Computer Architecture Final Project

Oracle SPARC M7 (ISSCC 2015)

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ORACLE

Outline

- About Oracle and SPARC
- Specification and Features
  - Spec of Oracle SPARC M7 Processor
  - Idea of Software in Silicon
- Major Competitor
- Future of Oracle
- References

Oracle Corporation

- Founder: Larry Ellison
- Founded:1977
- Members:~13,000

- Main Product:
  - Oracle Database, Oracle VM,servers, workstations

Oracle Corporation

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Oracle History

1977	**Founded**
1978	Oracle version 1(with assembly code)
1983	Oracle 3 rewritten in C(portable, make big success)
1988	Embedded SQL procedural language in database
1997	Jdeveloper(Java integrated development environment)
2005~2007	Acquisition of Global Logistics Technologies, Siebel Systems , Portal Software , Stellent, MetaSolv Software, Hyperion Solutions Corporation
2010	Acquisition of Sun Microsystems
2011~2014	Acquisition of Endeca,Taleo,Vitrue, Collective Intellect, Eloqua, BigMachines …..

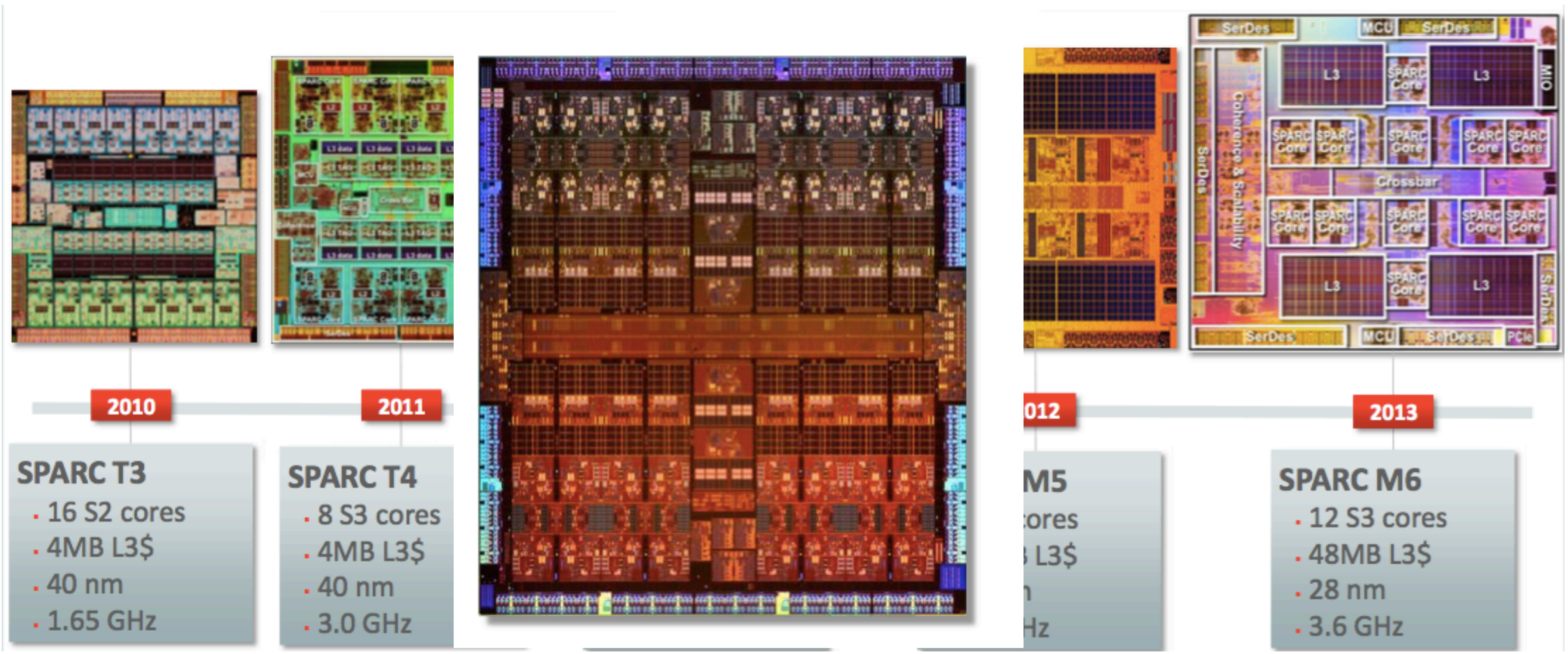
- **Sun & Oracle used to be competitor on database software. (MySQL lawsuit)**
- Sun & Fujitsu started SPARC Enterprise developing SPARC chip
- After acquisition of Sun(& SPRAC Enterprise)
  - Oracle becomes the major database software company
  - Continue SPARC developing

SPARC

- Scalable Processor ARChitecture
- Opensource, Open architecture
- Base on earlier RISC
  - as few opcodes as possible.
  - Aiming to have CPI~1
- Scalable: scale from embedded processors up through large server processors With the same core instruction set.
- History
  - 2006 Sun UltraSPARC Architecture
  - 2012 Oracle SPARC T Serirs

Oracle SPARC

THEN HERE COMES M7

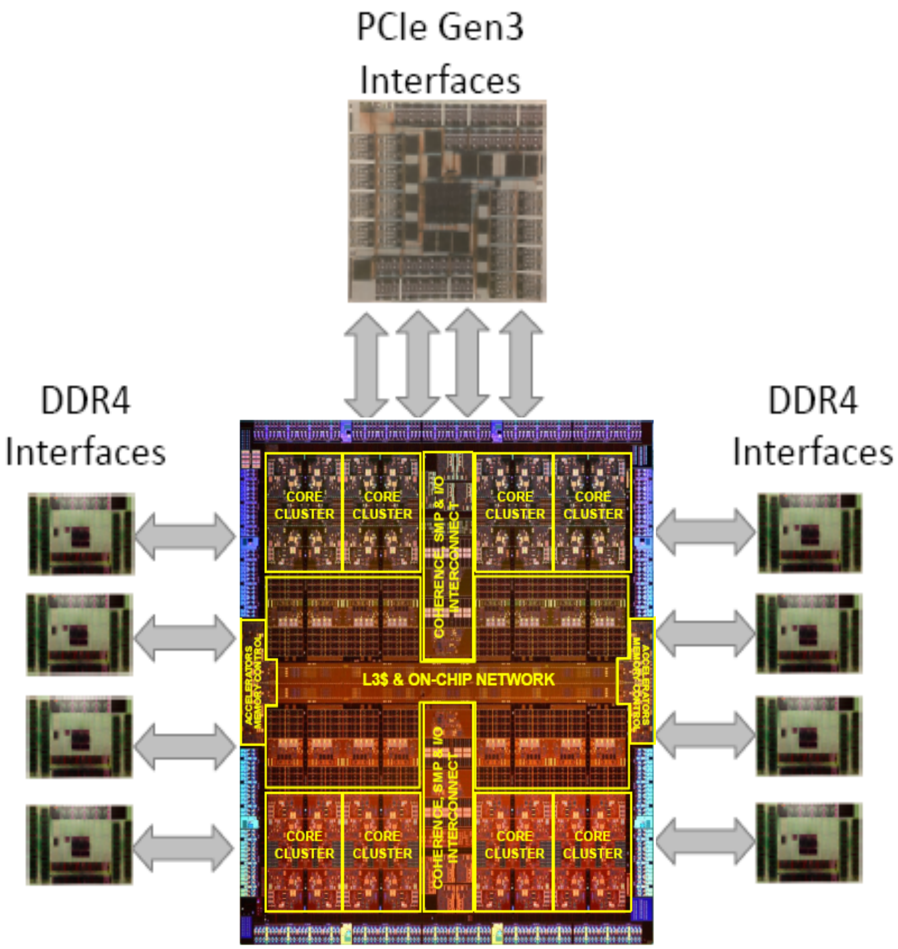


Few things about Oracle SPARK M7

- S4 Core
- New Cache organization with On Chip Network(OCN)
- **Software in Silicon**
- Power management
- Tremendously improved performance

