

# Future Vision of Memory Modules for DRAM

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# DDR2 Speed Grading

Data Rate	Clock Speed	Chip Bin	Module Bin
400 MT/s	200 MHz	DDR2-400	PC2-3200
533 MT/s	266 MHz	DDR2-533	PC2-4200
667 MT/s	333 MHz	DDR2-667	PC2-5300
800 MT/s	400 MHz	DDR2-800	PC2-6400

X64/x72 bit data  
bus \* chip speed



# DDR3 Speed Grading

Data Rate	Clock Speed	Chip Bin	Module Bin
800 MT/s	400 MHz	DDR3-800	PC3-6400
1066 MT/s	533 MHz	DDR3-1066	PC3-8500
1333 MT/s	667 MHz	DDR3-1333	PC3-10600
1600 MT/s	800 MHz	DDR3-1600	PC3-12800

***Example only;***

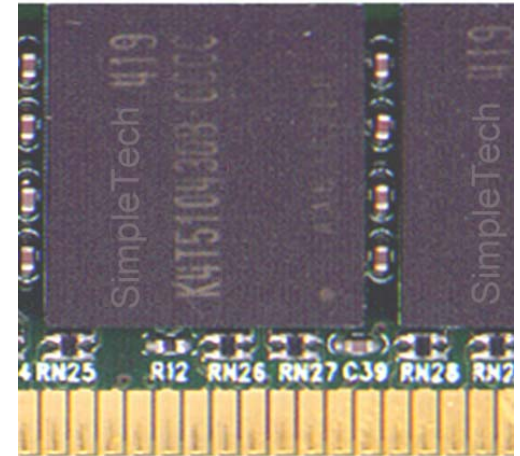
***This has not been approved by  
committee consensus yet***

X64/x72 bit data  
bus \* chip speed

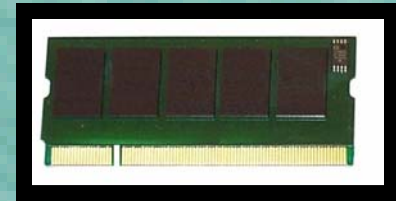
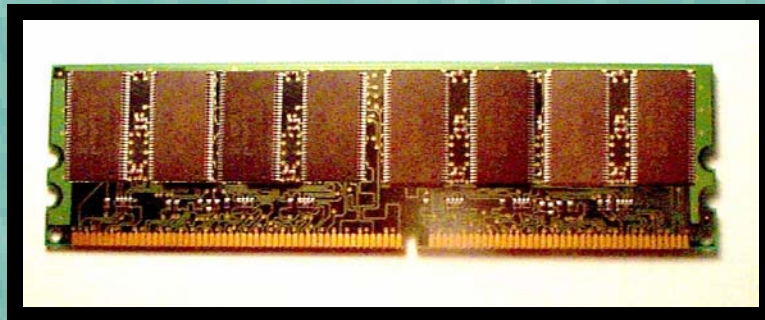
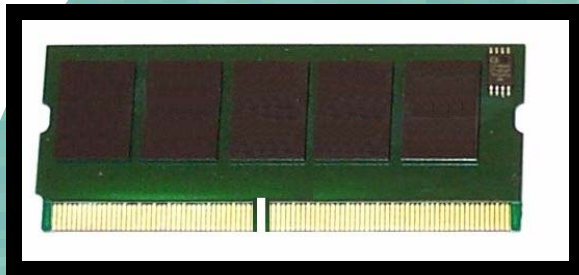
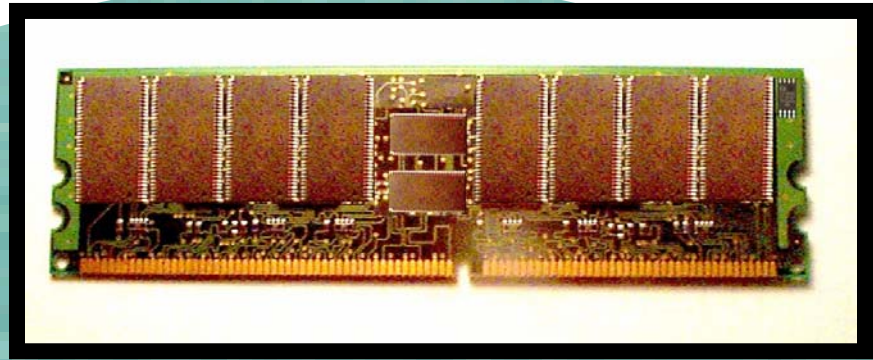


# Density Transitions

- DDR1 transition from 256Mb to 512Mb
  - 1Gb chip availability spotty, slower speed bins
  - TSOP for 200-333 & BGA for 400
- DDR2 mainstream part is 512Mb
  - 1Gb part coming on late in the year
- DDR3 test vehicle 1Gb
  - 2Gb first volume part
  
- Conclusion = 512Mb sweet spot for 2005
  - 2GB for 2 ranks, 4GB for 4 ranks



# Many Applications, Many Configurations




# Module Configurations

DDR1	Registered DIMM (4 rank) Unbuffered DIMM SO-DIMM	Micro-DIMM 32b-DIMM <b>16b-SO-DIMM</b>
DDR2	Registered DIMM (4 rank) <b>Mini-RDIMM</b> Unbuffered DIMM <b>FB-DIMM</b>	SO-DIMM Micro-DIMM <b>16b/32b-SO-DIMM</b>
DDR3	<b>Registered DIMM</b> Unbuffered DIMM <b>FB-DIMM</b>	SO-DIMM Micro-DIMM <b>16b/32b-SO-DIMM</b>

# Desktop & Mobile Markets



# PC Market: Unified Roadmap

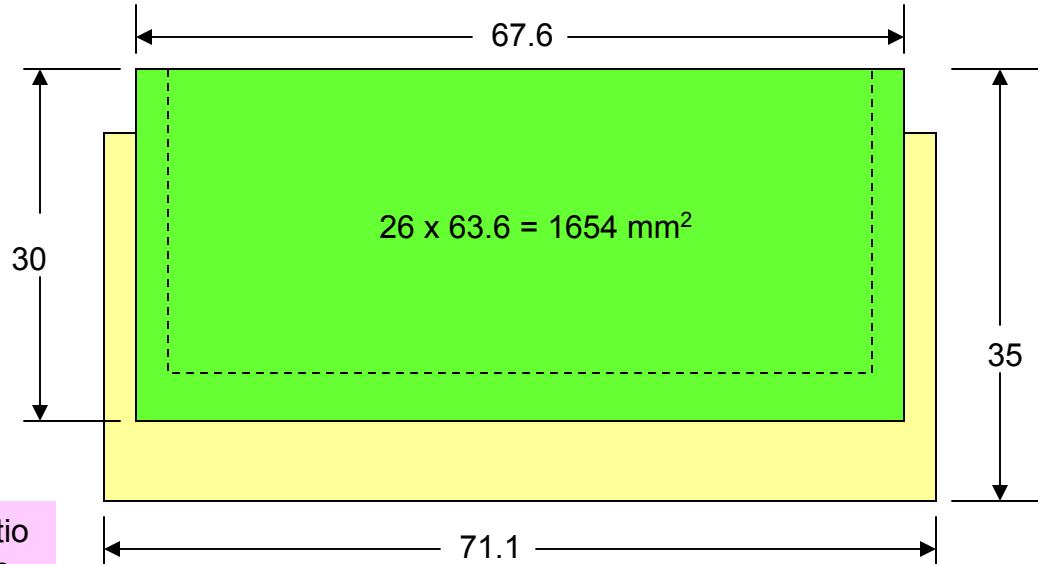
	2005	2006	2007
Desktop PC	DDR2-667 UDIMM 2 Rank	DDR2-800 UDIMM 2 Rank	DDR3-1066 UDIMM 2 Rank
			<b>DDR3 Transition</b> 
Notebook PC	DDR2-667 SO-DIMM 2 or 4 Rank	DDR2-800 SO-DIMM 2 or 4 Rank	DDR3-1066 SO-DIMM 2 or 4 Rank
Subnotebook PC	DDR2-667 Micro-DIMM 2 or 4 Rank	DDR2-800 Micro-DIMM 2 or 4 Rank	DDR3-1066 Micro-DIMM 2 or 4 Rank





