# Touching the Heart of Storage

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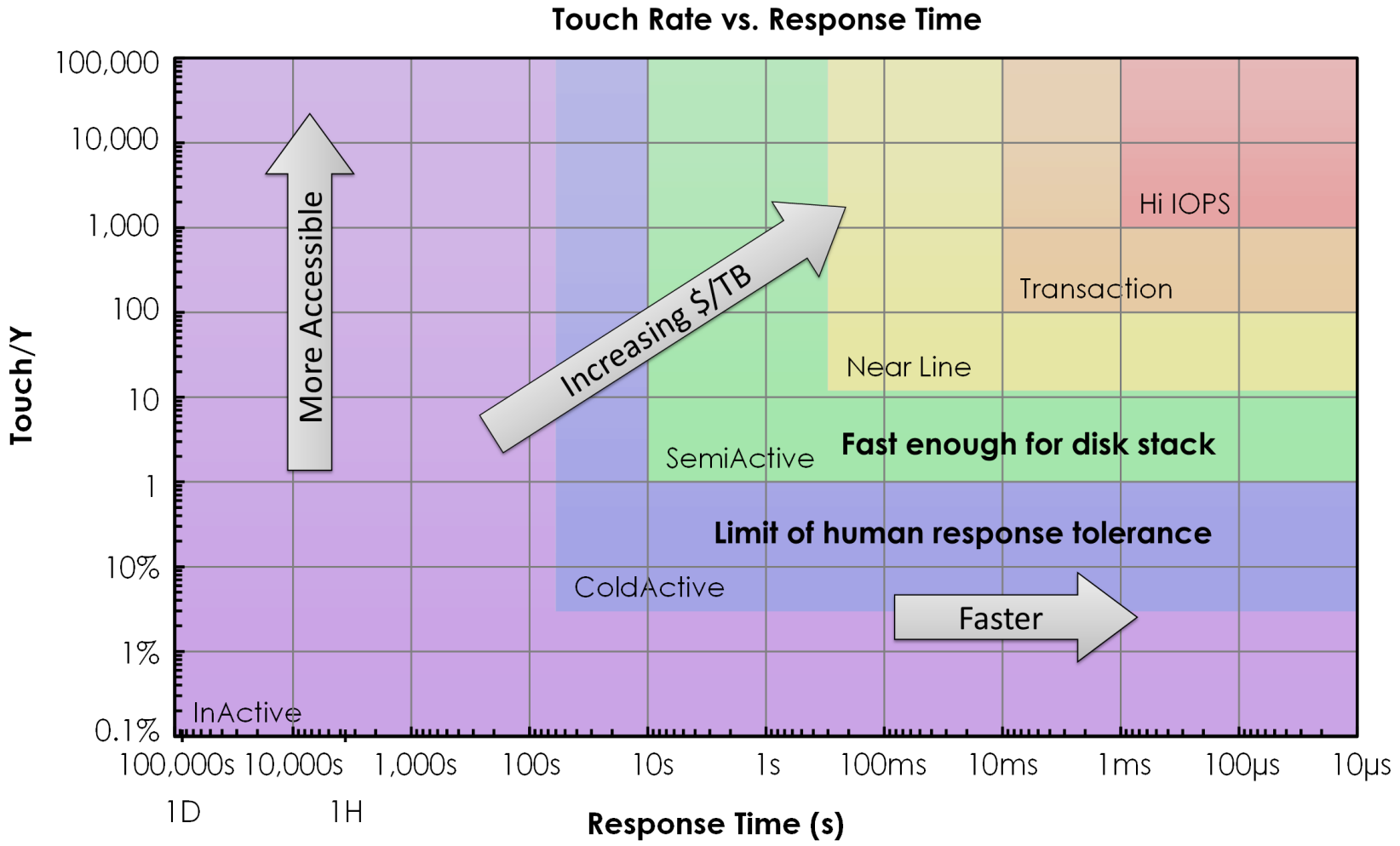
# Outline

- Touch rate and response time
- Customer needs and storage technologies
- Moving from hierarchy to applications
- HDDs
- Flash memory
- Archiving—tape and optical
- Storage system design
- Conclusions

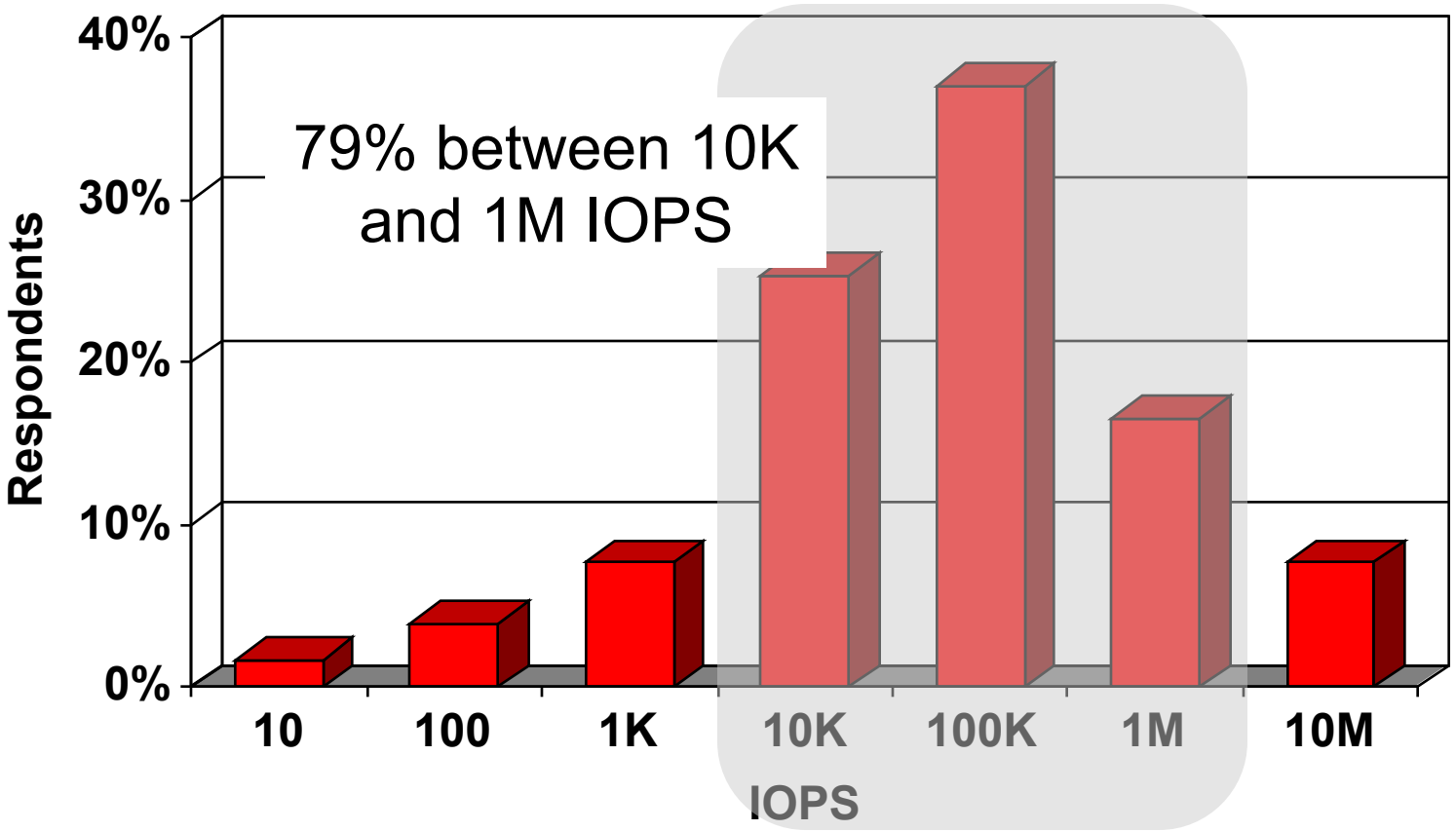
# Definitions

- *Touch rate* is defined as the portion of the total capacity of a system that can be accessed in a given interval of time.
  - Touch Rate/Year $$Touch/Y = \frac{ObjectSize(MB)}{ResponseTime(s) \times Capacity(PB) \times 0.0315}$$
- The *response time* is the time to complete an IO operation, including the transfer of data and restoring the system for a subsequent IO operation. The response time is therefore a function of the IO object size as well as the speed of ancillary support operations.

