

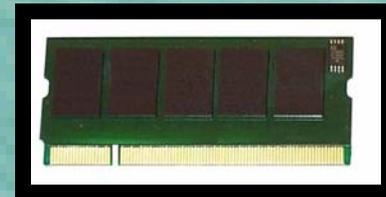
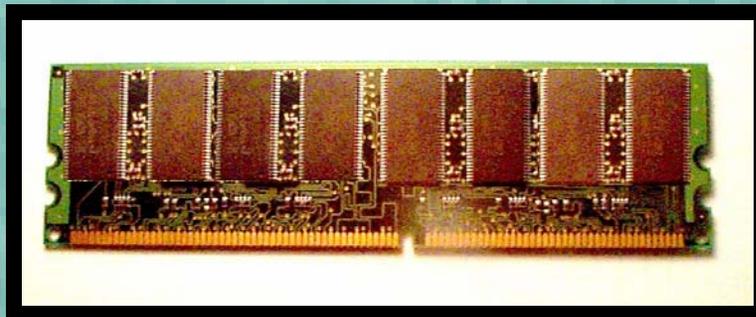
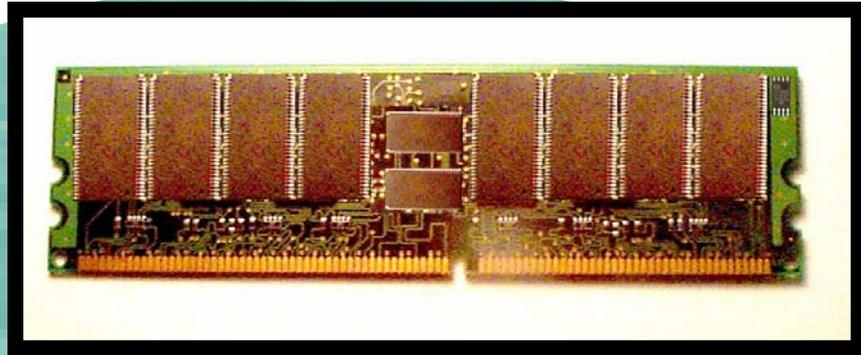
DRAM Memory Modules Overview & Future Outlook



