Advantages of Tester-Per-DUT for Parallel SSD Testing

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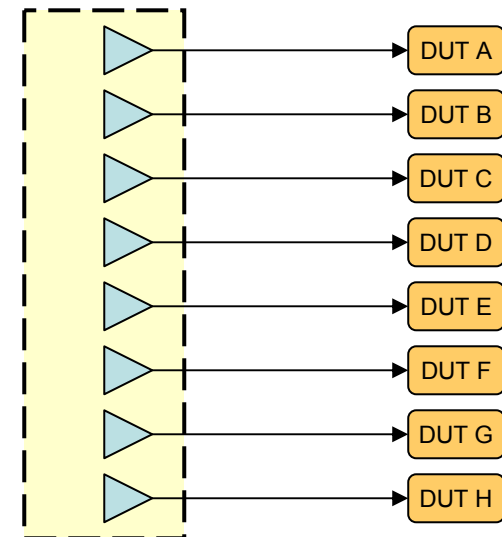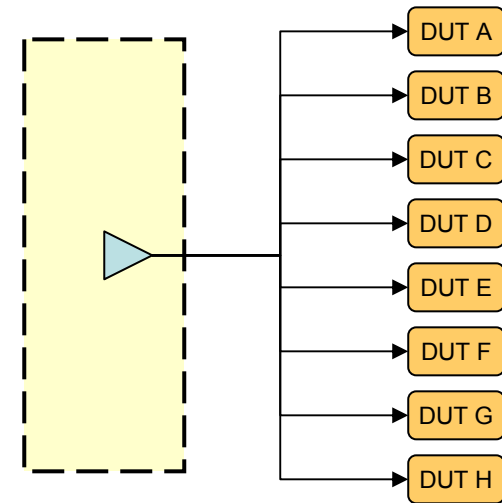
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SSD Volume Production Tester Considerations

- ## As SSD Volume Production Increases, combined with decrease in SSD price per GB:

  - ### Pressure to reduce COT (Cost Of Test)

  - ### Factors contributing to reduce COT and lower COO (Cost of Ownership):

    - Higher Parallelism of Test System
    - Higher Flexibility and Scalability of Test System
    - Higher Longevity of Test System
    - Higher Test Coverage Capability of Test System
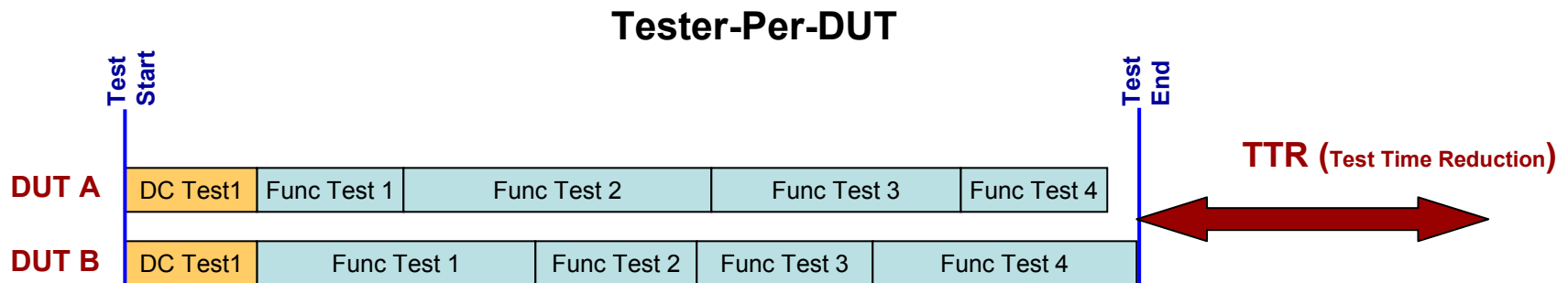   - Shorter Production Test Time

Different Production Tester Architectures

- ## Shared-Resource Architecture:
  - Multiple Devices sharing same tester resources (signals and powers) to test multiple devices (DUT) in parallel

- ## Tester-Per-DUT Architecture:
 - Dedicated tester resources for each DUT when testing multiple devices (DUT) in parallel