# Touch rate versus response time indicating various types of uses

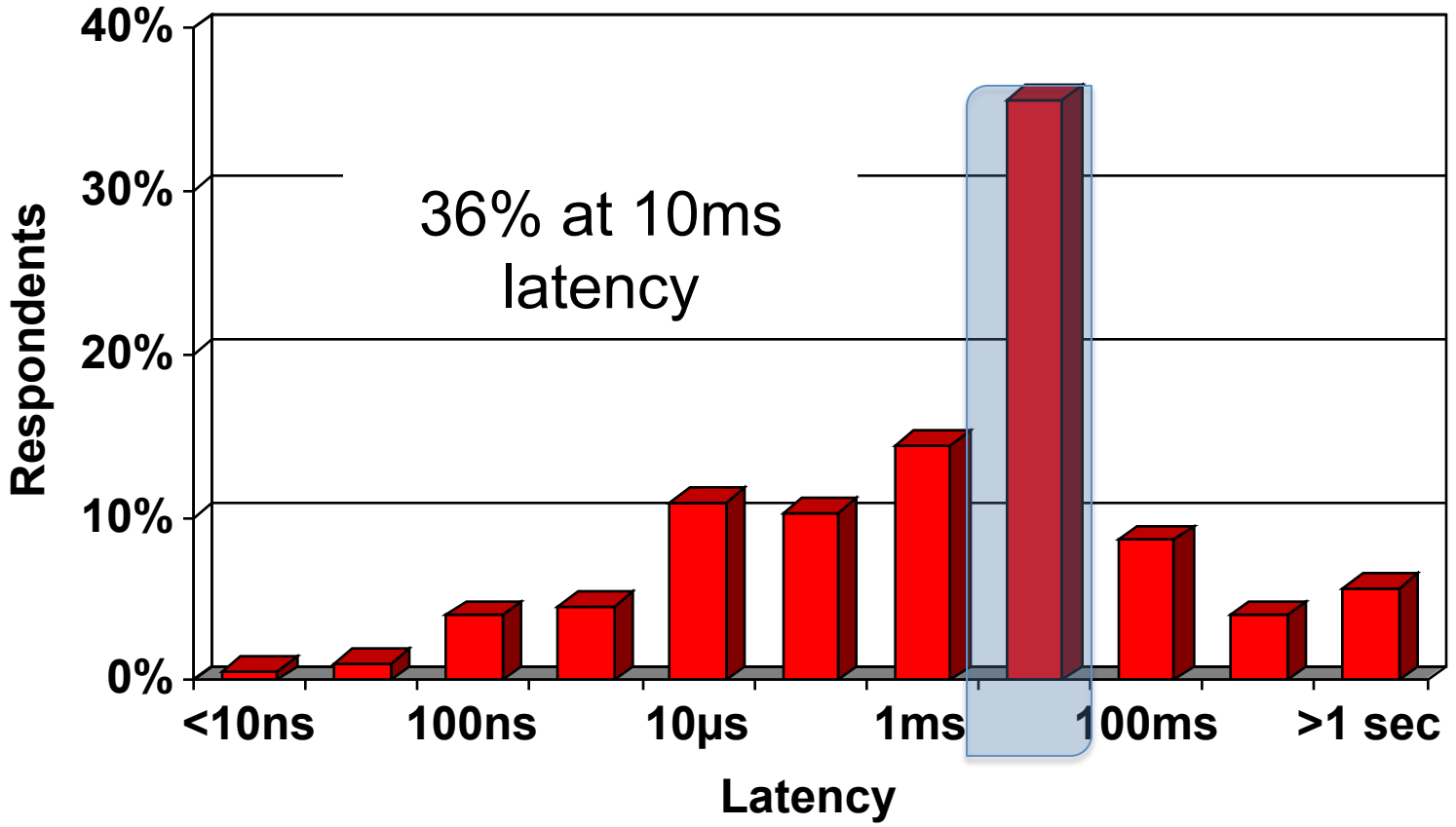


# IOPS Required




From the 2014 How Many IOPS Do You Really Need Report, Coughlin and Handy, http://www.tomcoughlin.com/techpapers.htm

# Minimum Latency Requirement



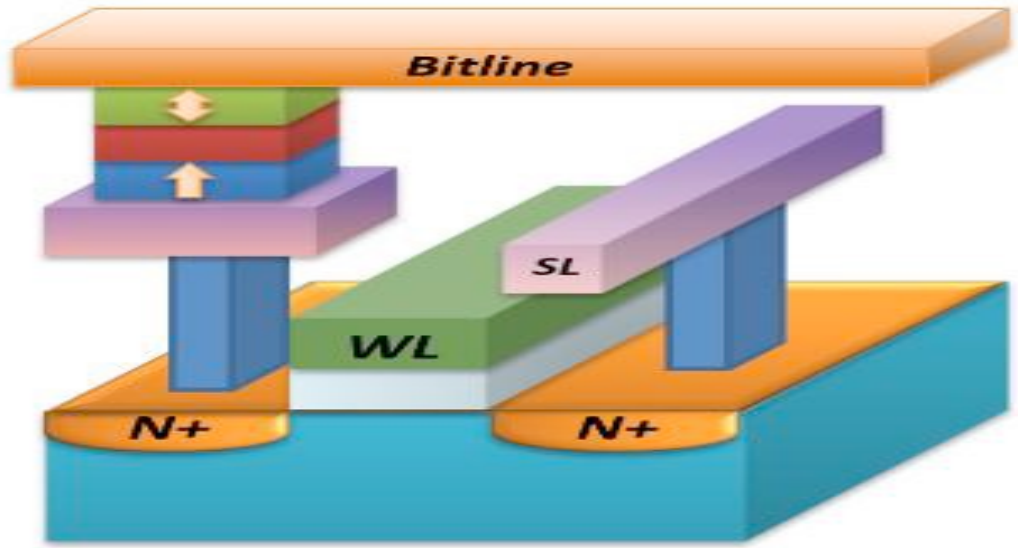

From the 2014 How Many IOPS Do You Really Need Report, Coughlin and Handy, http://www.tomcoughlin.com/techpapers.htm

# Storage Devices Developments

- Hard disk drives
  - Cold Storage Drives with SMR and He-filled drives promise 10 TB drives in 2015
  - Hybrid HDDs, as thin as 5 mm
  - New interfaces—Kinetic from Seagate, Thunderbolt 3, USB 3.1
- Flash Memory
  - Samsung 3D TLC flash (1 TB SSDs)
  - 15-16 nm flash production in 2015
  - SanDisk—up to 16 TB SSD by 2016

# Emerging Memory Technology

- NVM will save power
- Persistent memory enables memory sharing (RDMA)
- Embedded NVM technology can lead to “logic-in-memory architecture”

