
Introduction

Outline

- What is database tuning
- What is changing

  The trends that impact database systems and their applications
- What is NOT changing

  The principles that underly our approach
- What these lectures are about

Definition

- Database tuning is the activity of making database applications run faster
  - Faster means higher throughput or/and lower response time
  - Avoiding transactions that create bottlenecks or avoiding queries that run for hours unnecessarily is a must

Why database tuning

- Troubleshooting:
  - Make managers and users happy given an application as well as DBMS/OS/Hardware
- Capacity Sizing:
  - Buy the right DBMS/OS/Hardware given application requirements
- Application Programming:
  - Code your application for performance given DBMS/OS/Hardware

Why do we teach database tuning?

Simple case study:

The following query runs too slowly

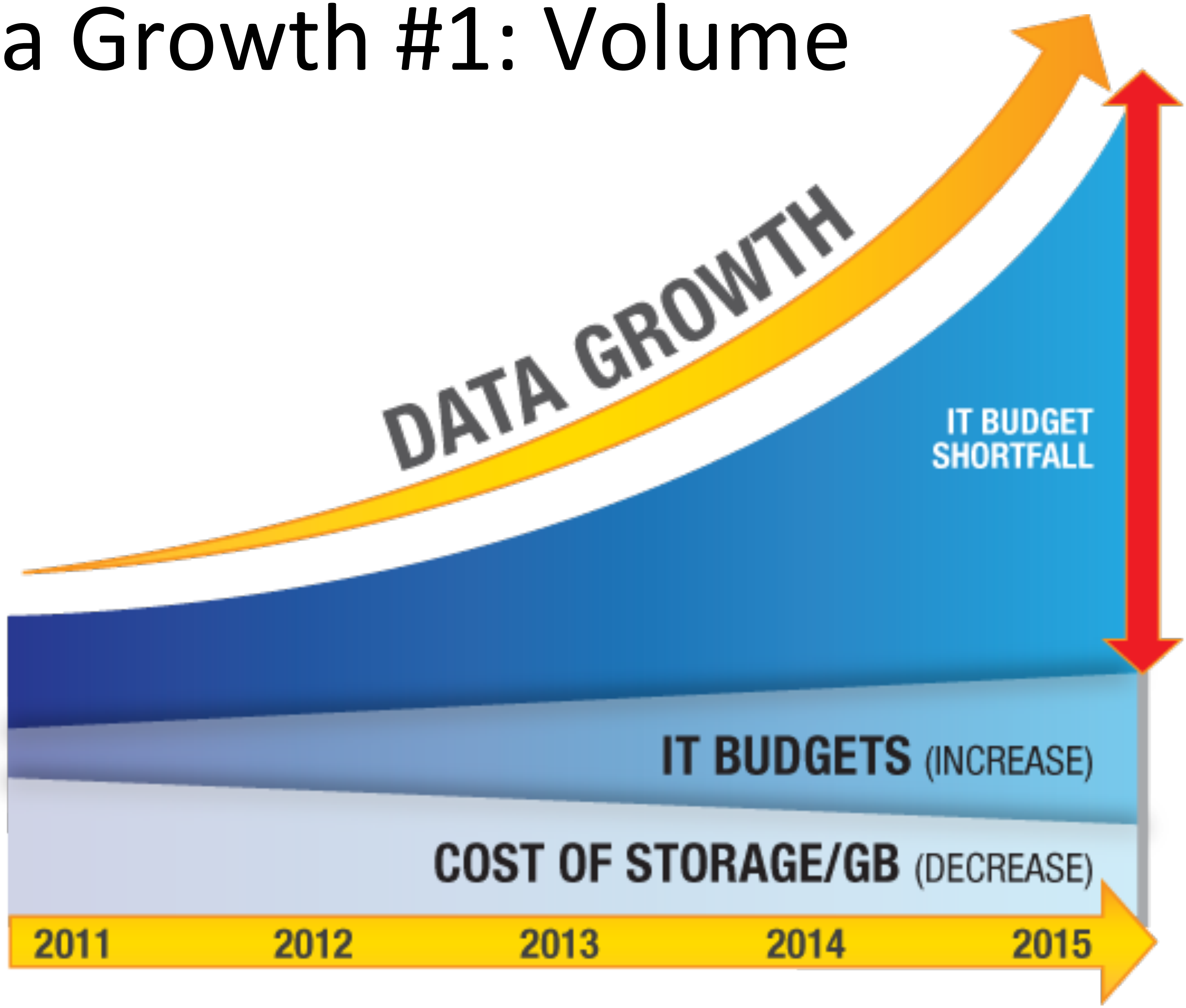
```
select *
from R
where R.a > 5;
```

What do you do?

Trends

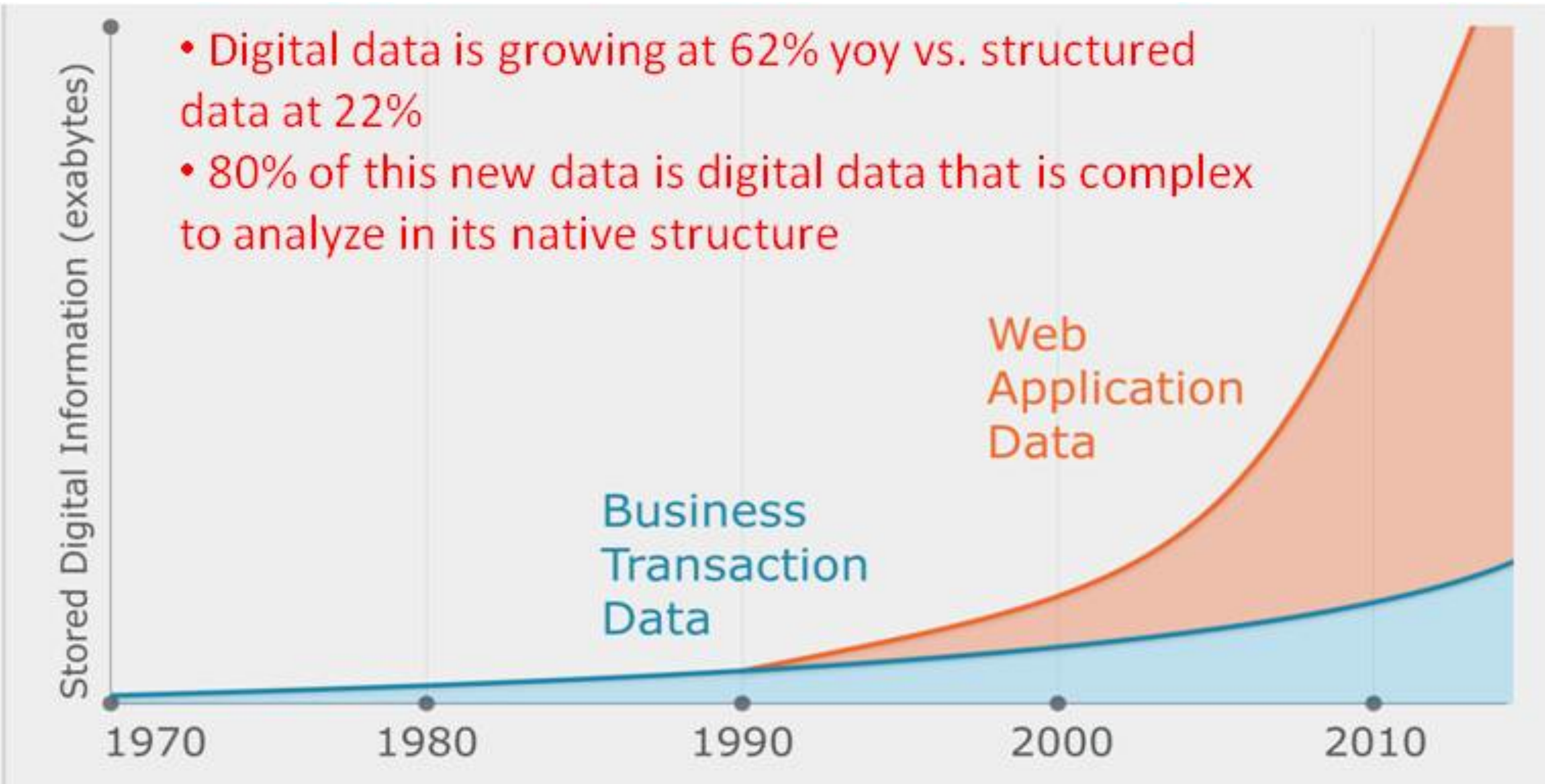
- Data
  - Sense making and the data deluge
- Hardware
  - Towards dark silicon
  - The age of semiconductor based persistence
  - The importance of parallelism

