Panel

Flash Cache Form Factors & HDD Economics

Moderator:

Jim Handy, Objective Analysis

Our Panelists

Seagate	Dave B. Anderson	Director of Strategic Planning, Seagate
NVELO	Jiurong Cheng	President & CEO, NVELO
hp invent	Walter Fry	Distinguished Technologist, Notebook Platform Architect, Hewlett Packard
intel	Rob Larsen	Strategic Marketing Manager, NAND Solutions Group Intel

Flash Cache Form Factors & HDD Economics

Speaker:

Dave B. Anderson

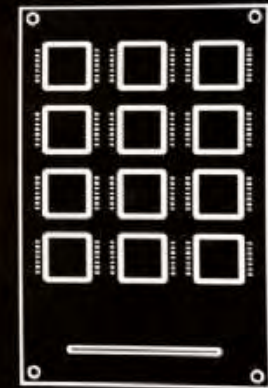## Seagate

Introducing Momentus XT

Part
Hard Disk Drive

Part
Solid State Drive

100% Fast, Big, & Affordable
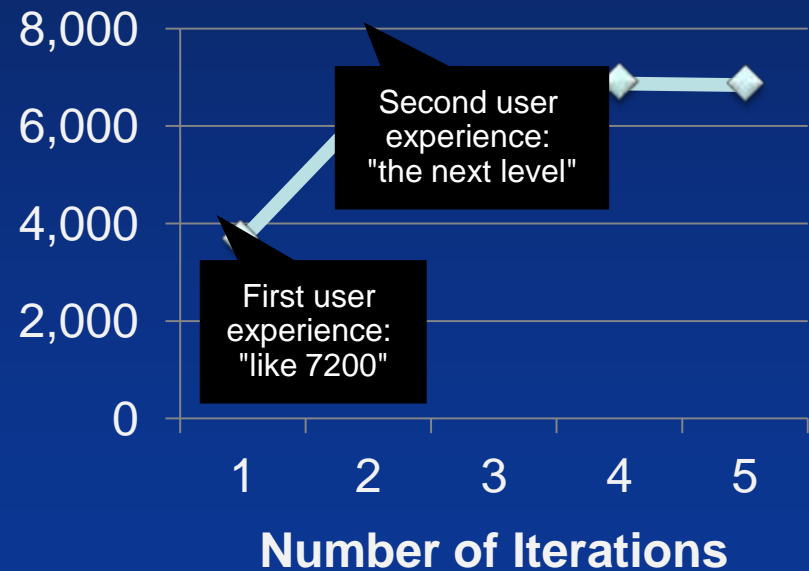
Adaptive Memory™ Technology by Seagate

- Adaptive Memory™

Intelligent algorithm designed to learn and anticipate your most demanding needs – driving custom tailored performance for every individual user.

1. Algorithms monitor data access transactions

2. Qualified data is placed in the SSD

3. Maintains frequently used data vs. not used data

All done completely OS independent.