Bill Gervasi
Vice President, DRAM Technology
SimpleTech
bilge@simpletech.com



Many Applications, Many Configurations

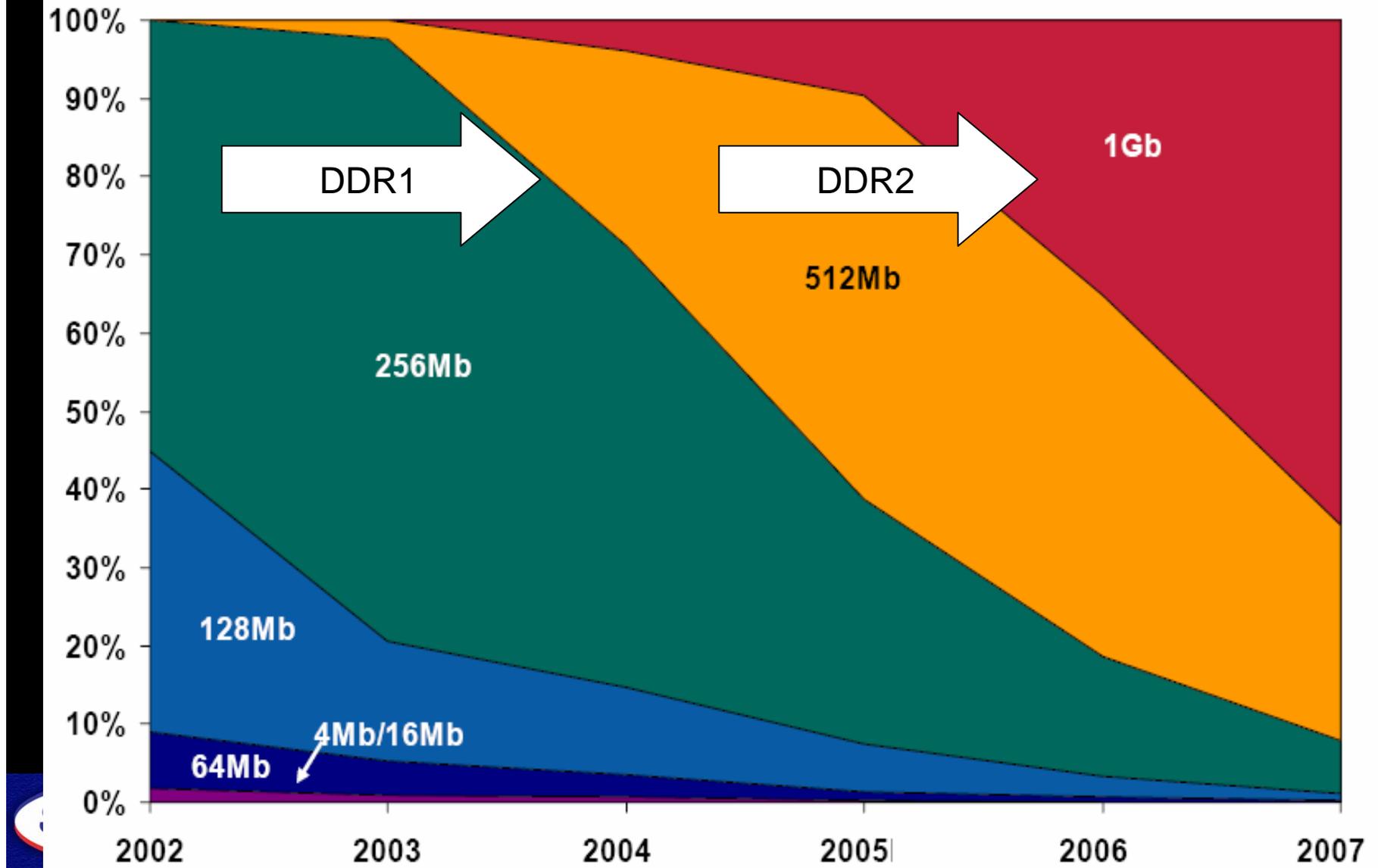


Module Configurations

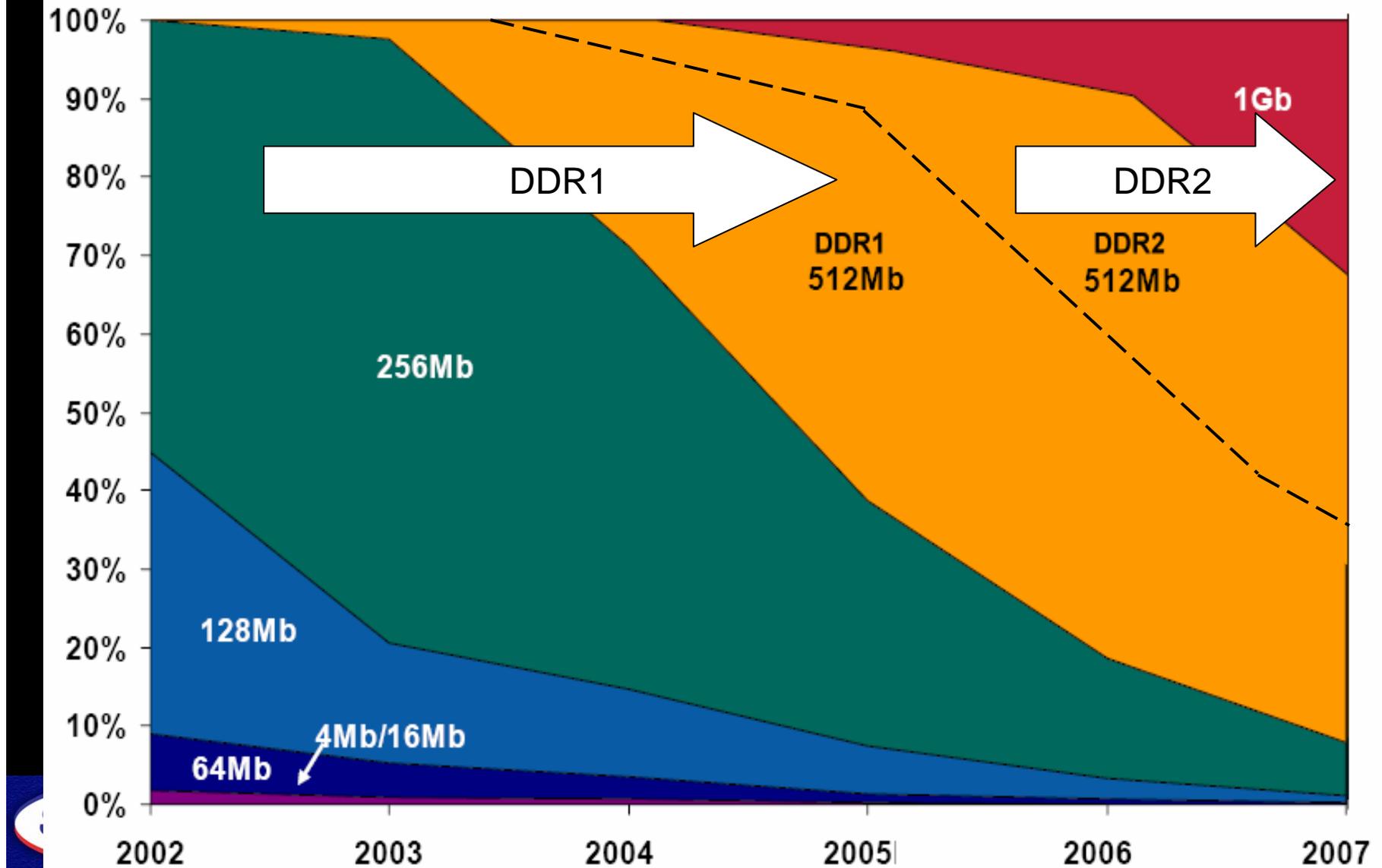
DDR1	Registered DIMM (VLP) Unbuffered DIMM SO-DIMM	Micro-DIMM 32b-DIMM 16b-SO-DIMM
DDR2	Registered DIMM (VLP) Mini-RDIMM Unbuffered DIMM FB-DIMM	SO-DIMM Micro-DIMM 16b/32b-SO-DIMM 72b-SO-DIMM (VLP)
DDR3	Registered DIMM (VLP) Unbuffered DIMM FB-DIMM	SO-DIMM Micro-DIMM 16b/32b-SO-DIMM



2003 Transition Forecast



Density Transition Reality



DRAM Density

1Gb transition hindered by the Perfect Storm

DDR1/DDR2 split on suppliers & designs

Fab process transition difficulties

10% die penalty for 8 banks

512Mb DRAM sweet spot 'til mid-2007!

→ 2GB/slot limit for 2-rank modules

- DDR3 → 2007 intro, 2008 ramp, 2009 crossover
- 4 rank will continue to increase momentum
- Stacking will be the lowest cost path to 4GB

SimpleTech Postage Stamp Stack

2 DRAMs
(one under
cavity)

Cavity
Substrate

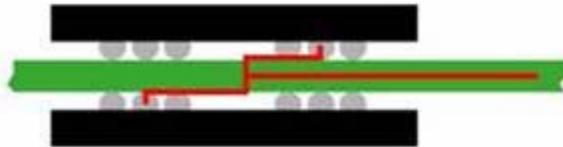
High Reliability
Ball-less Vertical
Interconnect