Data Growth #1: Volume



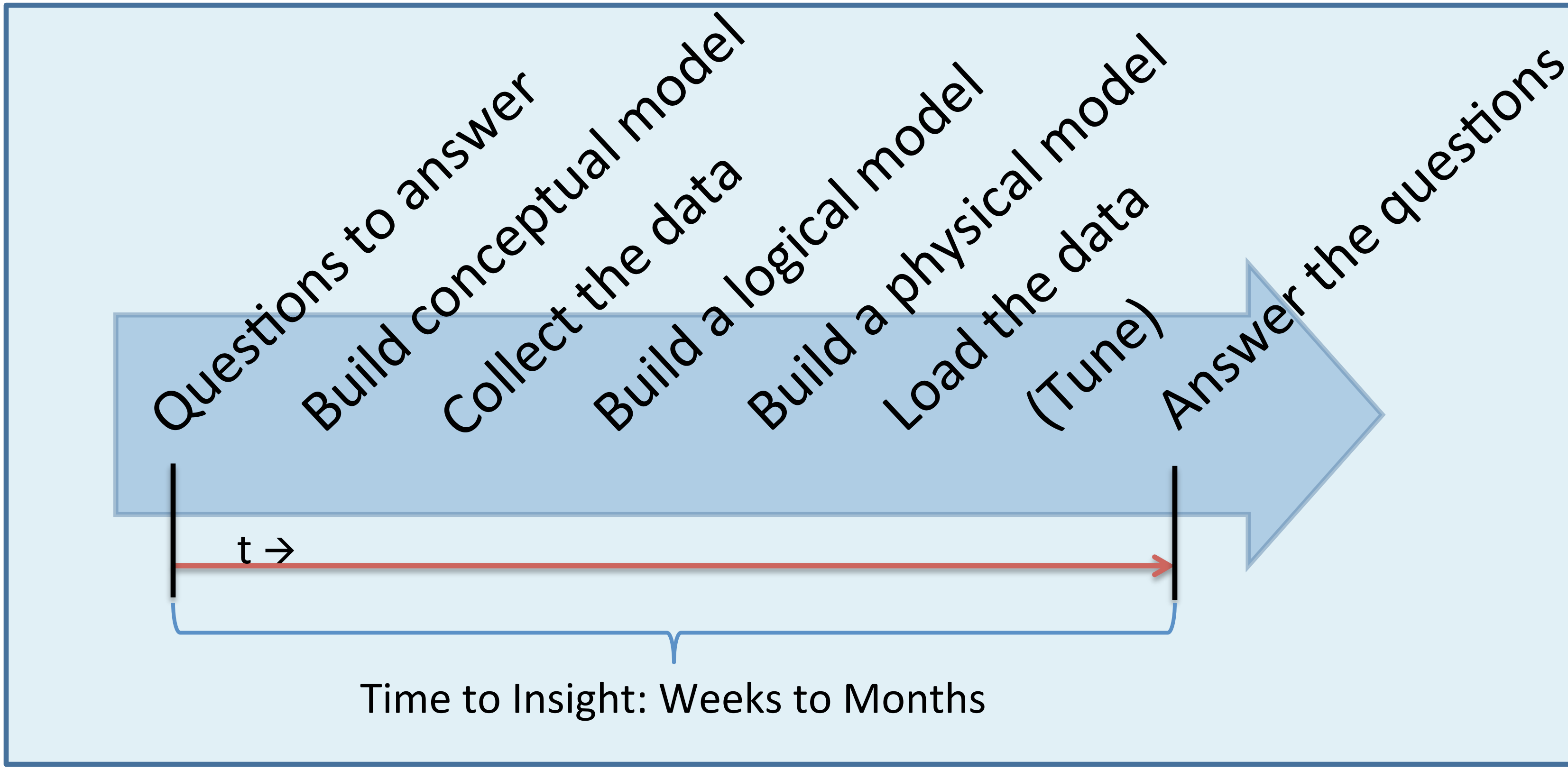
Source: http://permabit.com/media-center/blogs/

