Advantages of Tester-Per-DUT for Parallel SSD Testing

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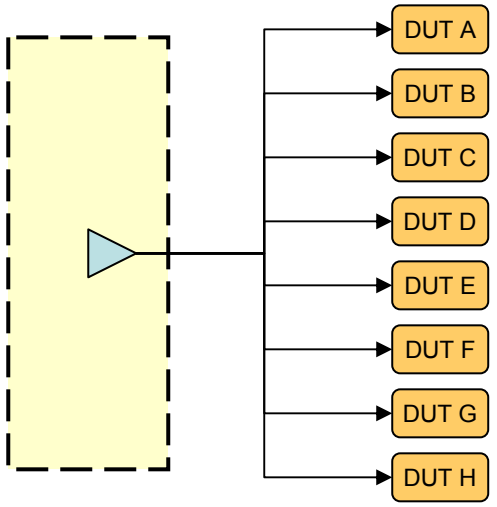
SSD Volume Production Tester Considerations

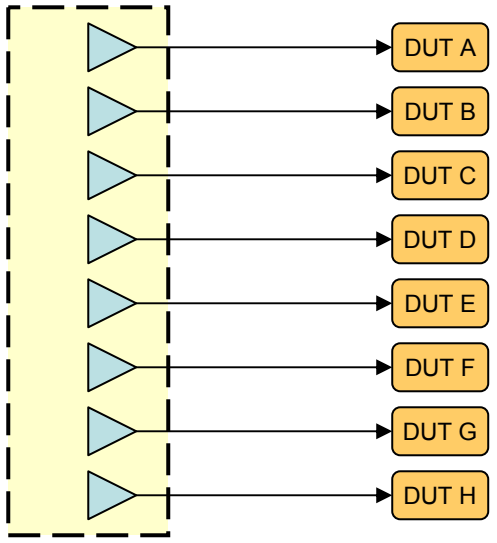
- As SSD Volume Production Increases, combined with decrease in SSD price per GB:
  - Pressure to reduce COT (Cost Of Test)
  - Factors contributing to reduce COT and lower COO (Cost of Ownership):
    - Higher Parallelism of Test System
    - Higher Flexibility and Scalability of Test System
    - Higher Longevity of Test System
    - Higher Test Coverage Capability of Test System
    - Shorter Production Test Time

Different Production Tester Architectures

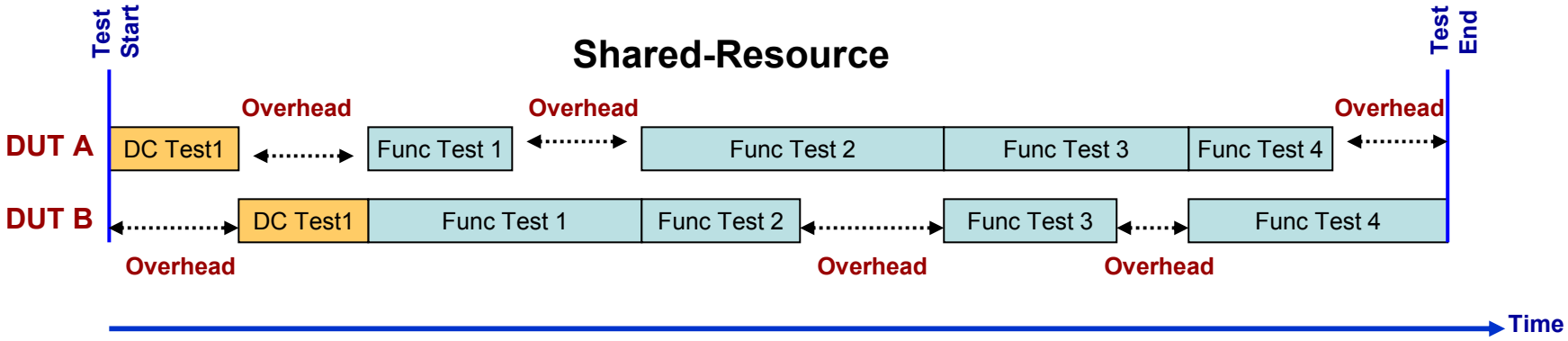
- Shared-Resource Architecture:
  - Multiple Devices sharing same tester resources (signals and powers) to test multiple devices (DUT) in parallel