Decoupling
Capacitors

Probe Points on
All Signals and
Voltages

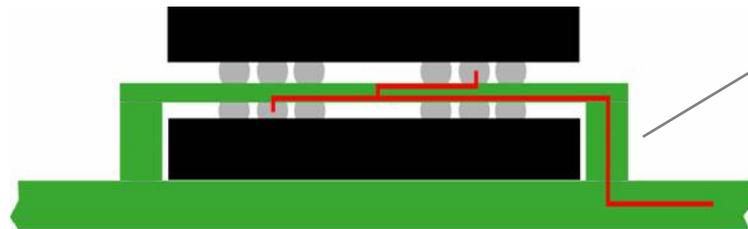


Symmetric, Low Parasitic



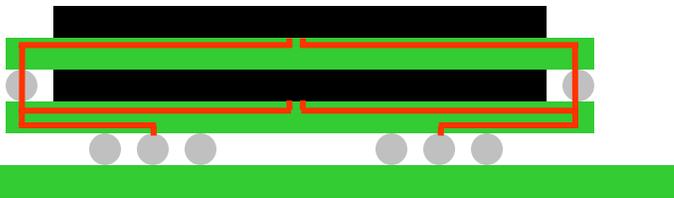
Planar
double sided

Postage
Stamp
stack

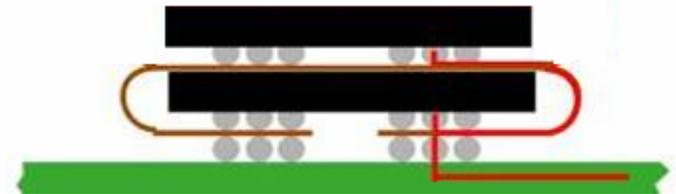


Same routing as planar
plus ~1.2 mm riser

Other
Package
Stacking
Solutions



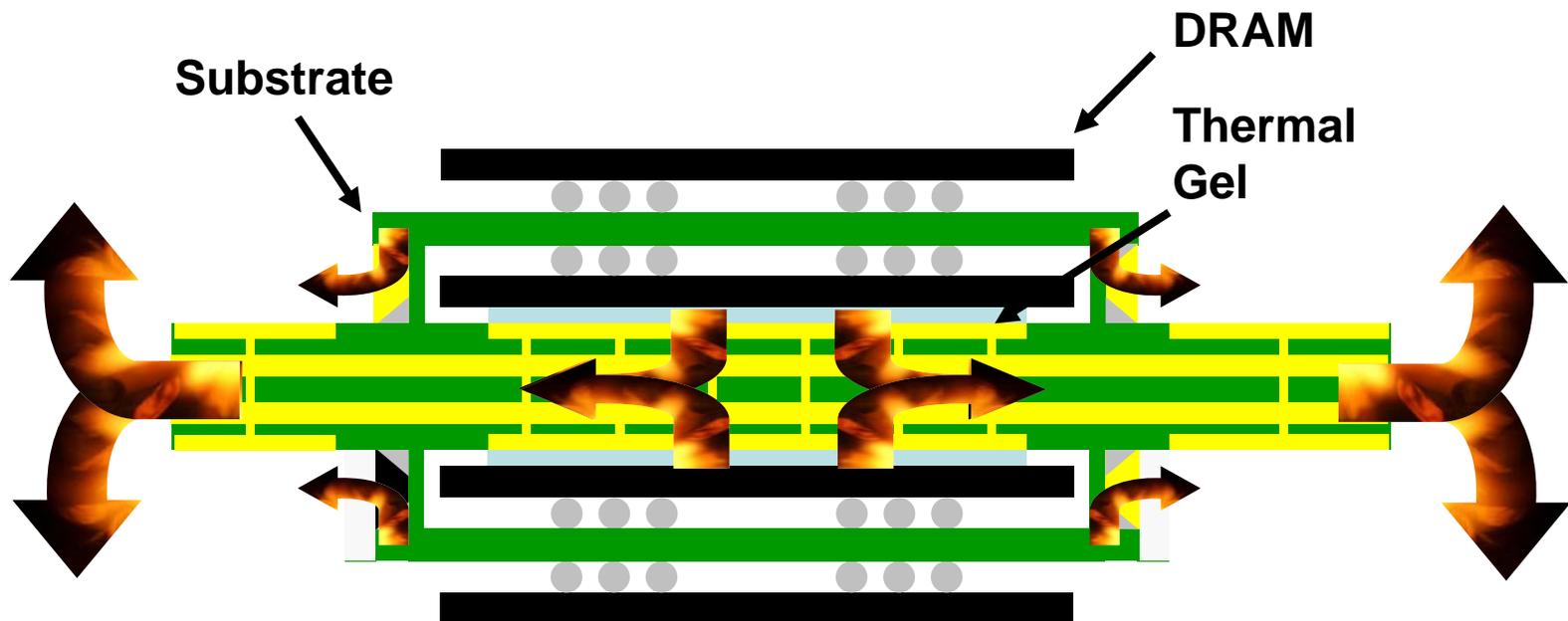
Package
stack with
interposer



Transmission
line stack



Thermal Design Techniques



2°C delta between top & bottom chips in each PS

Desktop & Mobile Markets



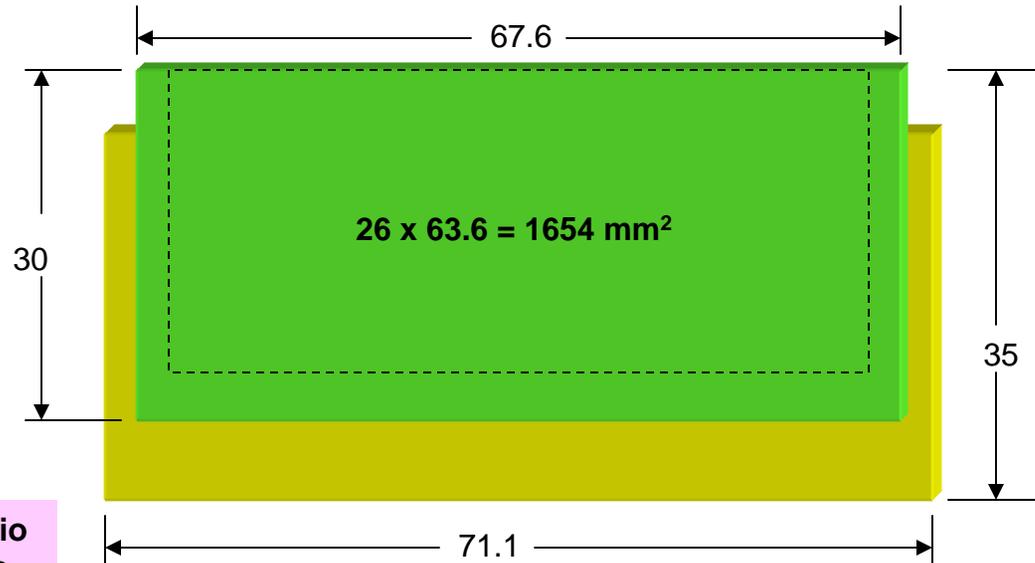
PC Market: Unified Roadmap

	2006	2007	2008
Desktop PC	DDR2-800 UDIMM		DDR3-1066 UDIMM
Notebook PC	DDR2-800 SO-DIMM		DDR3-1066 SO-DIMM
Subnotebook PC	DDR2-800 Micro-DIMM		DDR3-1066 Micro-DIMM



Mobile Module Comparison

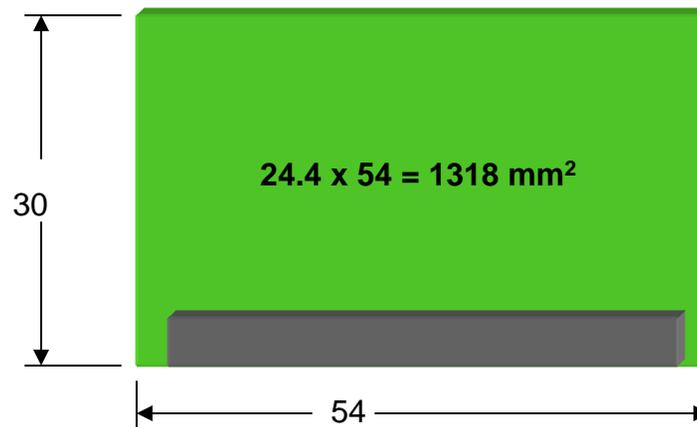
Thickness = 5.2 mm
2D Layout efficiency =
 $1654 / 2489 = 66\%$
1GB \rightarrow 79KB/mm³



DDR2 SO-DIMM
with Edge Connector
Socket

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

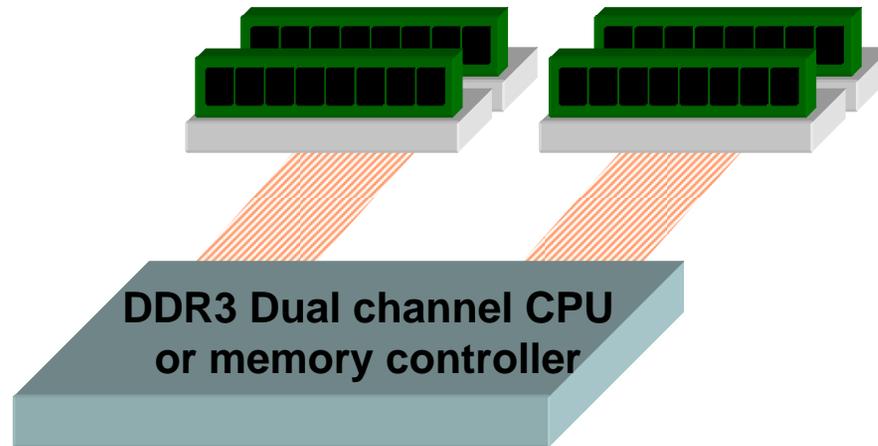
Thickness = 5.65 mm
2D Layout efficiency =
 $1318 / 1620 = 81\%$
1GB \rightarrow 112KB/mm³



