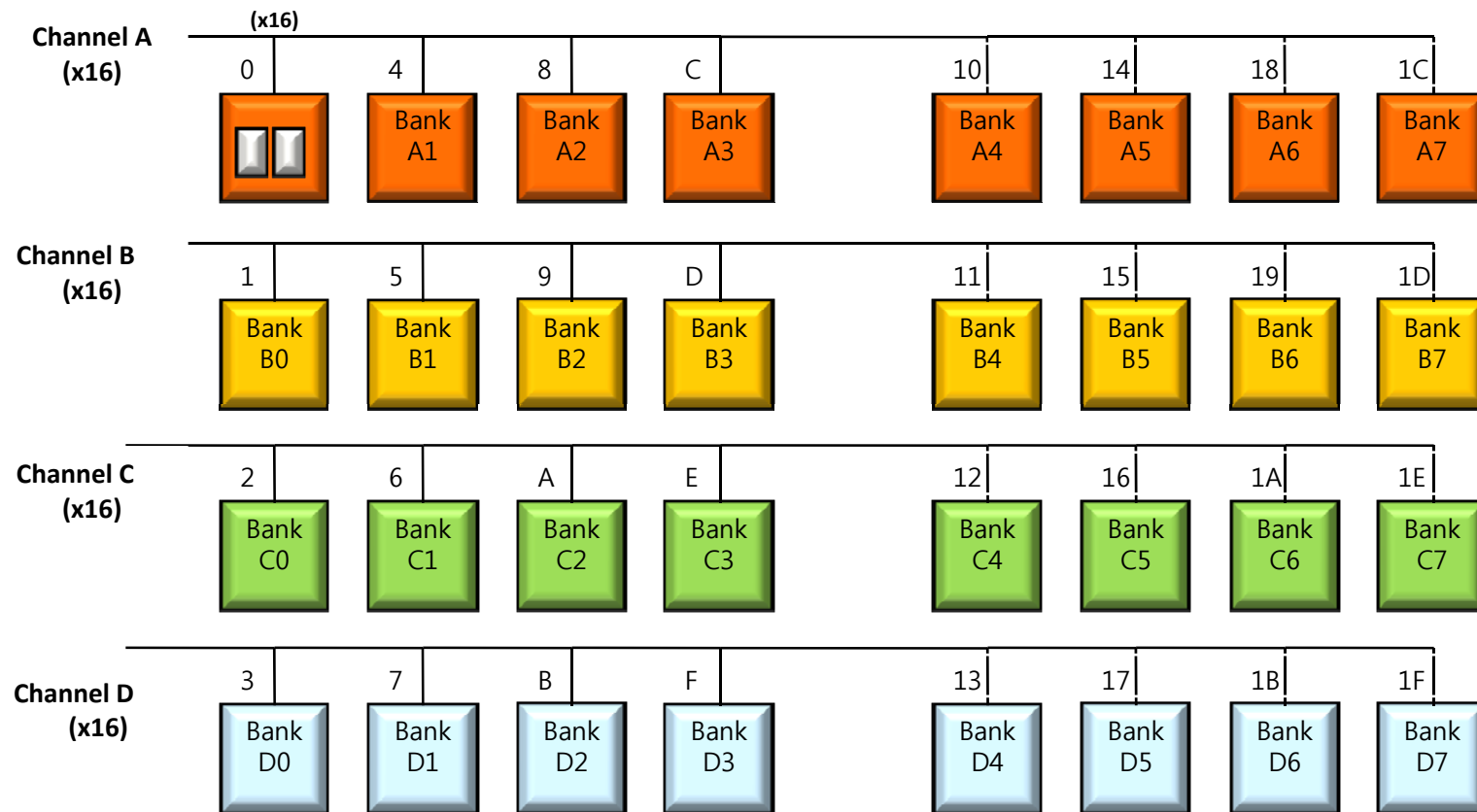
BarefootTM Architecture

- Embedded ARM7TDMI and Native SATA 3Gbp/s in Single chip controller
- 16~64MB LP SDRAM for buffer memory -> Less delay & latency
- Independent 4Channel (x16), 4way interleaving NAND I/F
- H/W memory search engine and the introduced high bandwidth AHB bus



NAND Flash BUS architecture

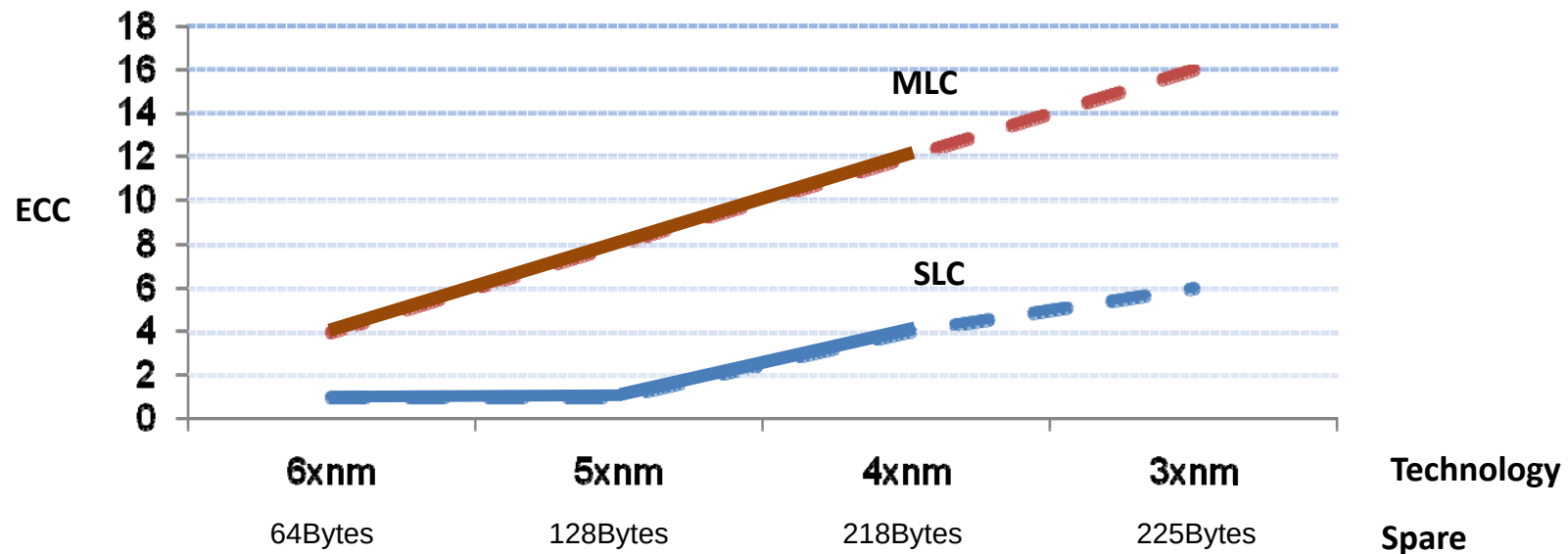
- Wide bus NAND I/F : 8 Channel, Actually 4channel(x16) and 4way interleaving



(1 CE/RB based)

Error Correction Capability

- Flash Memory
 - RS 6, 12bytes/sector Error Correction
 - BCH 8, 12, 16bits/sector Error Correction