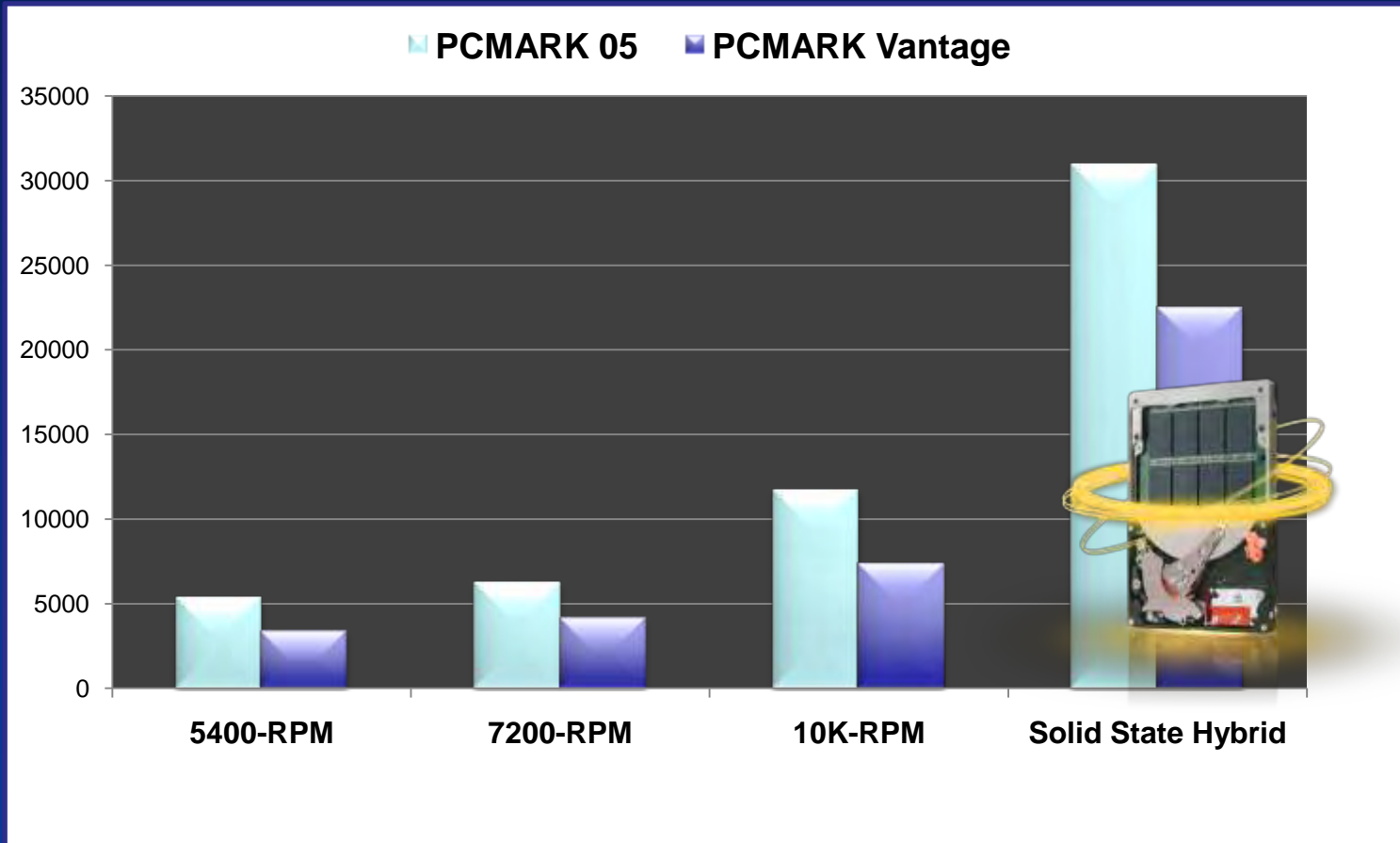## Adaptive MemoryTM Learns Quickly PCMark Vantage – HDD Score

Second user experience: "the next level"

First user experience: "like 7200"

Number of Iterations

Dell9200

PC Component Benchmarks
PCMark HDD Suite

Real World Testing

SSD

Elapsed Times	
Bootup :	18 s
MS Excel :	9.3 s
iTunes :	4.8 s
Crysis Warhead :	56.4 s
Premier Elements :	40.0 s
NI LabVIEW :	11.6 s
Total (seconds) :	140.1

Seagate Momentus XT

Elapsed Times	
Bootup :	23 s
MS Excel :	9.2 s
iTunes :	4.8 s
Crysis Warhead :	64.3 s
Premier Elements :	40.2 s
NI LabVIEW :	12.3 s
Total (seconds) :	153.8

05:31

10K RPM Drive

Elapsed Times	
Bootup :	38 s
MS Excel :	10.0 s
iTunes :	17.9 s
Crysis Warhead :	61.6 s
Premier Elements :	45.2 s
NI LabVIEW :	15.5 s
Total (seconds) :	188.2

7200 RPM Drive

| Elapsed Times	
Bootup :	59 s
MS Excel :	11.0 s
iTunes :	18.4 s
Crysis Warhead :	63.1 s
Premier Elements :	50.1 s
NI LabVIEW :	24.0 s
Total (seconds) :	225.6