DUT A	
DUT B	
DUT C	
DUT D	
DUT E	
DUT F	
DUT G	
DUT H	

Shared-Resource vs Tester-Per-DUT Test Time comparison for Traditional ATE Flash Tester

Shared-Resource

Test Start | Test End

DUT A	DC Test1	Overhead	Func Test 1	Overhead	Func Test 2	Func Test 3	Func Test 4	Overhead
DUT B	Overhead	DC Test1	Func Test 1	Func Test 2	Overhead	Func Test 3	Overhead	Func Test 4

Time →

Tester-Per-DUT

Test Start | Test End

DUT A	DC Test1	Func Test 1	Func Test 2	Func Test 3	Func Test 4
DUT B	DC Test1	Func Test 1	Func Test 2	Func Test 3	Func Test 4

TTR (Test Time Reduction)

➢ Would we observe a similar test time advantage if we can use a Tester-Per-DUT Test System for SSD Volume Production?

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Traditional PC Based SSD Tester Concept
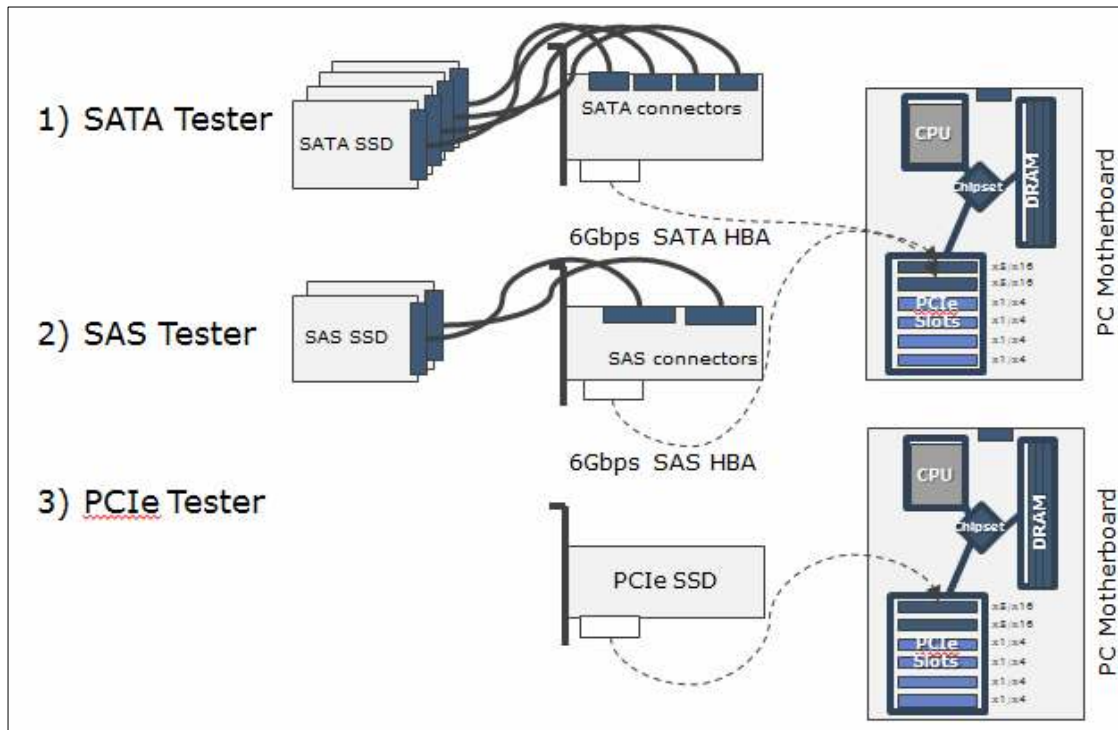
Potential bottlenecks due to:
- Sharing of HBA
- Sharing of System's CPU