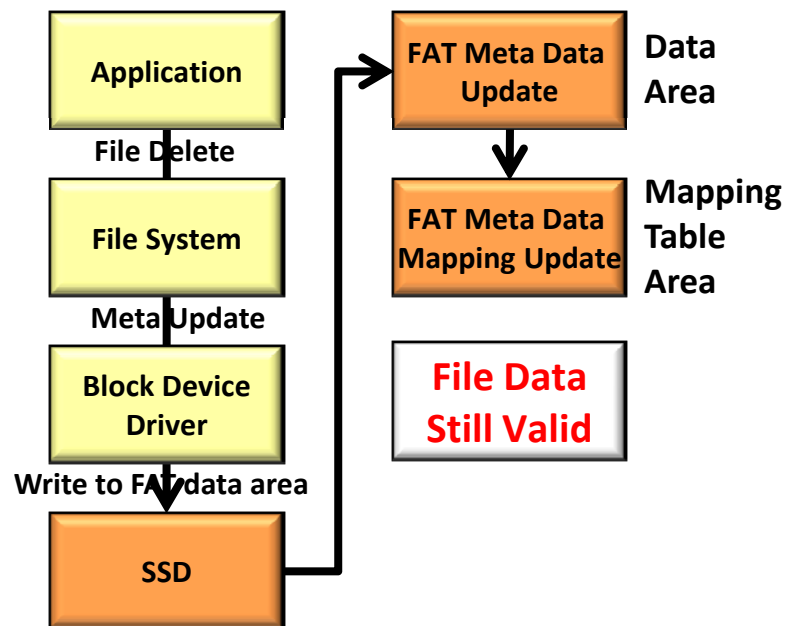


- SDRAM : 1Byte/64Bytes Error Correction

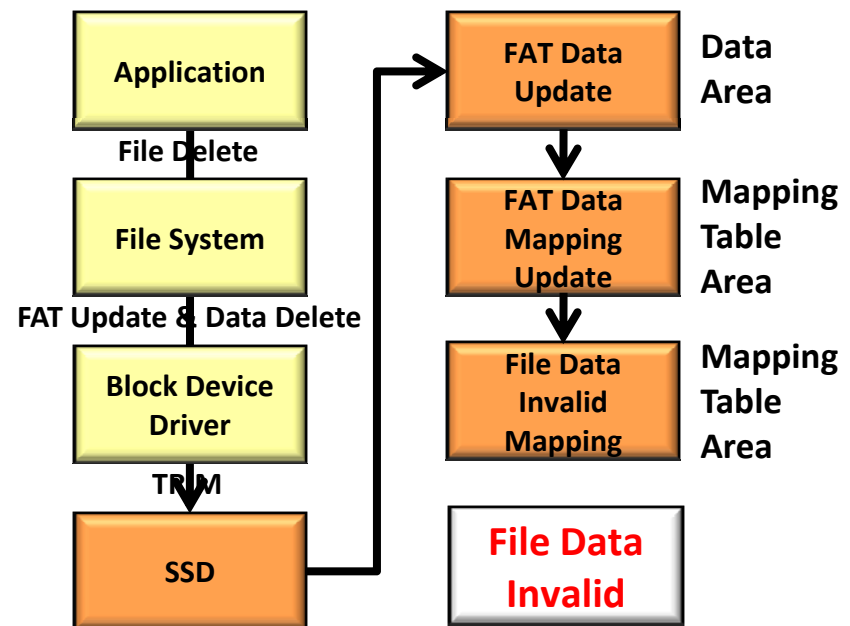
TRIM Command

- Resolves the mismatch between File System and FTL in SSD
- Enhanced performance and increased life time
- TRIM is proposed to T13 and planned to be a standard in next ATA spec.
- INDILINX has already developed TRIM solution for Linux

(Current)



(TRIM)



Test Cases

- **Device Test:**

 - Barefoot IOMETER Test

- **INDILINX Solutions:**

 - INDINux™** : Linux Kernel Patch Set (HillView)

 - INDIStreamer™** : Streaming Server (Niagara)

 - On-line Transaction Processing

- **Case Study:**

 - HTTP Download

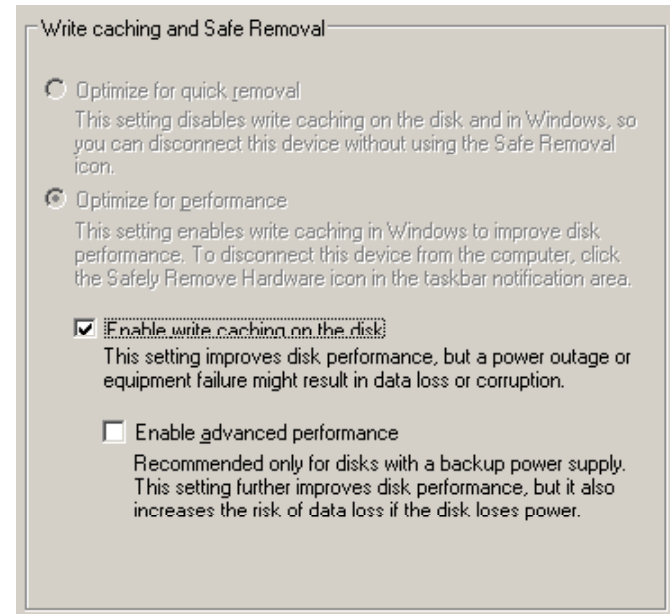
IOMETER Test Condition

Host:

- Motherboard LG Notebook RS10 CPU Intel Core2 Duo 2.0GHz
- RAM 3GB
- OS Windows VISTA
- AHCI enabled Write Cache Enabled (see Figure)
- Host controller Intel ICH9M AHCI