Breaking the I/O Bottleneck

- **CPU & DRAM performance has increased dramatically**
  - storage is the bottleneck for system performance

- **No "game-changing" developments in the near term**
  - HDD's provide optimal $/GB => use for capacity
  - SSD's provide optimal Mb/s => use for performance

- **Software enables the use of SSD's and HDD's - together**
  - Intelligent caching software provides SSD performance and HDD capacity
  - Example:
    - 16GB SSD + 320GB HDD + Cache SW = High-Performance, High-Capacity, Low-Cost

Cache Form-Factors

- Many options for form-factor and interconnect:
  - HDD + Standard SSD
  - HDD + mSATA module
  - HDD + mini-PCIe module, or full-sized PCIe card
  - Multiple HDDs or using multiple SSD…

Cache SW — SATA — SATA

Cache SW — SATA — SATA

Cache SW — SATA — PCIe

Cache SW — SATA — PCIe
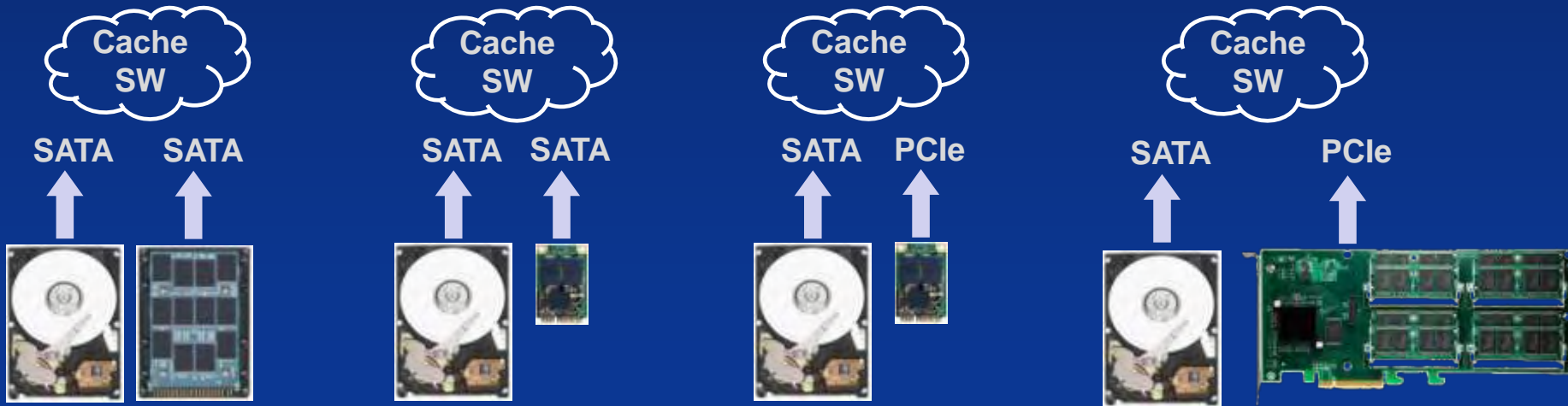
Communicating the Value

- End-user experience = system-level performance
    - Boot times
    - Application launch/execution times
    - File manipulation: open, copy/paste, etc.

- Different benchmarks measure different things, differently…
    - IOMeter, PCMark, SYSMark…
    - How does your benchmark map to <u>end-user-experience</u>?

- Intelligent caching solutions (like Dataplex™) are adaptive to user behavior, and optimize the use of the SSD and HDD accordingly
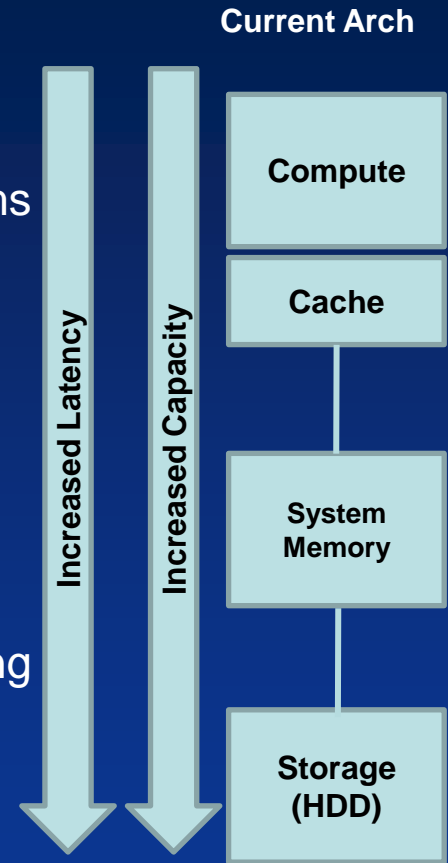
PC Client Architecture