# Mobile Module Comparison

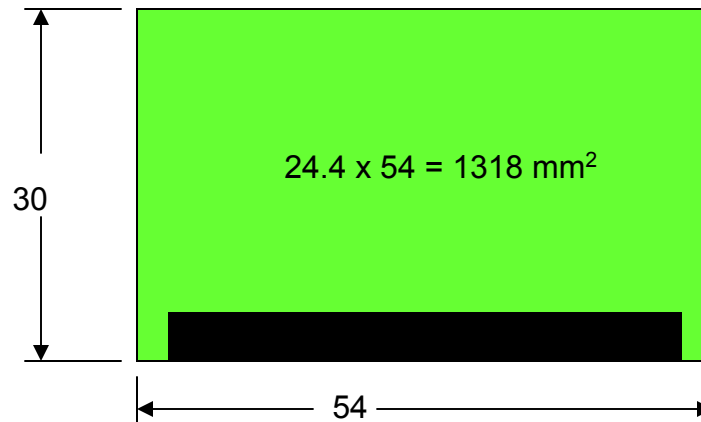
Thickness = 5.2 mm  
2D Layout efficiency =  
 $1654 / 2489 = 66\%$   
1GB  $\rightarrow$  79KB/mm<sup>3</sup>



DDR2 SO-DIMM  
with Edge Connector  
Socket

142% cubic density ratio  
advantage using Micro-  
DIMM versus SO-DIMM

Thickness = 5.65 mm  
2D Layout efficiency =  
 $1318 / 1620 = 81\%$   
1GB  $\rightarrow$  112KB/mm<sup>3</sup>

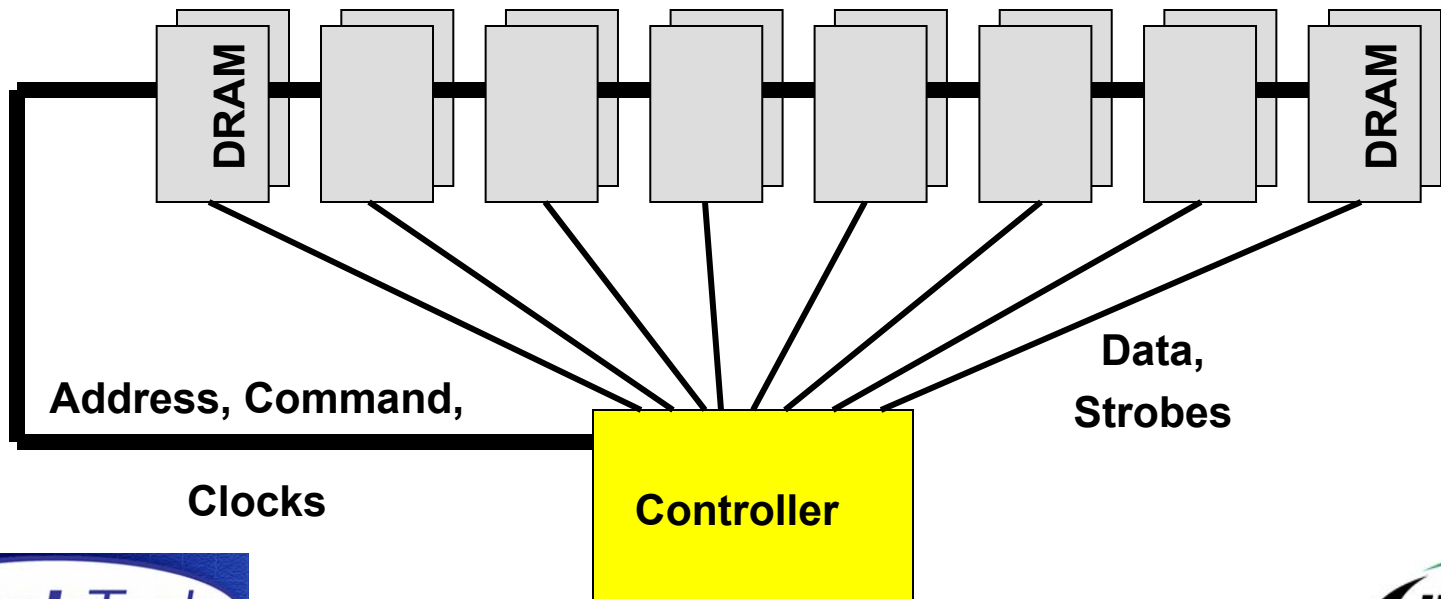


DDR2 Micro-DIMM with  
Mezzanine Connector



# DDR3 Unbuffered Modules

- UDIMM, SO-DIMM, Micro-DIMM
- Performance to 1.6Gbps per pin
- Fly-by buses with controller de-skew



# Server Markets



# Server Market: Fragmentation

Diverging views in server segment

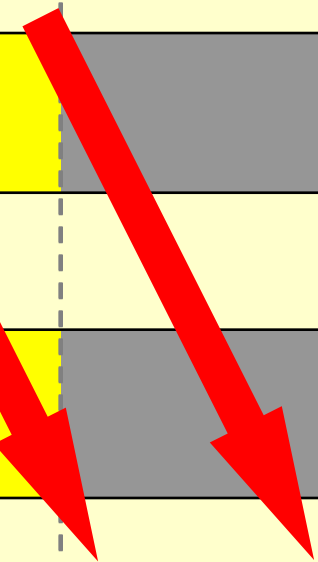
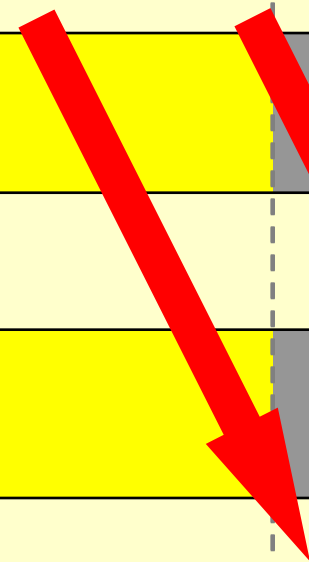
1. RDIMM completely replaced by FB-DIMM in all server segments
2. FB-DIMM serves high end and DDR3 RDIMM serves low end