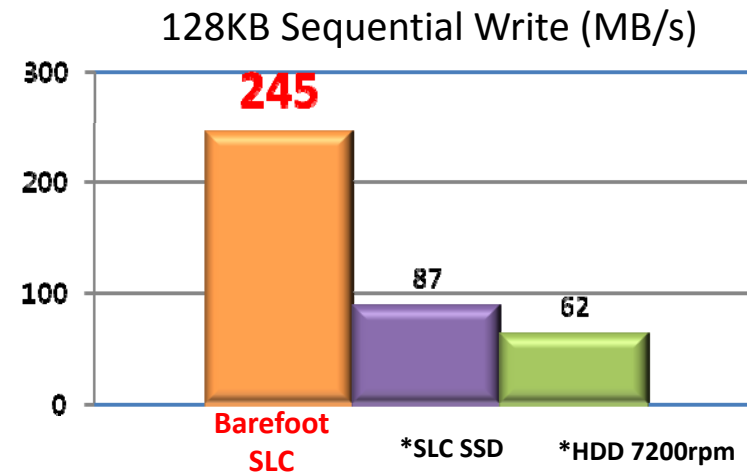
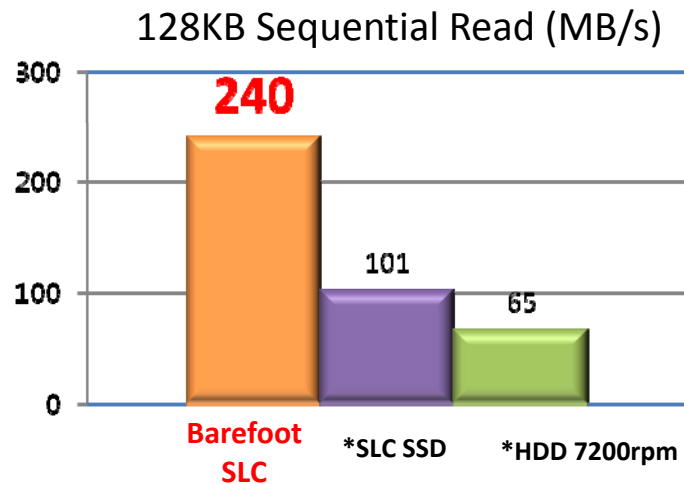
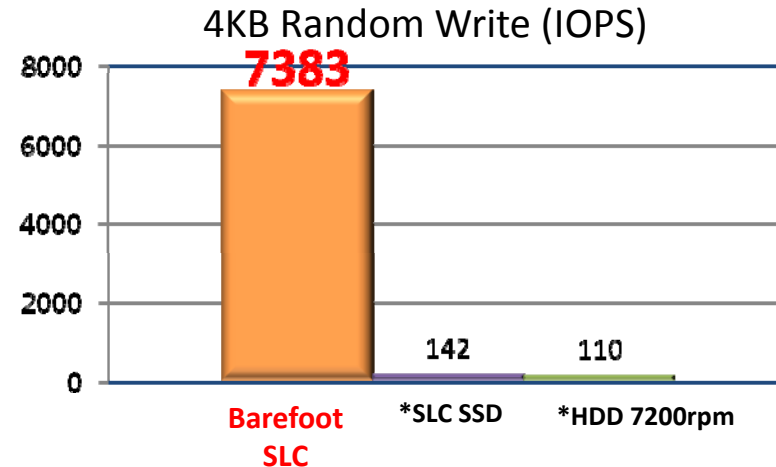
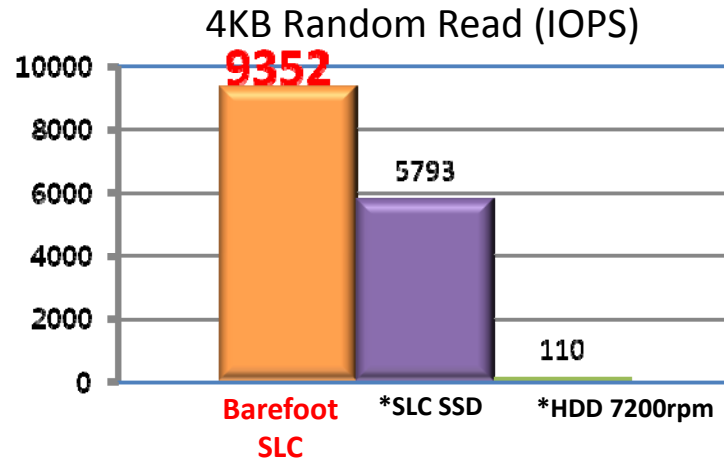
Device:

- Model Barefoot v0.9 (revision 357)
- Controller MPW prototype 175MHz NAND flash
samsung K9KAG08 (SLC 8Gb/die x DDP = 16Gb)
32GB total)
- SDRAM Samsung 64MB



Iometer Test Results - SLC

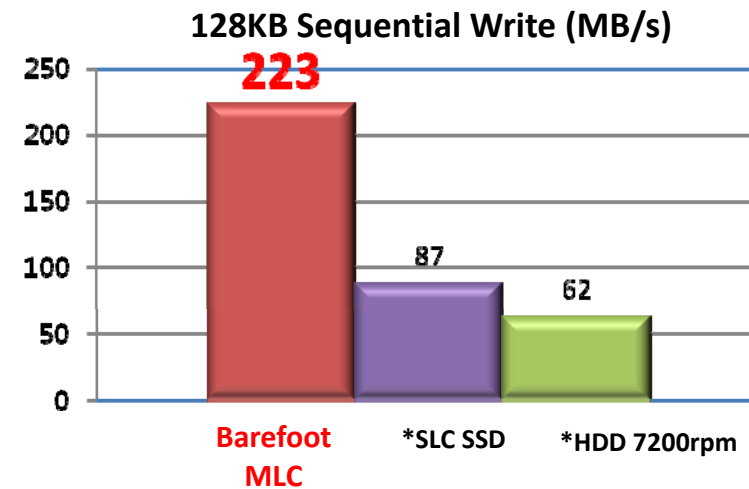
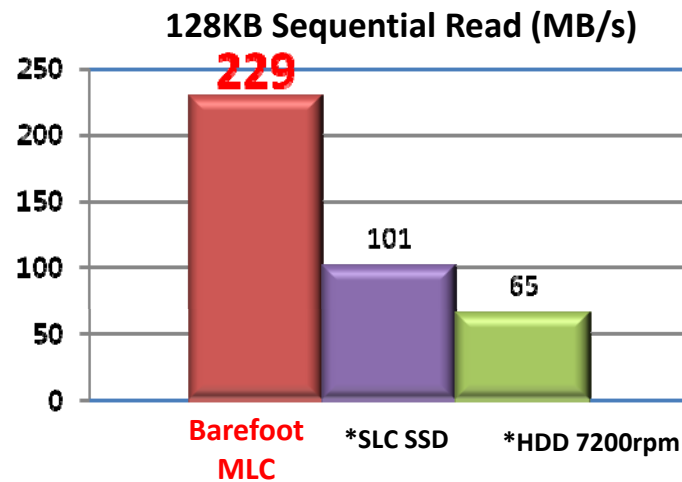
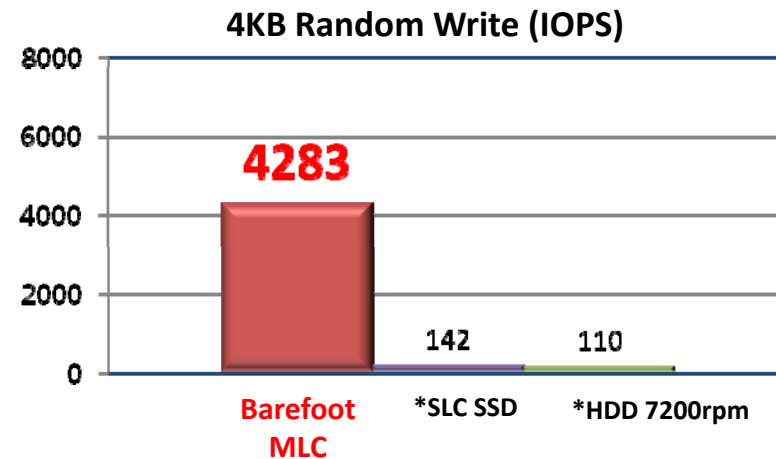
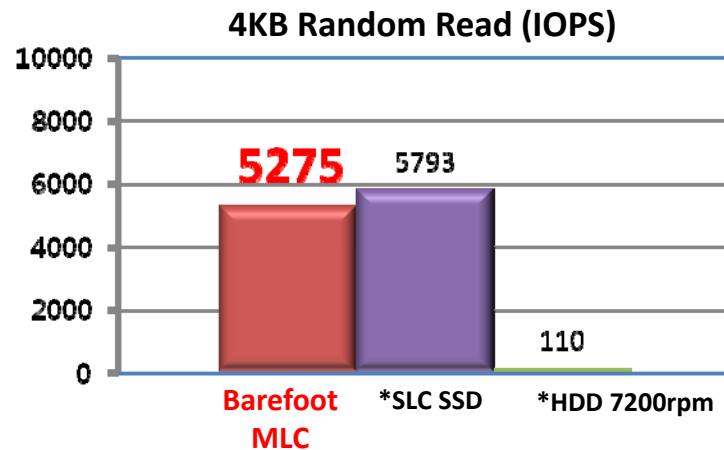
Same Price, Much Better Performance