- **CPUs and Gfx controllers continue to improve performance and performance efficiency (performance-per-watt)**
  - Provides increased capabilities and usages for client platforms
  - The rate of advancements is expected to be maintain for the foreseeable future
- **DRAM system memory improves throughput and capacity-per-watt**
  - DDR4 is expected to improve both performance and power efficiency
  - CPU memory cache used to remove memory latency
  - Memory controller architectures have expanded to improve performance in high-end workstation clients such as by adding additional memory channels
- **Rotating media (HDDs)**
  - Continues to offer the lowest $/GB storage medium
  - However, performance have not kept up with CPU, Gfx & system memory

Current Arch

Increased Latency

Increased Capacity

Compute
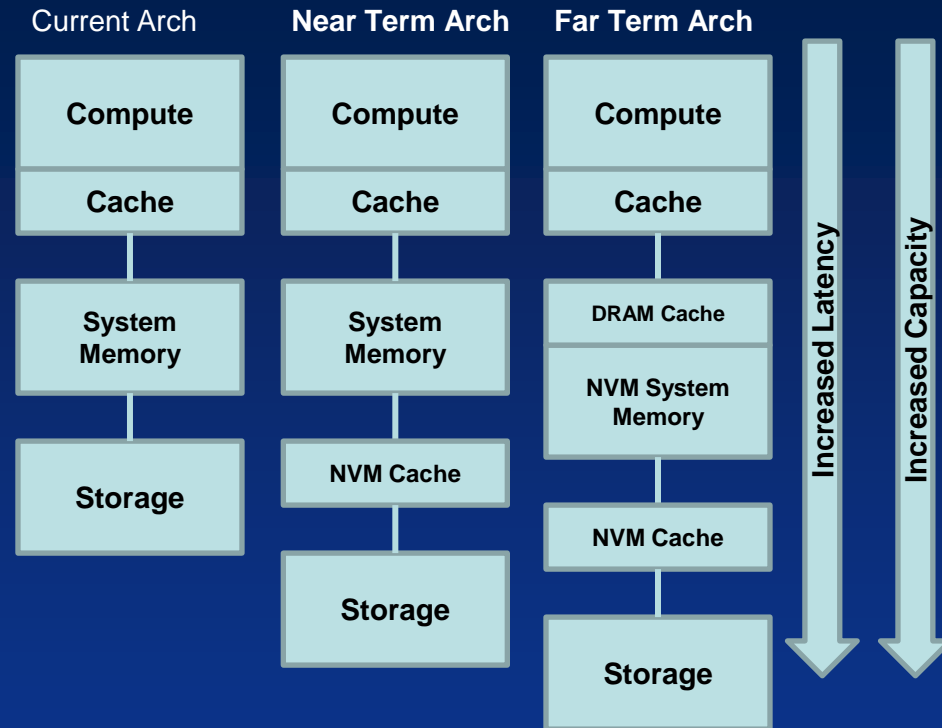
Cache

System Memory

Storage (HDD)

PC Client Architecture

- NAND Flash memory offers performance and power consumption improvements to enable it to enter the PC architecture

- Initially as Solid State Drives
  - Provides significant performance improvement over HDDs – especially in terms of latency and power efficiency
  - However the $/GB is much higher than HDD
    - Places SSD out of reach of most mainstream customers due to cost
    - For some high end users who are willing to pay the higher cost for the performance, battery life & durability may be disappointed with reduced capacity

