

Case Study: A Modern Superscalar Architecture—Intel Nehalem

55:132/22C:160
Spring, 2011

References

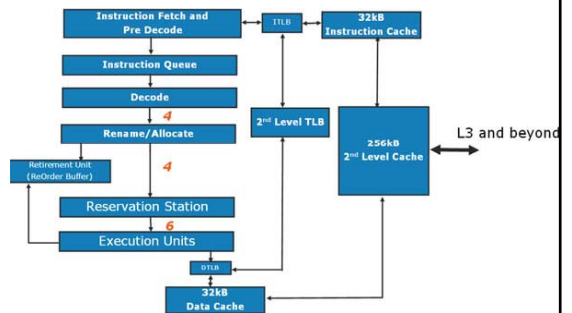
- **Inside Nehalem: Intel's Future Processor and System**, David Kantor, April, 2008, available at: <http://www.realworldtech.com/page.cfm?ArticleID=RWT040208182719&p=1>
- **First Look at Nehalem MicroArchitecture**, Ilya Gavrichenkov, Nov., 2008, available at: <http://www.xbitlabs.com/articles/cpu/display/nehalem-microarchitecture.html>
- **The Common System Interface: Intel's Future Interconnect**, David Kanter, Sept., 2007, available at: <http://www.realworldtech.com/page.cfm?ArticleID=RWT082807020032&p=1>

Nehalem-EX Overview

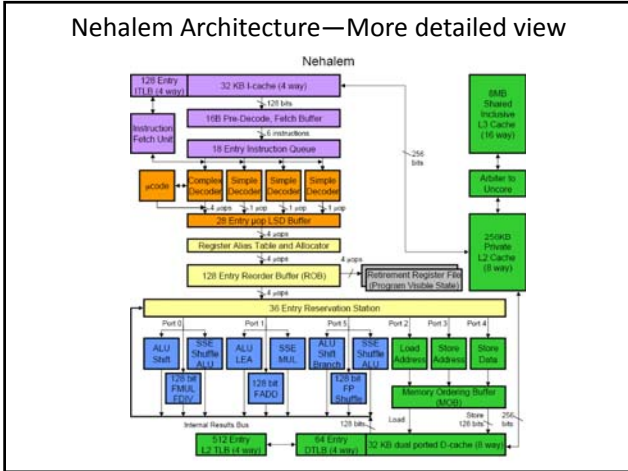
- Up to 8 Cores/16 Threads
- 24MB of Shared Cache
- Integrated Memory Controllers
- 4 High-bandwidth QPI Links
- Intel® Hyper-Threading
- Intel® Turbo Boost
- 2.3B Transistors