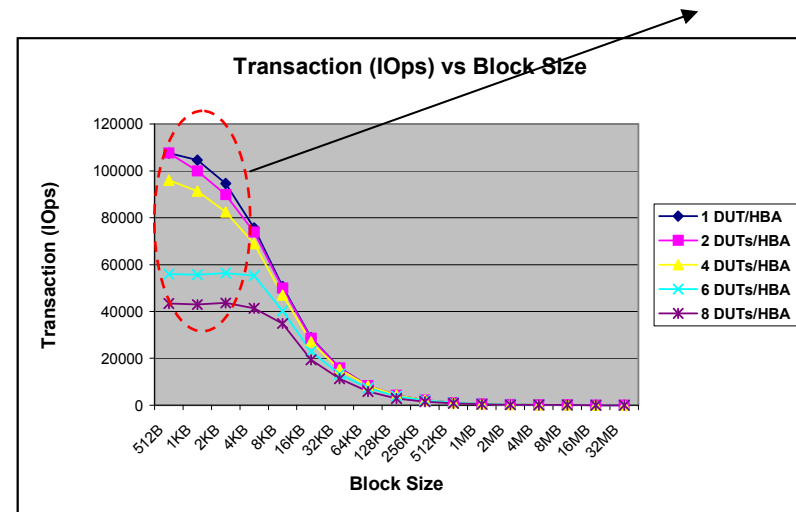# Performance drops due to HBA Sharing => Increase Test Time Overhead

IOps Performance drops:
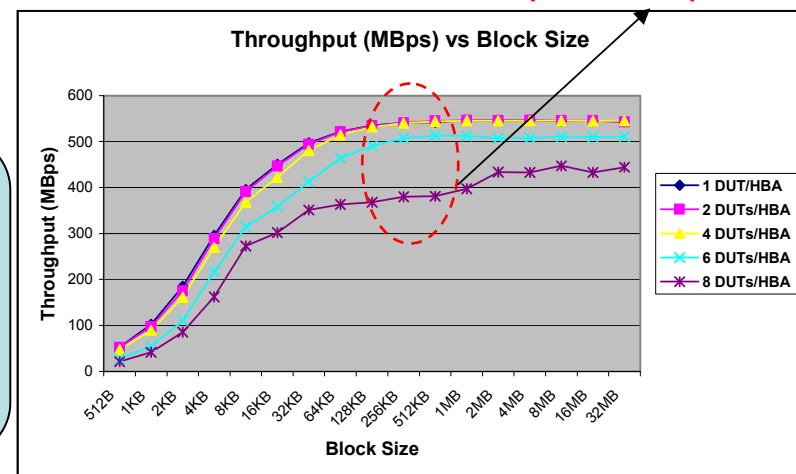-Start at 4 DUTS Sharing
-Up to 60% drops

Performance:

- IOps Performance degradation observed at 4 DUTs sharing and up to 60% drops at 8 DUTs Sharing
  - Bottleneck due to limitation of HBA

- Up to 30% Throughput (MBps) drops observed at 8 DUTs Sharing.
  - Bottleneck due to PCIe 2.0 interface

Setup: *3.7GHz i7 quad core*
Single 6Gb/s SATA/SAS HBA with PCIe 2.0 host interface
Windows 7 with Iometer

Note: *Assuming no other CPU loading related to testing:*
Compare, Data Processing, Communication with Test Controller, Data logging…etc.

Shared Resources Production Test Impact:
➤Performance does not scale: the higher the parallelism, **the lower the IOPs and Throughput**

➤Lower IOPs and Throughput result in *longer test time* and **less stress** on device.

Transaction (IOps) vs Block Size — 1 DUT/HBA, 2 DUTs/HBA, 4 DUTs/HBA, 6 DUTs/HBA, 8 DUTs/HBA