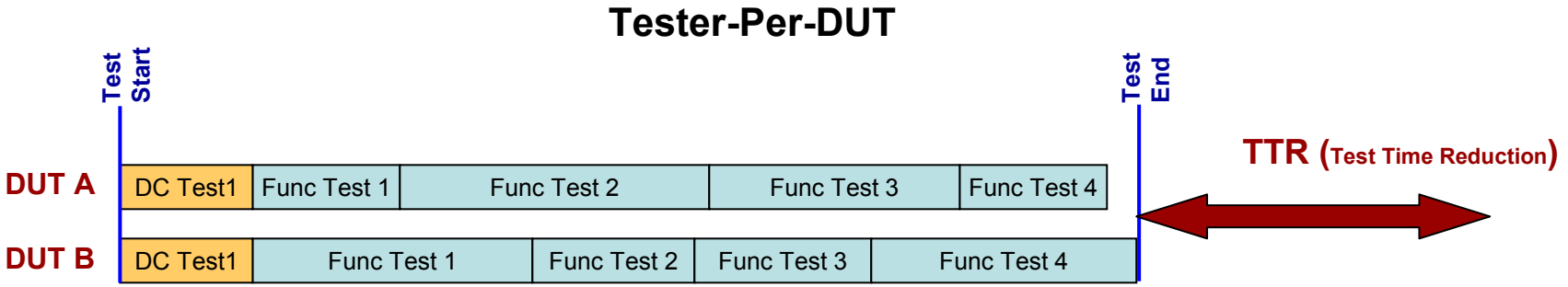


- Tester-Per-DUT Architecture:
  - Dedicated tester resources for each DUT when testing multiple devices (DUT) in parallel



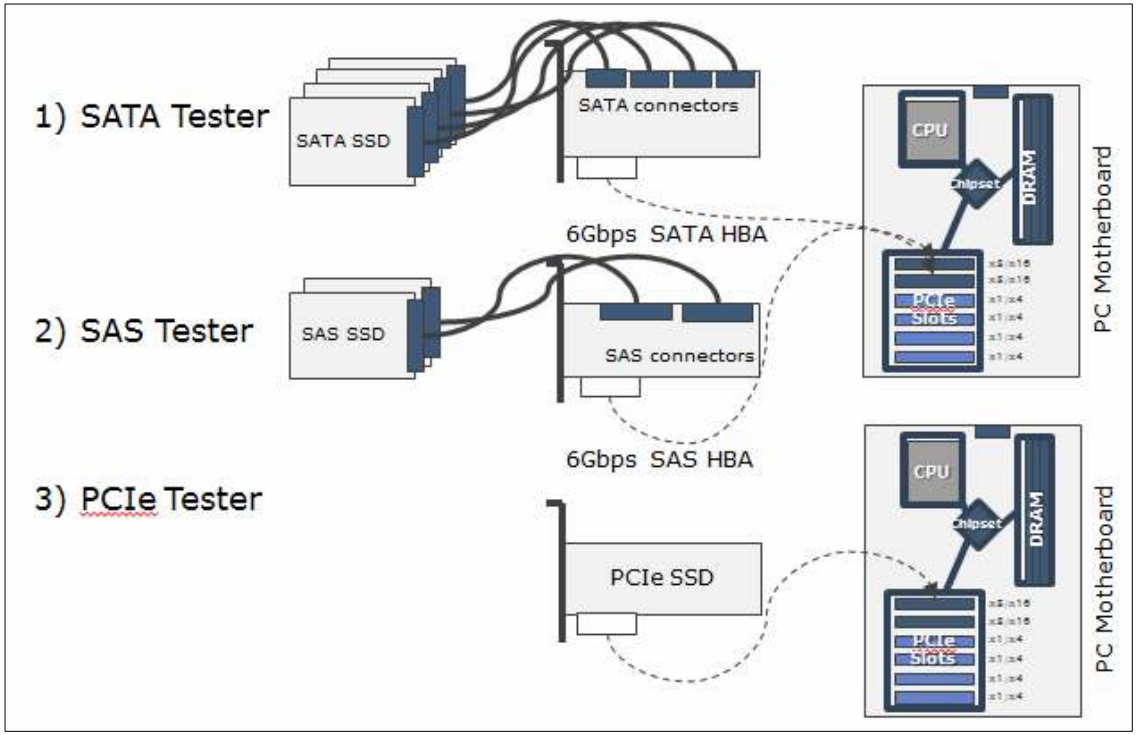
Shared-Resource vs Tester-Per-DUT Test Time comparison for Traditional ATE Flash Tester