~ will be discuss later ~

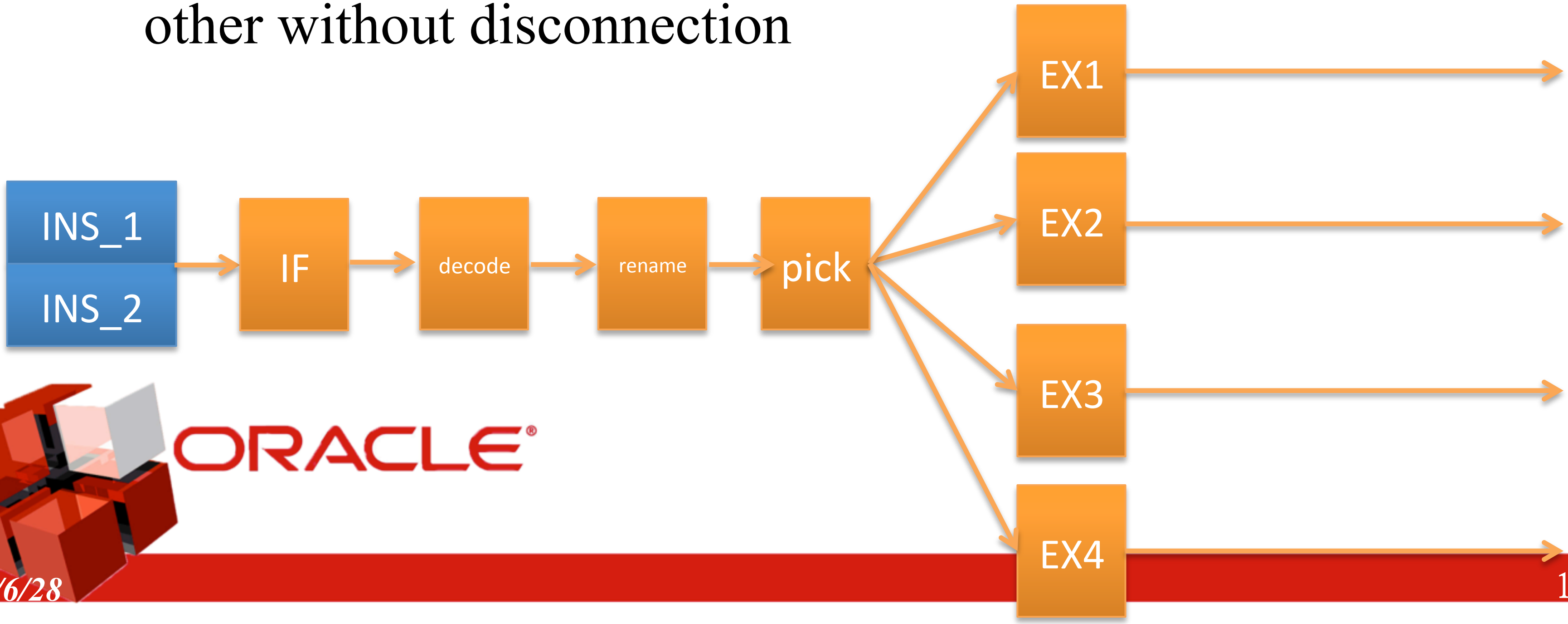
M7 Processor



- **32 cores**
  - 256 threads (1~8threads/core)
  - S4 core (before, M6 , T series are S3)
- **Cache architecture**
  - Each core has 1 L1 cache
  - Each cluster(4 cores) shares 1 L2-Icache and 2 L2-Dcache
  - Each processor 64MB L3-cache
    - Cut into 8 partitions(L3$ partition), each cluster has 1 L3$ partition(8MB)
- **Main Memory**
  - DDR4 DRAM(before, M6 and T series used DDR3)
- **Technology:20nm**
- **SMP Scalability (1~32 processor)**
- **App acceleration**
- **Coherent Memory Clusters**

M7 core (S4)

- 1 to 8 dynamic thread, with increased freq
- Dual-issue
  - Instruction grouped into 2-instruction decode group
  - Then sent to one of the 4 execution pipelined
- Power estimator
- Live migration
  - Application can change from one physical memory to the other without disconnection

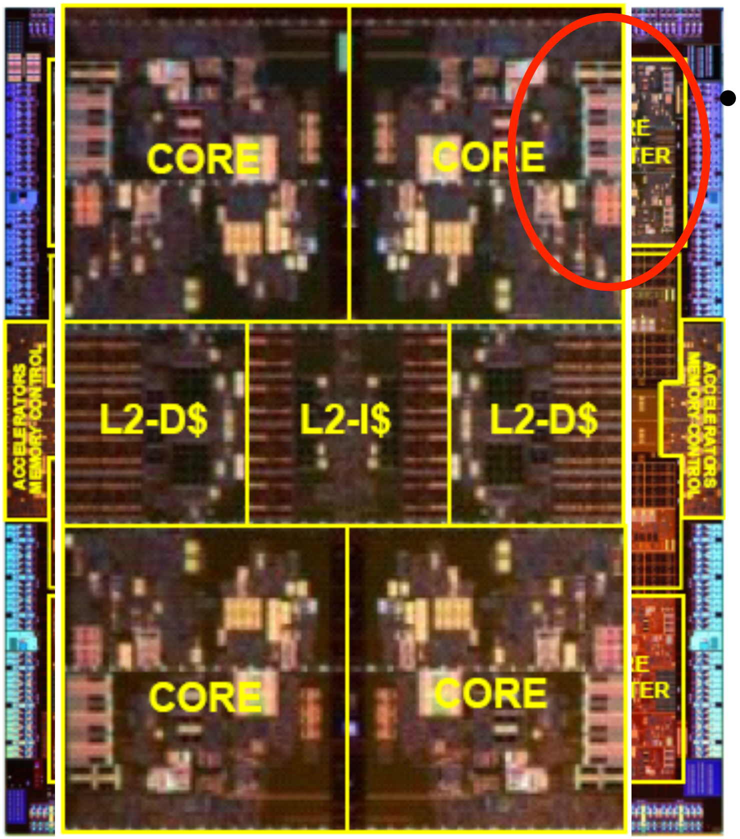


S4 Core Enhancement

- L2 cache scheme
  - Visual Instruction Set (VIS) extensions
  - Continuous Single-thread Performance
    - Virtual Address Masking and User-level Synchronization Instructions (SPARC T4~)

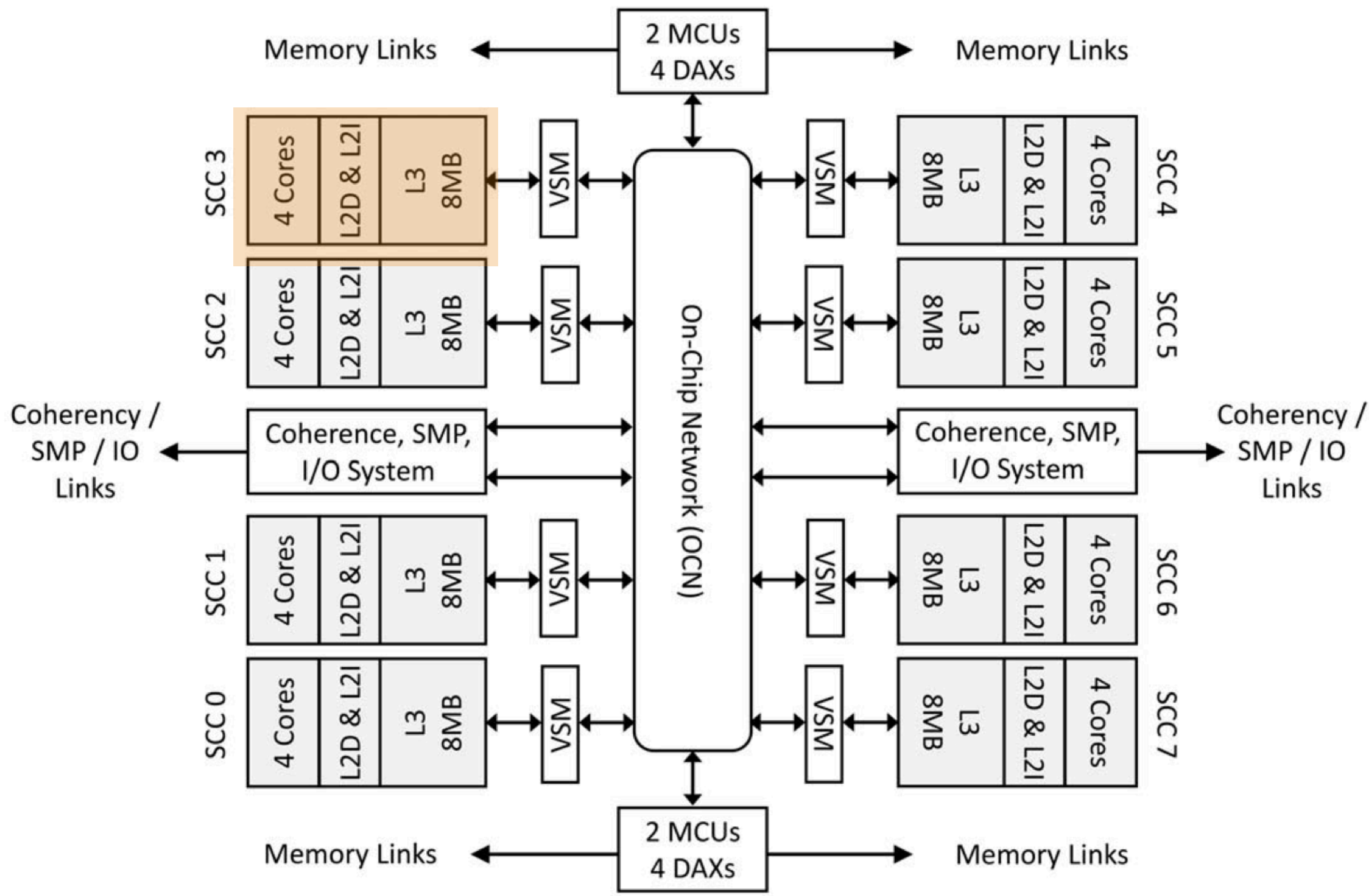
- **SPARC core cluster (SCC)**

SPARC core cluster (SCC) [2]



- **4 SPARC Cores Per Cluster**
  - 4 cores share a single 256KB L2 instruction cache
  - Pair core share a 256KB L2 data cache
  - Self-contained unit
    - clock generator, temperature sensors, power supply calibrator, global controller

L2-L3 Cache System



L2-L3 Cache System

- L2 Write-back cache
  - 2-banks, 8-ways set-associative → 1TB/s bandwidth
  - Throughput: 2x
  - Size: 1.5x
  - Latency: same as previous generation
- L3 cache
  - 8MB, 8-ways set-associative
  - Latency: reduce by 25% (localized cache in SCC)