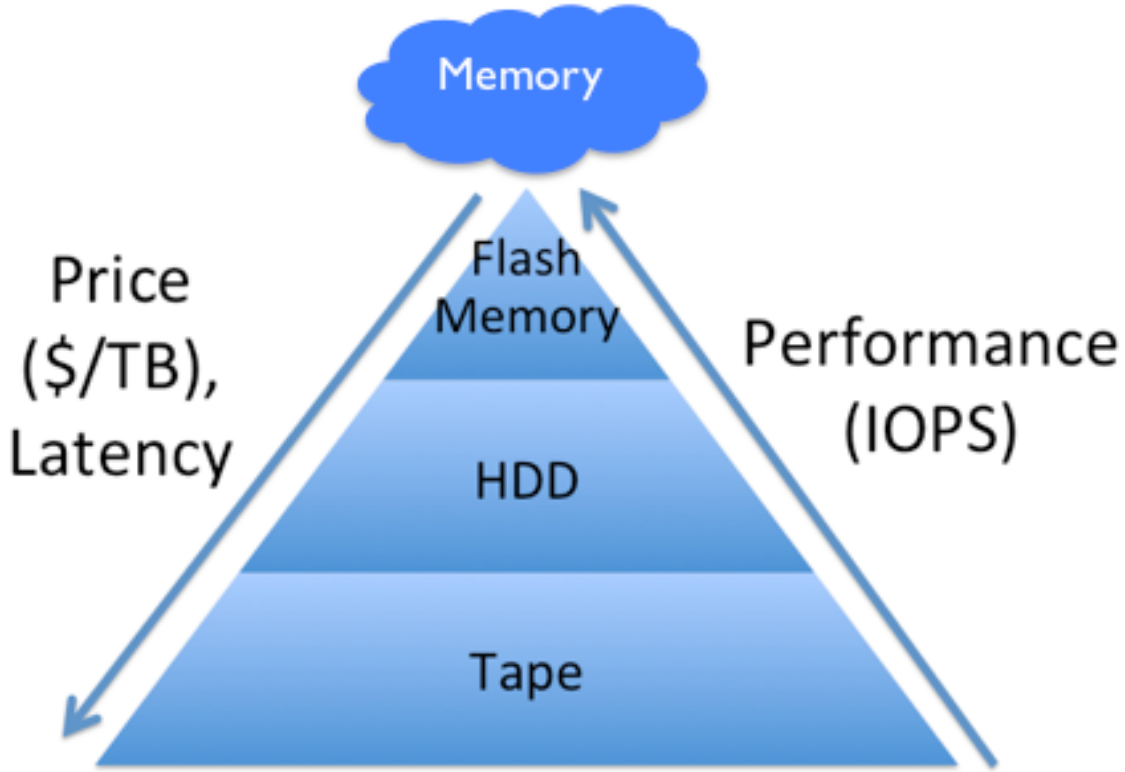



STT MRAM market could exceed $2 B by 2019

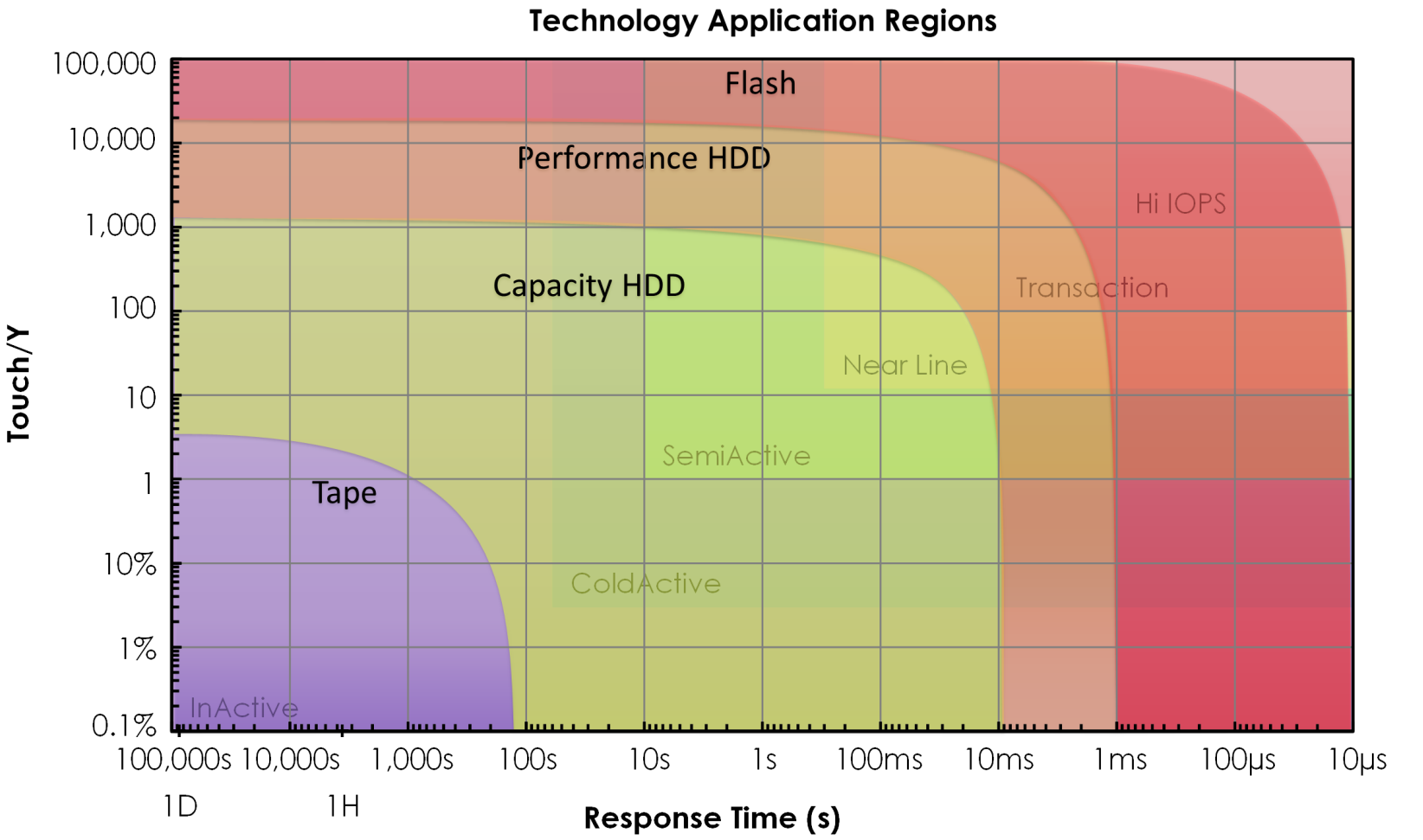
2014 Emerging NVM Report and Their Manufacture, Coughlin Associates

# Memory/Storage Hierarchy

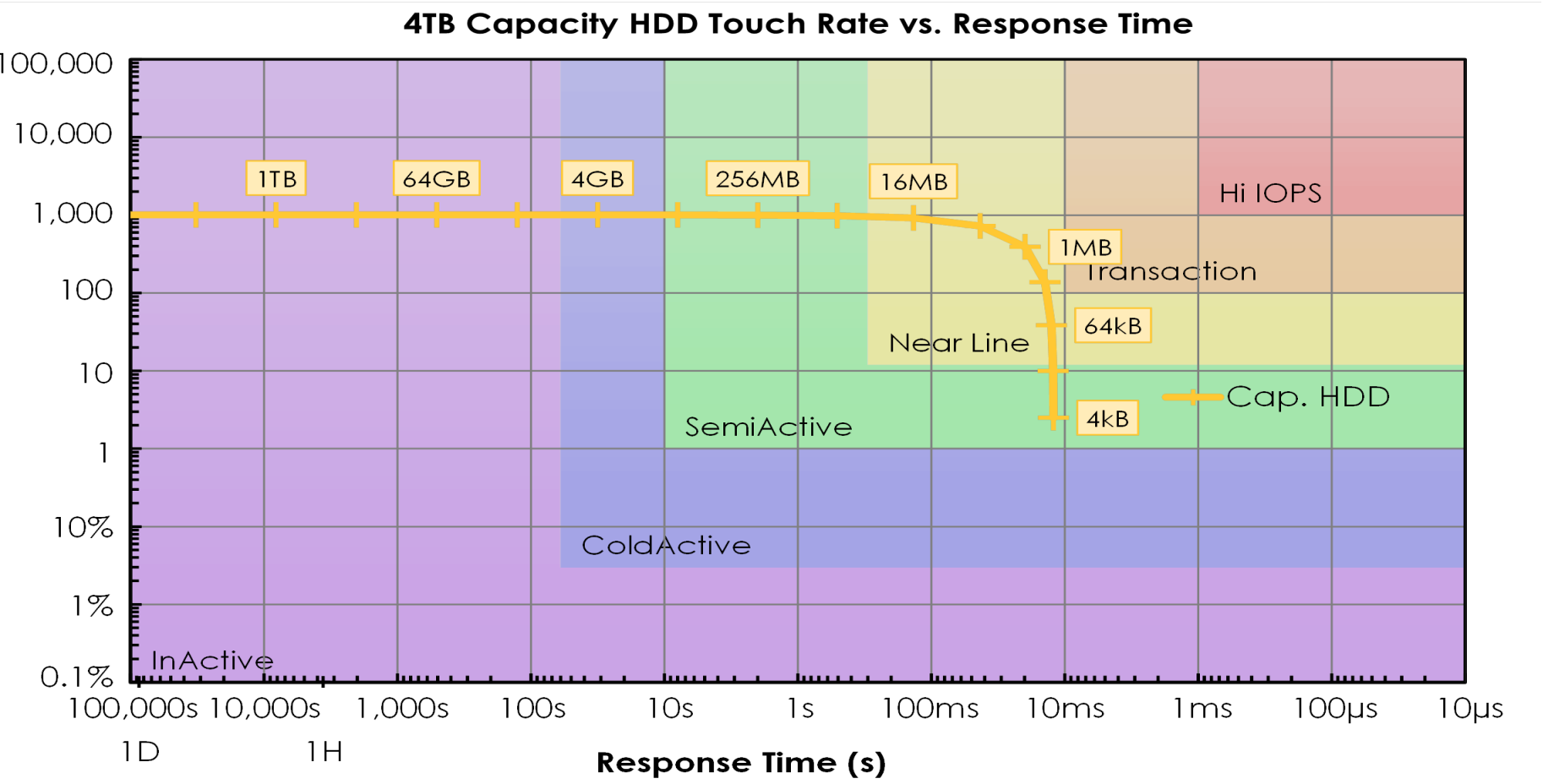
- Qualitative trade offs between volatile (and non-volatile) memory and non-volatile storage technology
  - costs to store data ($/TB)
  - performance of the storage technology (IOPS) or data rates).