JEDEC roadmaps support either path



# Server Market Perspective #1

	2005	2006	2007
HE Server	DDR2-400 RDIMM 2 Rank	DDR2-533 FB-DIMM	DDR2-667 FB-DIMM    DDR3-800 FB-DIMM
Mid Server	DDR2-400 RDIMM 2 Rank		
LE Server, HPC	DDR2-400 RDIMM 2 Rank		



# Server Market Perspective #2

	2005	2006	2007
HE Server	DDR1-266 RDIMM 4 Rank	DDR2-533 RDIMM 4 Rank	DDR3-800 FB-DIMM
Mid Server	DDR1-333 RDIMM 4 Rank	DDR2-667 RDIMM 4 Rank	DDR3-1066 RDIMM 4 Rank
LE Server, HPC	DDR1-400 RDIMM 4 Rank	DDR2-667 RDIMM 4 Rank	DDR3-1066 RDIMM 4 Rank



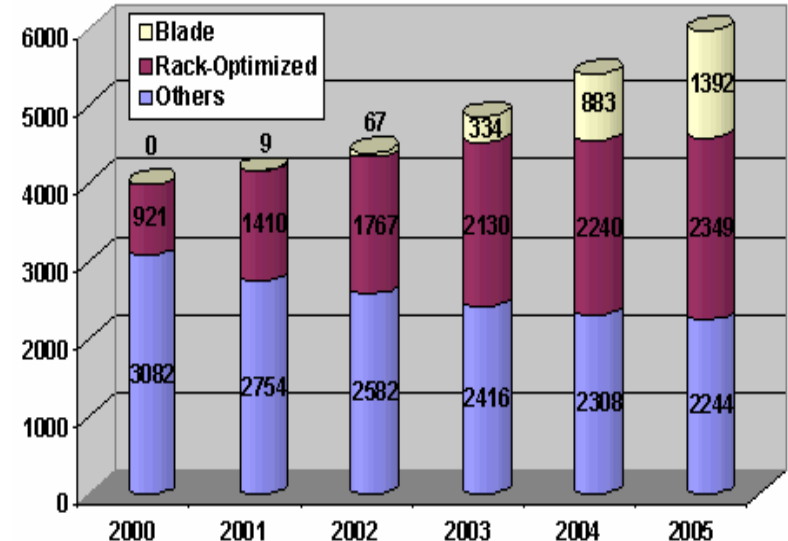
# Form Factor Wars



- 1.2" (30mm) standard chosen in 1999 based on 1U server market projections

HP First to Reach Milestone of 100,000 Blade Servers Sold

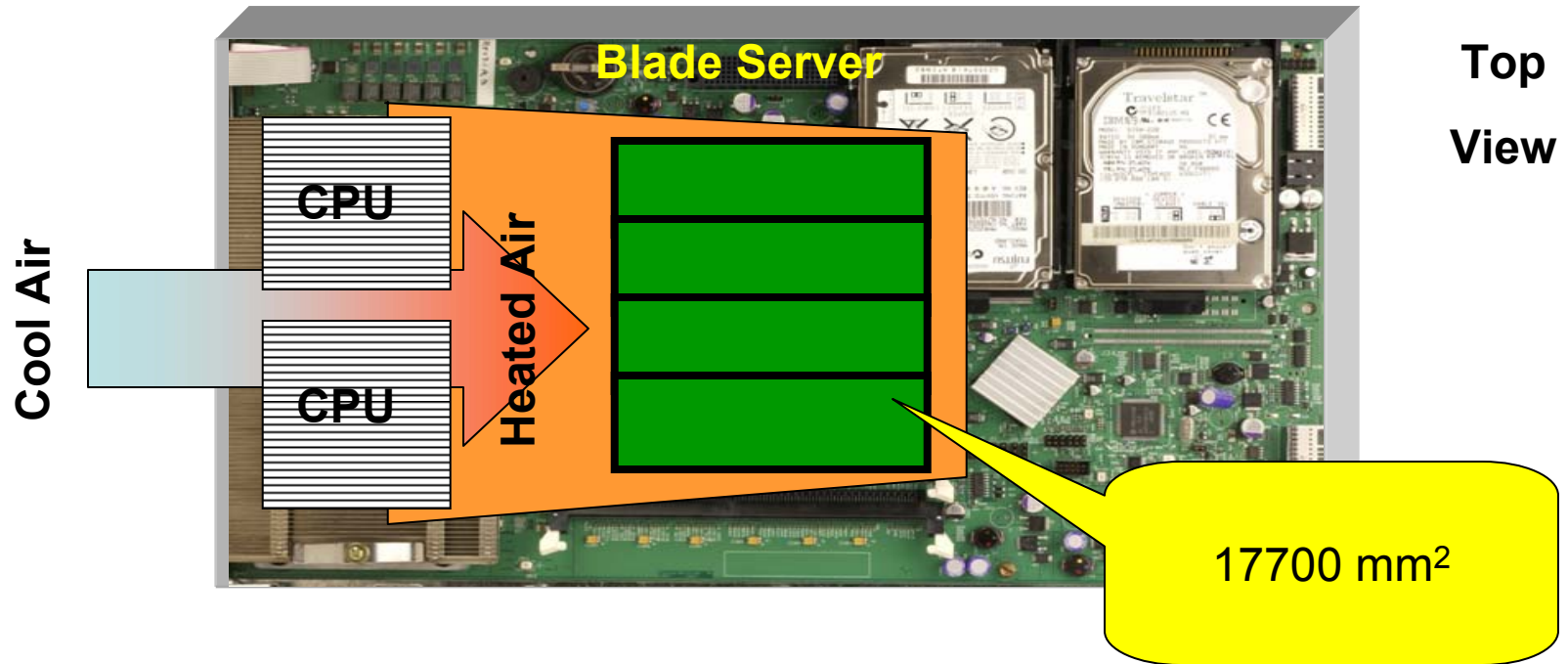
- But, market fragmenting
  - Blade needs 18.3mm (VLP)
  - 1U needs 30mm (LP)
  - 2U can use 38mm or taller



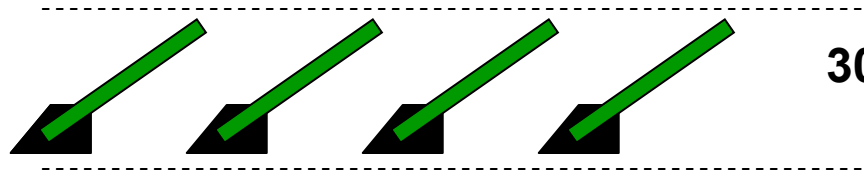
- OEMs “demand” one size fits all ... but ...