DDR2 Micro-DIMM with
Mezzanine Connector



DDR3 Slots per Channel



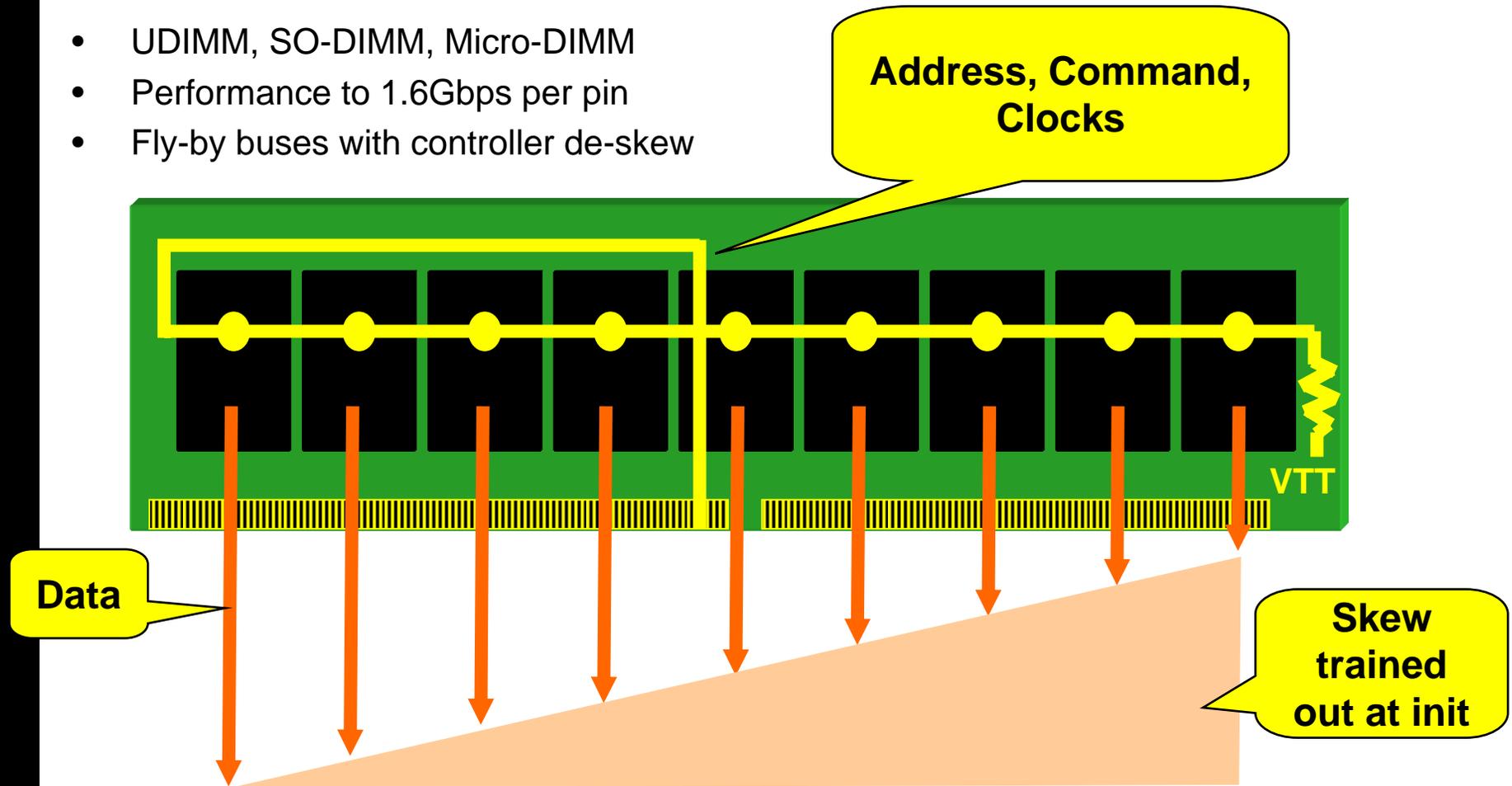
Original plan was for one slot per channel, 2 ranks per slot

Updated plan is for two slots per channel, 2-4 ranks per slot

Most mobile solutions limit to two slots total – space limited

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

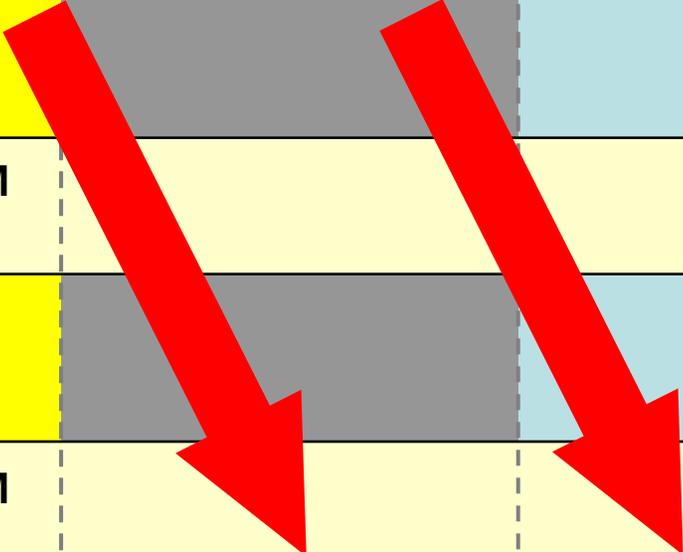
1. RDIMM completely replaced by FB-DIMM in all server segments
2. FB-DIMM serves high end and DDR3 RDIMM serves low end

JEDEC roadmaps support either path

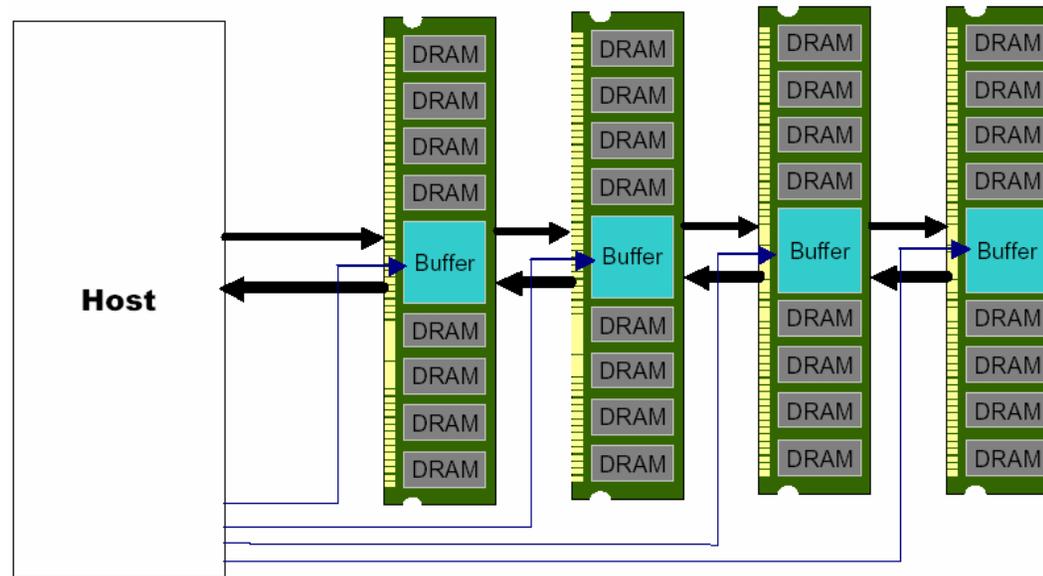


Server Market Perspective #1

	2006	2007	2008
HE Server	DDR2-533 FB-DIMM 2 Rank	DDR2-667 FB-DIMM 2 Rank	DDR3-800 FB-DIMM 4 Rank
Mid Server	DDR2-400 RDIMM 2 Rank		
LE Server	DDR2-400 RDIMM 2 Rank		