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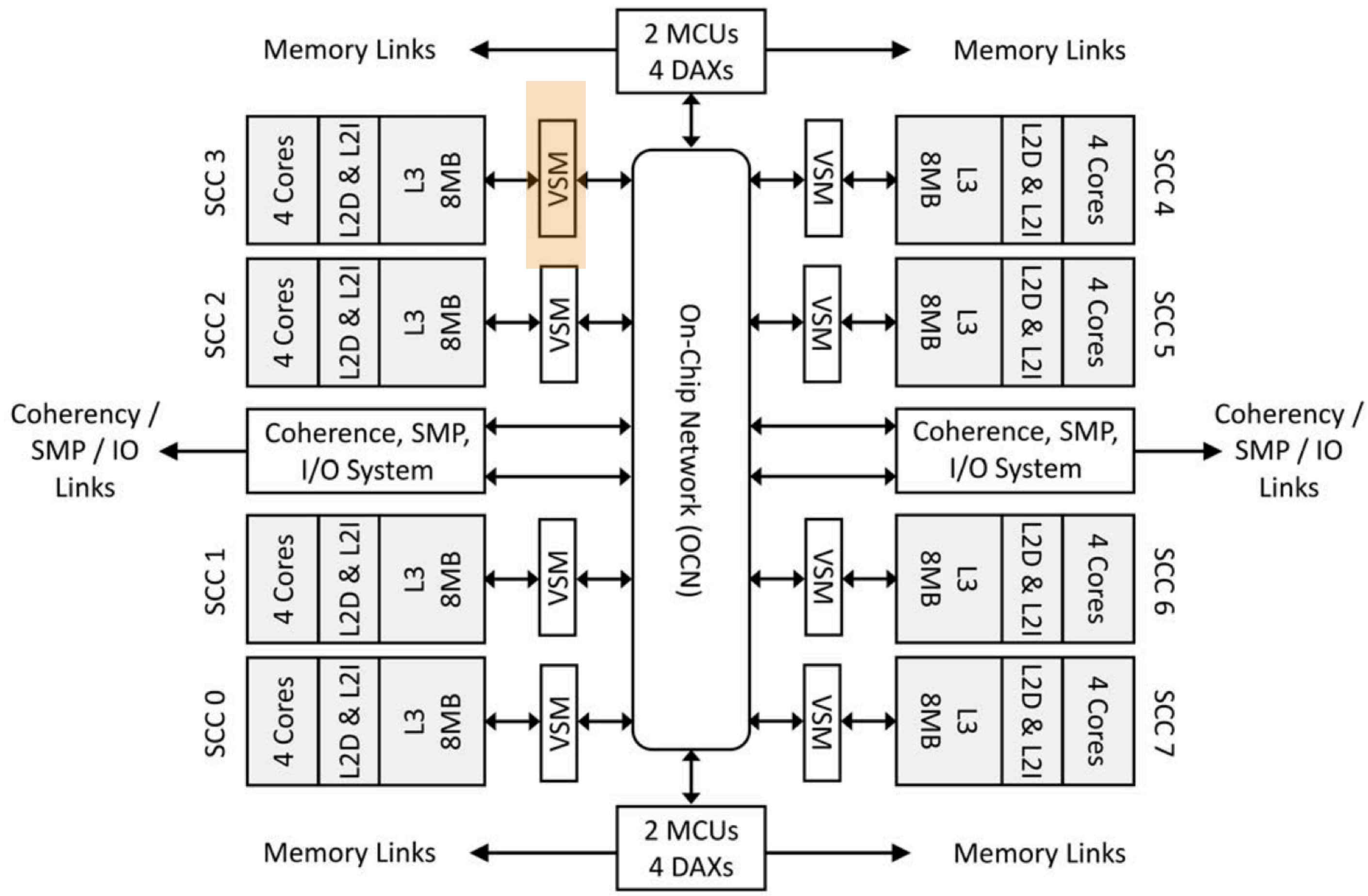
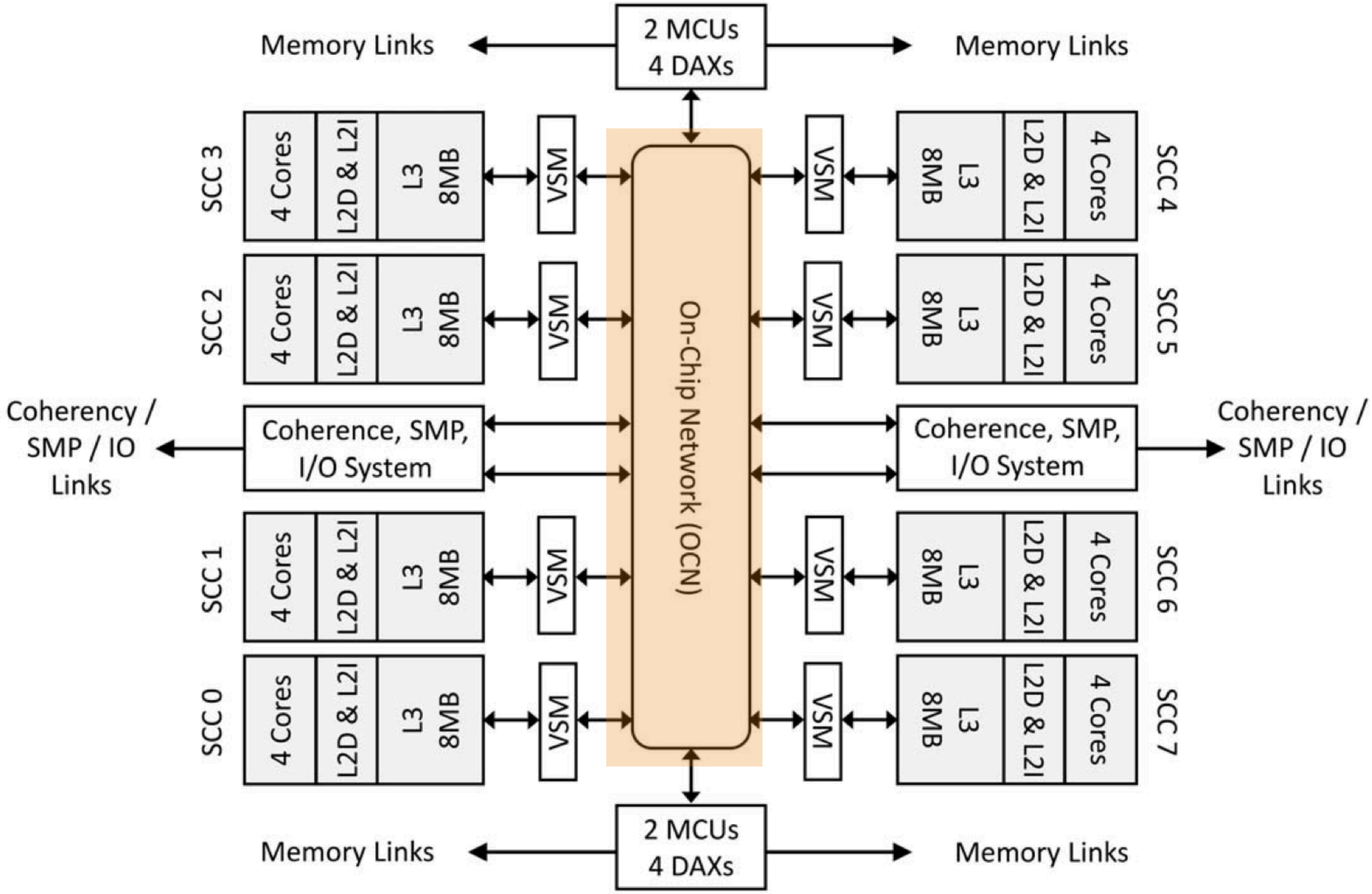
L2-L3 Cache System