* Denotes major S vendor devices

Less Money - Better Performance

MLC



* Denotes major S vendor devices

INDINuxTM : Linux Kernel Patch Set Test

INDINux:

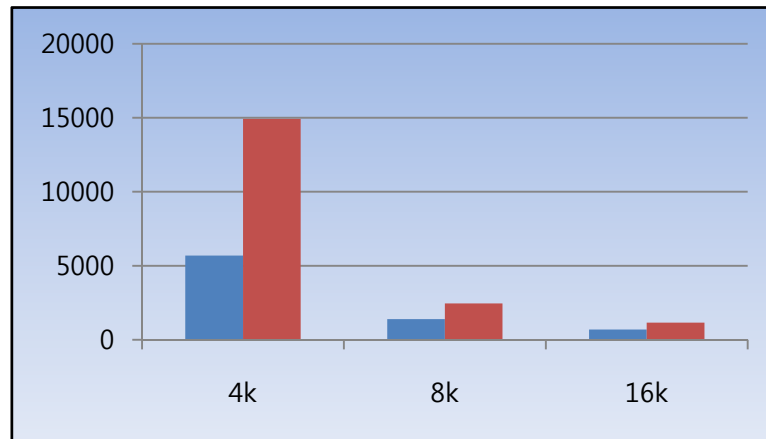
- INDILINX Linux Patch to improve performance
- Memory Management, Scheduler, File System
- Write Performance improvement

Test Condition:

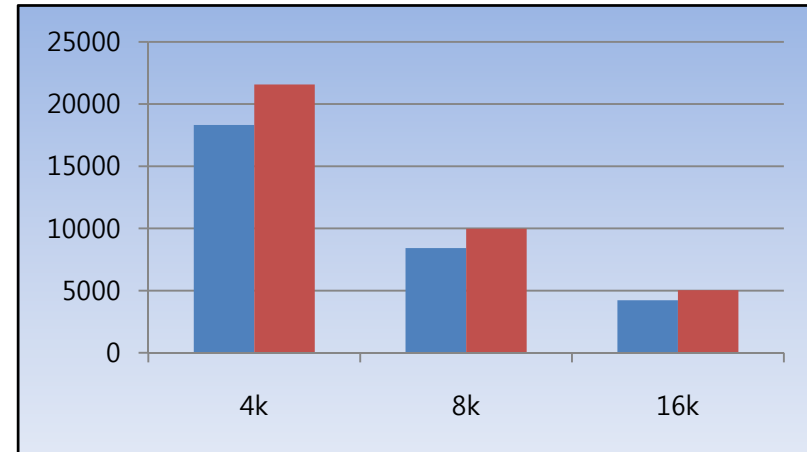
- Hardware
 - CPU : Intel Atom N270 @1.6GHz
 - Memory : 1GB
- Operating System
 - Ubuntu eee / Kernel 2.6.24 + **INDINux**
- SSD
 - Amigos 2ch 32G MLC
- Test Tool
 - iiozone

INDINuxTM : Test Result (1)

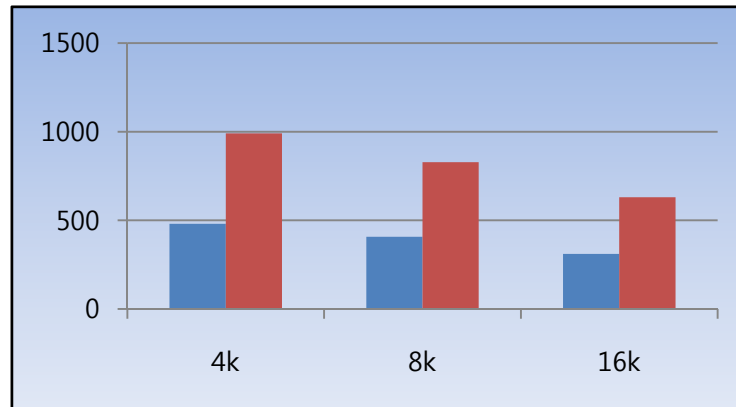
■ 4k, 8k, 16k Sequential write IOPS



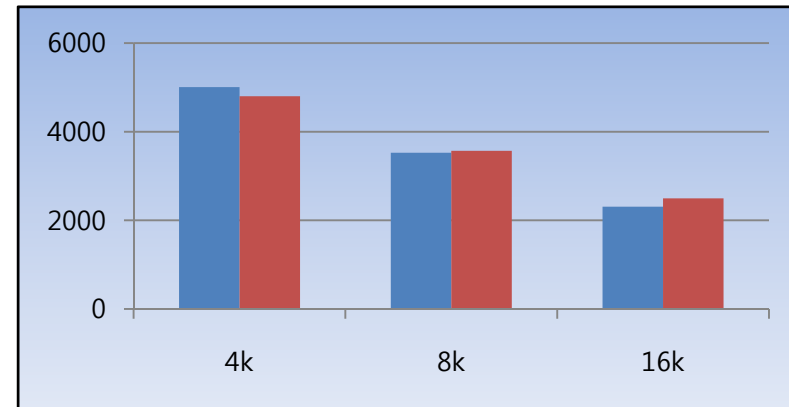
■ 4k, 8k, 16k Sequential Read IOPS



■ 4k, 8k, 16k Random write IOPS



■ 4k, 8k, 16k Random read IOPS

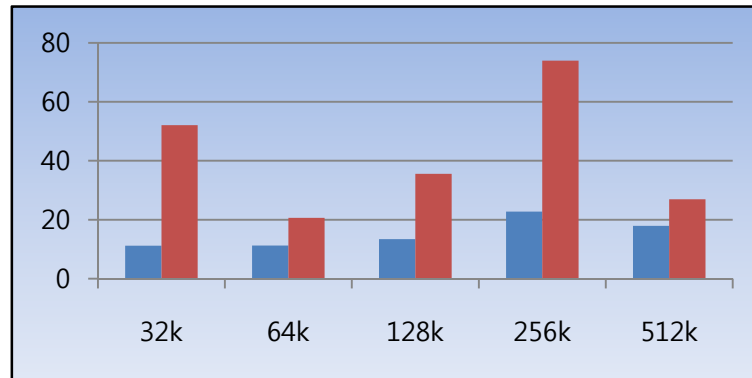


■ Original Linux

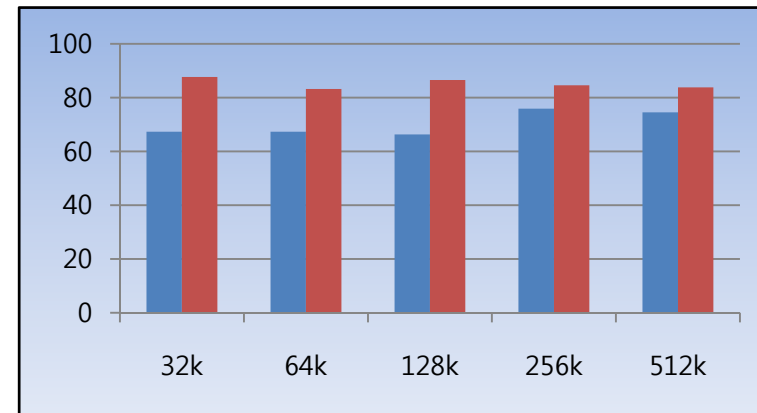
■ INDINux

INDINuxTM : Test Result (2)