Data Growth #2: Data Complexity



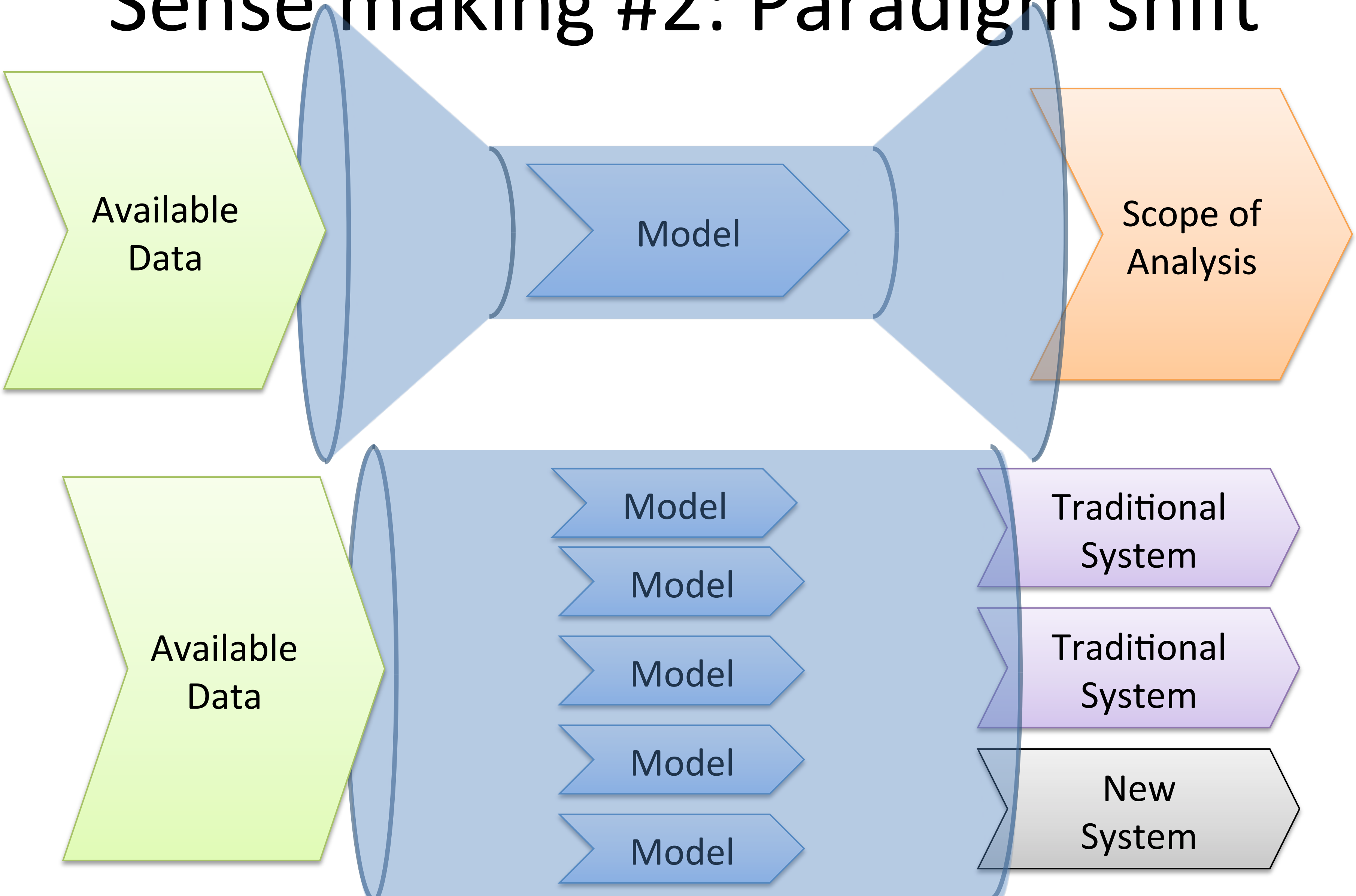
Source: https://practicalanalytics.wordpress.com/2011/11/06/explaining-hadoop-to-management-whats-the-big-data-deal/

Sense making #1: Current Paradigm



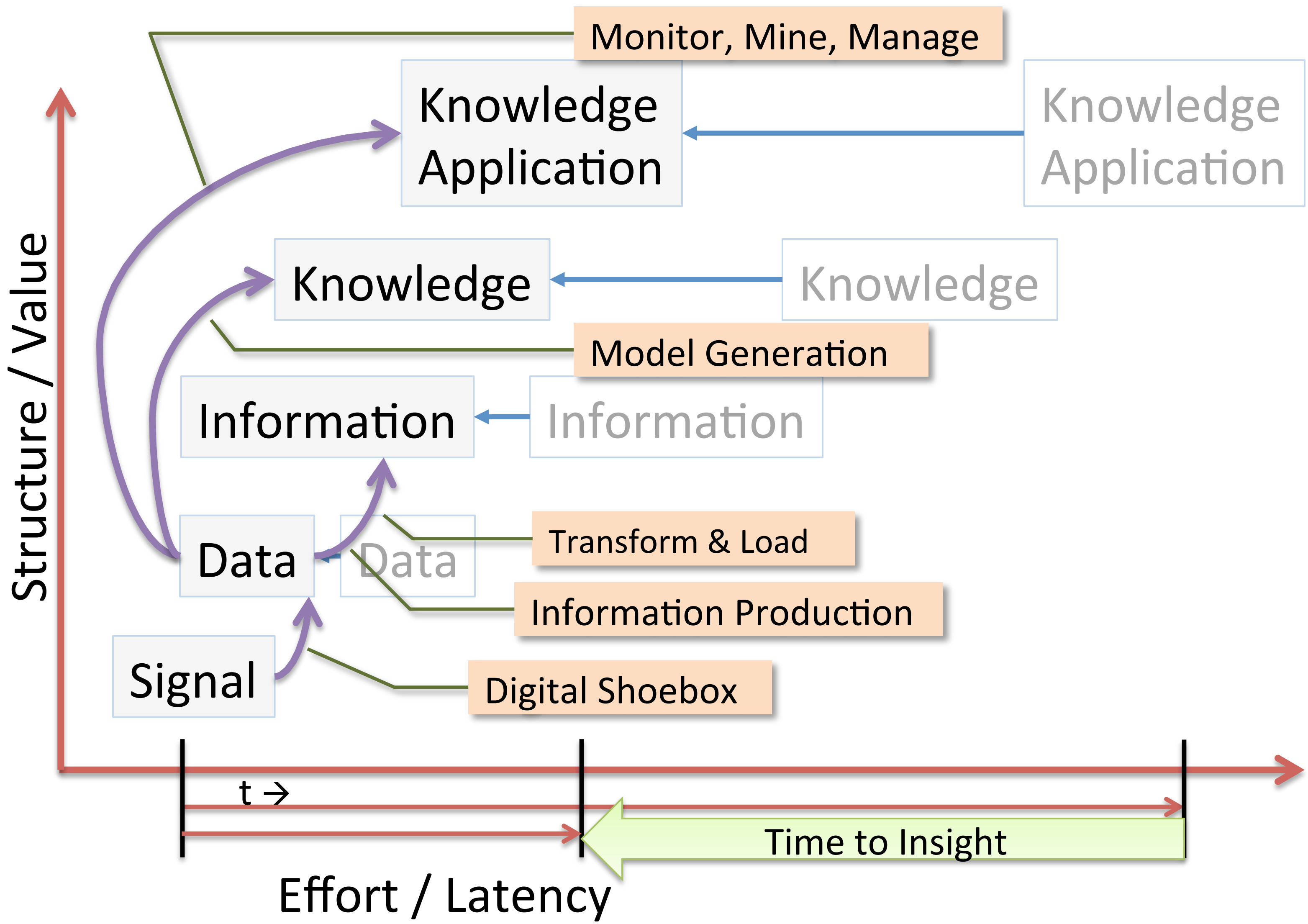
Source - http://www.youtube.com/watch?v=2YWvmBtEymE