Throughput Performance drops:
-Up to 30% drops

Throughput (MBps) vs Block Size — 1 DUT/HBA, 2 DUTs/HBA, 4 DUTs/HBA, 6 DUTs/HBA, 8 DUTs/HBA
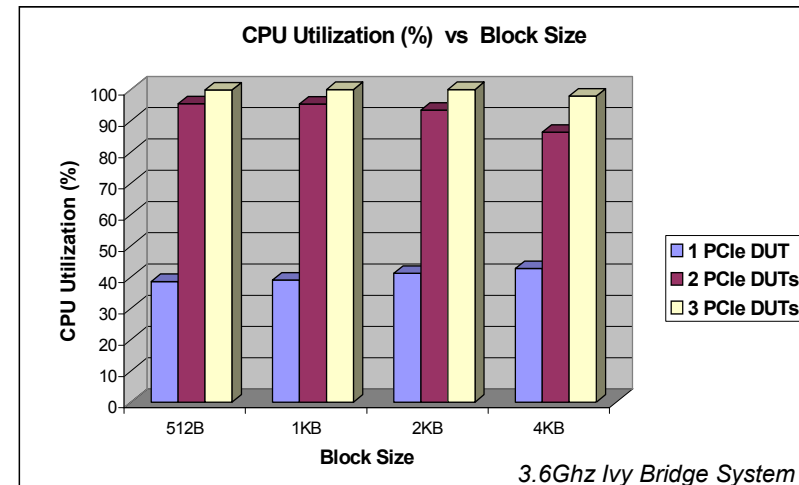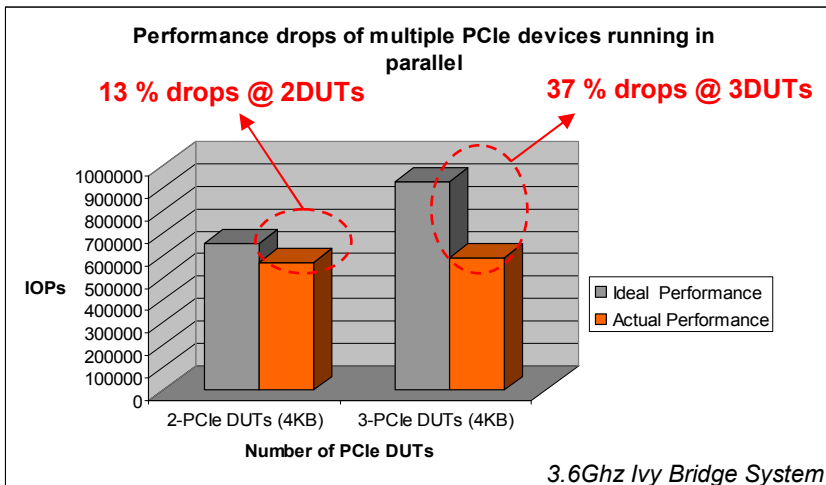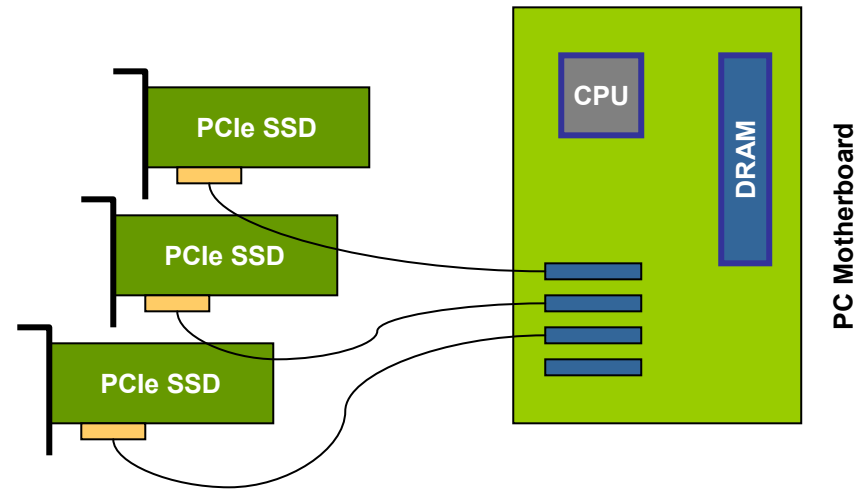
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Performance drops due to increase PCIe SSD loading on PC Motherboard

Performance:

- IOps Performance degradation observed when adding additional PCIe SSD DUTs and up to 37% drops at 4KB Block Size for 3 PCIe SSD DUTs.