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

Traditional PC Based SSD Tester Concept



Potential bottlenecks due to:

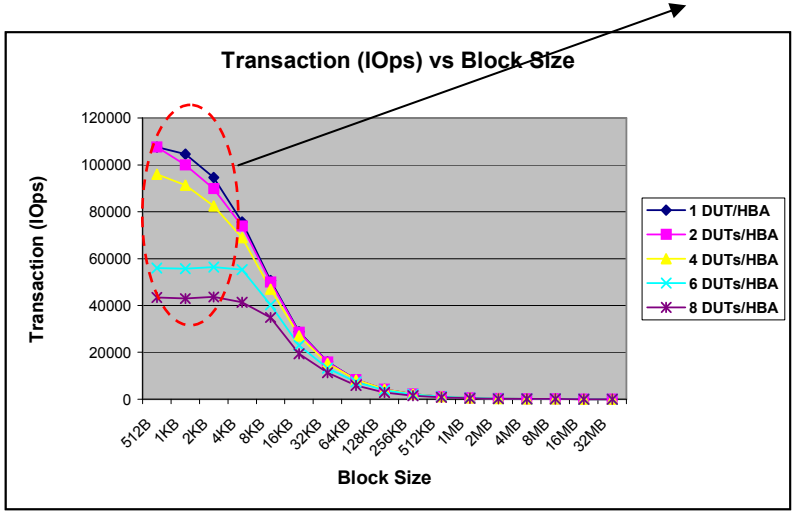
- Sharing of HBA
- Sharing of System's CPU

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

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

Performance:

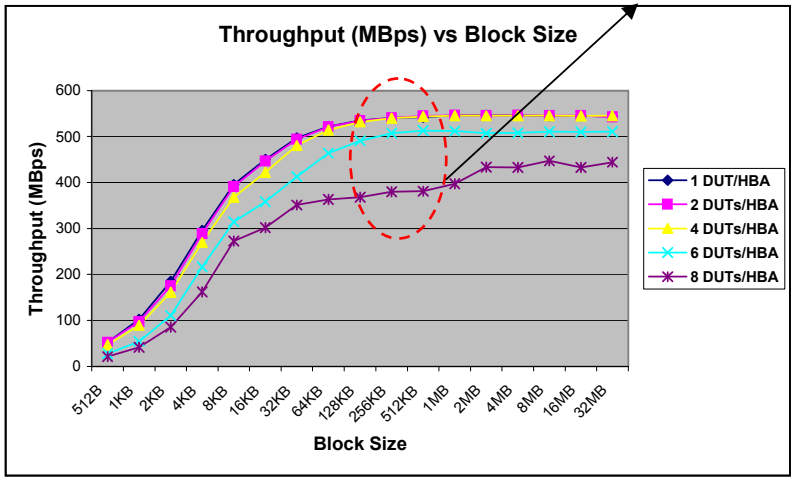
- IOps Performance degradation observed at 4 DUTs sharing and up to 60% drops at 8 DUTs Sharing
  - Bottleneck due to limitation of HBA
- Up to 30% Throughput (MBps) drops observed at 8 DUTs Sharing.
  - Bottleneck due to PCIe 2.0 interface



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.*

Throughput Performance drops:
-Up to 30% drops



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.