VSM

- Voltage Shift Module
- SCC ← VSM → OCN
- source-synchronous interface

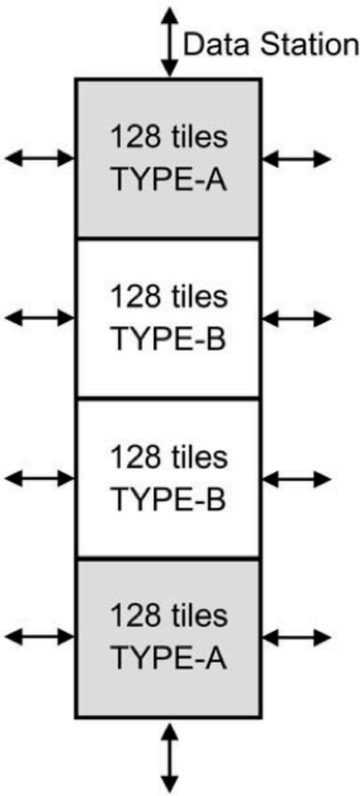
M7 Level 3 Cache and On-Chip Network

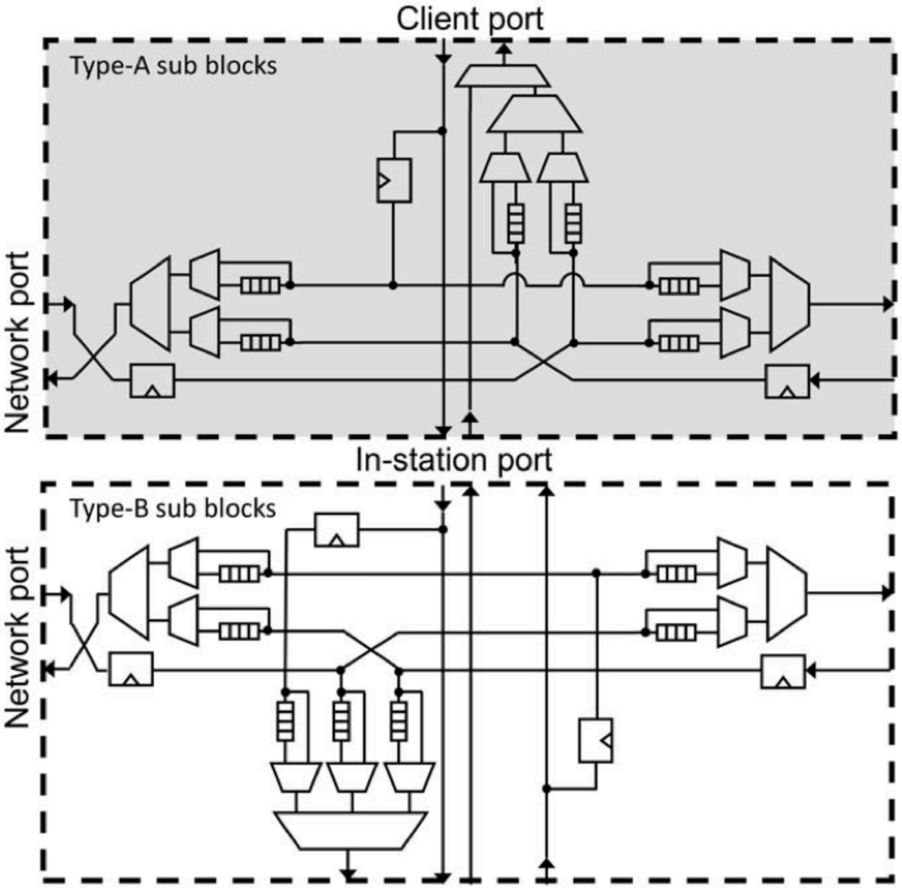


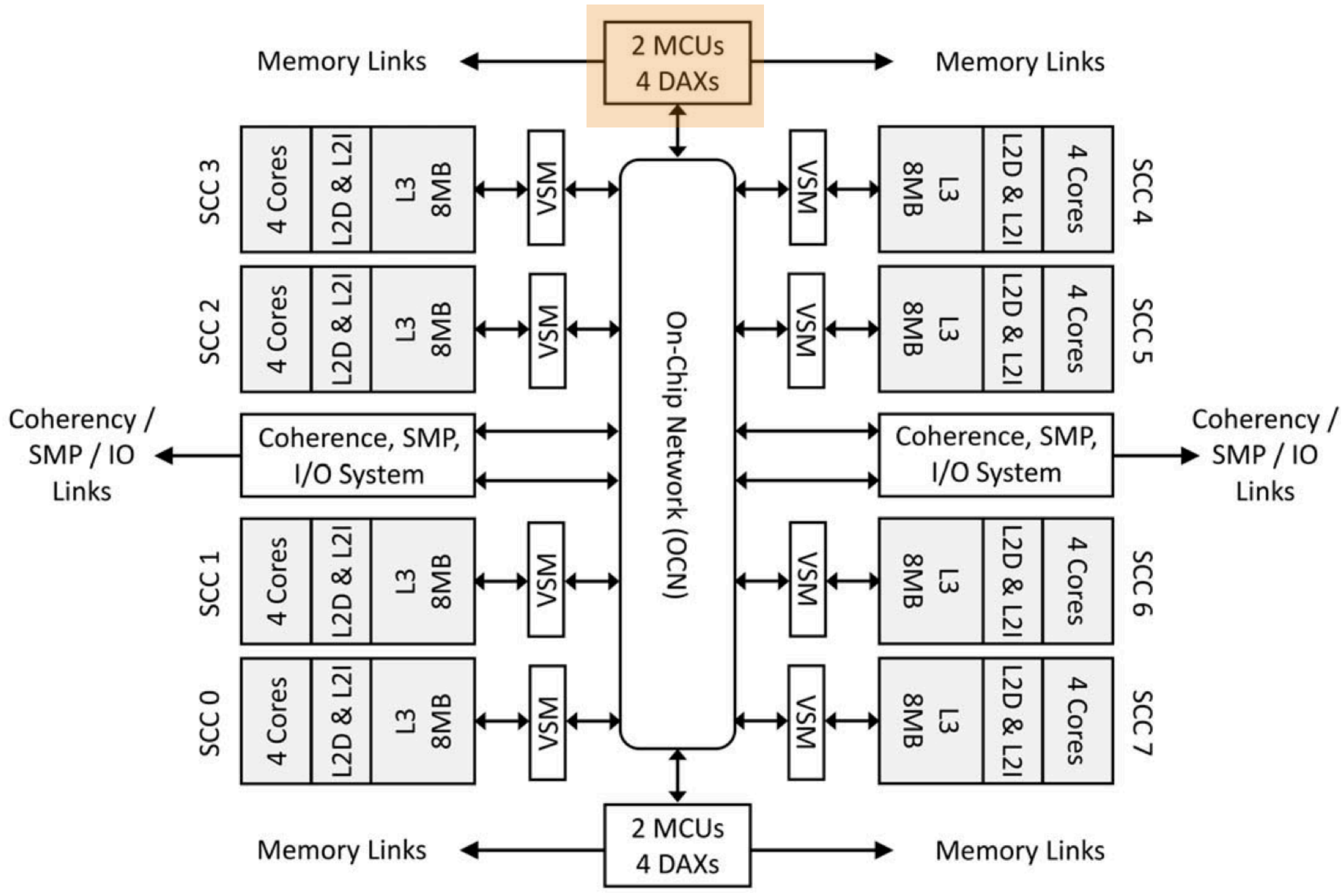
OCN[2]

- Substitute crossbar based network
- Connect to
  - 4 on-chip memory controllers (MCUs)
  - 8 database analytic accelerator engines (DAX)
- Made of
  - A multi-stage data network
  - A request network with 4 ring topology
  - A point-to-point response network

Multi-Stage Data Network[2]






Memory Links
2 MCUs
4 DAXs
Memory Links
SCC 3
4 Cores
L2D & L2I
L3
8MB
VSM
SCC 4
SCC 2
SCC 5
On-Chip Network (OCN)
Coherency /
SMP / IO
Links
Coherence, SMP,
I/O System
SCC 1
SCC 6
SCC 0
SCC 7
Memory Links
2 MCUs
4 DAXs
Memory Links

DAX

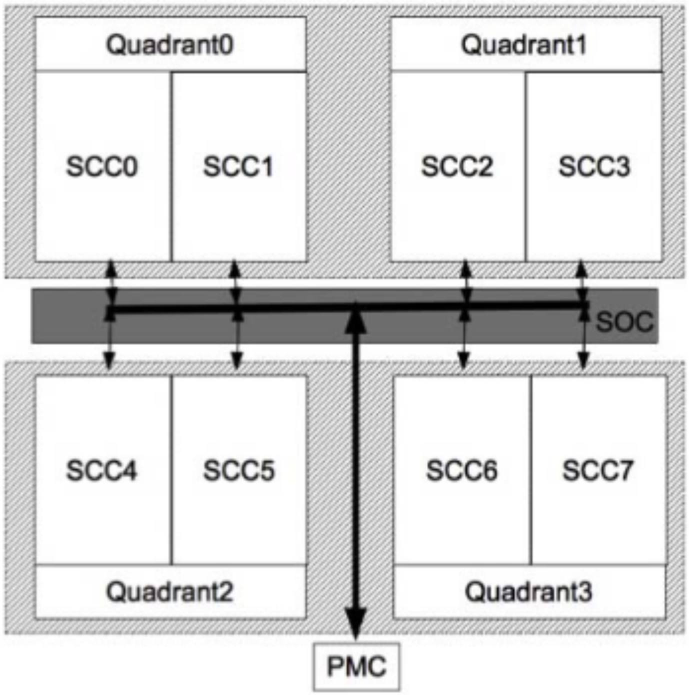
- Simple query predicates
- Decompression
- Message passing
- Interrupts across cluster nodes
- 10x better performance!

Power Consumption

- SRAMs
  - Mixed V_t approach
    - Small V_t: NMOS wordline driver
    - High V_t: PMOS wordline driver
- SerDes
  - Feedback
  - Power-up calibration
  - Real-time adaptation circuits

Power management(1/2)

- Detecting power
  - on-die digital dynamic power meter(SCC(Quadrant)-basis)
  - Estimation every 250 ns
  - hardware-power-management controller (PMC)
- Manage power in 2 ways:
  1. SCC-level clock cycle skipping (frequency scaling)
     - Each SCC supports frequency scaling in steps of 133MHz
  2. Voltage scaling for groups of 2 or 4 SCCs

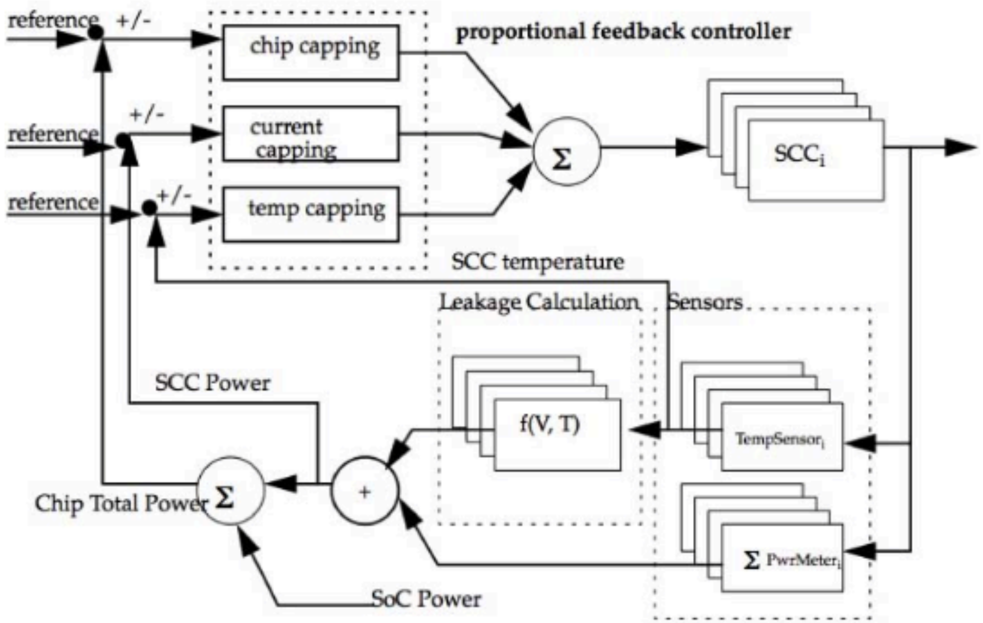


Power management(2/2)