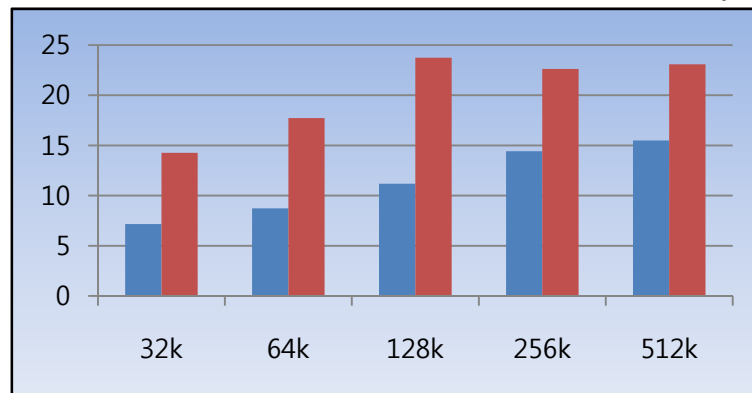
■ 32k~512k Sequential write MB/s



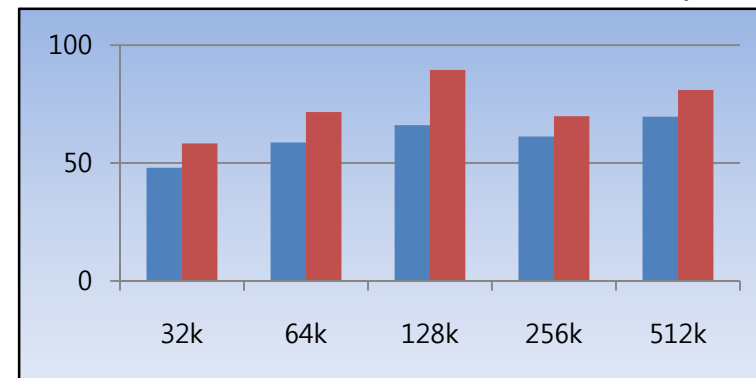
■ 32k~512k Sequential read MB/s



■ 32k~512k random write MB/s



■ 32k~512k random read MB/s

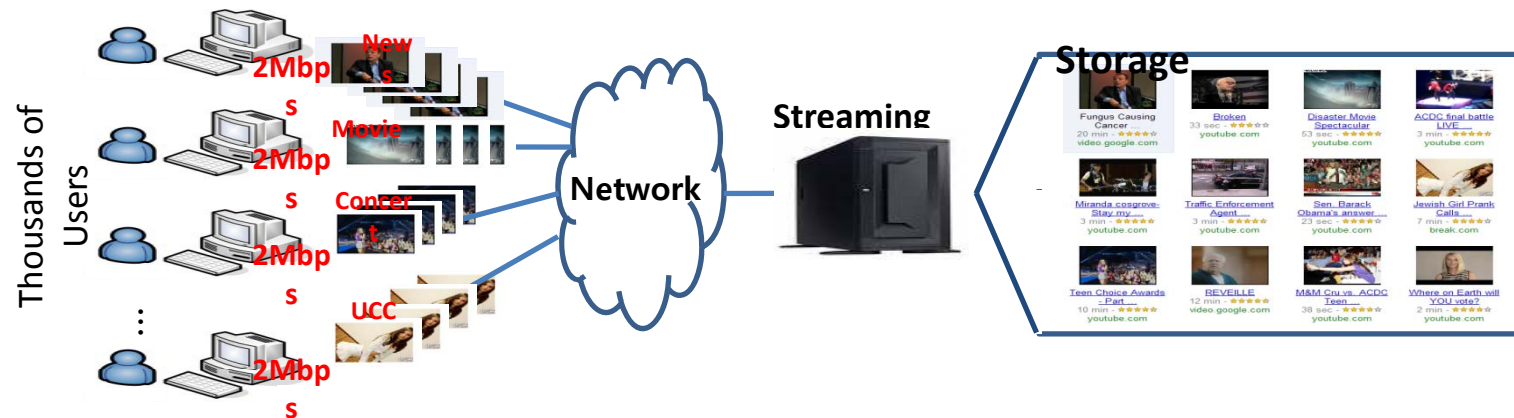


■ Original Linux

■ INDINux

INDIStreamerTM : Streaming Server Niagara

- Up to 20Gbps Streaming Performance
- Support for Progressive Download
- Session Control through RTCP
- Support for Trick & Fast Mode
- Protocol: Unicast (RTP/(RTCP), UDP(TCP), RTSP/TCP, HTTP)
- Supported Media Format:
 - Video: MPEG-1,-2,-4 , H.264, H.263
 - Audio: AAC, AAC+, AMR, QCELP
 - System: MP4, MPEG2-TS



- Streaming Service like IPTV uses Large (256KB~1MB) Size Random Read Pattern
- Number of simultaneous accesses is most important

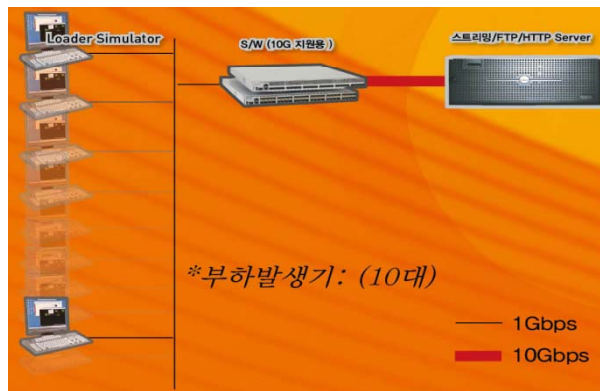
INDIStreamTM Simulation Environment



- **Server and Client**
 - OS : Windows 2003 R2 Standard x64 Edition
 - CPU : Xeon 5160 3.0GHz dual core * 2
 - Memory : 8GB
- **Connection Type**
 - Contents : H.264 2Mbps encoding
 - All connection read different files (worst case)
- **RAID Controller**
 - Intel RAID Controller SRCASJV
 - RAID Level : Raid0, 8 Disks
 - Stripe Size : 256KB
- **Streaming Server Solution **Niagara****
 - INDILINX Proprietary Solution Engine
- **Client Load Generator **INDILoader****
 - Proprietary Solution
 - Over 5000 User Load generation in a server

INDILoaderTM : 10Gbps Network Load Generator

- Easy to use User Interface
- Streaming/HTTP/FTP Server Network Load Generator
- 5Gbps Network Load Generator each (10Gbps currently in work)
- Supported Client Protocols: RTSP/RTP/RTCP, HTTP, FTP
- Supported Media Formats: MP2-TS, MP4, H.264, H.263, AAC, QCELP, etc.
- Support for IIS (Internet Information Services) log generated Network Load
- **Applications:** Server Development, Benchmarking, Validation, etc