# Digital storage technologies regions overlaid on the Touch Rate/Response Time chart

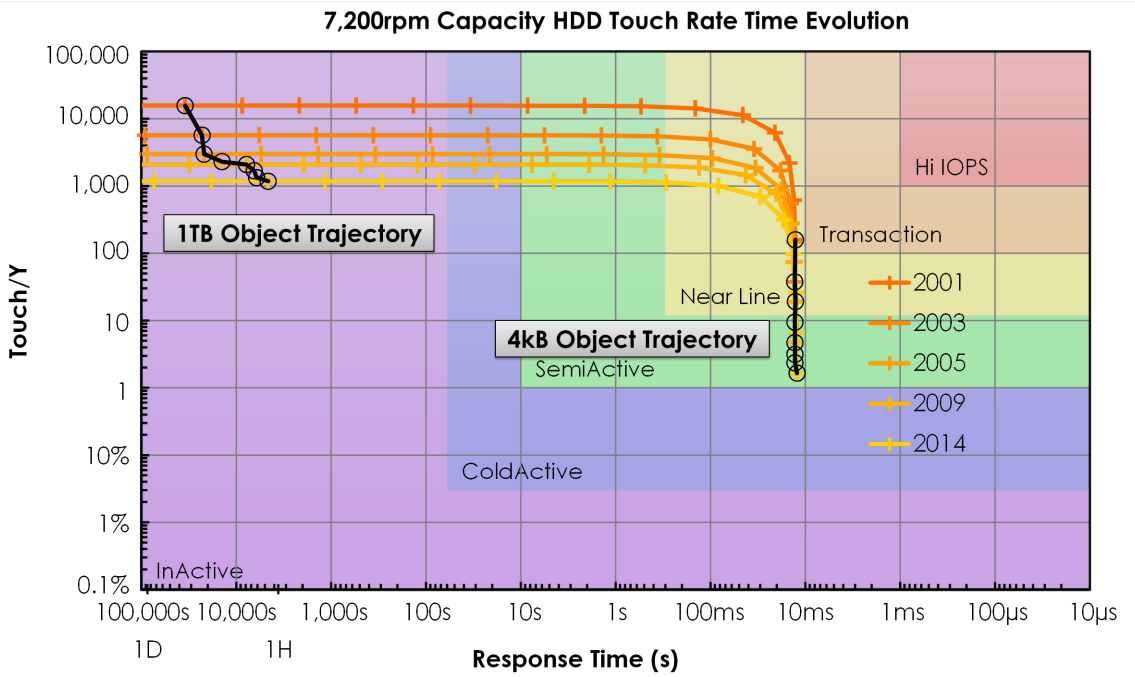


# Touch/Y and response time for 100% random IO in a 4 TB capacity HDD



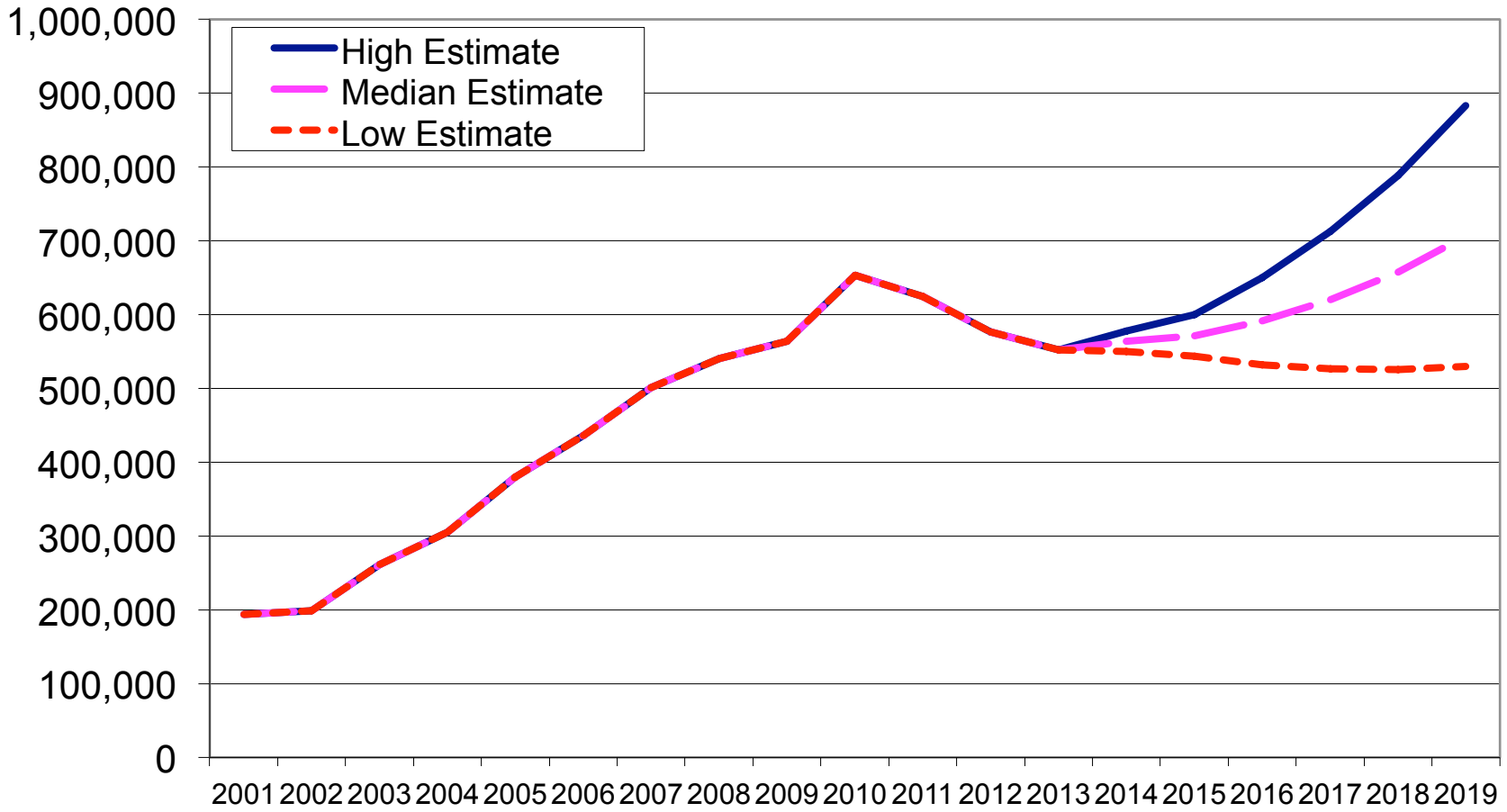
# The tyranny of density (High Perf. HDDs)

- In HDDs, the increase in capacity with areal density reduces the touch rate, since HDDs generally increase their capacity faster than their data rate.
- Other technologies, e.g flash, can thus provide high touch rates and displace these HDDs
- But the same trend is happening to flash memory, which may be displaced by some other NVM in time