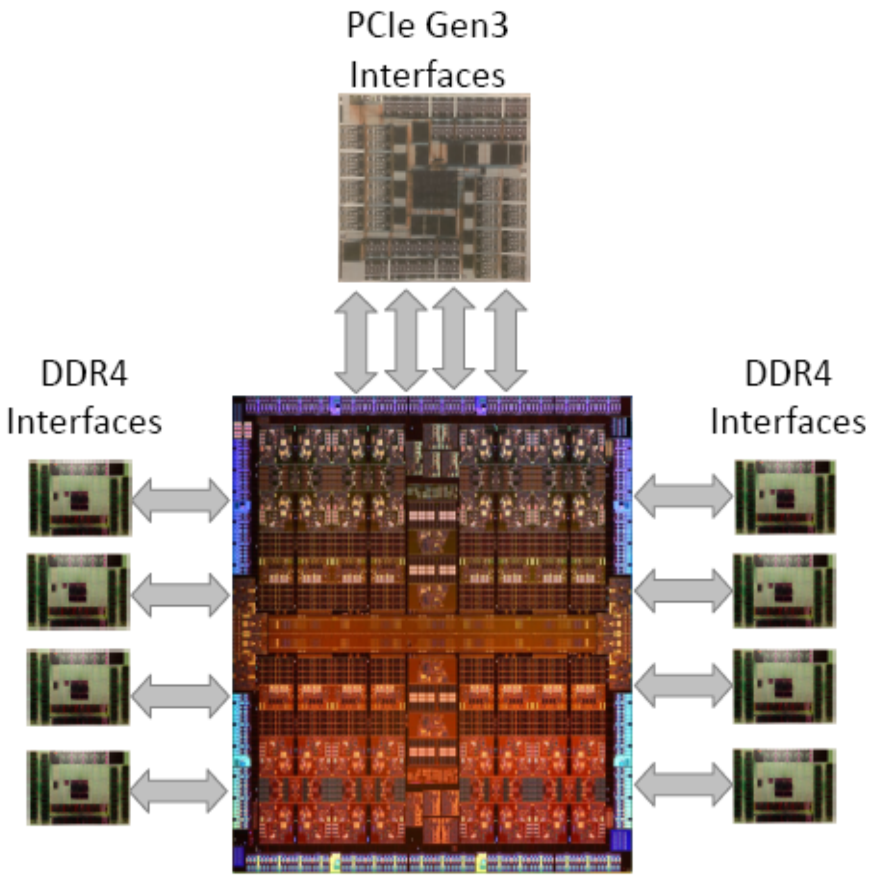
- Feature
  - Hardware-power-management controller (PMC)

    By detecting dynamic power, leakage, temperature…

    Can set different power threshold to different SCC, for different application

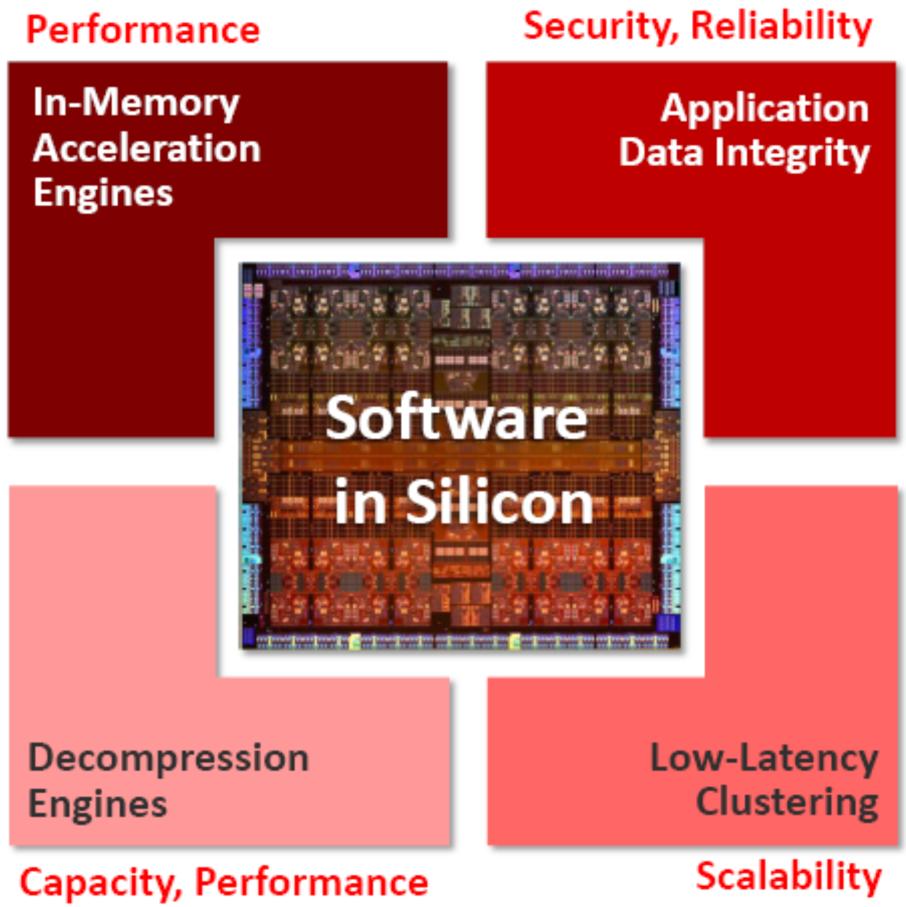


Memory & I/O



- 2TB DDR4 DRAM
- 4 DDR4 controller
- PCIe technology
  - High-speed data transfer within I/O subsystem

Software in Silicon



Moving Software Functions into Hardware !!!

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Security, Reliability: Application Data Integrity

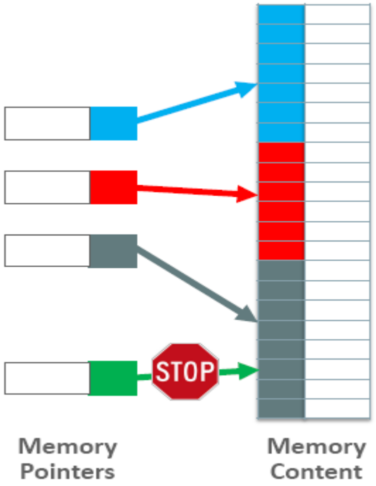
Sophisticated software and large memory create risk on **security** and **reliability** :

- Memory corruptions due to program errors
- Databases and applications have tens of millions code
- In-memory database(terabytes of critical data) increases risk
- Buffer overflows are a major source of security concern

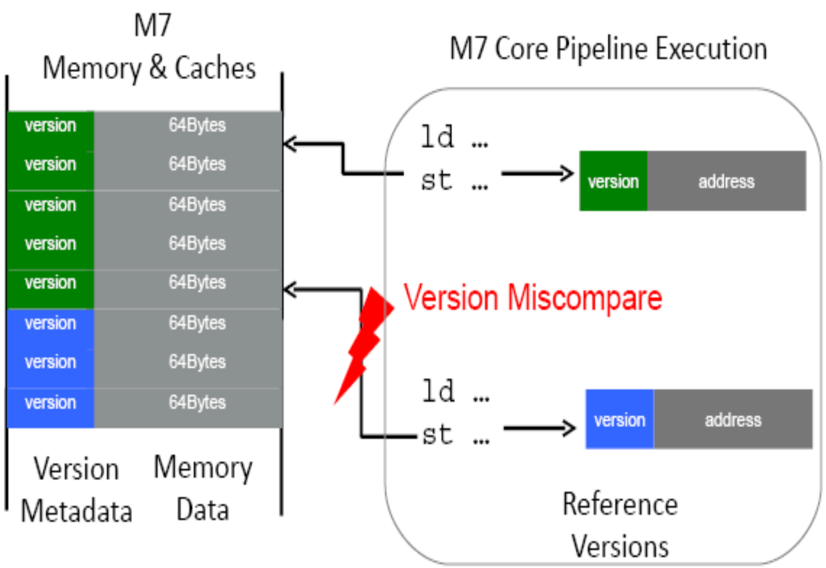
Application Data Integrity[1]

M7 Application Data Integrity :

- Memory pointer color must match content color
  - Stop memory corruption
  - Stop malicious code from accessing (Buffer overflow)