Performance drops due to increase PCIe SSD loading on PC Motherboard

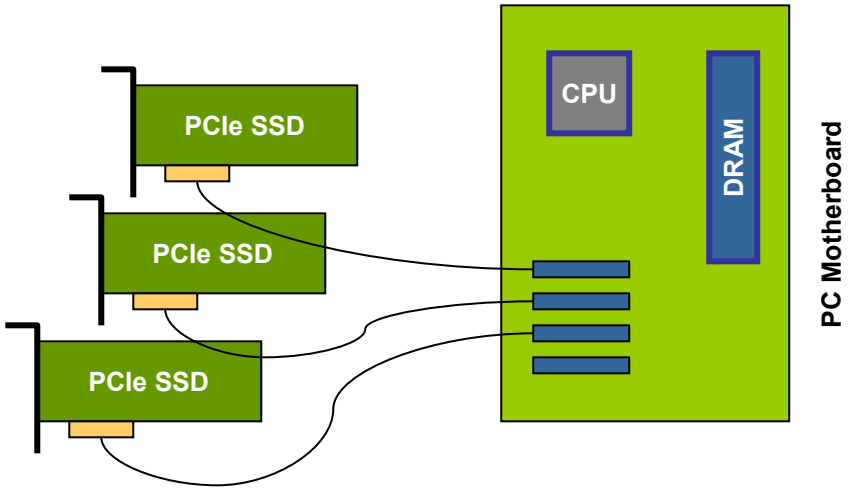
Performance:

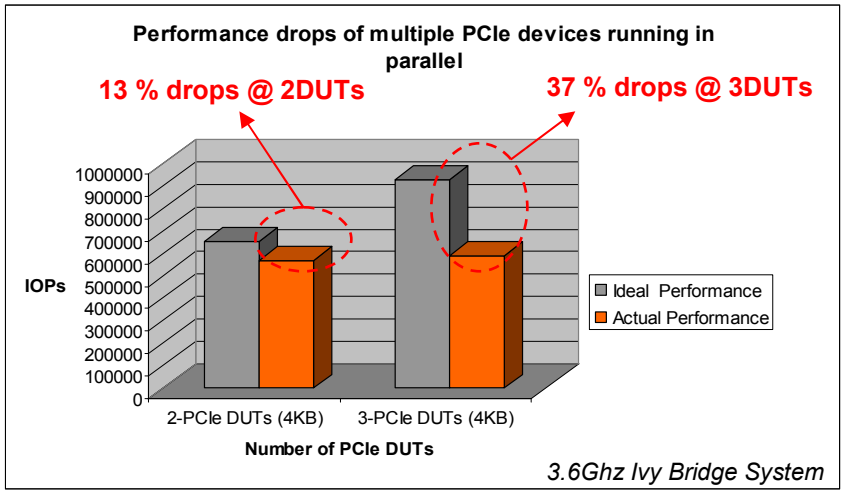
- IOps Performance degradation observed when adding additional PCIe SSD DUTs and up to 37% drops at 4KB Block Size for 3 PCIe SSD DUTs.
- CPU utilization increases with additional PCIe SSD DUTs and already max out at 3 PCIe SSD DUTs

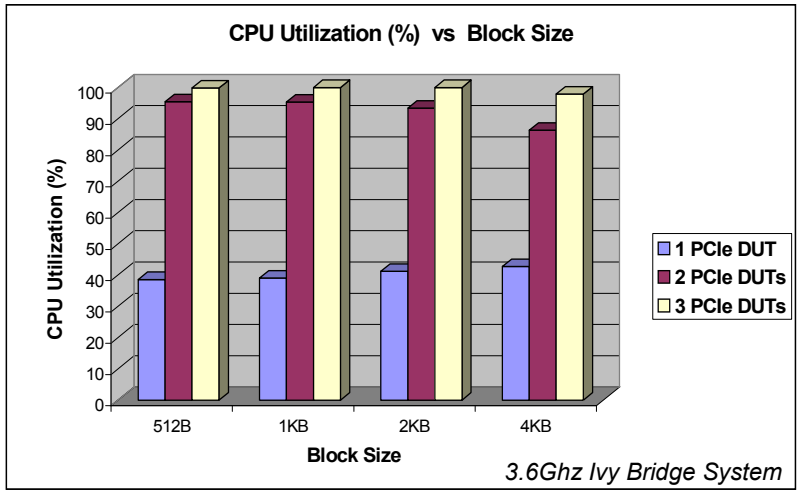
Shared Resources Production Test Impact:

➢Similar to HBA sharing: ***Performance does not scale***

➢Maximizing PC resources could lead to stability issue.