# Standard Profile Module



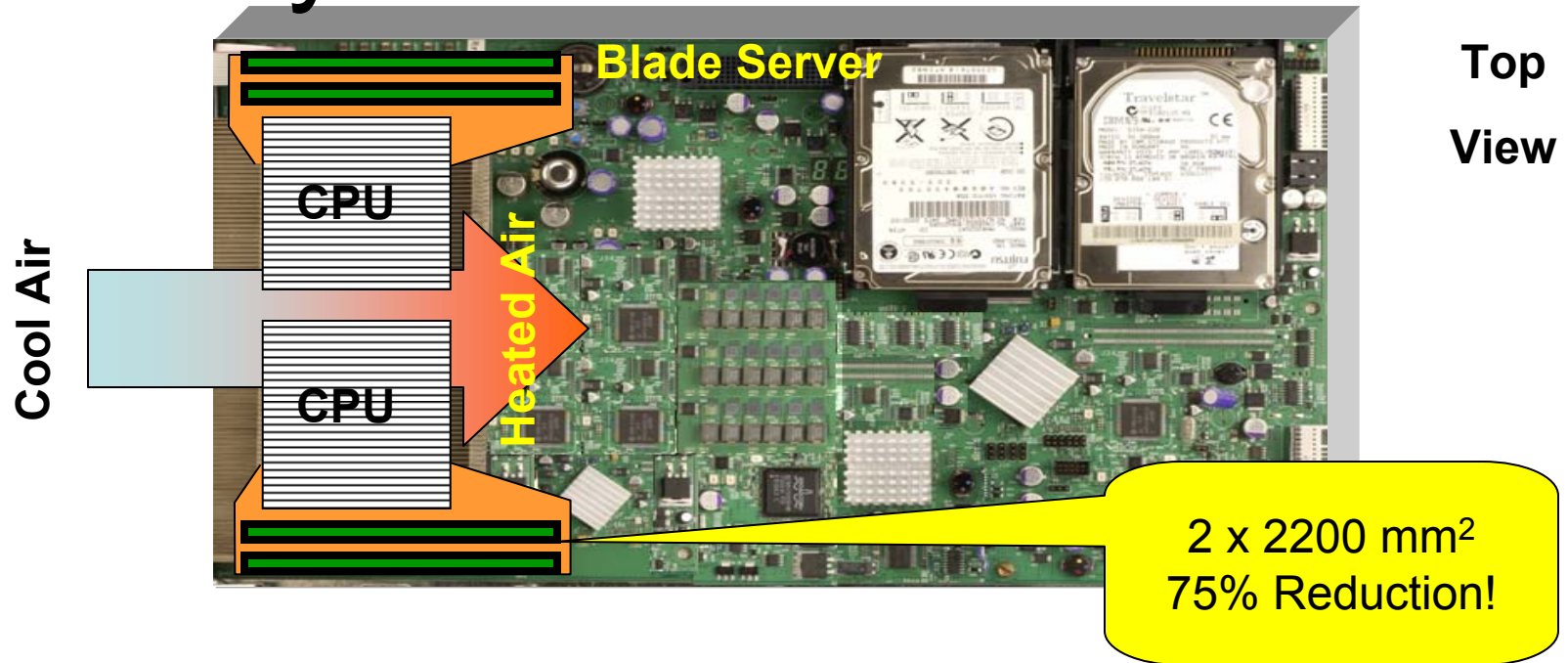
Angled Socket



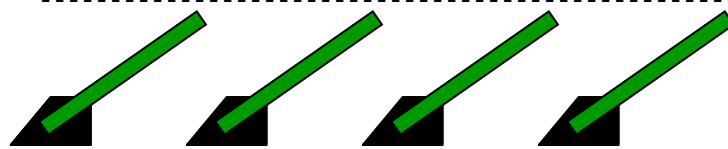
30 mm DIMM



# Very Low Profile Module

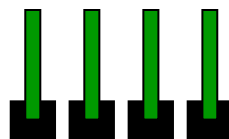


Angled Socket



30 mm DIMM

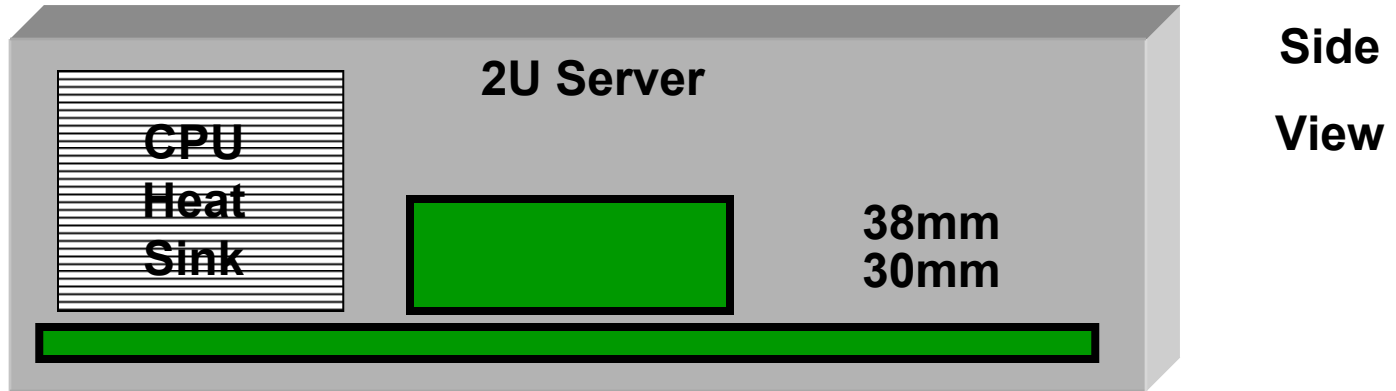
Vertical Socket



18.3 mm DIMM

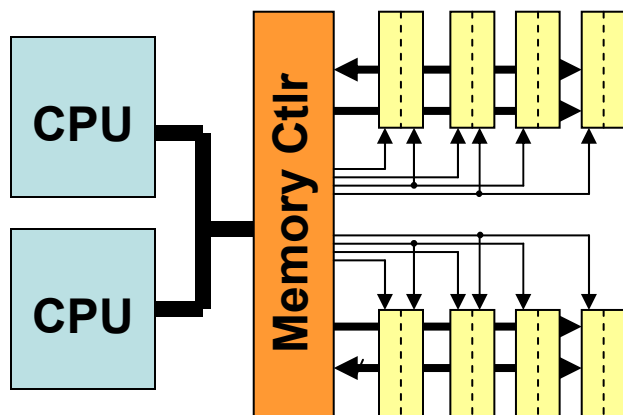


# High Profile Module



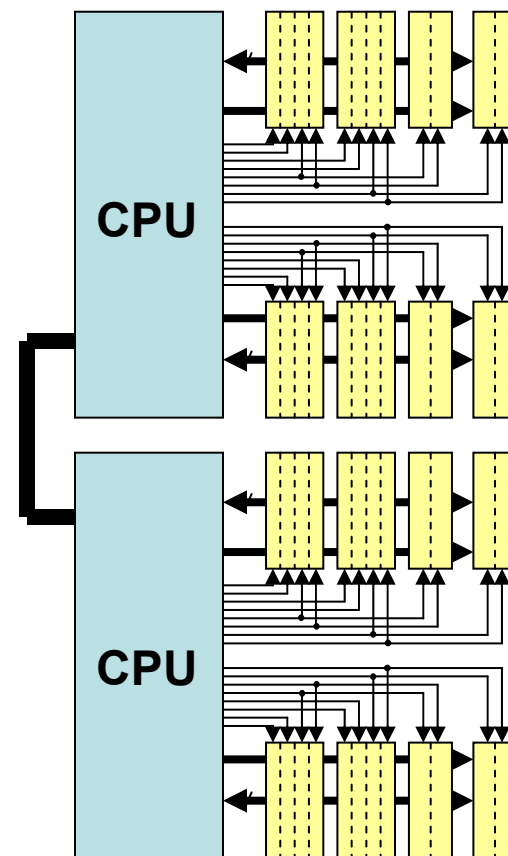
- Lots of headroom due to huge heat sinks
- Tall module (e.g., 38mm) fits fine
- Better thermal characteristics
- More DRAM supplier options