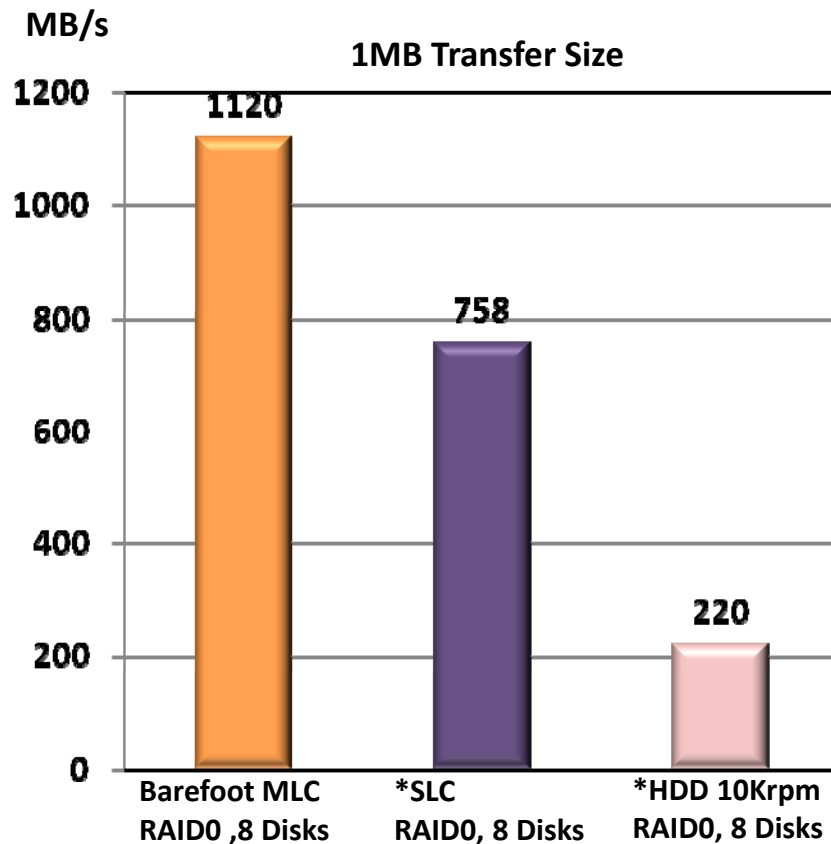
10Gbps Test W/O INDILoader



10Gbps Test **With INDILoader**

INDIStreamTM Streaming Simulation Result

- SSD streaming server even with MLC exceeds 10Gbps bandwidth
- SSD adoption can reduce the number of servers up to 80%



Barefoot MLC
4480 users / server



*SLC SSD
3032 users / server



*HDD 10Krpm
880 users / server

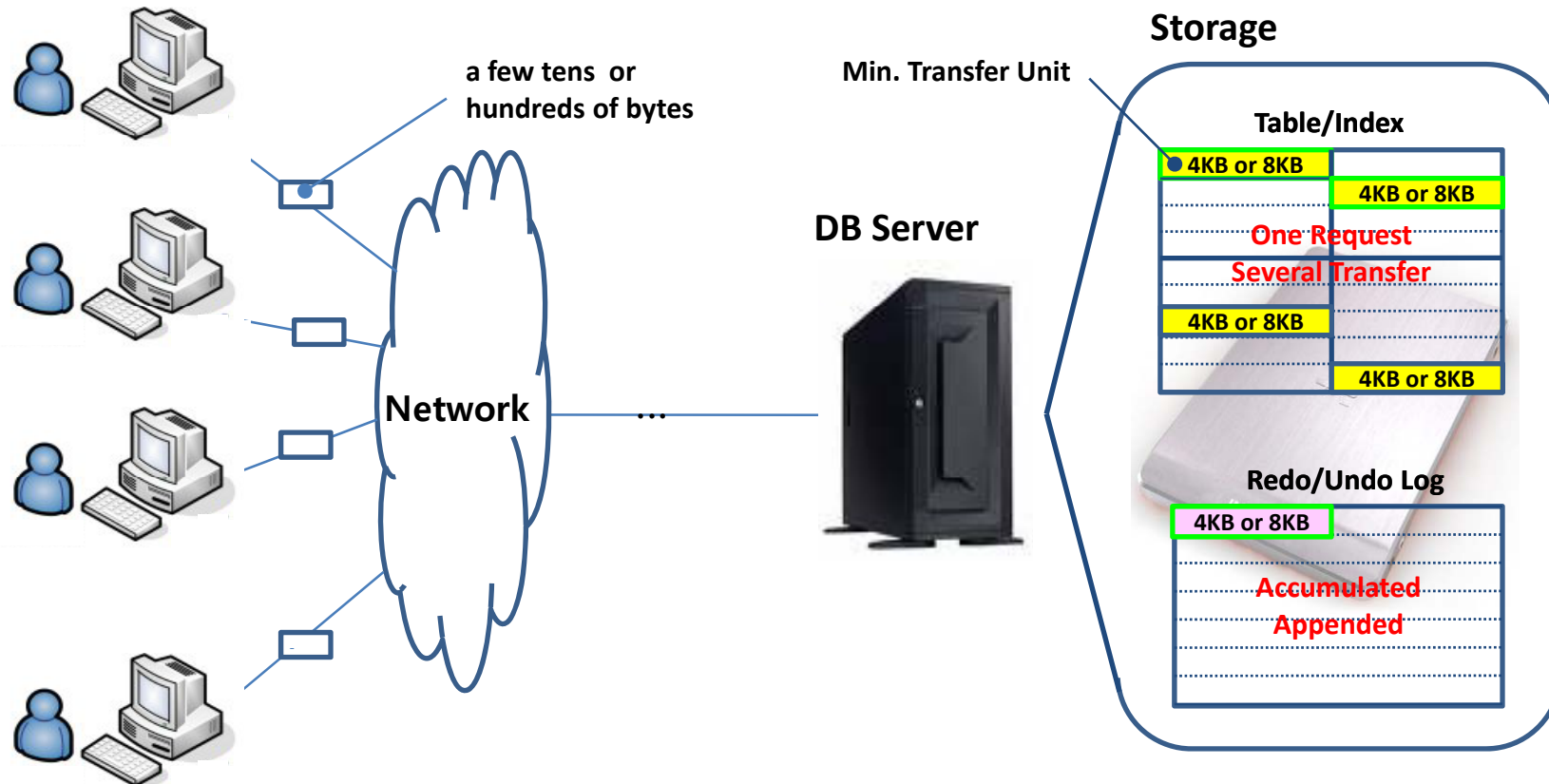


(2Mbps/user)

* Denotes Different Vendor Devices

OLTP I/O Characteristics

- OLTP I/O characteristic is 4K or 8KB size random transfer
- 4KB or 8KB transfer size is matched with NAND Flash page size