Sense making #2: Paradigm shift



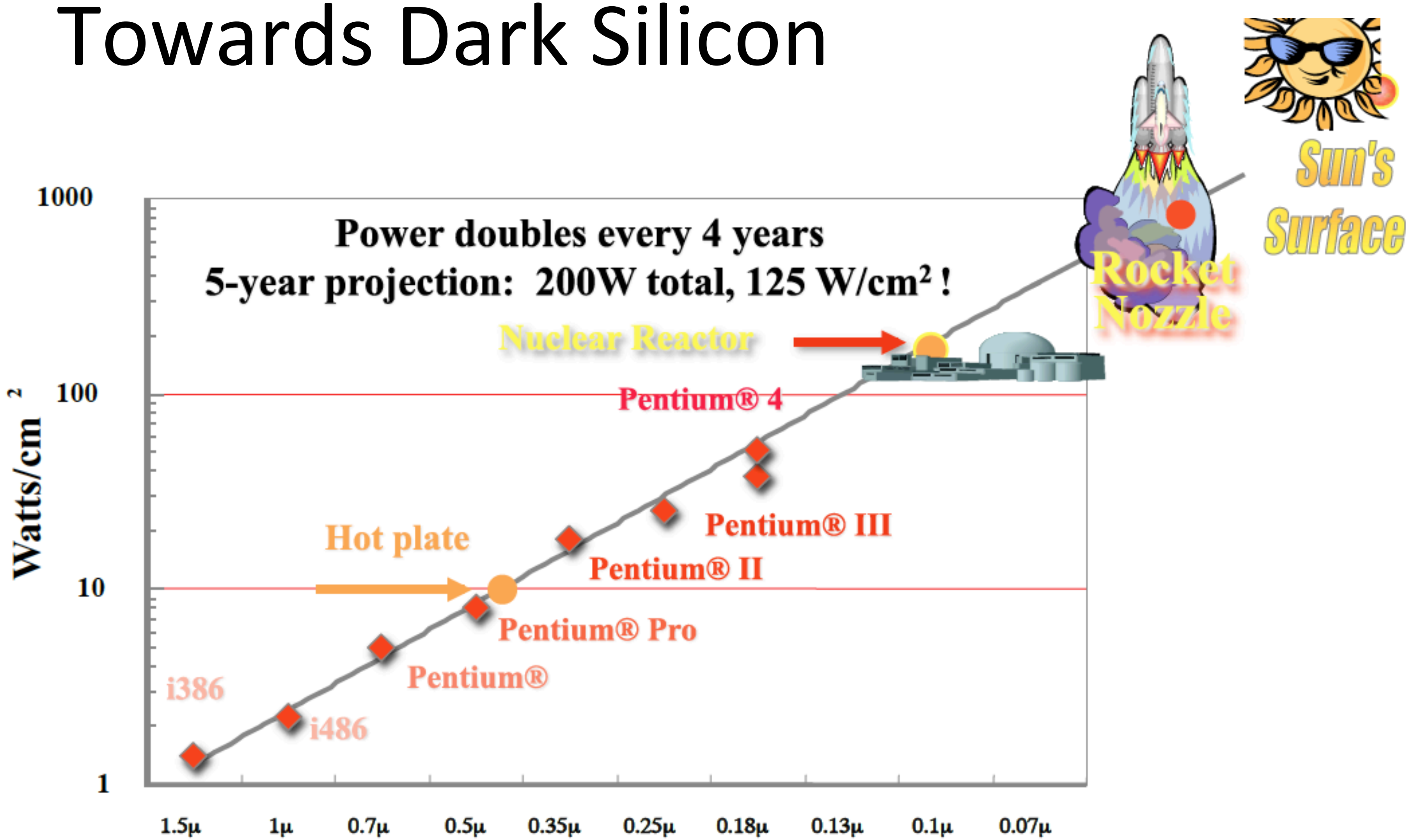
Source – http://www.vldb.org/2011/files/slides/keynotes/**campbell**_keynote.pptx

Sense making #3: New Paradigm



Source: http://www.vldb.org/pvldb/vol4/p694-campbell.pdf

Towards Dark Silicon

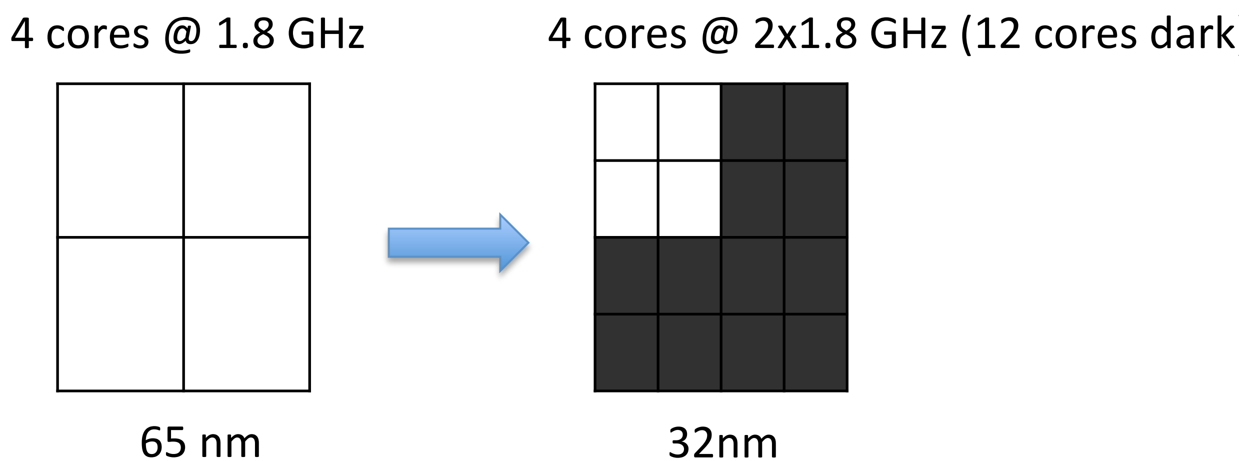


From "New Microarchitecture Challenges in the Coming Generations of CMOS Process Technologies" – Fred Pollack, Intel Corp. Micro32 conference key note - 1999.