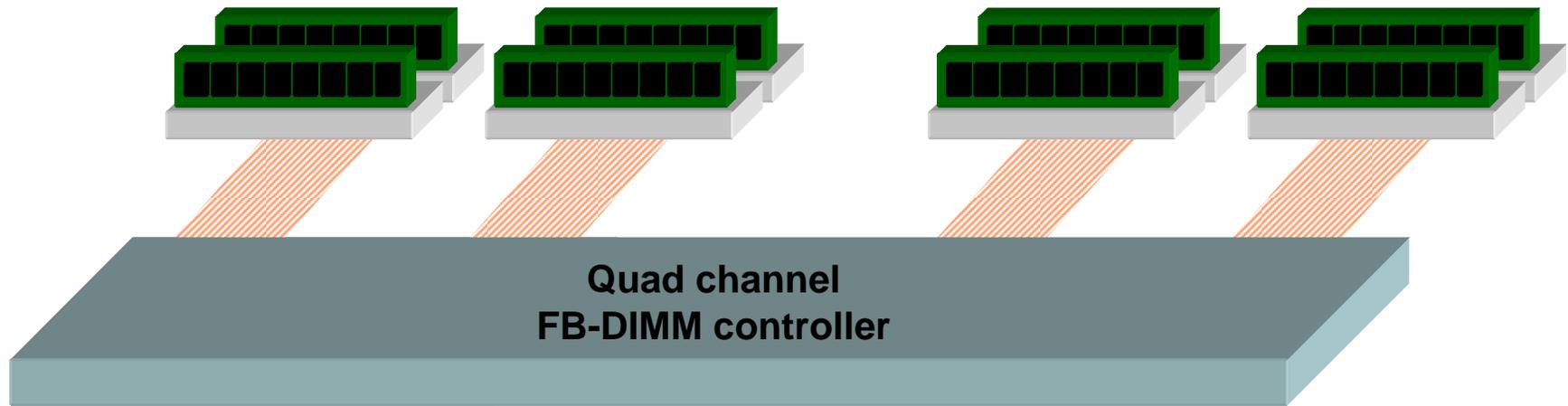


Fully Buffered DIMM



- Solves the stub bus timing challenges
- 16GB/channel supported (8 slots/ch)
- Eases DDR2 → DDR3 transition
- Significant cost, thermal, and IP issues

Mainstream Dual-CPU Server



FB-DIMM
2 ranks of 512Mb

8GB/CPU

16GB Total

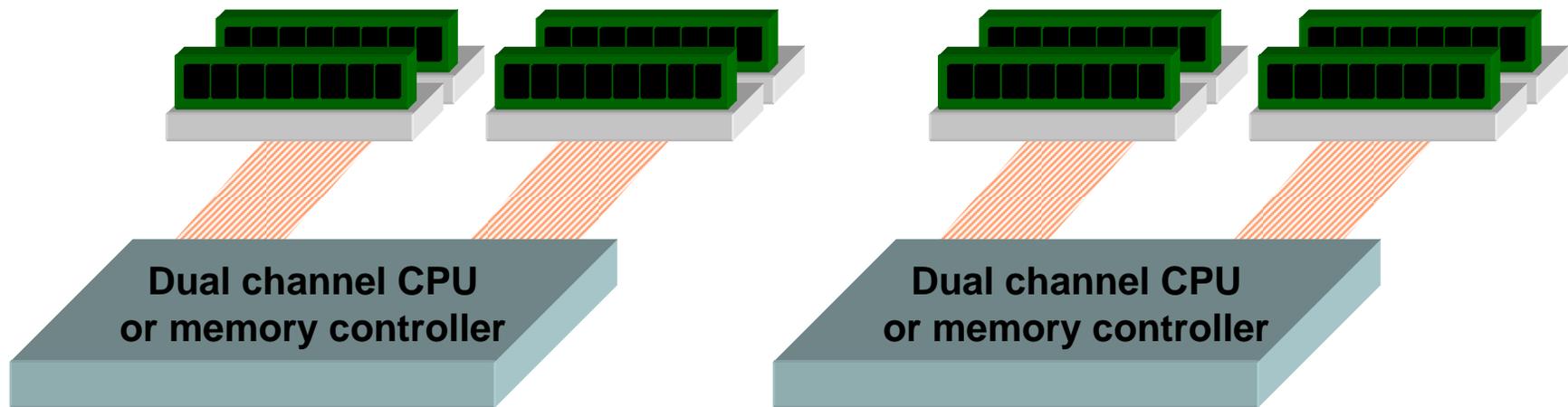
Servers typically limited by space to 4 or 8 slots
Small percentage have > 8 slots

Server Market Perspective #2

	2006	2007	2008
HE Server	DDR2-533 RDIMM 4 Rank	DDR2-533 RDIMM 4 Rank	DDR3-800 FB-DIMM 4 Rank
Mid Server	DDR2-667 RDIMM 4 Rank	DDR2-667 RDIMM 4 Rank	DDR3-1066 RDIMM 4 Rank
LE Server, HPC	DDR2-667 RDIMM 4 Rank	DDR2-667 RDIMM 4 Rank	DDR3-1066 RDIMM 4 Rank