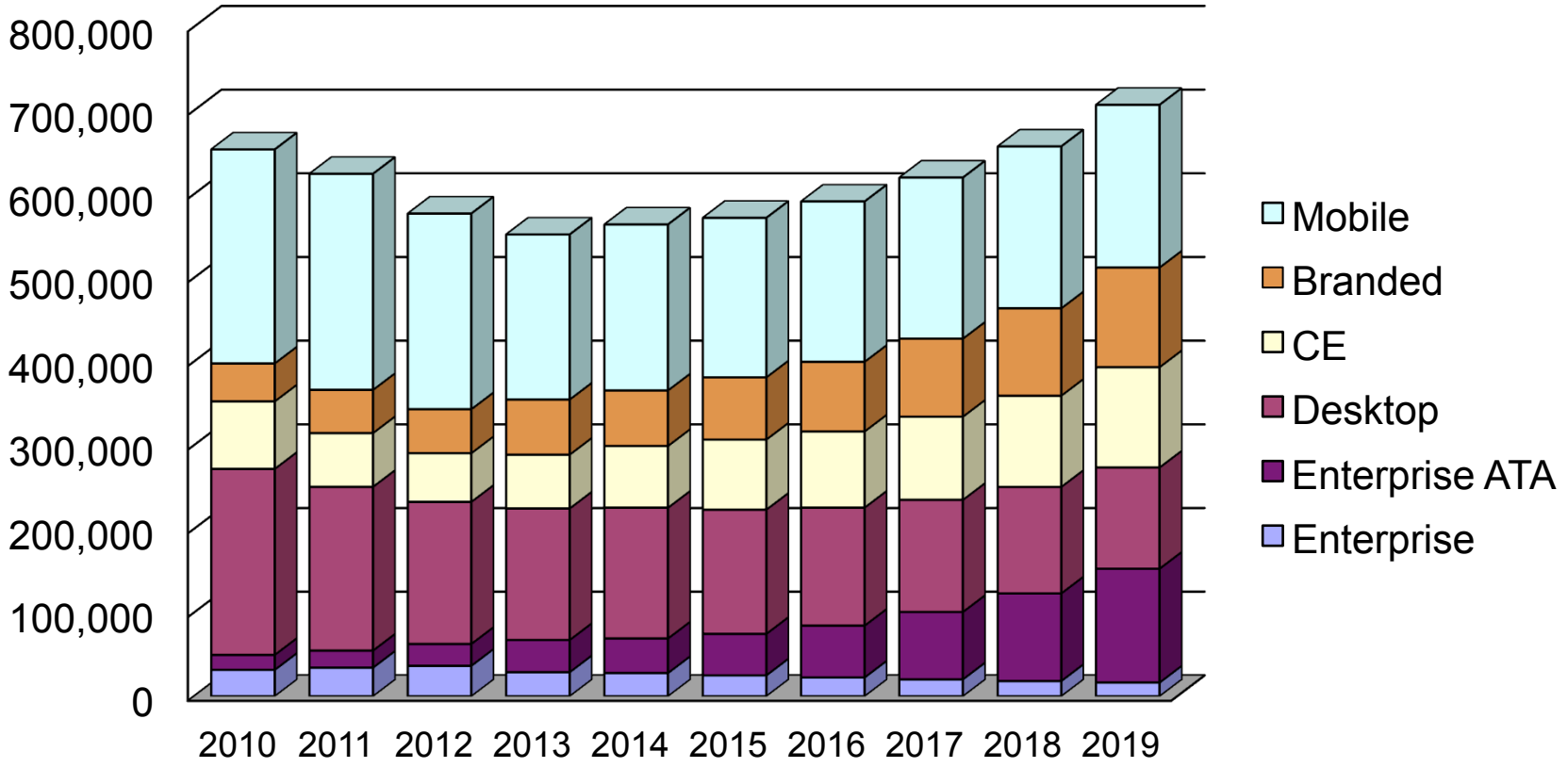



- TW increases don't increase data rate and thus reduce touch rates
- Likewise increasing # of disks in a HDD reduce touch rates