Source: http://darksilicon.org/horsemen/horsemen_slides.pdf

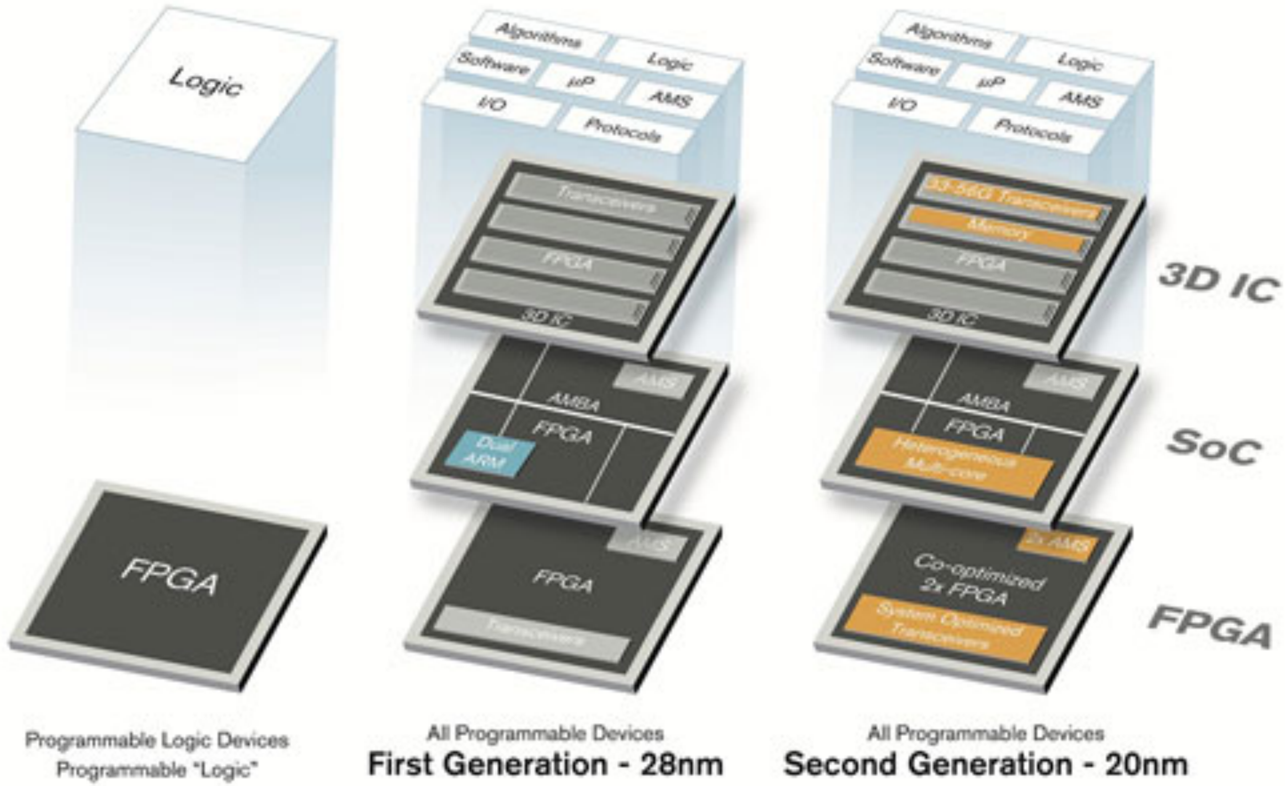
The End of Multicore Scaling

- Utilization Wall: With each successive process generation, the percentage of a chip that can actively switch drops exponentially due to power constraints.



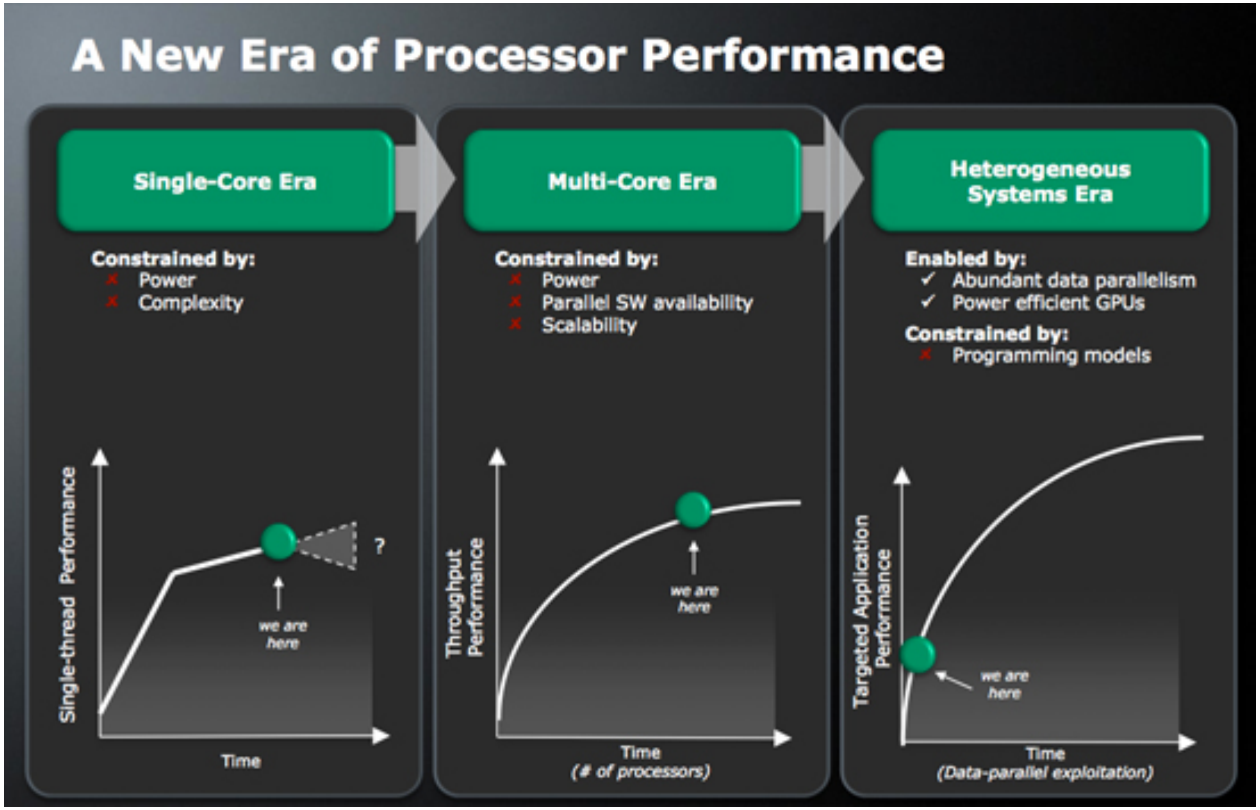
Source: http://darksilicon.org/horsemen/horsemen_slides.pdf