Mainstream Dual-CPU Server



RDIMM
2 ranks of 512Mb

8GB/CPU

16GB Total

RDIMM
4 ranks of 512Mb

16GB/CPU

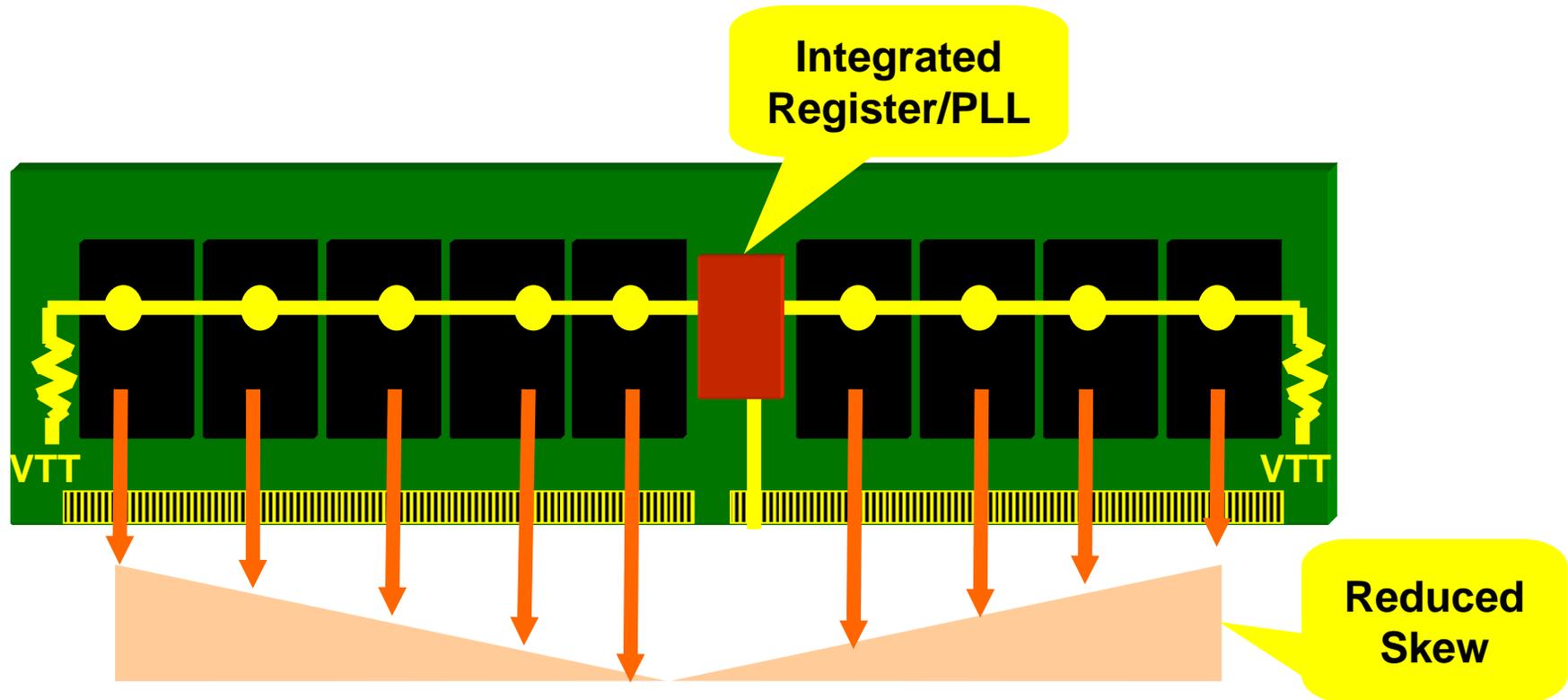
32GB Total

Conclusion: 2 slot enablement allowed DDR3 RDIMM to continue to meet the needs of most servers

4 rank doubles per-slot capacity



DDR3 RDIMM Inside-Out Fly-By

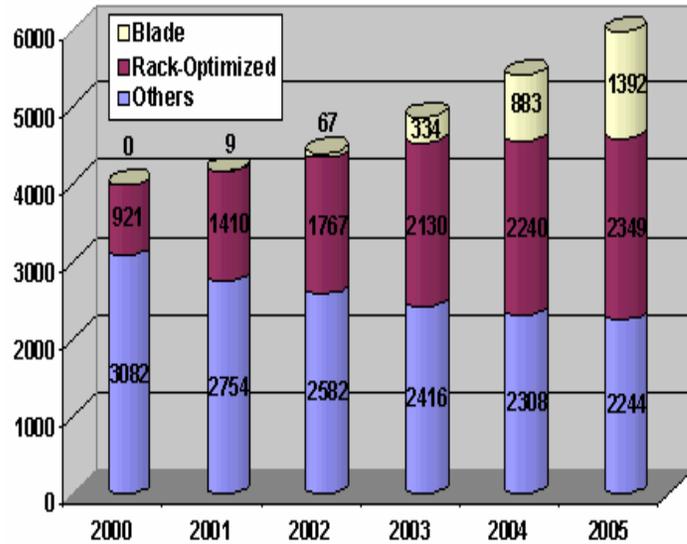


Support for 2 ranks (36 DRAMs) and
4 ranks (72 DRAMs) – VLP enabled

Form Factor Wars

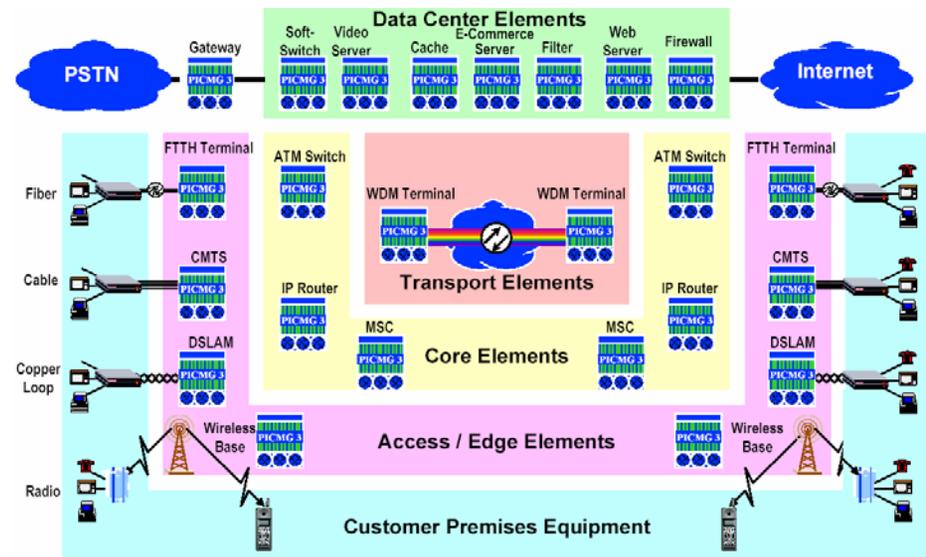


1.2" (30mm) standard chosen in 1999 based on 1U server market projections...