Current Arch

Increased Latency

Increased Capacity

Compute

Cache

System Memory

Storage (HDD)
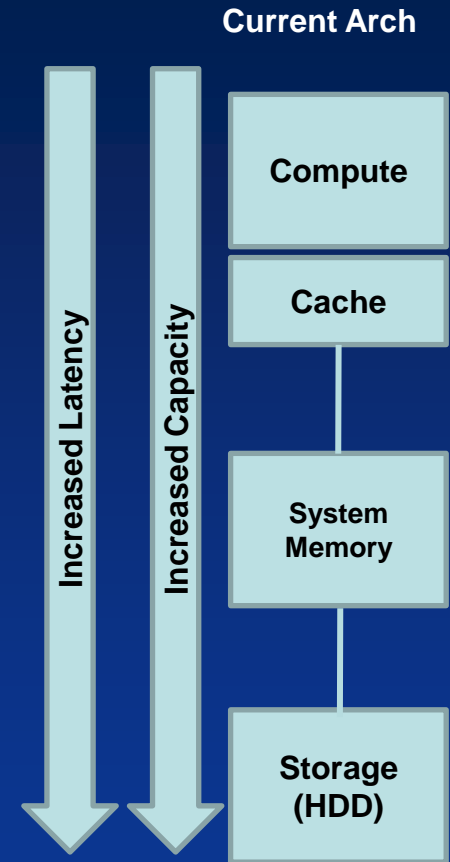
Memory Hierarchy Evolution

- Looking ahead, taking into account the performance advancements of the compute subsystem, the continued challenges with the storage subsystem, and the advancements in memory technologies (both volatile and non-volatile), evolutionary changes will occur in the platform's memory hierarchy

  - Near term: cache to the storage sub-system
    - Value proposition: Provide near SSD level performance while maintaining the capacity of the HDD at a affordable cost level

- Position on hierarchy is determined by the relative level of performance, specifically the relative amount of latency and capacity (including $/GB)

Current Arch

Compute
Cache
System Memory
Storage

Near Term Arch

Compute
Cache
System Memory
NVM Cache
Storage

Far Term Arch

Compute
Cache
DRAM Cache
NVM System Memory
NVM Cache
Storage

Increased Latency

Increased Capacity

As non-volatile memory technologies emerge with improved performance, power & durability, the memory hierarchy will evolve to enable new levels of performance, user experience and features

Flash Cache Form Factors & HDD Economics

Speaker:

Rob Larsen

Intel

Dual Drive is the storage enabler
(SSD & HDD)

- Platforms continue to shrink
  - Everyone wants …
    - Portability
    - Fast responsiveness
    - Low cost storage

- Some SSDs offer great performance and features, but is difficult to meet low consumer price/capacity requirements

- HDDs provide lowest cost/bit, but performance is lacking.