Hardware Acceleration



Source: http://eecatalog.com/fpga/2012/11/13/xilinx-20nm-all-programmable-portfolio-builds-on-28nm-breakthroughs-to-stay-a-generation-ahead/

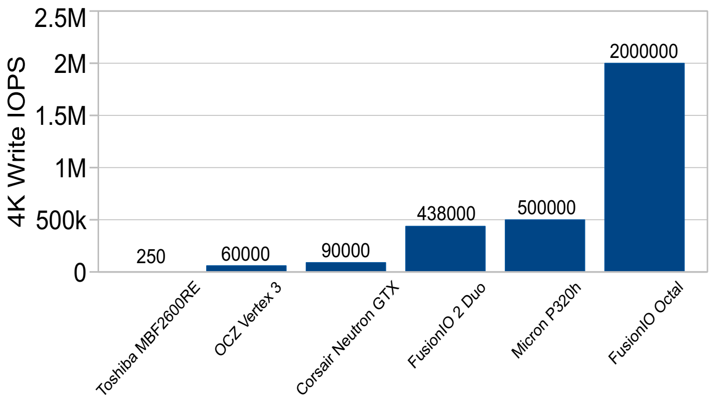
Slotnik's Law of Effort #1: Heterogeneous Systems



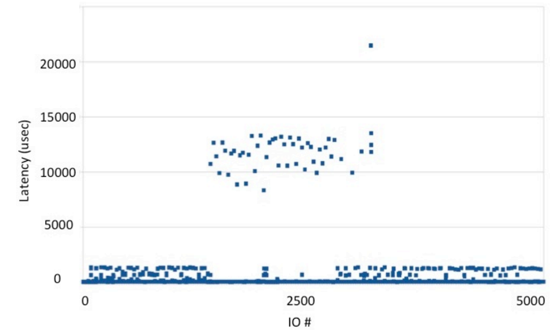
LOOK UP: Slotnik vs. Amdahl (AFIPS'67), Michael Flynn's talk on dataflow machines, Ryan Johnson's paper on bionic databases.

Source: http://www.anandtech.com/show/2933

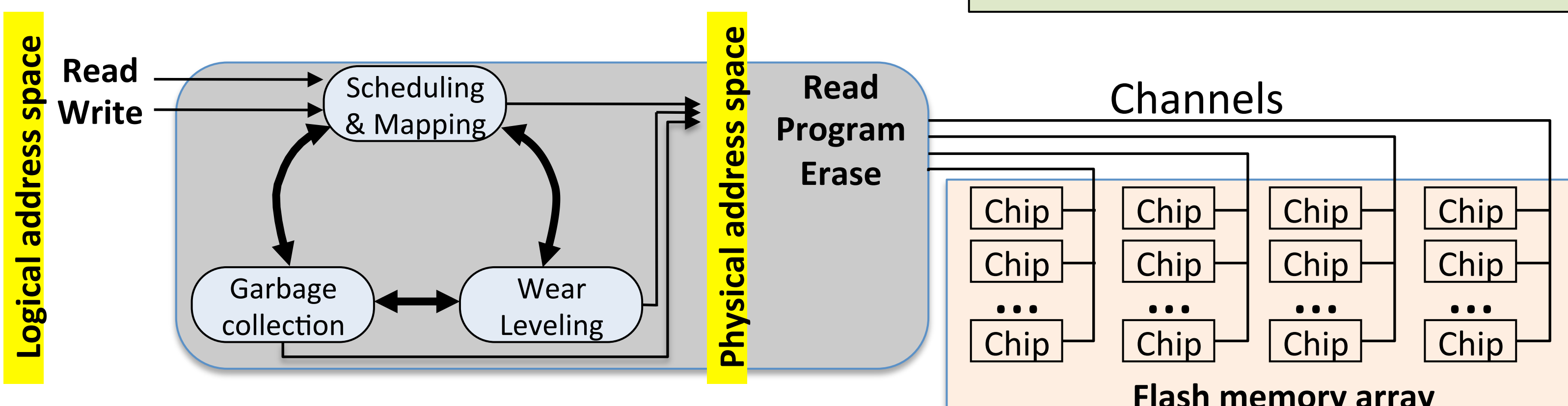
Slotnik's Law of Effort #2: The emergence of SSDs



Throughput for 4K read IOs from product specifications



Latency of 5000 random writes on an Intel 710 SSD (10 successive passes over 250 KB with 512B random writes on a random formatted device).



LOOK UP: [The necessary death of the block device interface]

Warehouse-Scale Computer

THE DATACENTER AS A COMPUTER

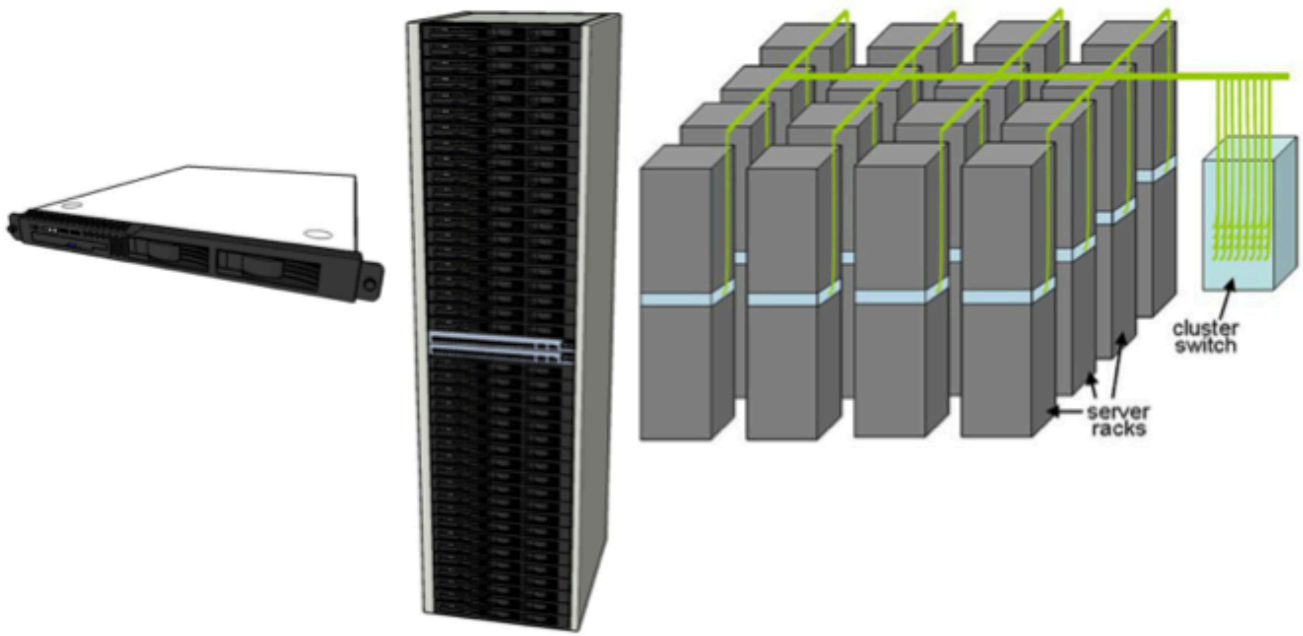


FIGURE 1.1: Typical elements in warehouse-scale systems: 1U server (left), 7′ rack with Ethernet switch (middle), and diagram of a small cluster with a cluster-level Ethernet switch/router (right).