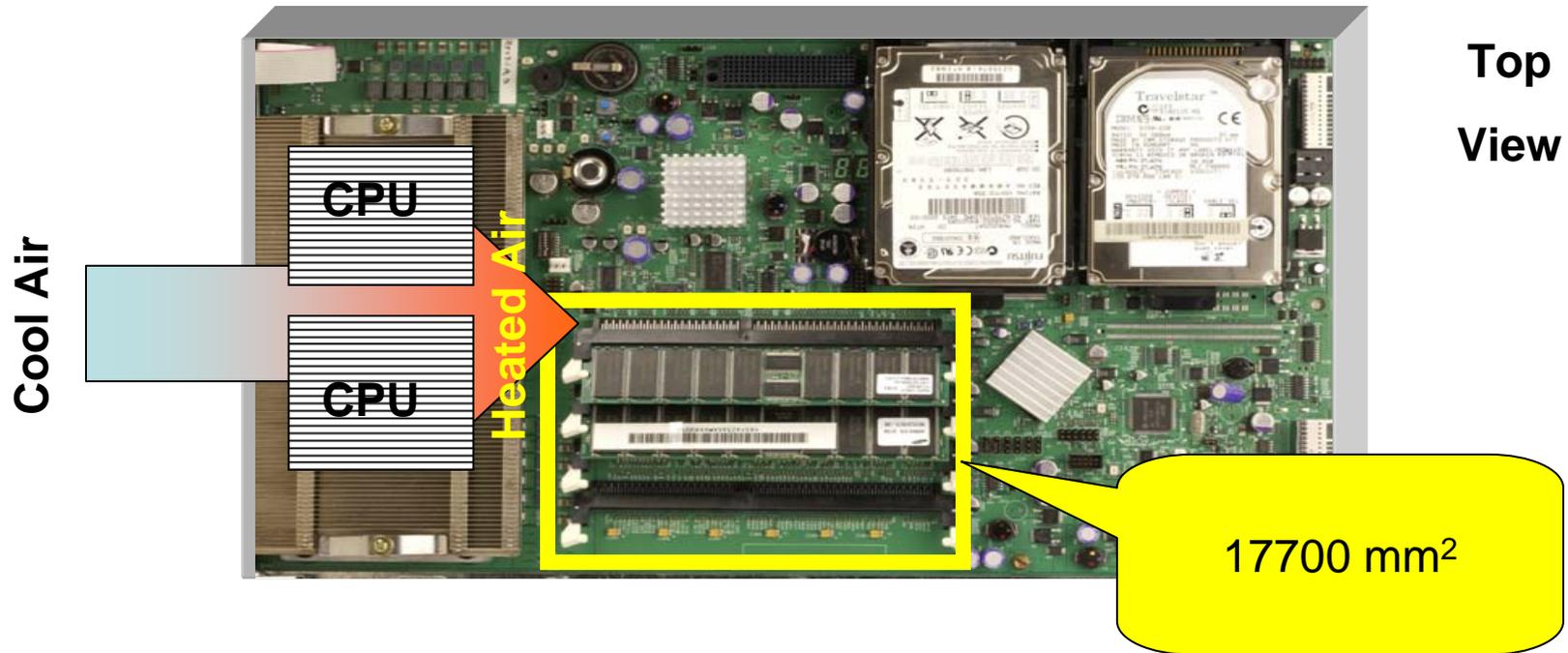


...with "VLP" and "ATCA" height requirements...

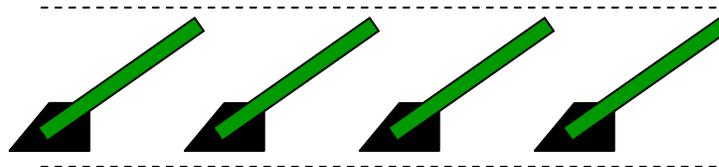
...then the Blade architecture arrived...