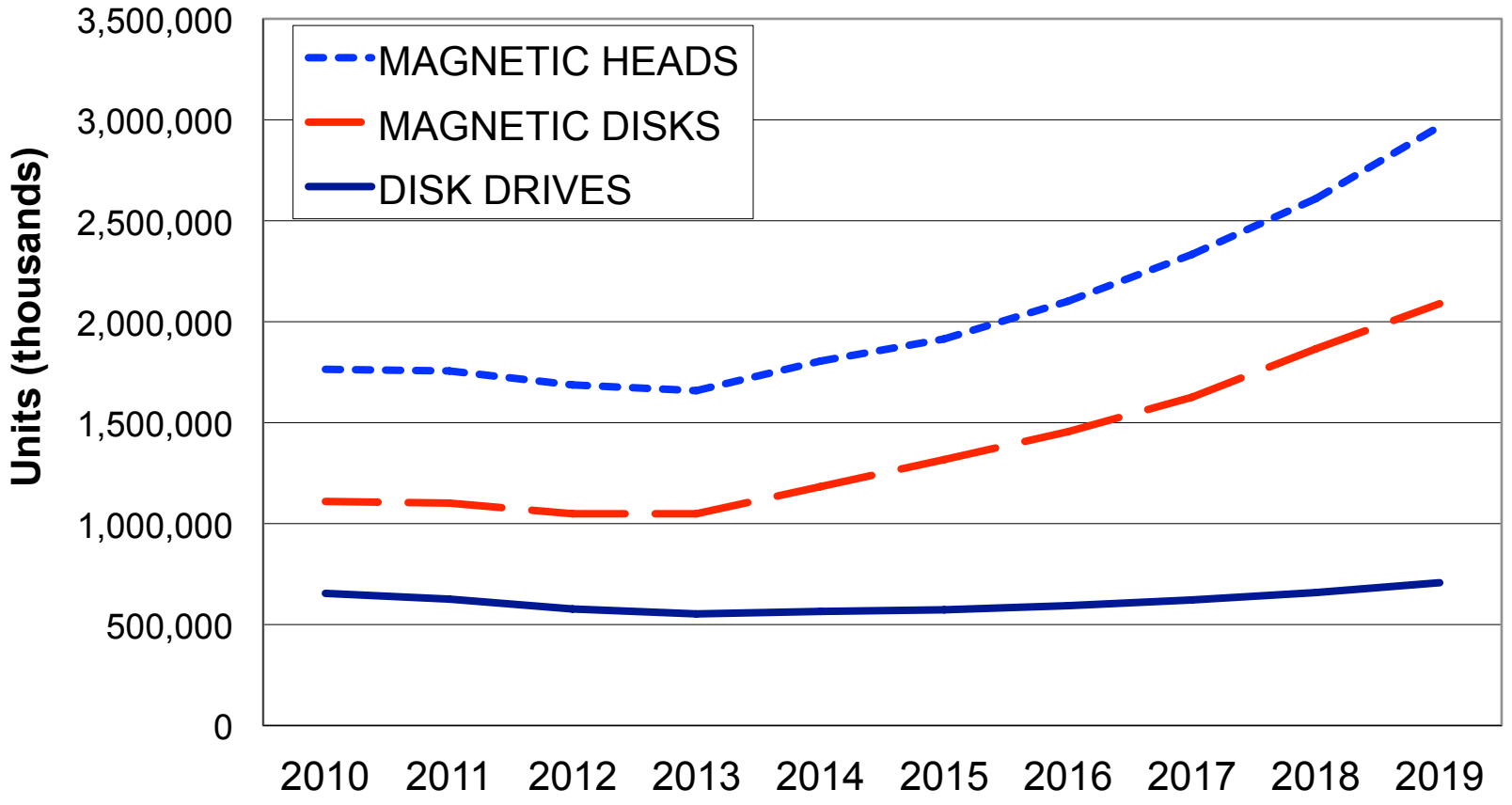
# Banded HDD Unit Projections



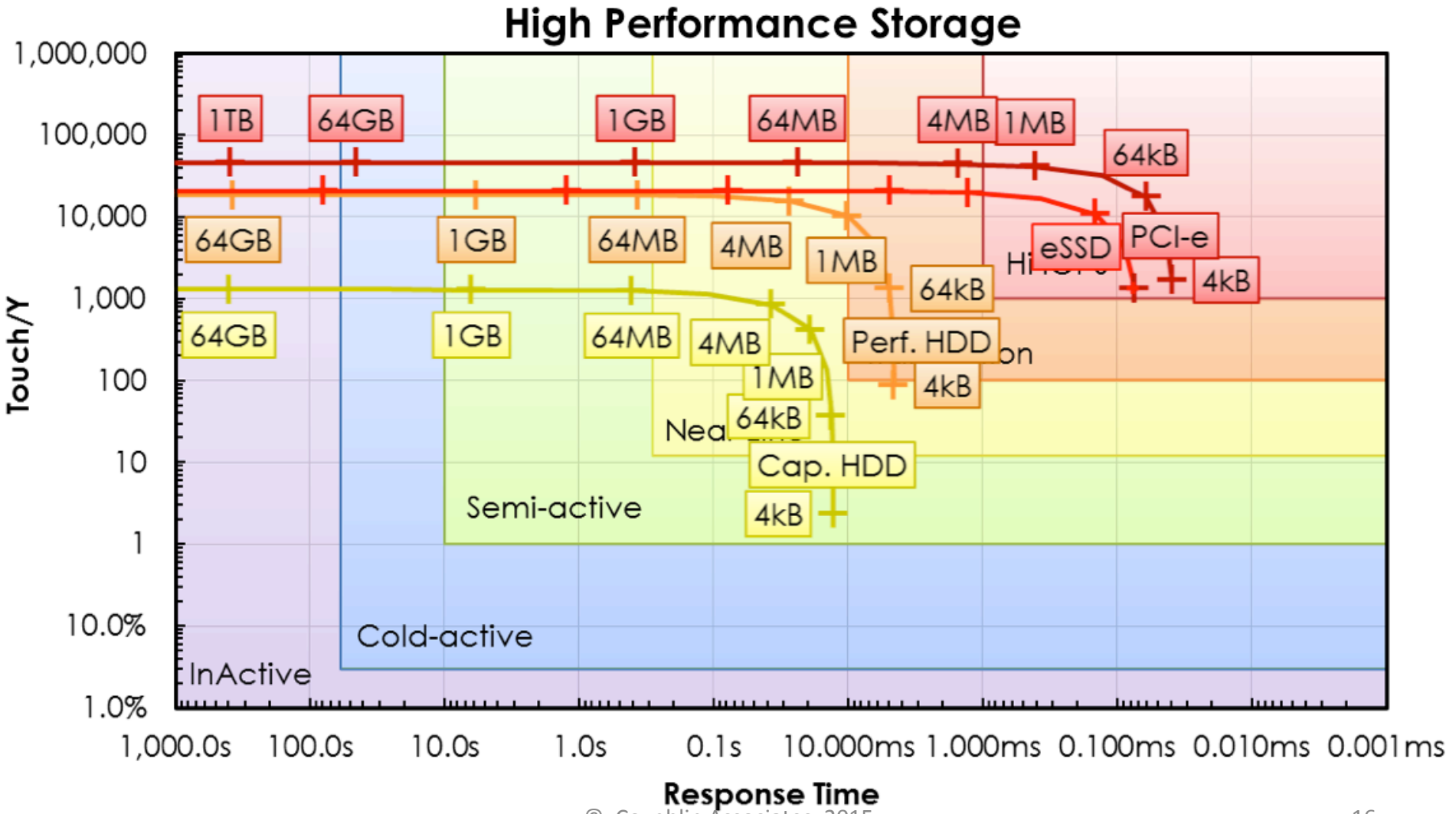
# HDD application unit projections



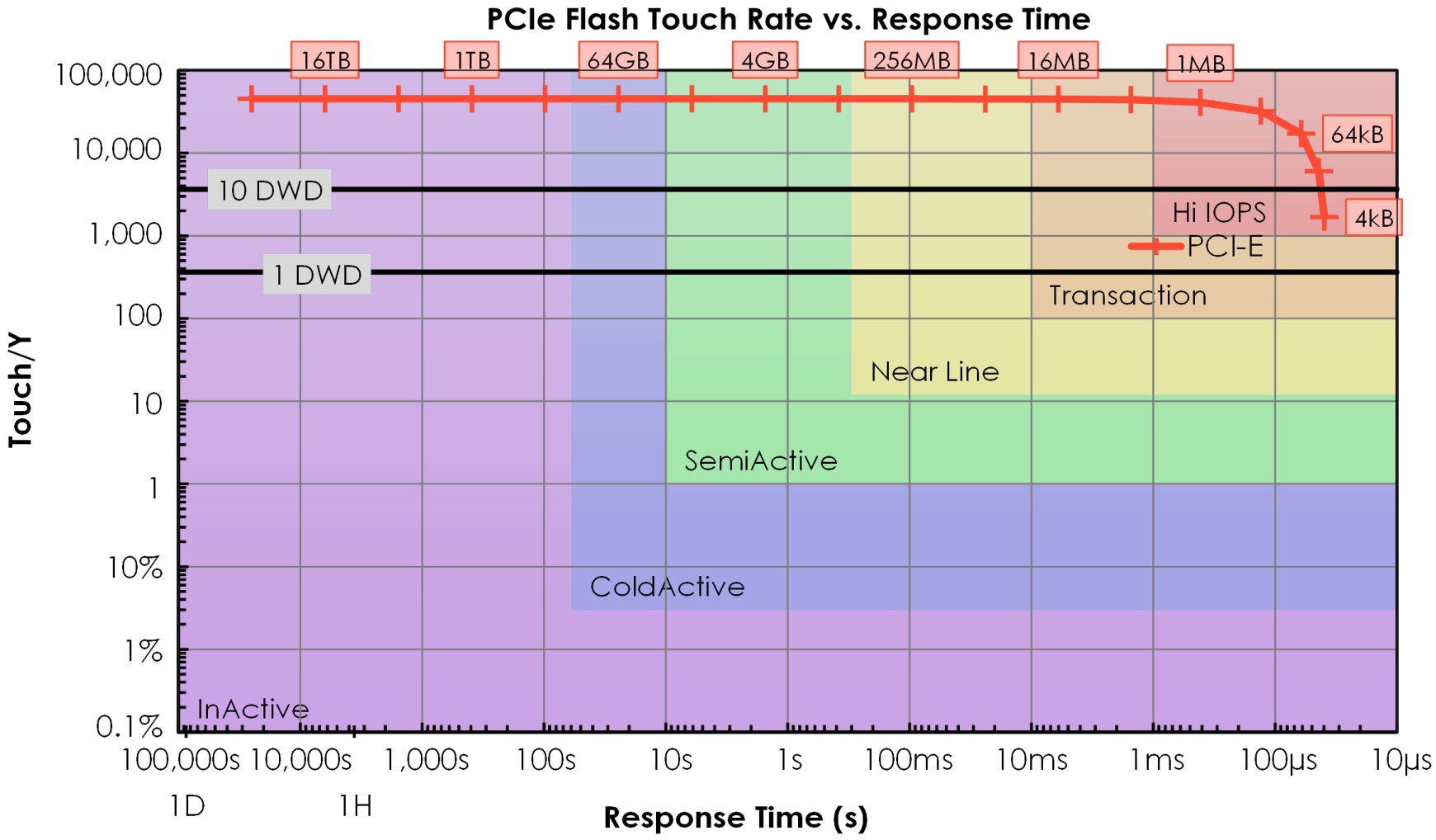
# Heads and media projections



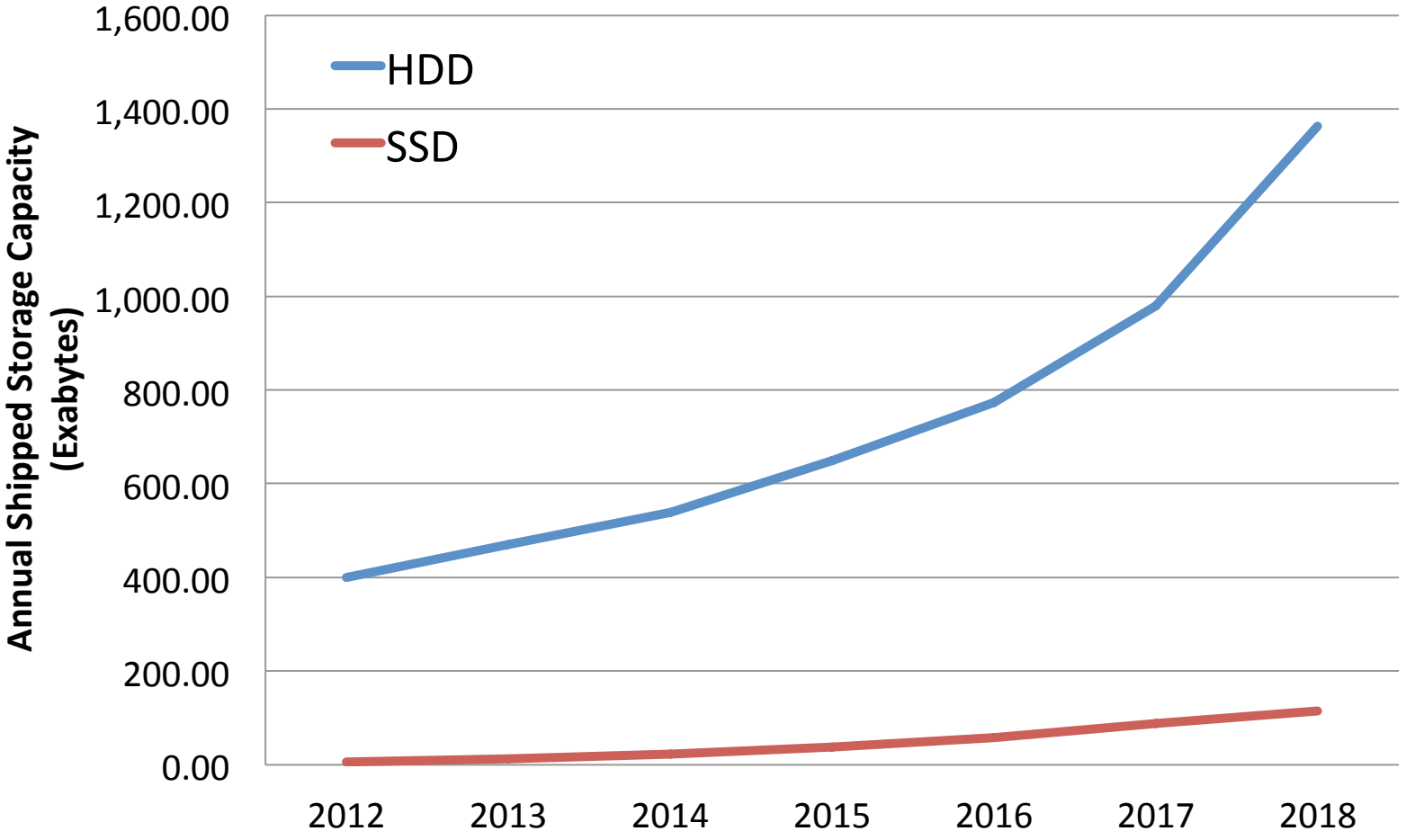
# Ent. SSDs, perf. HDDs and capacity HDDs