# 4 Rank RDIMM



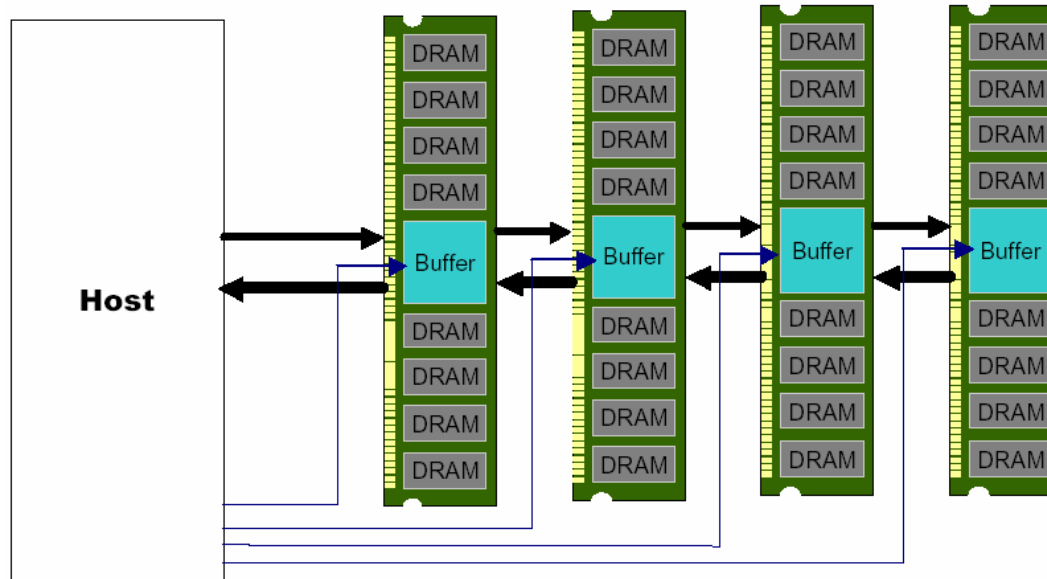
← From 8 ranks  
(16GB) max for  
dual CPU...

... to 32 ranks  
(64GB) max for  
dual CPU →



- Requires 2 rank select signals routed on motherboard
- BIOS updated to detect SPD byte 5 = '4'
- DDR1 pinout & block diagrams approved
- DDR2 full design approved to PC2-4200, PC2-5300 review now, PC2-6400 after

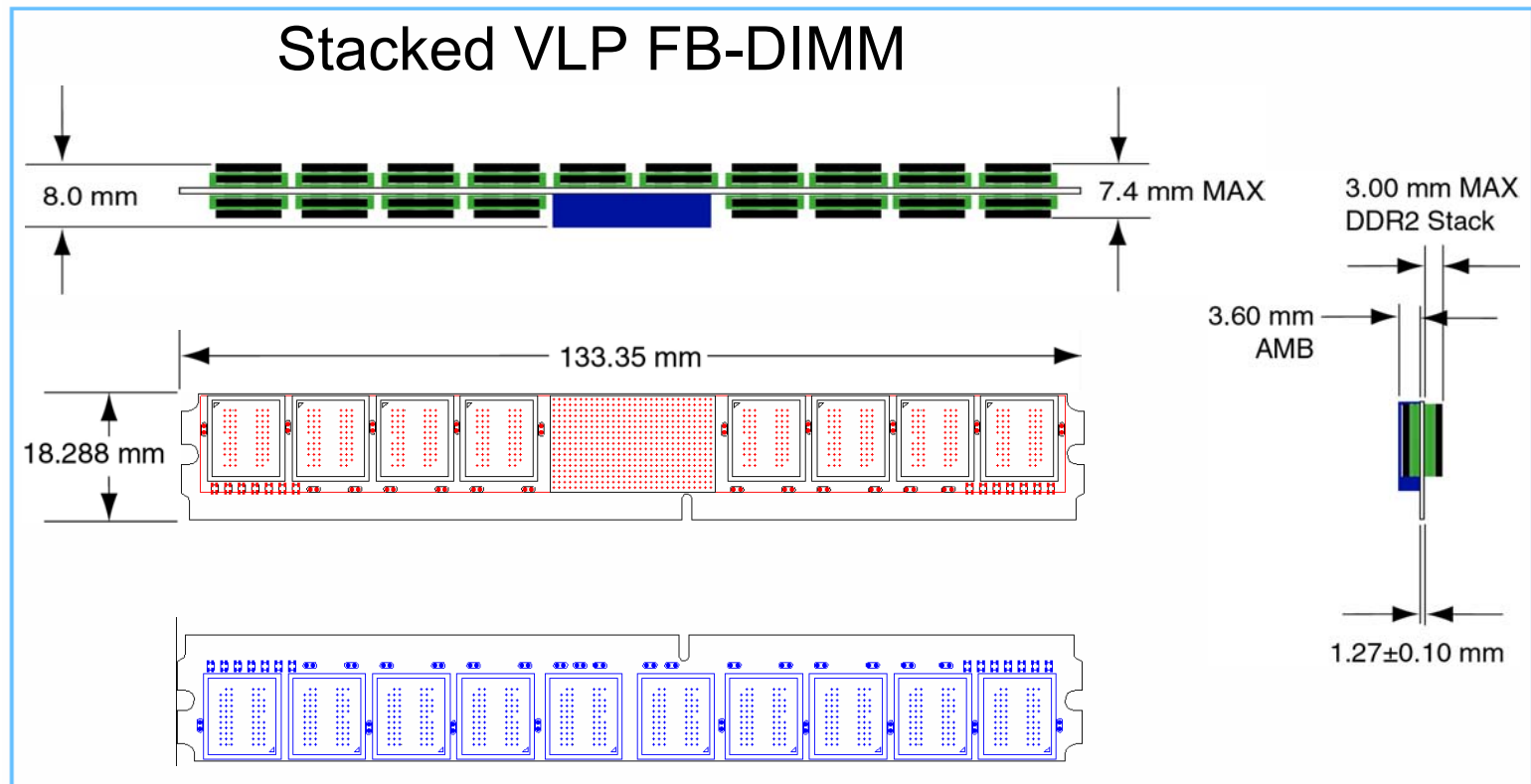
# Fully Buffered DIMM



- Solves the stub bus timing challenges
- 16GB/channel easily supported
- Cost and thermal issues may limit use
- Difficult to support VLP form factor
- Eases DDR2 → DDR3 transition