- CPU utilization increases with additional PCIe SSD DUTs and already max out at 3 PCIe SSD DUTs

Shared Resources Production Test Impact:
➤ Similar to HBA sharing: *Performance does not scale*

➤ Maximizing PC resources could lead to stability issue.

Performance drops of multiple PCIe devices running in parallel

13 % drops @ 2DUTs   37 % drops @ 3DUTs

IOPs — Number of PCIe DUTs
- Ideal Performance
- Actual Performance

2-PCIe DUTs (4KB)   3-PCIe DUTs (4KB)

3.6Ghz Ivy Bridge System

CPU Utilization (%) vs Block Size

- 1 PCIe DUT
- 2 PCIe DUTs
- 3 PCIe DUTs

Block Size: 512B, 1KB, 2KB, 4KB

3.6Ghz Ivy Bridge System

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Longer Test Time due to Serialization required for Resource Sharing

- Any Tests, with shared DC power, where voltage or current measurement is required will need to be run serially (eg. *ICC Tests*)

- Any Tests where CPU Loading or Bandwidth Sharing will affect the accuracy of the test results will need to be run serially (eg. *Speed Tests*)

Shared Resources Production Test Impact:
- ➢ Serialization will result in *longer test time*
- ➢ Parallel testing on these tests will result in *yield loss*
- ➢ Omitting these tests to reduce production test time results in *sacrificing of test coverage*

Longer Test Time due to Synchronization required for Resource Sharing

- **Any Tests, with shared DC power, where change in voltage is required will need to be synchronized for all the shared DUTs:**

  - Vcc Margining

  - Write Shutoff

  - Power cycling

Shared Resources Production Test Impact:
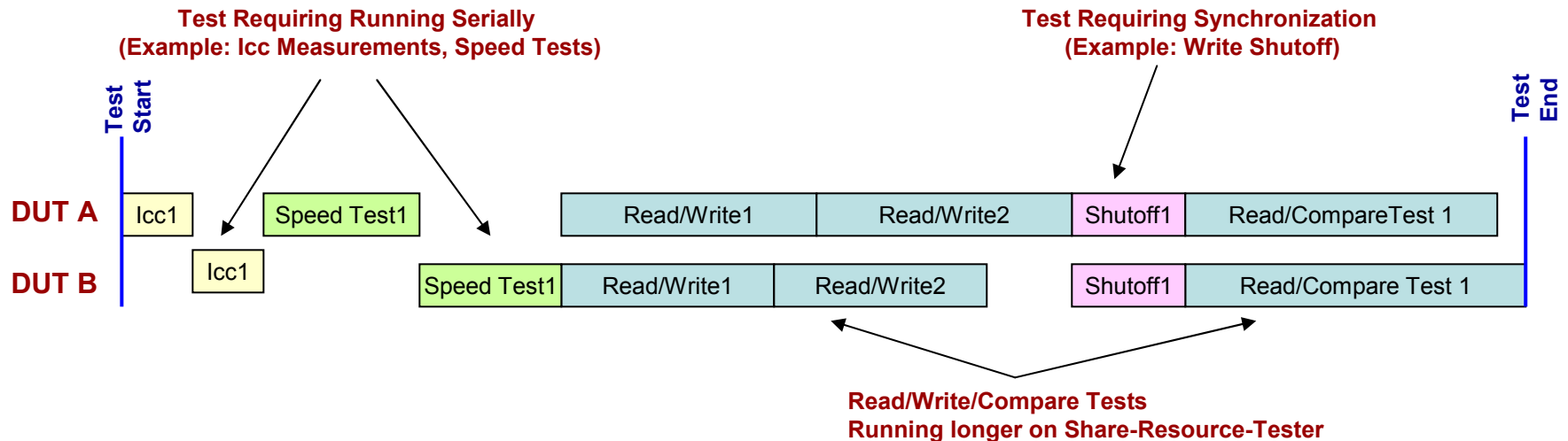 ➢Synchronization of tests will result in *longer test time*

What else could affect SSD Production Test Time when using a Shared-Resource Tester?