LOOK UP: [Werner Voegels on virtualization].

Source: http://www.morganclaypool.com/doi/abs/10.2200/S00193ED1V01Y200905CAC006

Database Appliances

<u>Database Grid</u>

- 8 Dual-processor x64 database servers

OR

- 2 Eight-processor x64 database servers

<u>InfiniBand Network</u>

- Redundant 40Gb/s switches
- <u>Unified</u> server & storage network

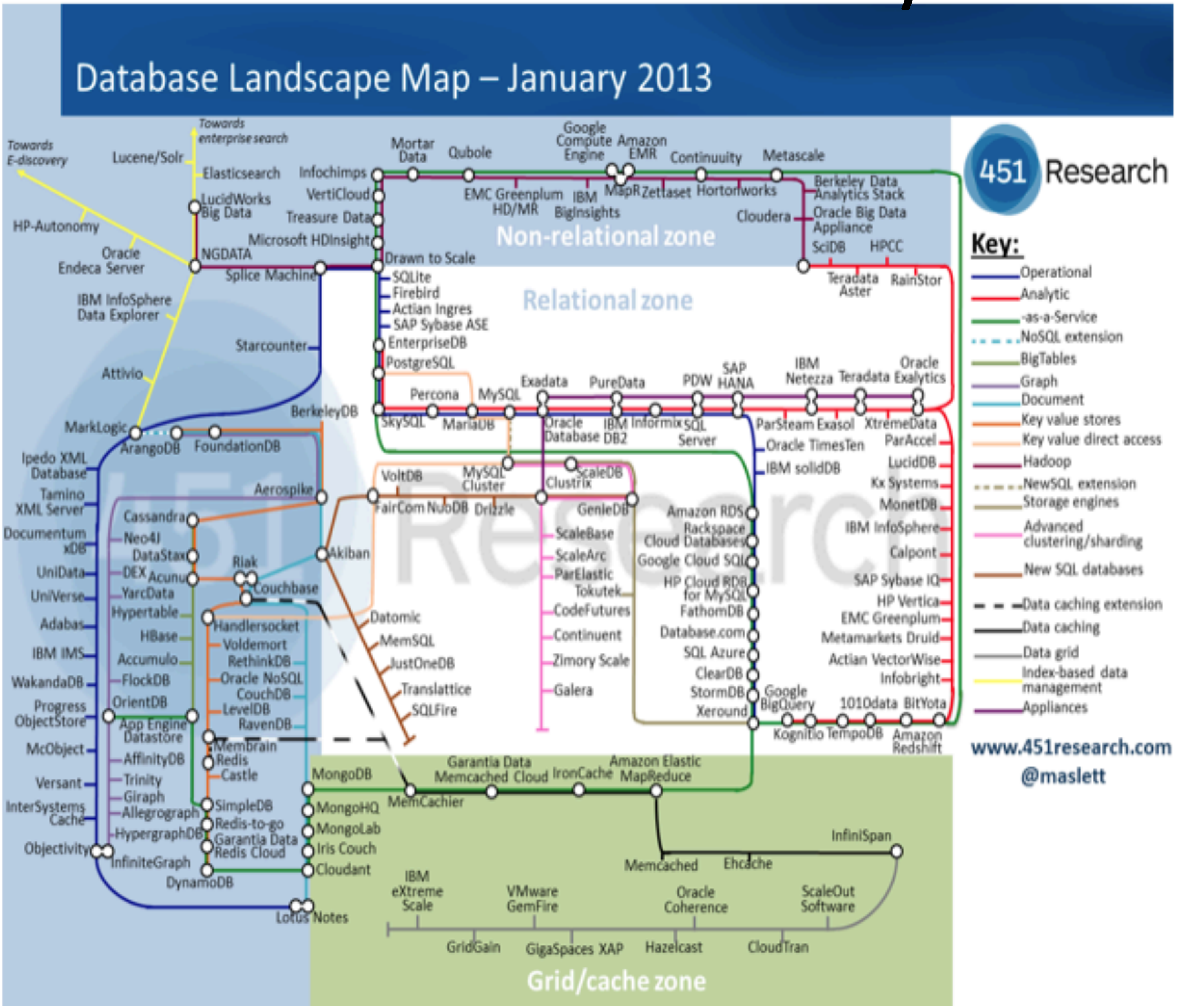
<u>Intelligent Storage Grid</u>

- 14 High-performance low-cost storage servers

- 100 TB **High Performance** disk, or 336 TB **High Capacity** disk
- **<u>5.3 TB PCI Flash</u>**
- Data mirrored across storage servers

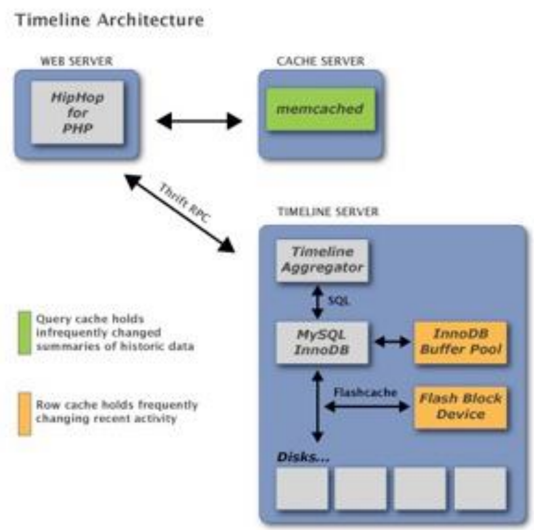
Source: http://www.oracle.com/us/products/database/exadata/overview/index.html