- The optimal consumer solution is to combine the best of both worlds (performance & capacity), **but** with minimal impact on portability.
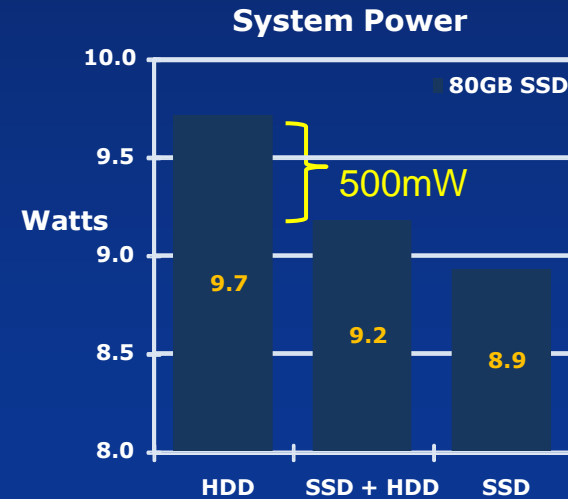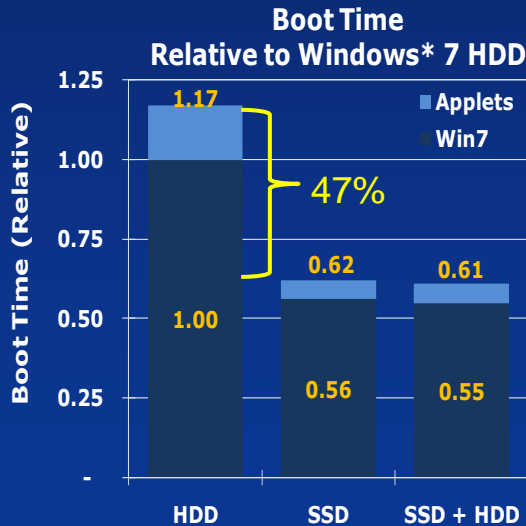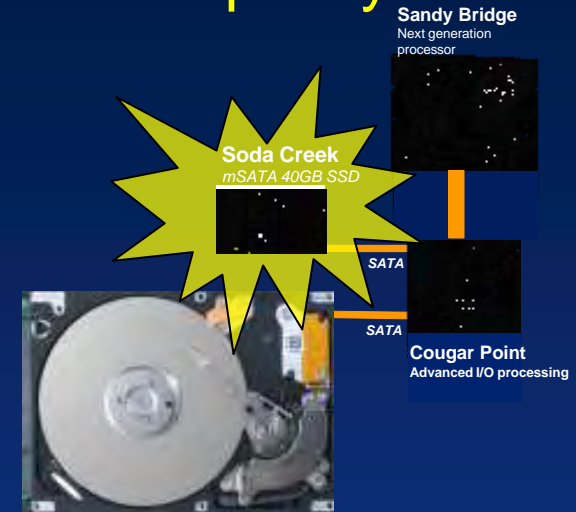 - Small form factor SSD (mSATA) with Hard Disk Drive

Dual Drive Solution
Small SSD for performance, HDD for capacity

Sandy Bridge
Next generation processor

Soda Creek
mSATA 40GB SSD

SATA

SATA

Cougar Point
Advanced I/O processing

- **Augments HDD in Dual-Drive Systems**
  - Up to ~50% boot-time reduction[1]
  - Up to a 55% increased system benchmark performance[2]
  - Enables HDD spin-down for power savings[3]
  - HDD bay for capacity scalability
  - Notebooks, All-In-Ones, and SFF Desktops
  - Scalable architecture for future improvements

Boot Time
Relative to Windows* 7 HDD

Boot Time (Relative)

	Applets	Win7

- 1.25
- 1.00
- 0.75
- 0.50
- 0.25
- -

1.17
47%
0.62 / 0.56 (SSD)
0.61 / 0.55 (SSD + HDD)
1.00 (HDD)

HDD   SSD   SSD + HDD

System Power

Watts

- 10.0
- 9.5
- 9.0
- 8.5
- 8.0

80GB SSD

9.7 (HDD)
500mW
9.2 (SSD + HDD)
8.9 (SSD)

HDD   SSD + HDD   SSD

1 Boot time measurements were ran on a X58SO motherboard with an Intel® Core i7-975 processor, 6GB of DDR3 at 1333 MHz and Hitachi Travelstar* 320GB HDD running Windows *7 Ultimate 64bit with Intel ® Rapid Storage Technology drive version 8.9
2 Performance measurements done with PCMARK Vantage overall on an Intel® Core™ i5-430M processor , Dell* Inspiron 1464 with default settings, Integrated Intel® HD Graphics, 4Gb (2x2GB) Dual Channel DDR3-1066, Microsoft* Windows *7 Ultimate 64bit , Intel® X25-M 80GB Intel® Rapid Storage Technology 9.6.0.1014, Hitachi* Travelstar 320GB SATA2
3 Power measurements performed using a MobileMark* 2007 workload on an Intel® Redfort Rev 3 CRB motherboard with an Arrendale C2 2.66GHz CPU, 4GB of DDR3 at 1333 MHz, and Hitachi Travelstar * 320GB HDD running Windows* 7 Ultimate 64bit with Intel® Rapid Storage Technology version 8.9

*Other names and brands may be claimed as the property of others.

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