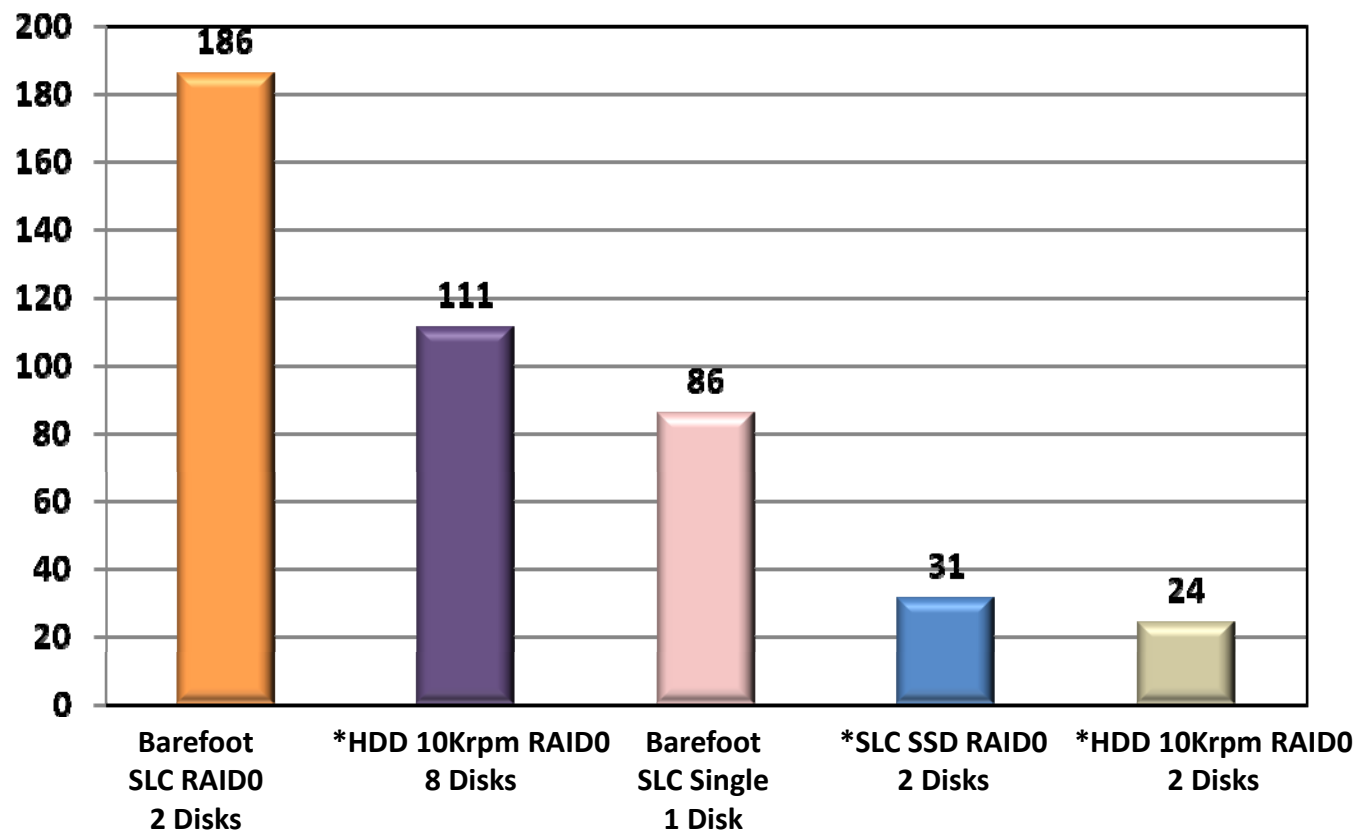
TPC-C Benchmark Test Environment



- **Server**
 - OS : Redhat Enterprise Linux 5.0 + **INDINux**
 - Board : Intel S5000PAL
 - CPU : Xeon 3.0GHz x 4
 - Memory : 2GB
- **Client**
 - OS : Windows Server 2003 R2
 - Board : Tyan thunder s2915
 - CPU : Dual core AMD Opteron 2.4 GHz
 - Memory : 2GB
- **RAID Controller**
 - Intel RAID Controller SRCASJV
 - RAID Level : RAID0, 2 Disks
 - Stripe Size : 256KB
- **Oracle Enterprise 11g**
 - Data & index size : 15GB
 - Buffer cache : 300MB
- **Benchmark Factory 5.5**
 - Scale factor : 150
 - Latency : no delay

TPC-C Mixed Query Result

- Barefoot performs 8 times more transaction than HDD in OLTP application
- Barefoot 2 disks is better than HDD 8 disks
- Barefoot, even single device performance is almost similar to HDD 8 disks



* Denotes Different Vendor Devices

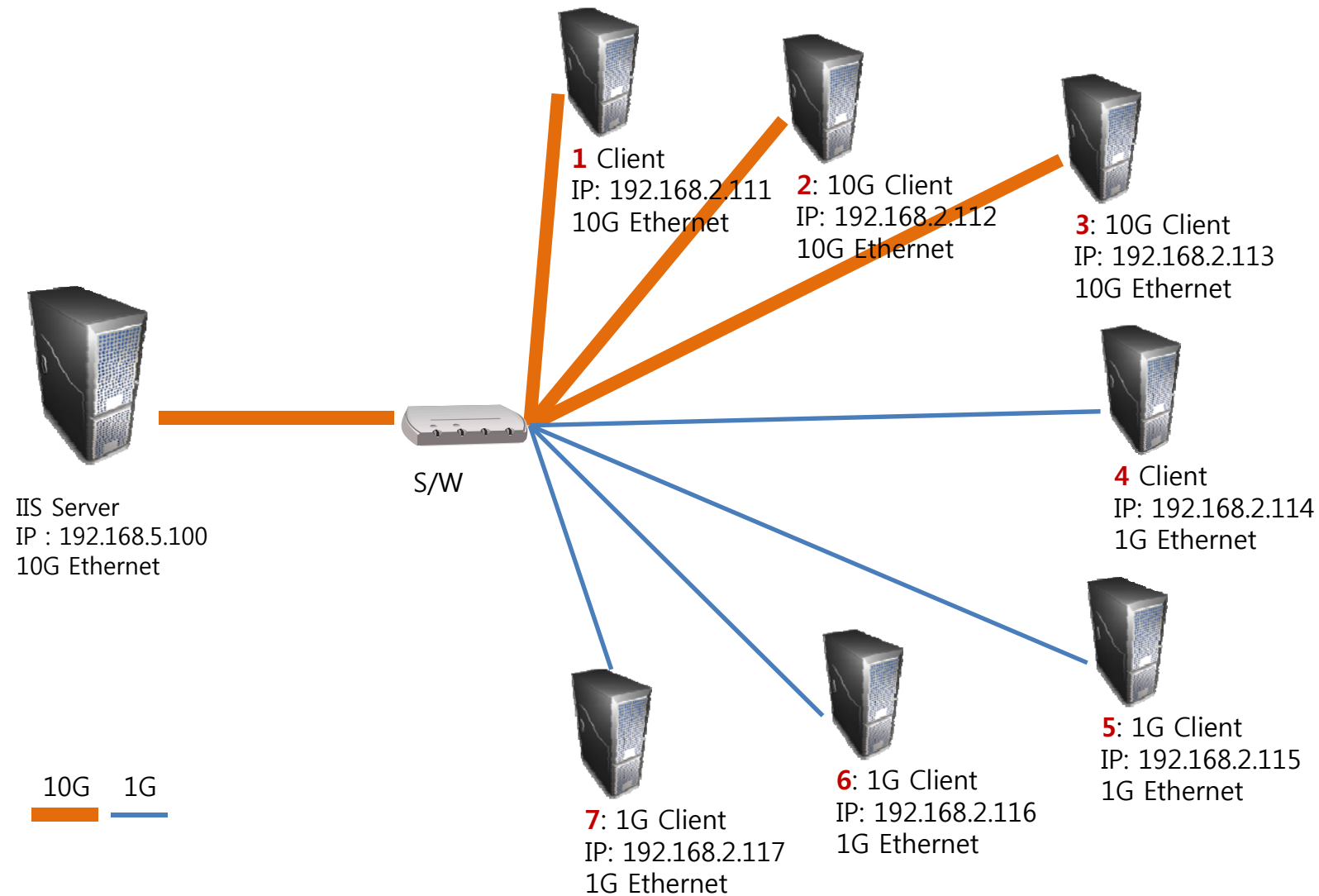
Case Study: HTTP Download Real World Test