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

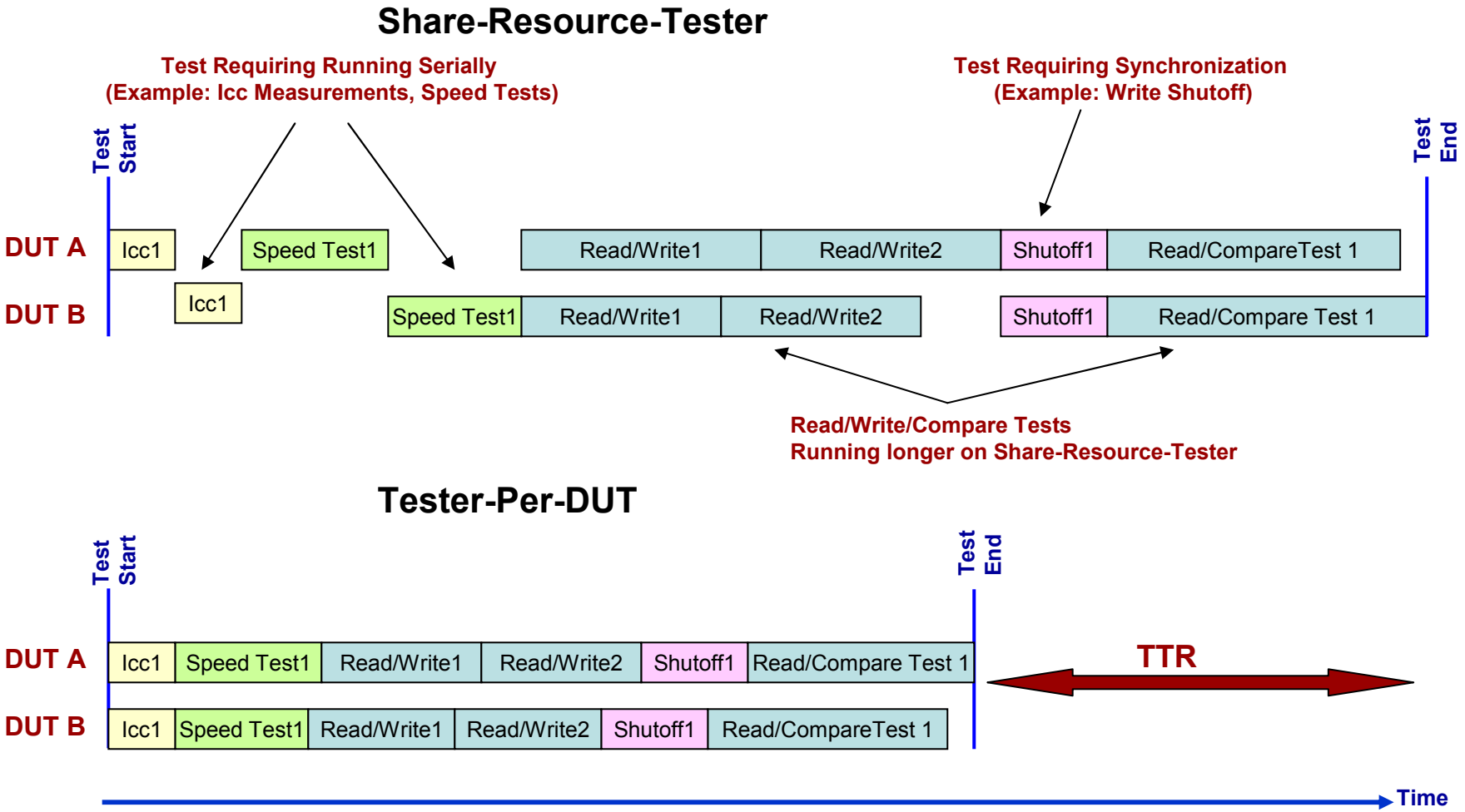
Shared Resources Production Test Impact:

➢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

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

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!

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