The Next Generation Intelligent Expandable Platform

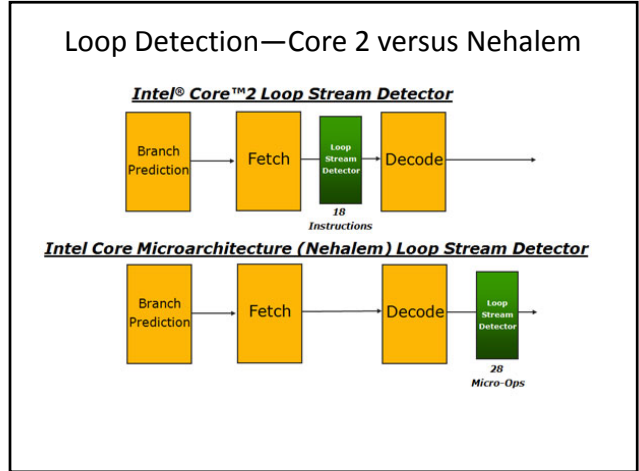
Nehalem Architecture—High-level view



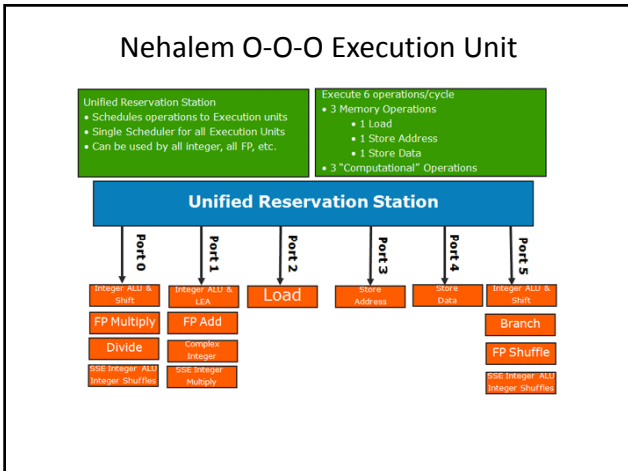
Nehalem Architecture—More detailed view



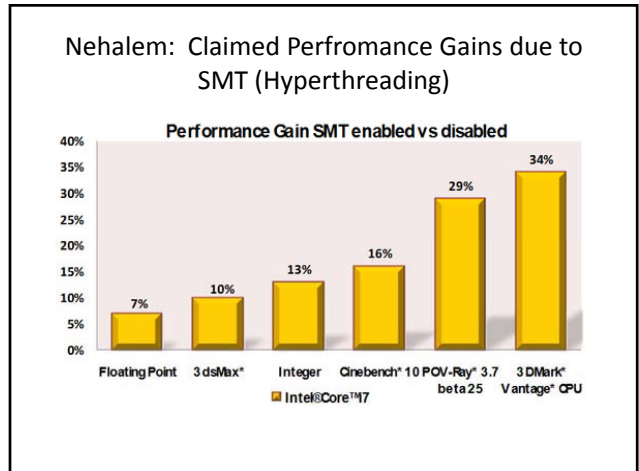
Loop Detection—Core 2 versus Nehalem



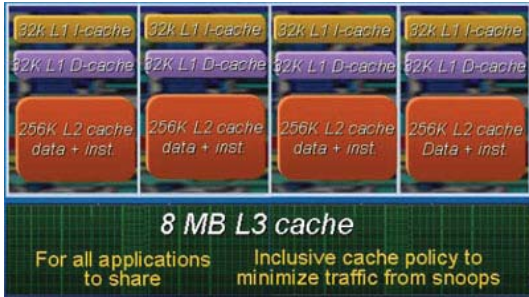
Nehalem O-O-O Execution Unit



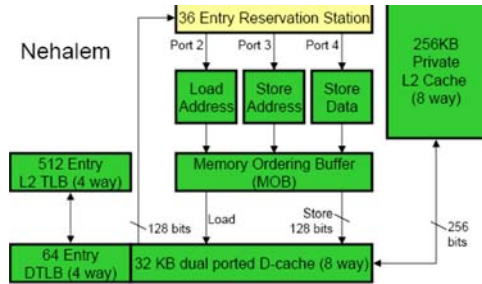
Nehalem: Claimed Performance Gains due to SMT (Hyperthreading)



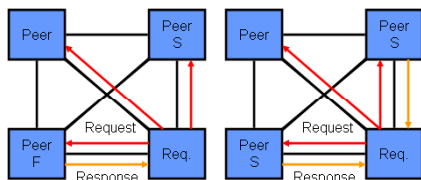
Nehalem Memory Hierarchy



Nehalem Memory Subsystem



Nehalem Cache Coherency Protocol



Nehalem (MESIF)
Added forwarding (F) state

Traditional (MESI)

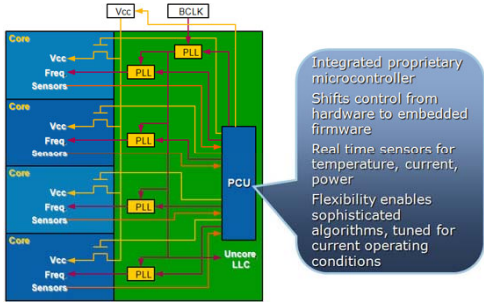
Comparison of MESI, MESIF, MEOSI

	Clean/Dirty	Unique?	Can Write?	Can Forward?	Can Silent Transition to	Comments
Modified	Dirty	Yes	Yes	Yes	Yes	Must writeback to share or replace
Exclusive	Clean	Yes	Yes	Yes	MSIF	Transitions to M on write
Shared	Clean	No	No	No	I	Does not forward
Invalid	NA	NA	NA	NA		Cannot Read
Forwarding	Clean	Yes	No	Yes	SI	Must invalidate other copies to write

	Clean/Dirty	Unique?	Can Write?	Can Forward?	Can Silent Transition to	Comments
Modified	Dirty	Yes	Yes	Yes	O	Can share without writeback
Owned	Dirty	Yes	Yes	Yes		Must writeback to transition
Exclusive	Clean	Yes	Yes	Yes	MSI	Transitions to M on write
Shared	Either	No	No	No	I	Shared can be dirty or clean
Invalid	NA	NA	NA	NA		Cannot Read

	Clean/Dirty	Unique?	Can Write?	Can Forward?	Can Silent Transition to	Comments
Modified	Dirty	Yes	Yes	Yes		Must writeback to share or replace
Exclusive	Clean	Yes	Yes	Yes	MSI	Transitions to M on write
Shared	Clean	No	No	Yes	I	Shared implies clean, can forward
Invalid	NA	NA	NA	NA		Cannot Read

Nehalem Power Management



Nehalem Power-saving states

	C0	C1	C3	C5
Core clock		off	off	off
PLL			off	off
Core caches			flushed	flushed
Shared cache				
Wakeup time*	active			
Core Idle power*				~ 0

* Rough approximation

Nehalem: Allocation of chip real-estate