# VLP FB-DIMM

Requires a repackaging of AMB chip

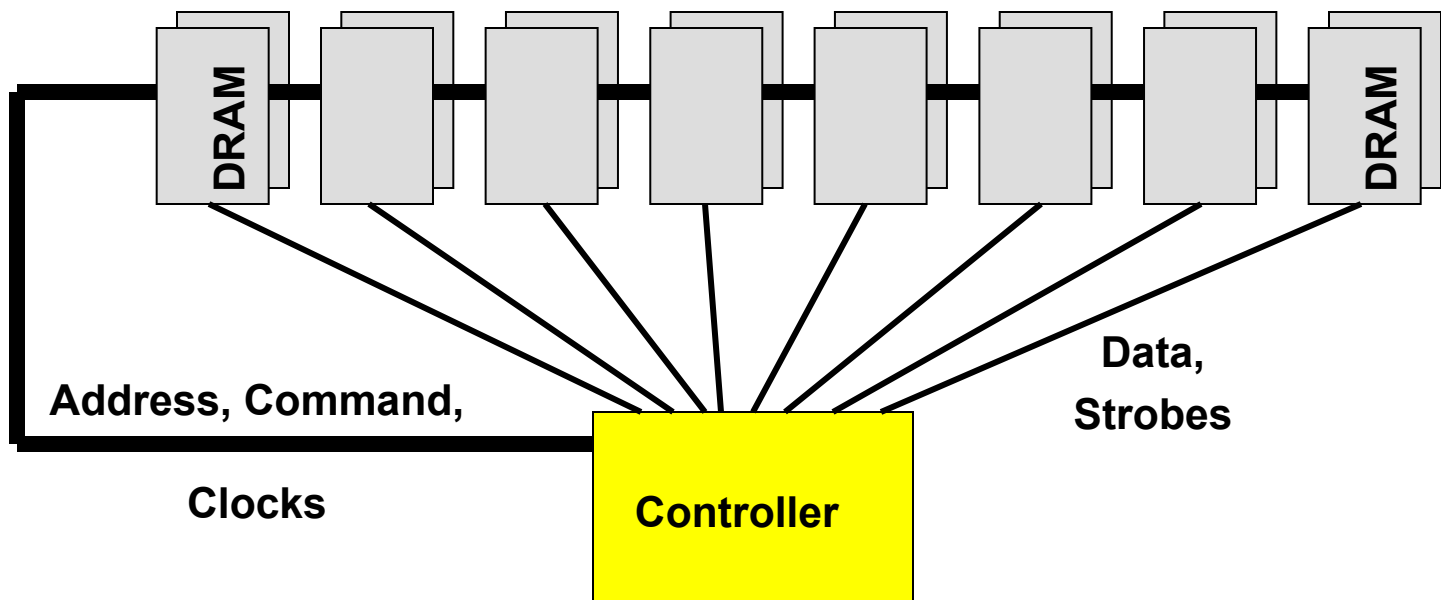


*Separate JEDEX talk on this subject*

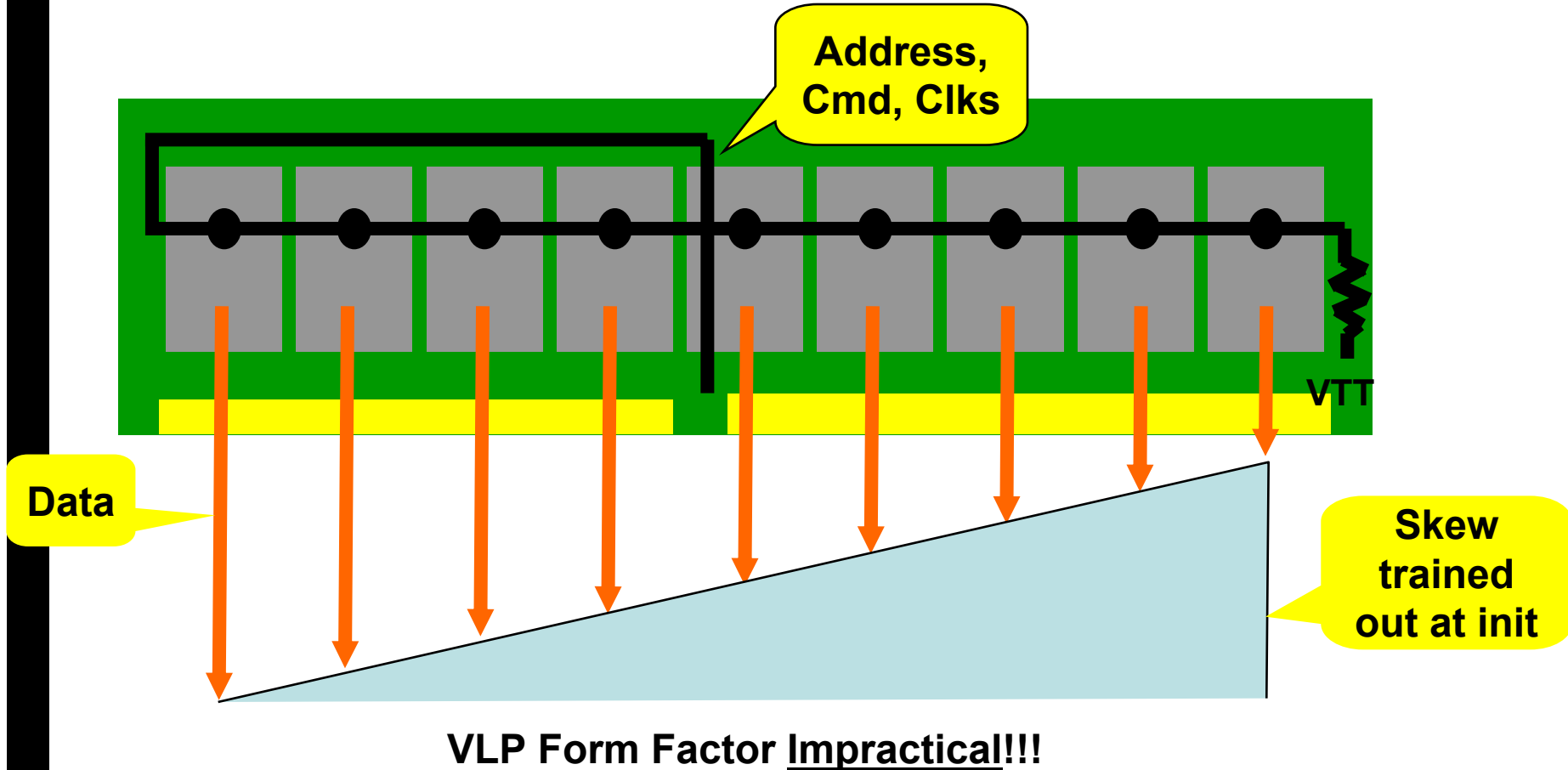


# DDR3 Modules

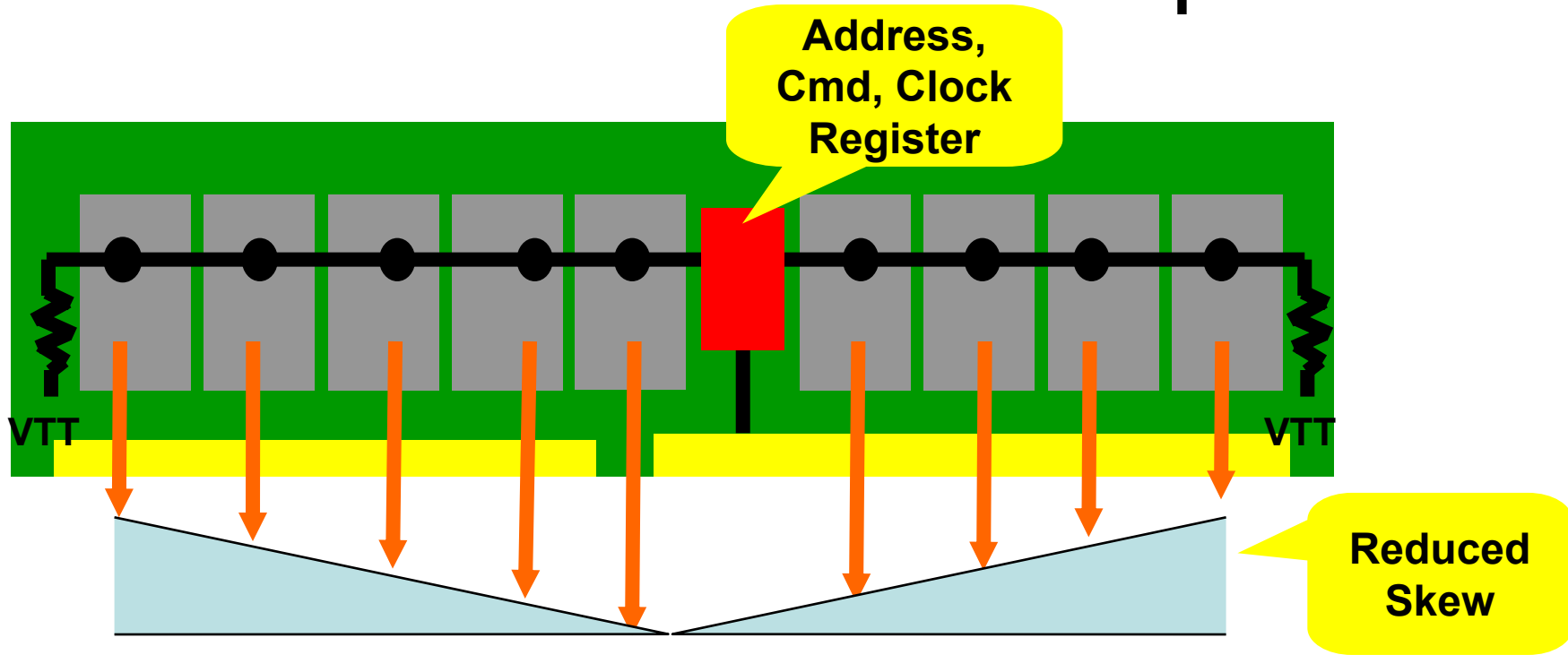
- The fly-by enhancements create new opportunities for enhancement



# Skew Across the Word Width



# DDR3 RDIMM Concept



VLP Form Factor Supported

Support for 2 ranks (36 DRAMs) and up to 4 ranks (72 DRAMs)