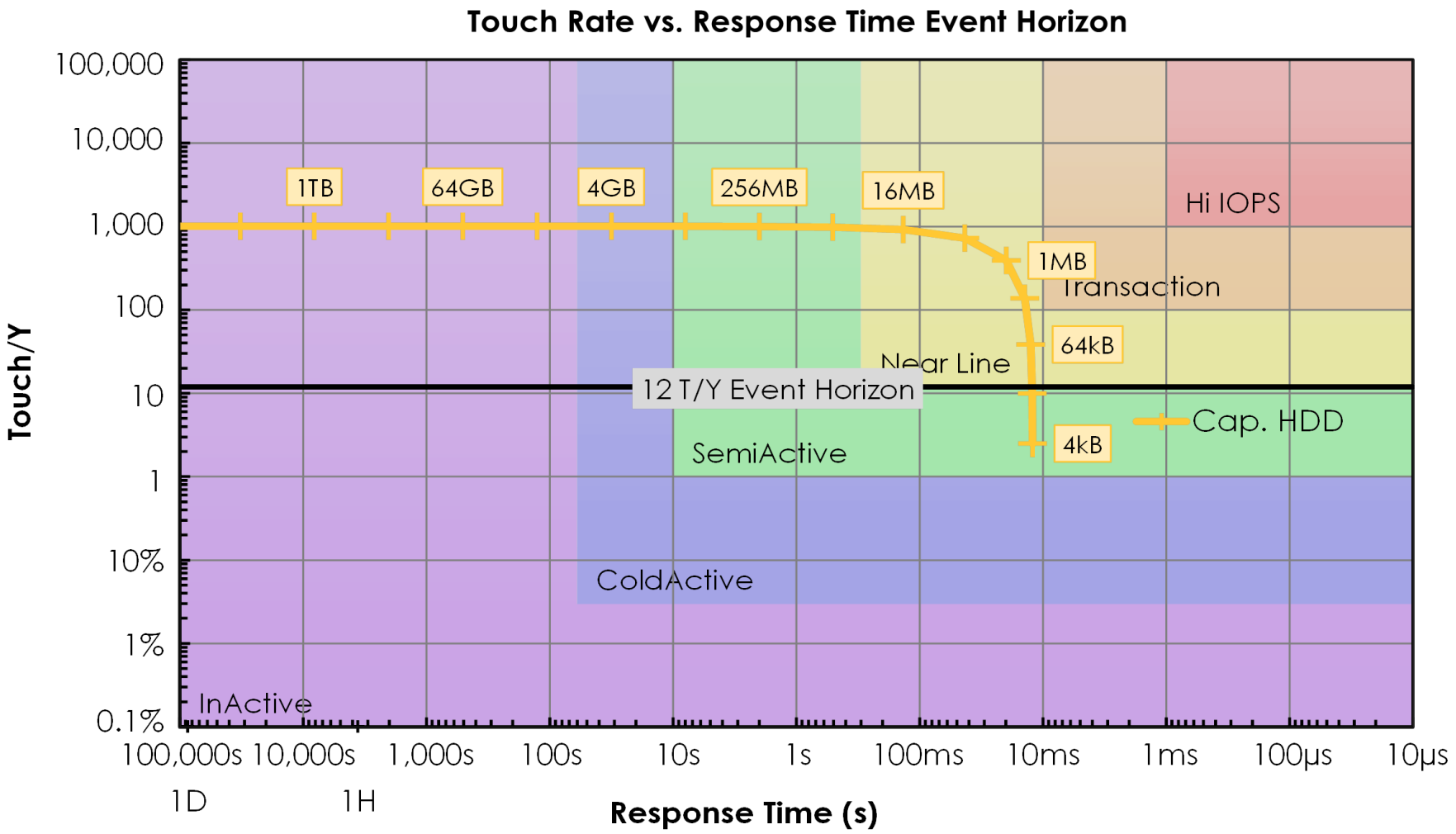
# Flash DWD limits in a touch rate chart



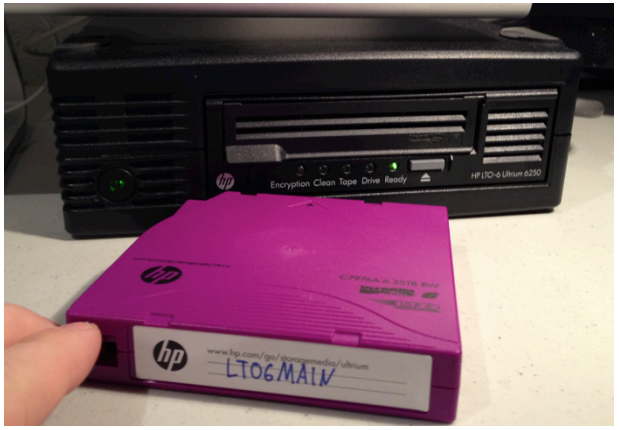
# Projections for HDD and flash memory capacity shipments



# 4 TB capacity HDD data event horizon



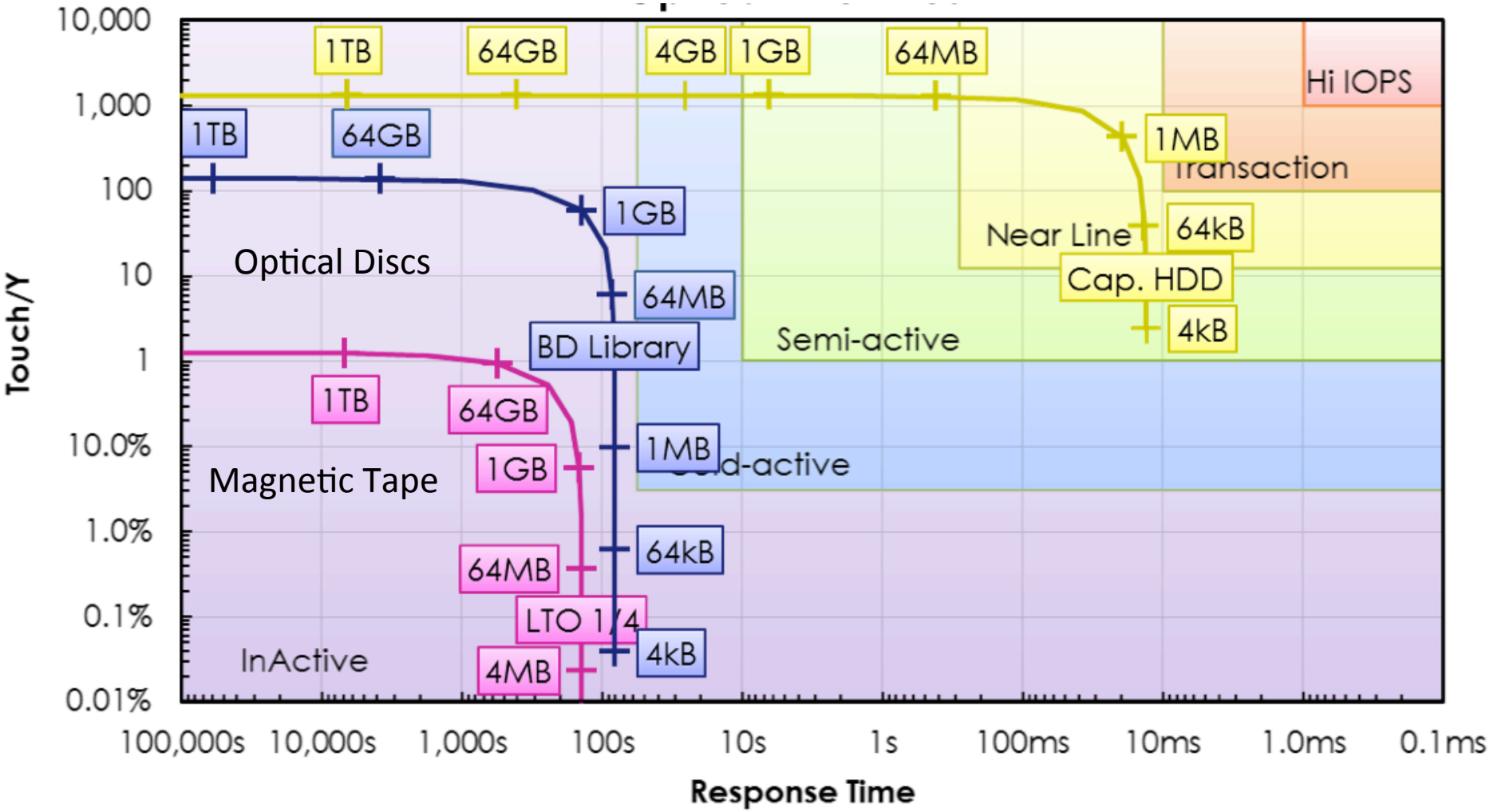
# Storage Devices Developments (2)