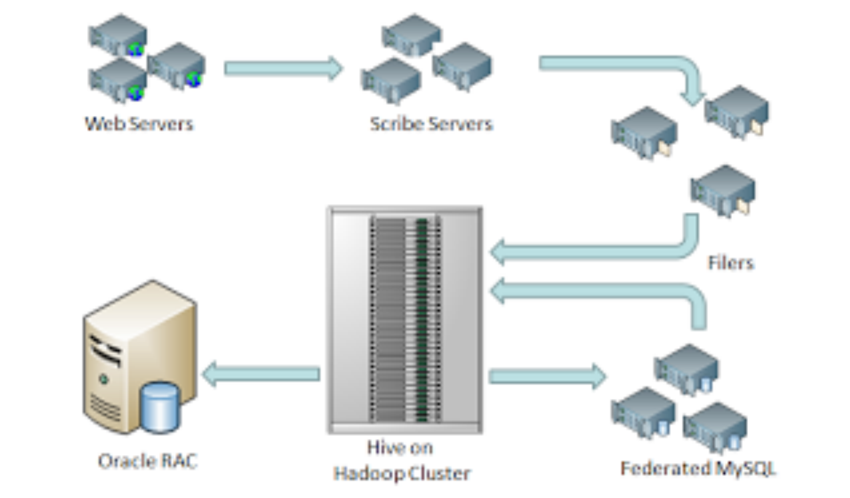
Trends and Database Systems



Source: http://451research.com/

Trends and Database Applications





Source: https://www.facebook.com/notes/facebook-engineering/building-timeline-scaling-up-to-hold-your-life-story/10150468255628920; http://www.vldb.org/pvldb/2/vldb09-938.pdf

Trends & Database Tuning

- Compression is of the essence
- Different classes of systems adapted to different classes of applications
- Data outgrows any well-defined model
- Time to insight is impacting all applications
- Energy is a key metric
- Dealing with parallelism requires efforts
  - RAM locality is king
  - Incorporating hardware acceleration
  - Emergence of utility computing/storage
  - Vertical integration removes abstraction layers

Database Systems Invariants

- The power of transactions
  - **LOOK UP**: Virtues and limitations by Jim Gray, reflections on the CAP theorem by Eric Brewer**.**
- The primacy of data independence
  - **LOOK UP**: System R
- The beauty of declarative queries
  - **LOOK UP**: The birth of SQL
- A success story for parallelism
  - **LOOK UP**: Parallel Database Systems

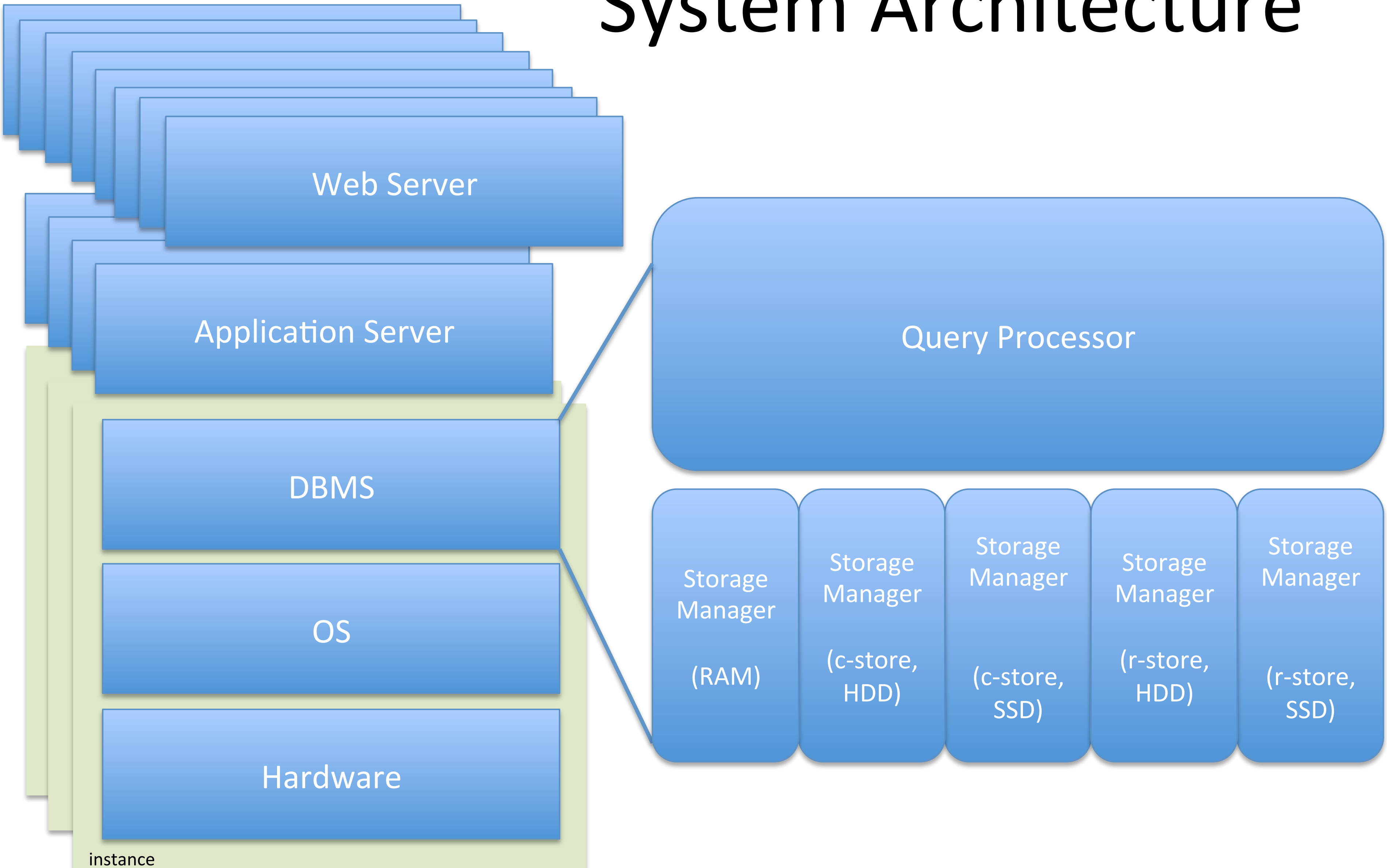
Tuning Invariants

1. Think globally; fix locally
2. Partitioning breaks bottlenecks
3. Start-up costs are high; running costs are low
4. Render unto server what is due unto server
5. Be prepared for trade-off

Classes of Applications/Systems

- OLAP + OLTP applications
- Relational systems:
  - Oracle 12g
  - IBM DB2 10.1
  - SQL Server 2012
  - MySQL 6 & InnoDB 5
  - Exadata

System Architecture



Lectures

- Troubleshooting techniques
- Tuning the guts
- Tuning transactions
- Tuning the writes
- Index tuning
- Schema tuning
- Query tuning
- Tuning the application interface
- Tuning across instances
- OLAP tuning
- OLTP tuning