# Router/Networking Markets

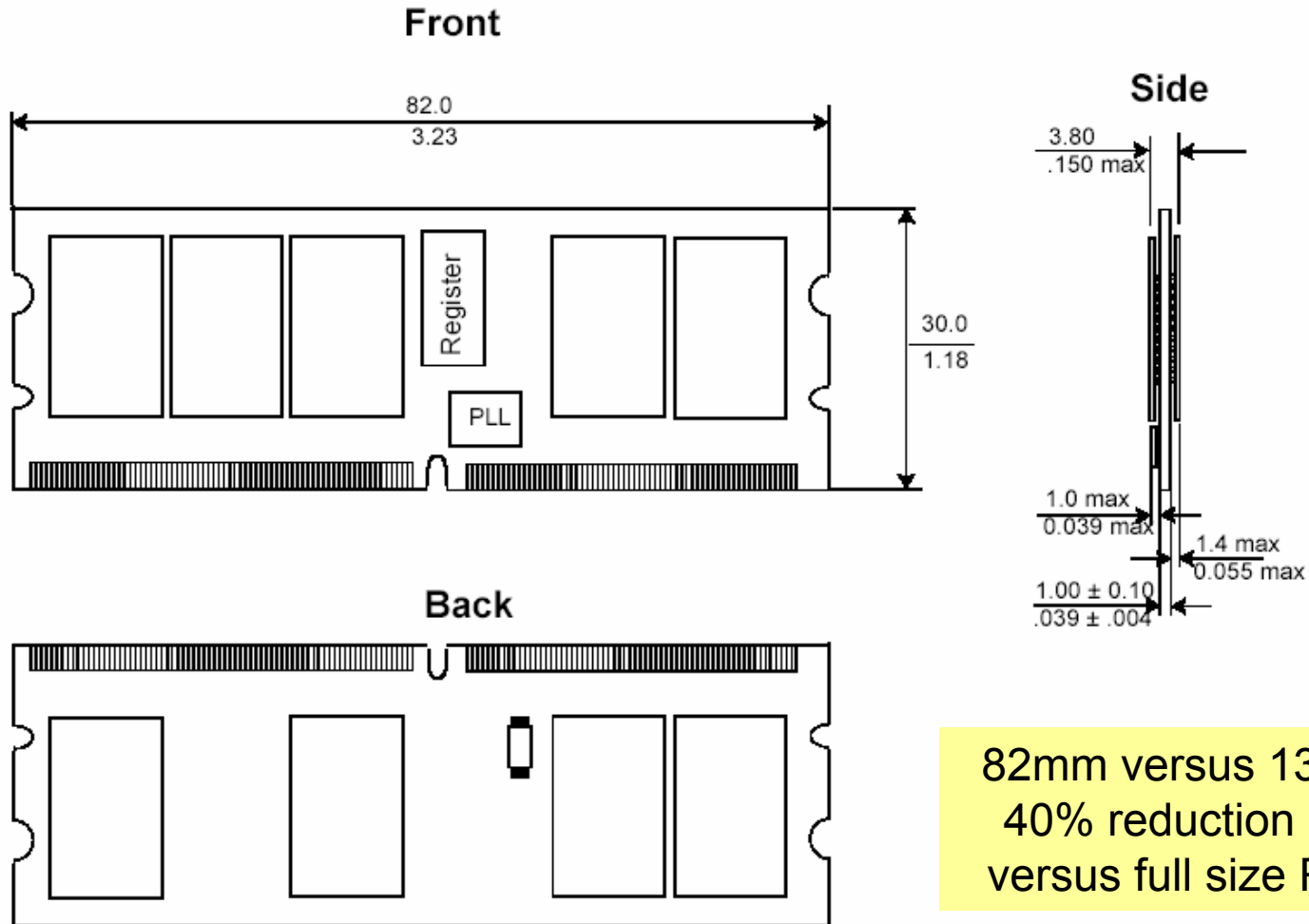


# Router & Networking

	2005	2006	2007
High End Routers	DDR1 RDIMM	DDR2 Mini-RDIMM	DDR3 Mini-RDIMM?
Low End Routers	DDR1 SO-DIMM	DDR2 SO-DIMM	DDR3 SO-DIMM

- Split between those that need ECC and those that don't need ECC
- Some demand for a Mini-UDIMM, too, from this market segment

# Mini-RDIMM Form Factor



82mm versus 133mm =  
40% reduction in size  
versus full size RDIMM

# Peripheral Markets



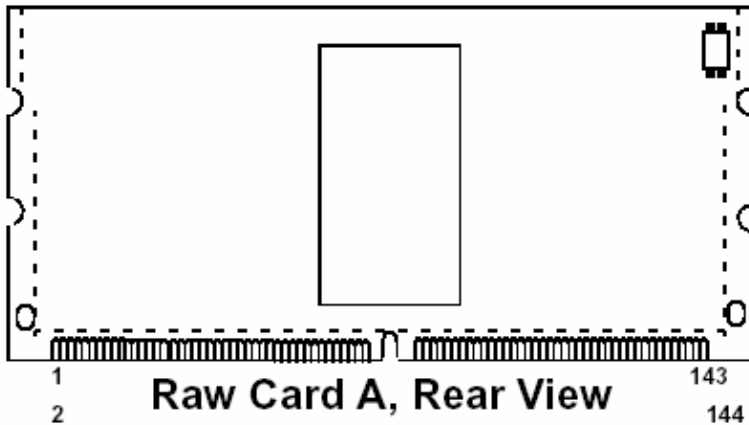
# Peripherals

	2005		2006		2007	
Peripherals	DDR1 32b-DIMM	DDR1 16b-SO-DIMM	DDR2 16b-SO-DIMM	DDR2 32b-SO-DIMM		

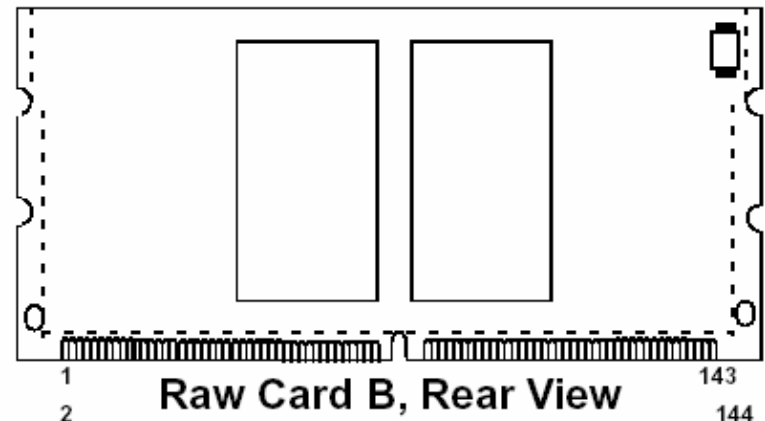
- Devices that need smaller granularity
  - A single 512Mb chip contains 64MB of data!
- Small footprint is desirable
  - 1 to 4 DRAMs typical
- Reuses SDRAM 144-pin SO-DIMM form
- Common pinout for DDR1/2/3 and 16/32 bits

# Modules for Peripherals

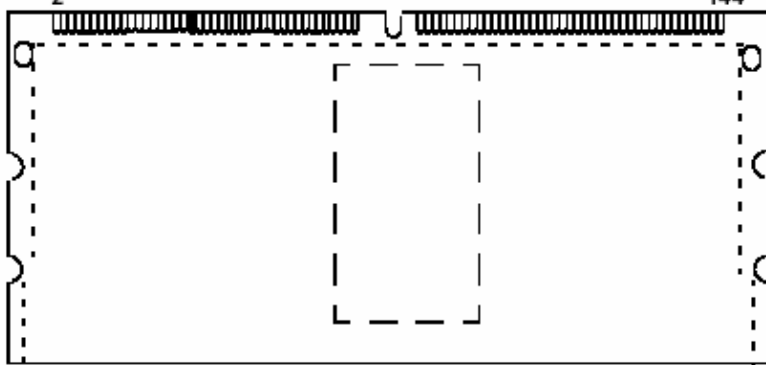
Raw Card A, Front View



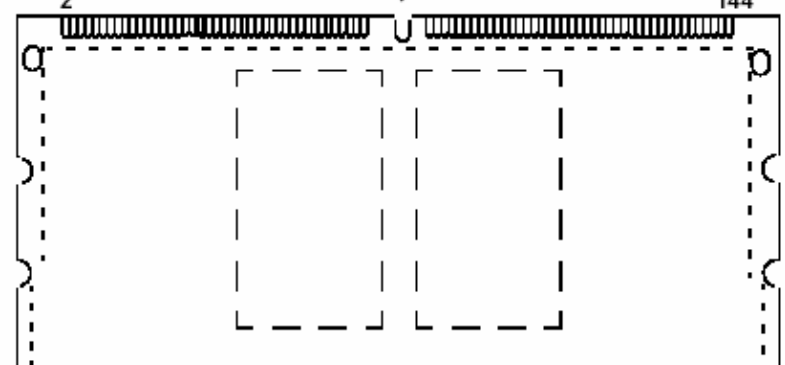
Raw Card B, Front View



Raw Card A, Rear View



Raw Card B, Rear View



# Memory Module Summary

- DDR2 transition has begun, DDR3 coming
- PC market form factors fairly stable
  - UDIMM, SO-DIMM, Micro-DIMM
  - DDR1 → DDR2 → DDR3
- Server market fragmenting
  - RDIMM → FB-DIMM or RDIMM → RDIMM?
  - Module height = 38mm? 30mm? 18.3mm?
- Networking module: Mini-RDIMM
- Peripherals module: 16b-SO-DIMM



# Thank You

- Questions?

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