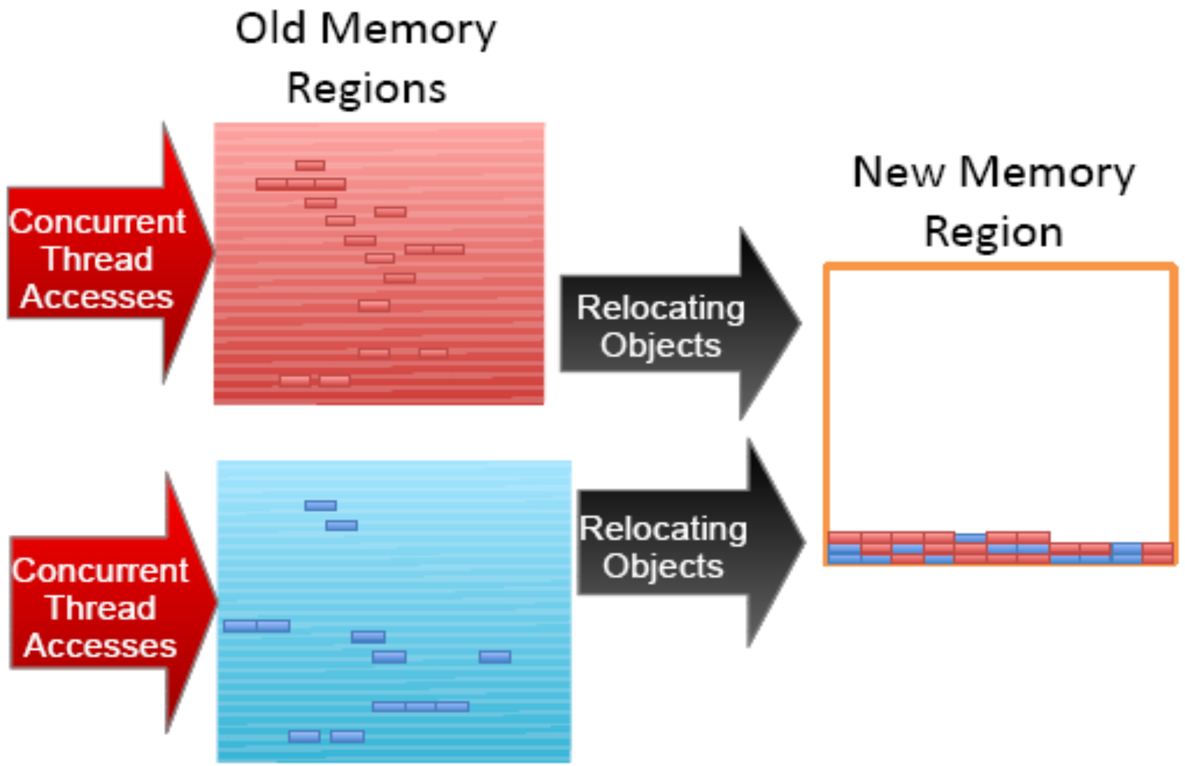


- Real-time Data Integrity Checking
  - Version Metadata Associated with 64Byte Memory Data
  - Memory Version Metadata checked against Reference Version
  - Low overhead due to HW implementation,



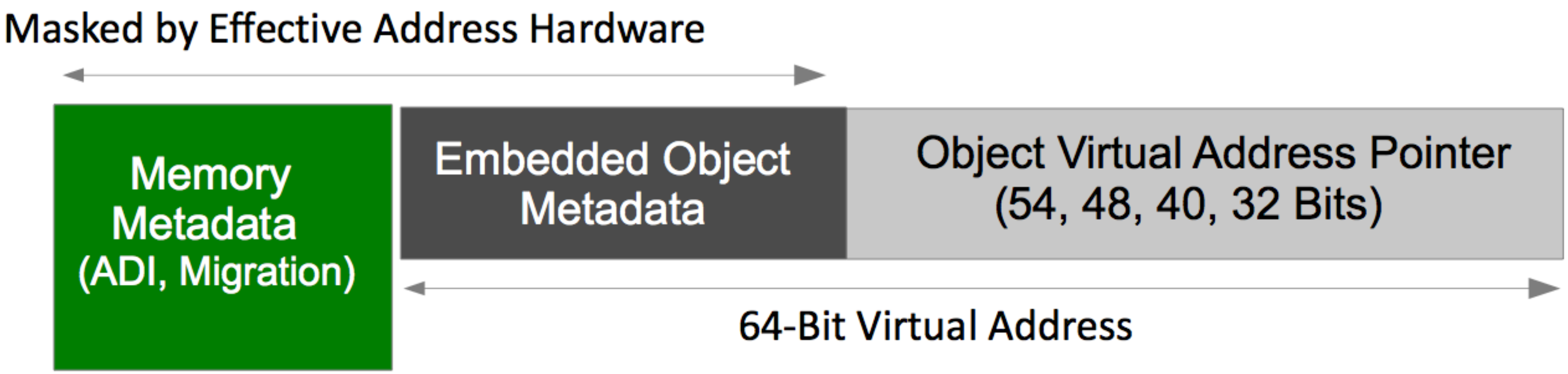
Application Data Integrity[1]

- Memory metadata of relocating objects are marked for migration



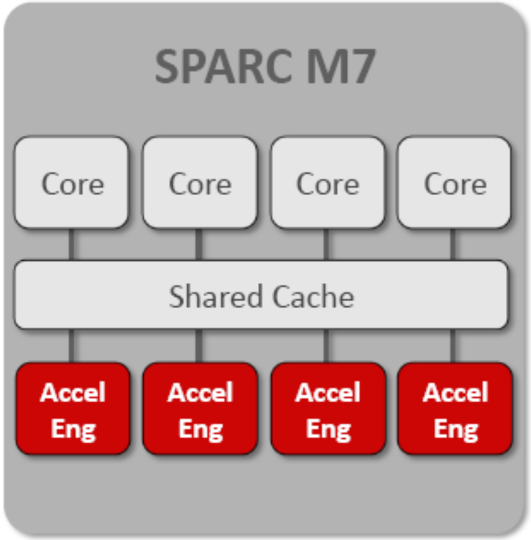
Application Data Integrity[1]

M7 Virtual Address (VA) Masking :



- Allow programs to mask upper unused bits of virtual address pointers
- Enables Managed Runtimes (e.g. JVM's) to Embed Metadata for Tracking Object Information

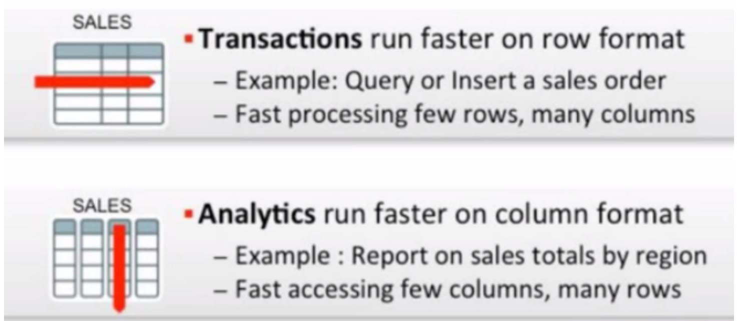
In-Memory Query Acceleration Engines



- Independently process streams of database column elements placed in system memory
- Reads data directly from memory, processes it, and places results in cache for core usage
- Frees processor cores

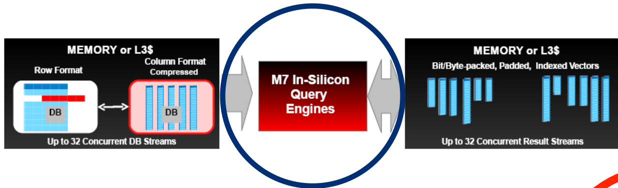
In-Memory Query Acceleration Engines

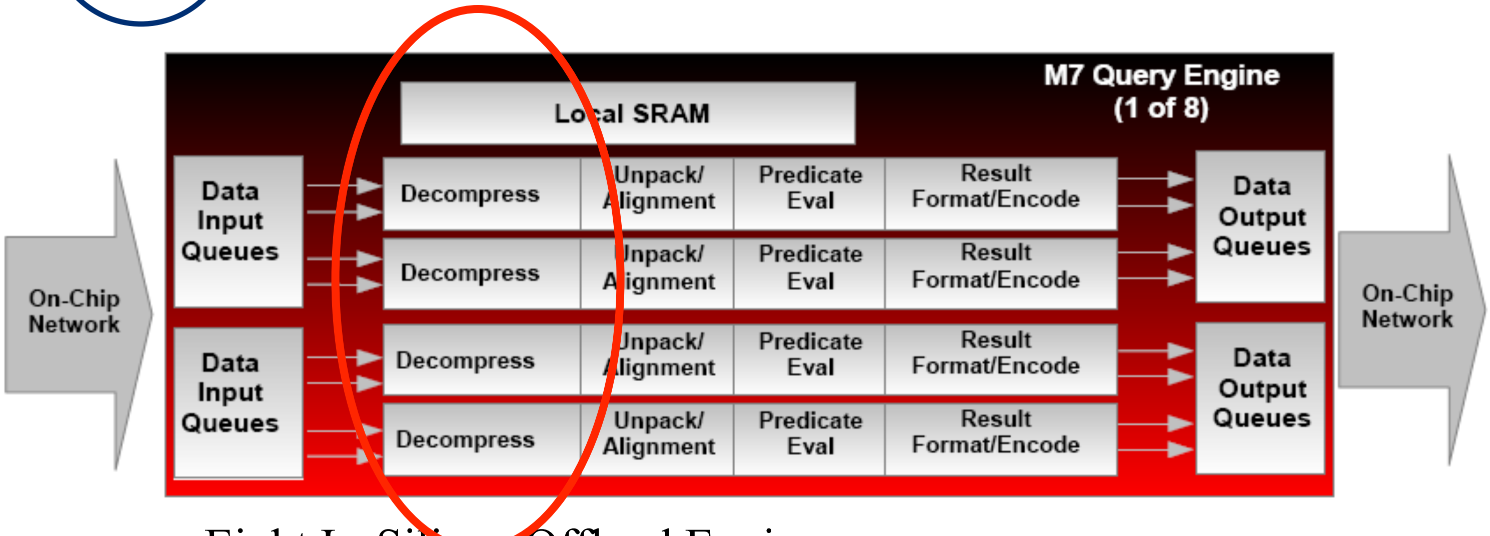
- Query Engine Functions
  - In-Memory Format Conversions
  - Value and Range Comparisons
  - Set Membership Lookups