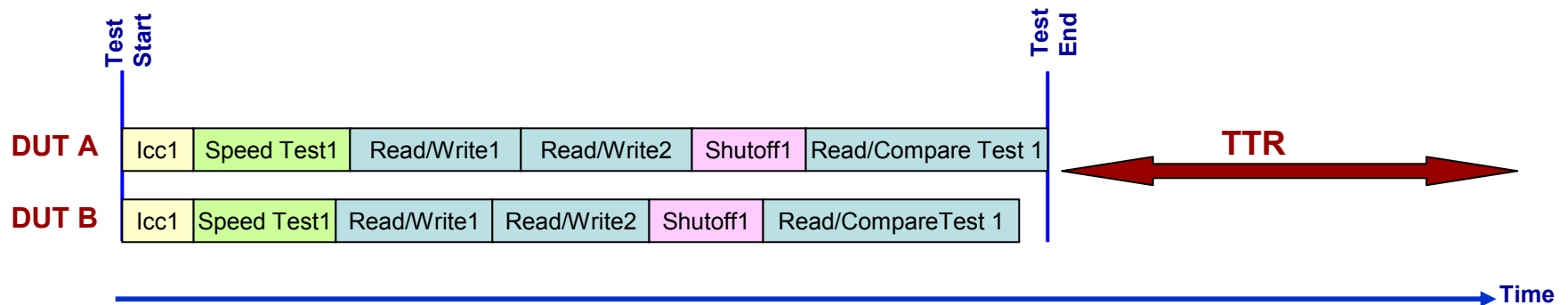- Read and Compare (where CPU will heavily be used, especially if high number of DUTs are being tested in parallel)

- Level of on-the-fly data computation and fail analysis

- Level of data transfer of Test Data Results to server (Test Log, SMART data, Fail Information for post-production analysis)

- Efficiency of CPU

- Efficiency of OS & Tester Software

- Performance of the DUT itself

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How does Tester-Per-DUT Architecture help SSD production test time?

Share-Resource-Tester

Test Requiring Running Serially
(Example: Icc Measurements, Speed Tests)

Test Requiring Synchronization
(Example: Write Shutoff)

Test Start								Test End

DUT A Icc1 Speed Test1 Read/Write1 Read/Write2 Shutoff1 Read/CompareTest 1

DUT B Icc1 Speed Test1 Read/Write1 Read/Write2 Shutoff1 Read/Compare Test 1

Read/Write/Compare Tests
Running longer on Share-Resource-Tester

Tester-Per-DUT

Test Start			Test End

DUT A Icc1 Speed Test1 Read/Write1 Read/Write2 Shutoff1 Read/Compare Test 1

DUT B Icc1 Speed Test1 Read/Write1 Read/Write2 Shutoff1 Read/CompareTest 1

TTR

Time

Yield Loss and Cost of Retest due to Resource Sharing

- A Defective DUT could affect results of the other shared DUTs
  - DUT gets into a bad state and could not be recovered
  - If sharing power resource, a shorted Power Pin on a DUT will cause all shared DUTs to fail.

- Likewise, a Defective Shared Resource will cause all shared DUTs to fail

Shared Resources Production Test Impact:
➢ Yield Loss
➢ Cost (time and money) of Retest

Issues with Shared Resource PC Based Tester in SSD Volume Production

- **Shared-Resource based PC tester results in:**
  - Longer production test time
    - Test time overhead penalty depends on level of sharing and production test flow methodology
    - Lower sharing results in lower parallelism and higher COT
  - Lower test coverage
  - Yield Loss & Cost of Retest
  - Higher COT

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Ideal SSD Production Test System

- Ideal SSD Production Tester should give best COT, while being designed specifically for SSD Production:
  - High Parallel Testing capability
  - Tester-Per-DUT Architecture
    - Shorter Production Test Time (i.e. lower COT)
    - Higher test coverage
    - Higher yield
  - Architecture design to minimize dependency on CPU usage
  - Architecture design allowing flexibility to handle different product mix and future protocol standards
    - Lengthen the tester life
    - Reducing the cost of often system upgrade

Thank You!