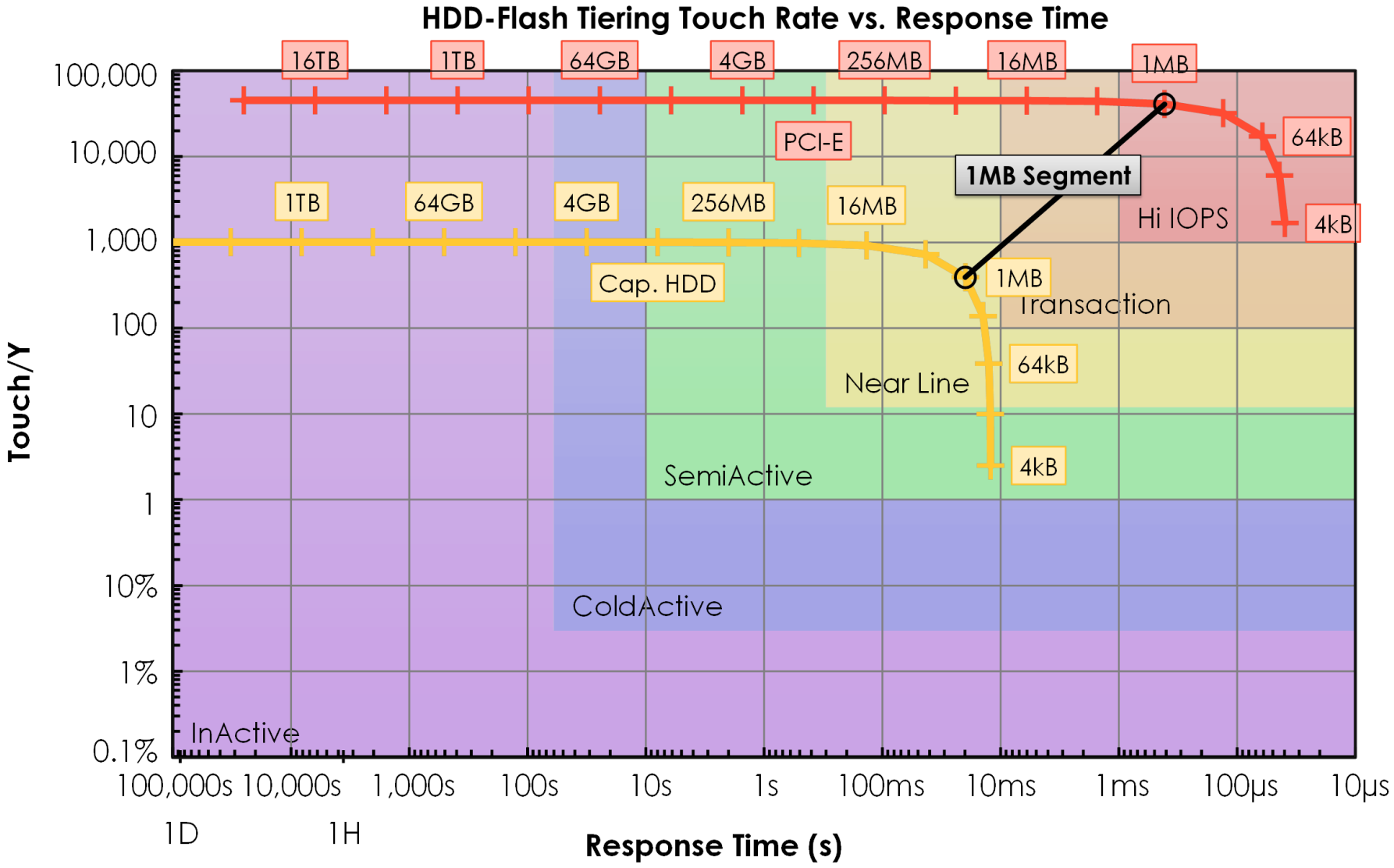


- Magnetic data tape
  - LTO roadmap to gen 10 with 48 TB
  - IBM 10 TB
  - Object based tape
- Blu-ray WORM
  - 300 GB Discs by 2015, 500 GB by 2017 and 1 TB by 2019
  - 12 disc cartridges

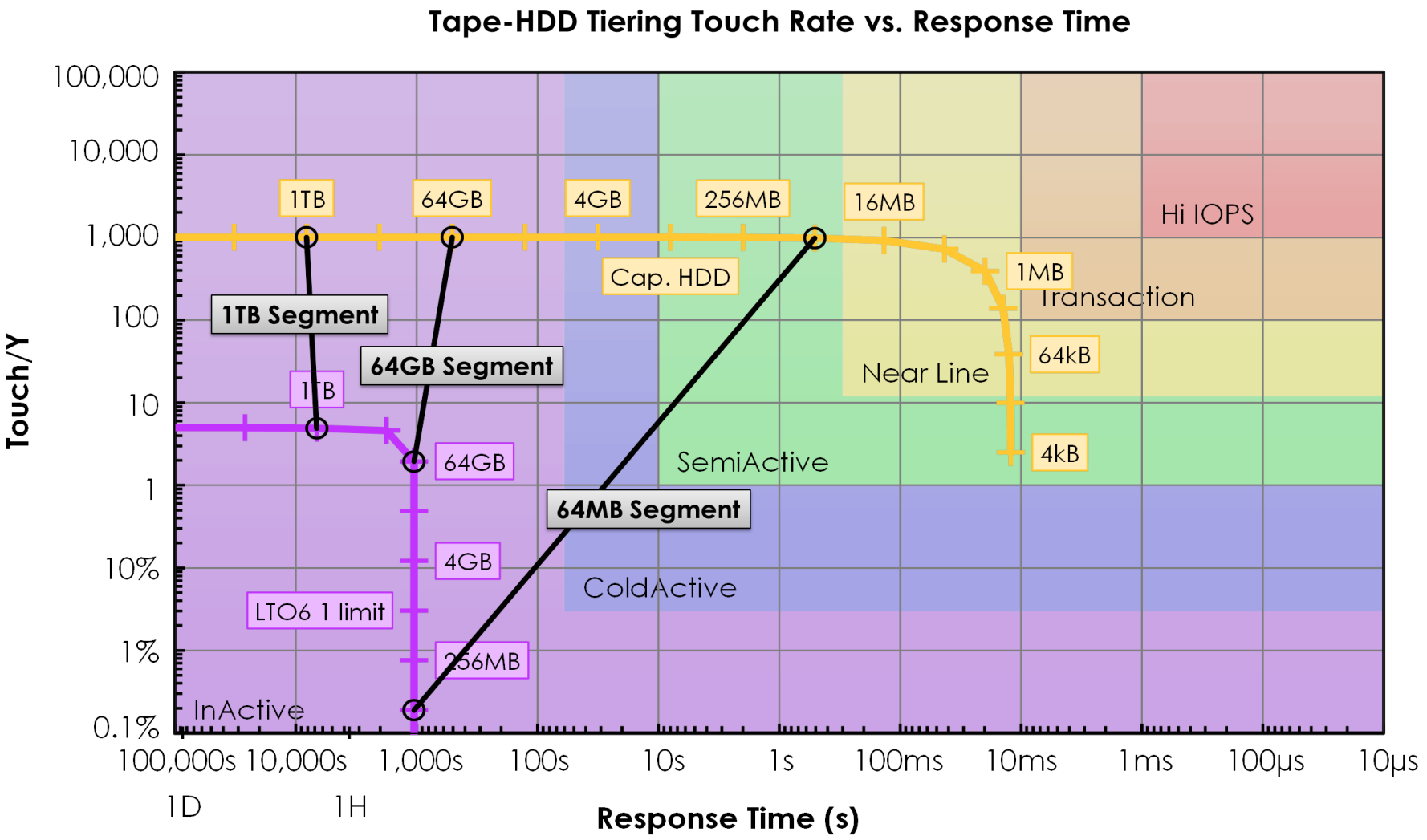
# Comparison of archive storage



# HDD-Flash tiering/caching touch rate chart



# Tape-HDD tiering touch rate chart




# Conclusions

- A new metric comparing touch rate and response time can be used to characterize storage devices and in system design
- We gave examples with HDDs, flash memory, tape and optical disc on how different storage provides different advantages depending upon the application

# References


- 2014 How Many IOPS Do You Really Need Report, Coughlin and Handy, http://www.tomcoughlin.com/techpapers.htm
- Touch Rate:  A metric for analyzing storage system performance, Steven Heltzer and Tom Coughlin, 2015, http://www.tomcoughlin.com/techpapers.htm


Thanks