- Fused Decompression + Query Functions
  - Further reduce task overhead, core processing cycles and memory bandwidth per query

In-Memory Query Acceleration Engines

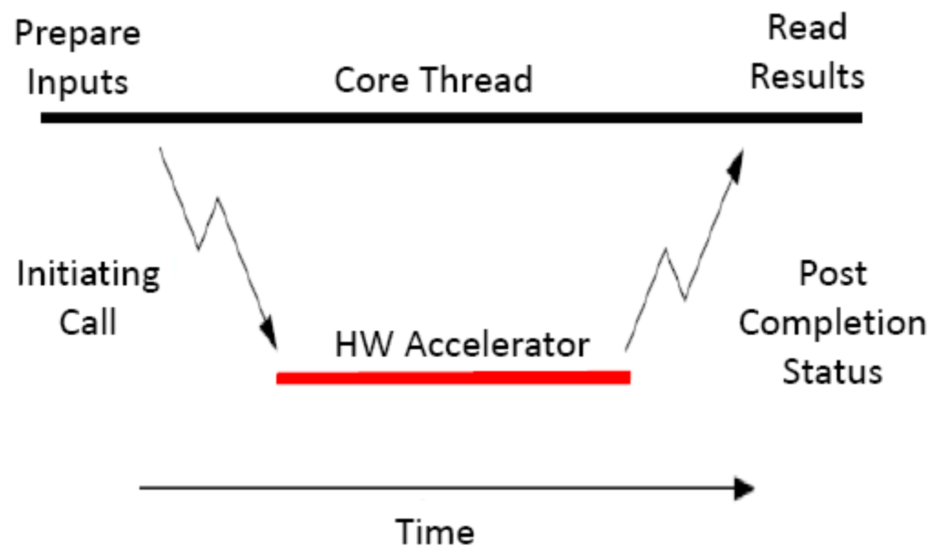




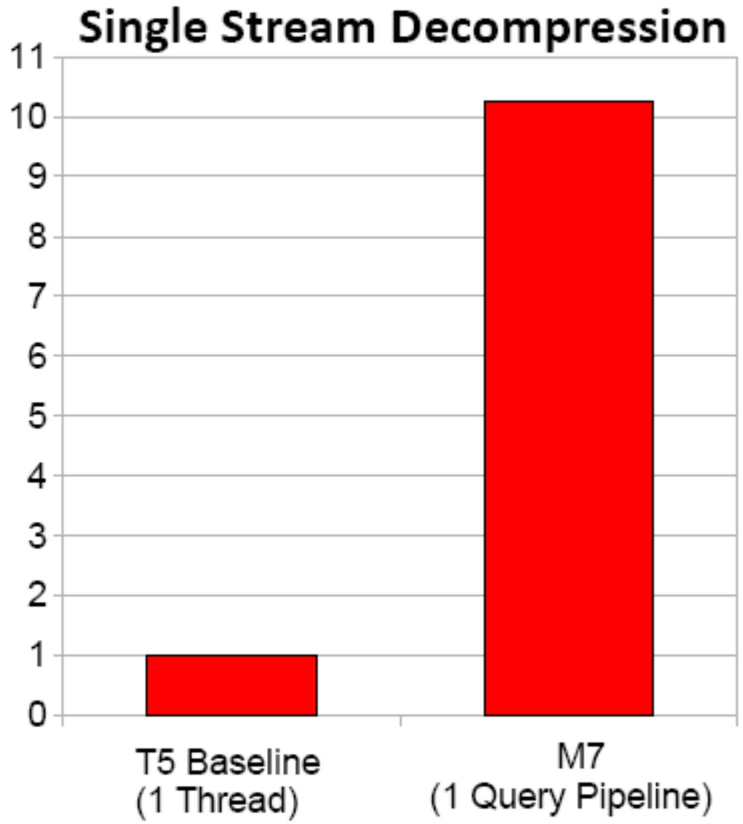
- Eight In-Silicon Offload Engines
- Cores/Threads Operate Synchronous or Asynchronous to Offload Engines
- User Level Synchronization Through Shared Memory
- High Performance at Low Power

In-Memory Query Acceleration Engines

- **Core Thread Initiates a Query Plan Task to Offload Engine**
- **User-Level LDMONITOR, MWAIT**
  - Halt until Expired or Update
- **Offload Engine Completion**
  - Results written back to memory or target L3$ Partition
  - MWAIT detection, hardware resume core thread

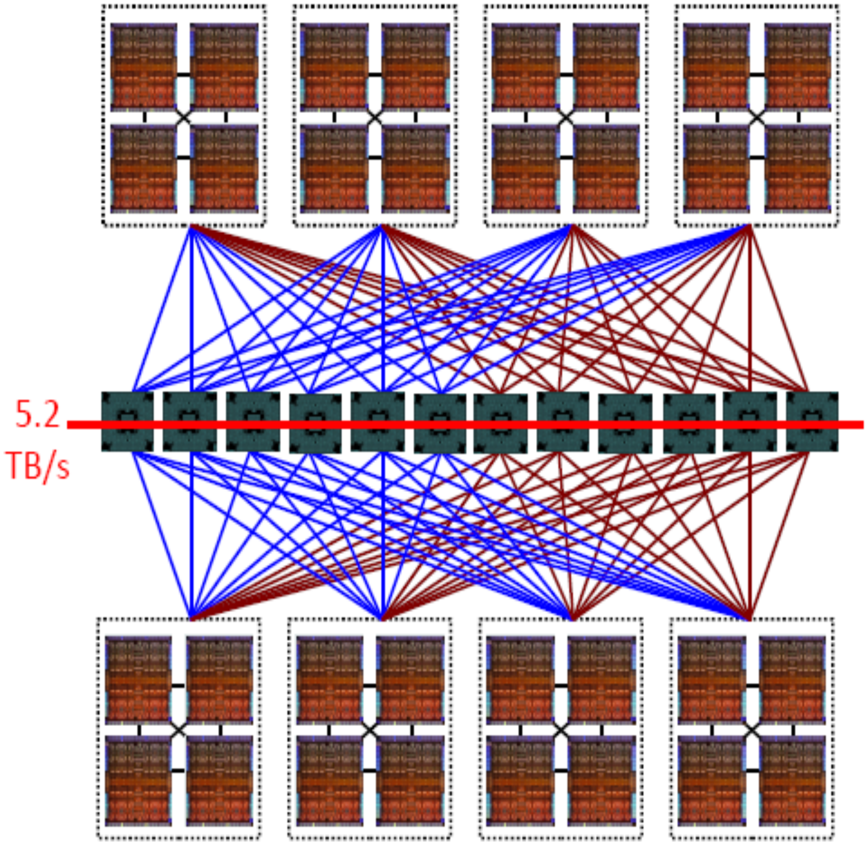


Decompression Acceleration



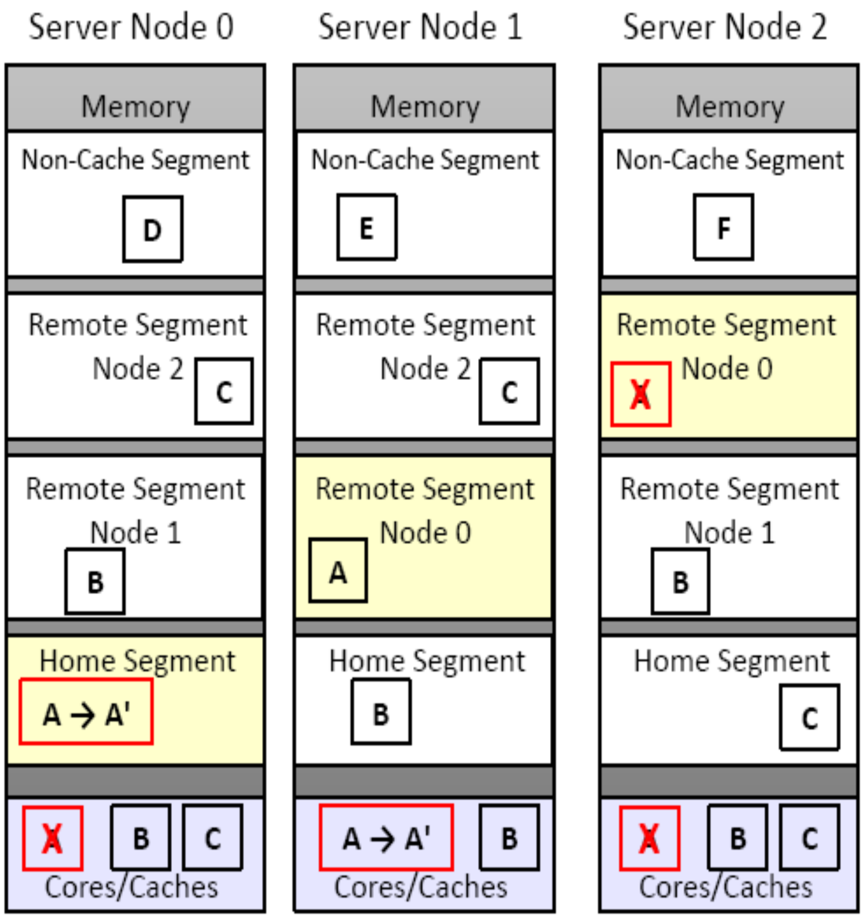
- **Compression is key to placing more data in-memory and in storage**
- **Speed of decompression is most important**
  - Reading typically outweighs writing for database
  - Huge bottleneck for in-memory database
- **Solution:** Efficient compression algorithm plus acceleration engines
  - Equivalent to 16 decompression PCI cards, 60 CPU cores