- HTTP download 6.2Gbps
- IIS Log generation simulation

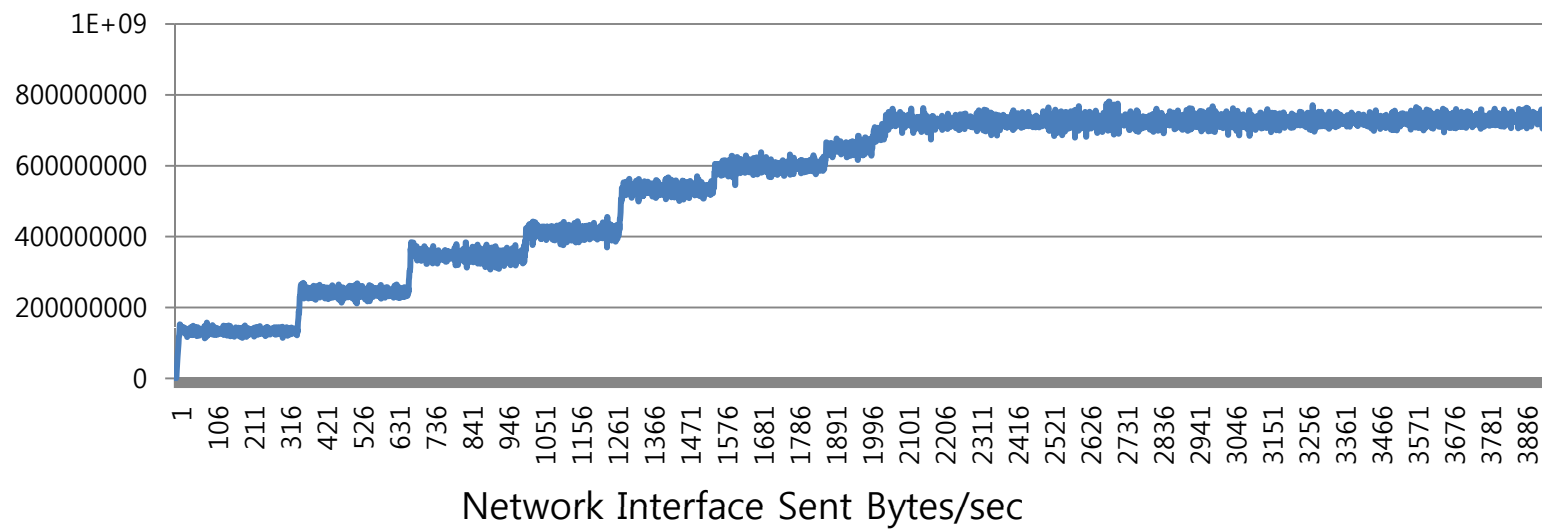
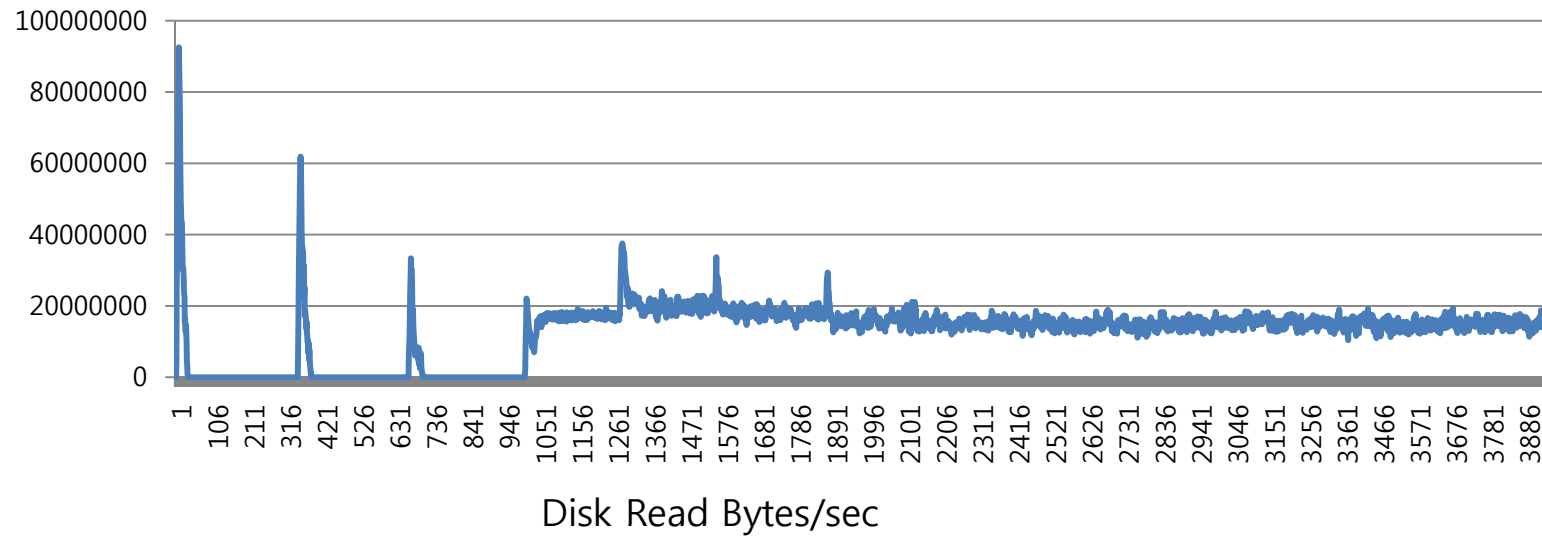


- Server and Client
 - OS : Windows 2003 R2 Standard x32 Edition
 - CPU : Xeon 5430 2.66GHz quad core * 2
 - Memory : 8GB
- RAID Controller
 - Intel RAID Controller SRCASJV
 - RAID Level : Raid0, 4 Disks
 - Stripe Size : 256KB
- Web Server Solution
 - Microsoft IIS
- Client Load Generator (INDILoader)
 - Proprietary Solution
 - Over 5Gbps User Load generation in a server
 - RTP/Http/FTP

HTTP Download Real World Test



HTTP Download Real World Test



Summary

- High Performance GEN2 SSD: Over 200MB/s throughput and High random IOPS
- SSD dramatically improves OLTP performance, Streaming, Download
- Even GEN2 MLC SSD is sufficient for 10G streaming server
- TCO  ROI 
- INDILINX tries to lead the SSD industry by rapid enabling of SSD market in conjunction with SSD based Platform
- New approach to deal with SSD is necessary from HW and SW (i.e. Pacific)
- To maximize the system performance, OS tuning is necessary
- Fine tune HW & SW according to the end-user applications



Thank You!

Sean In

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