M7 SMP Scalability



- **SMP Scalability to 32 Processors**
  - Four processors as a cluster(a server)
  - Fully associative connect
- **Fully Connected Switch Topology**
  - 2 Links Connecting Every Processor and Switch
  - Coherence Directory Distributed Among Switches
- **No need Redundant server as traditional did**

M7 SMP Scalability



Highly Reliable and Secure Shared Memory Clustering Technology :

- **Cacheable Memory Segments**
  - Load-Hit Latency Accessing Remote Segments
    - > Same as local node memory and caches
  - Stores to Remote Segments
    - > Update home node and invalidate remote nodes
- **Cluster-wide Security**
  - 64-bit Access Key
  - Memory Version Checking Across Cluster

Oracle's Competitor

- Server and Develop tools
  - IBM, Microsoft

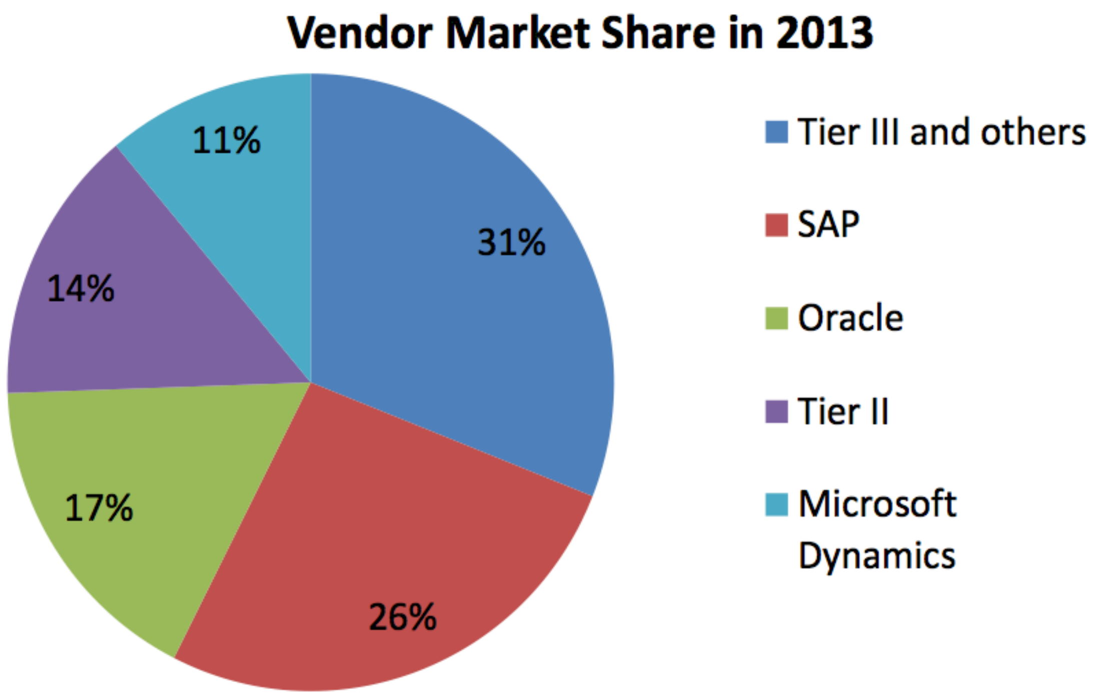
277 systems in ranking, June 2015

Rank			DBMS	Database Model	Score		
Jun 2015	May 2015	Jun 2014			Jun 2015	May 2015	Jun 2014
1.	1.	1.	Oracle	Relational DBMS	1466.36	+24.26	-34.56
2.	2.	2.	MySQL	Relational DBMS	1278.36	-15.91	-31.20
3.	3.	3.	Microsoft SQL Server	Relational DBMS	1118.05	-12.98	-105.74
4.	↑ 5.	4.	PostgreSQL	Relational DBMS	280.90	+7.39	+40.92
5.	↓ 4.	5.	MongoDB	Document store	279.05	+1.73	+47.61
6.	6.	6.	DB2	Relational DBMS	198.70	-2.35	+0.67
7.	7.	7.	Microsoft Access	Relational DBMS	146.49	+0.91	+4.13
8.	8.	↑ 9.	Cassandra	Wide column store	108.91	+2.36	+27.06
9.	9.	↓ 8.	SQLite	Relational DBMS	107.97	+2.81	+18.79
10.	10.	↑ 12.	Redis	Key-value store	95.49	+0.76	+30.36

http://db-engines.com/en/ranking

Oracle's Competitor

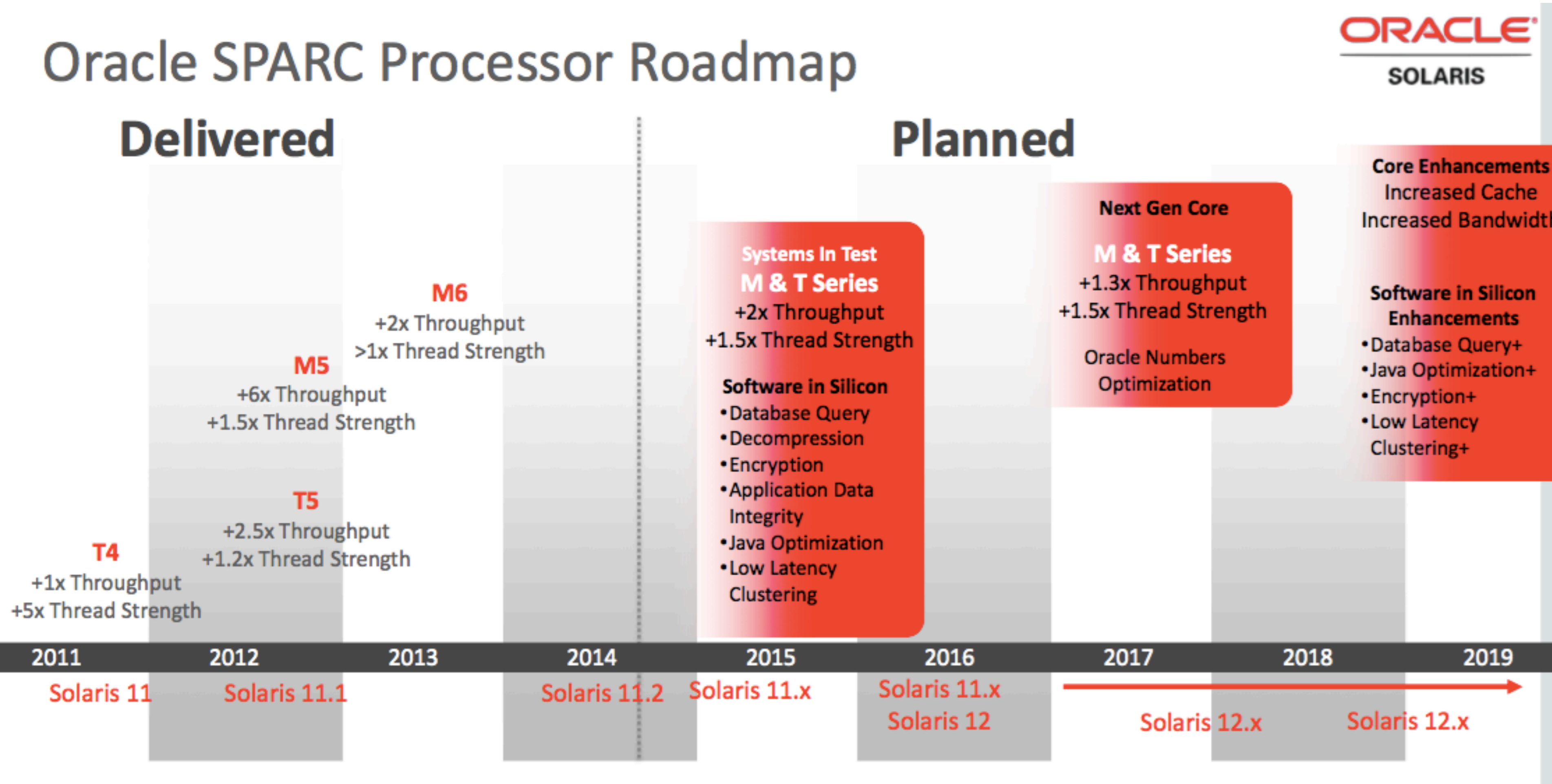
- Applications (ERP, CRM, HCM):
  - SAP, Microsoft



Source: Clash of the Titans

http://panorama-consulting.com/resource-center/clash-of-the-titans-2014-sap-vs-oracle-vs-microsoft-dynamics/

Future of Oracle



Future of Oracle

SPARC Accelerated Program :

- Enables third party software to utilize SPARC hardware
- Application data integrity support in future Solaris and all the tools chain
- Future Solaris support all the Software in Silicon enhancements

Future of Oracle

Support for other database or query software systems :

http://www.ithome.com.tw/news/95185

甲骨文大資料布局再進一步，ODI也能整合大資料平臺，傳統DBA用SQL就能操作Hadoop

http://www.ithome.com.tw/news/96387

甲骨文找Mirantis相助，讓12c資料庫更容易部署成OpenStack資料庫服務

Future of Oracle

Cloud :

Applications (SaaS)

Platform (PaaS)

Infrastructure (IaaS)

Data (DaaS)

Private Cloud

Managed Cloud

Conclusion

- ORACLE SPARC M7 is the best processor for database application
- The most important feature is **Software-In-Silicon**
- M7 has outstanding **security** and **reliability**, which are two most-concerned issues in database application
- ORACLE aims to integrate hardware and software, and enhance their compatibility
- ORACLE aims to develop Cloud-Computing

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http://db-engines.com/en/ranking

NEWs :

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Thank You