Case Study: Blade Server

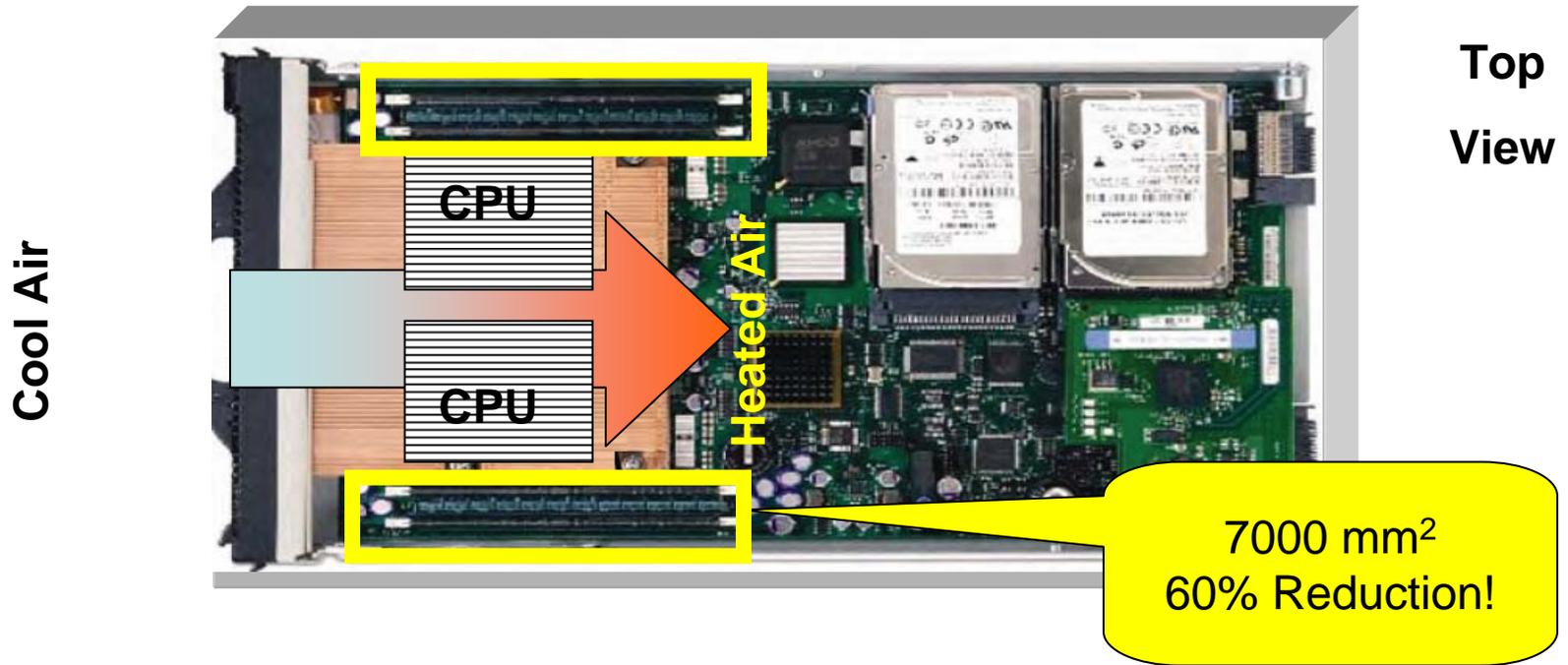


Angled Socket

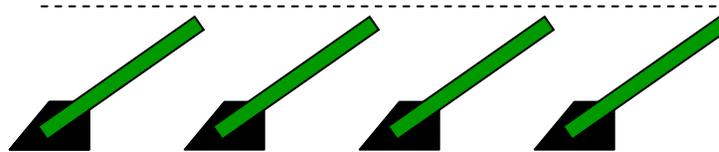


30 mm DIMM

Case Study: Blade Server, VLP

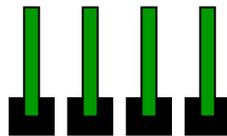


Angled Socket



30 mm DIMM

Vertical Socket

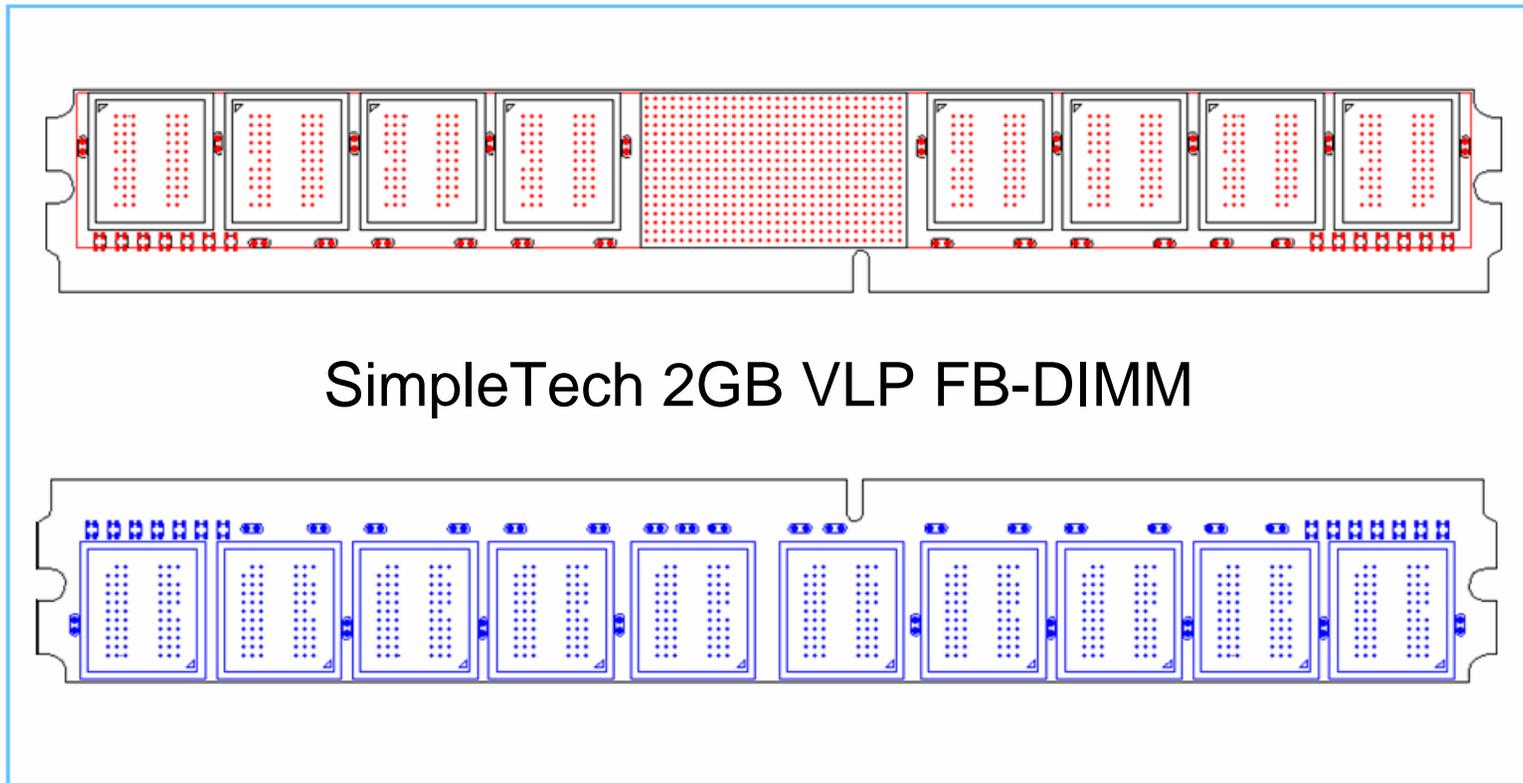


18.3 mm DIMM

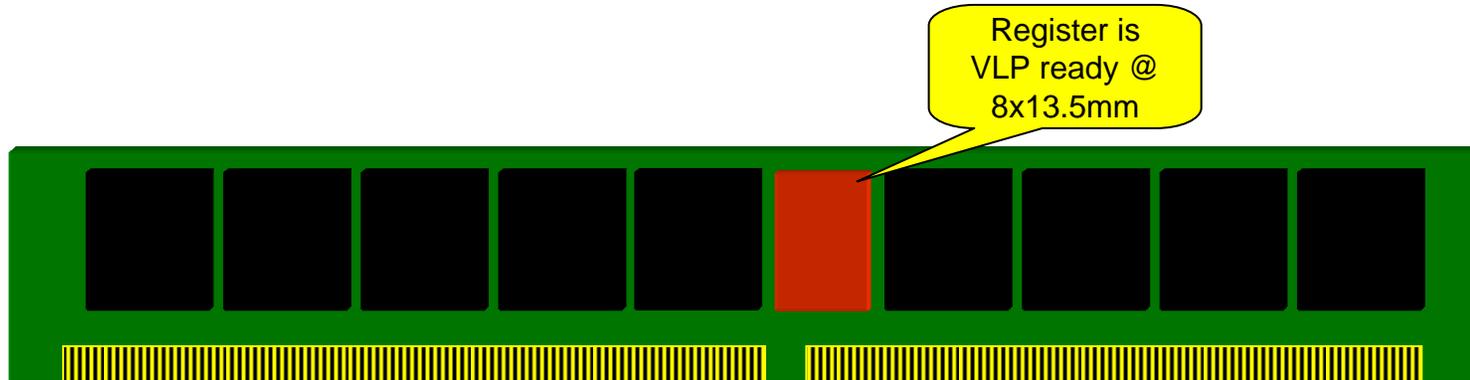


VLP FB-DIMM

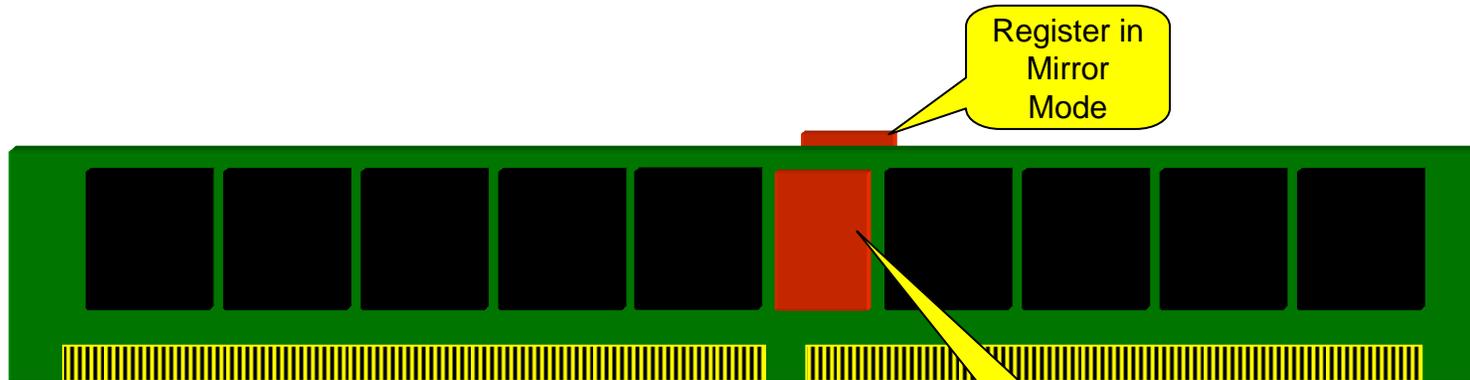
Requires a repackaging of AMB chip



VLP DDR3 RDIMM



4GB 2 Rank



8GB 4 Rank



Summary of VLP Activity

- **DDR1 RDIMM**
 - New raw cards approved
 - K (1Rx8), L (2Rx8), M (1Rx4), N (2Rx4)
- **DDR2 RDIMM**
 - New raw cards approved
 - R (1Rx8), T (2Rx8), U & V (1Rx4), W & Y (2Rx4)
- **DDR3 RDIMM**
 - Supported at first release
- **VLP FB-DIMM**
 - Task group formed
- **VLP Mini-RDIMM, 72b-SO-DIMM**
 - Task group discussions under way



Router/Networking Markets

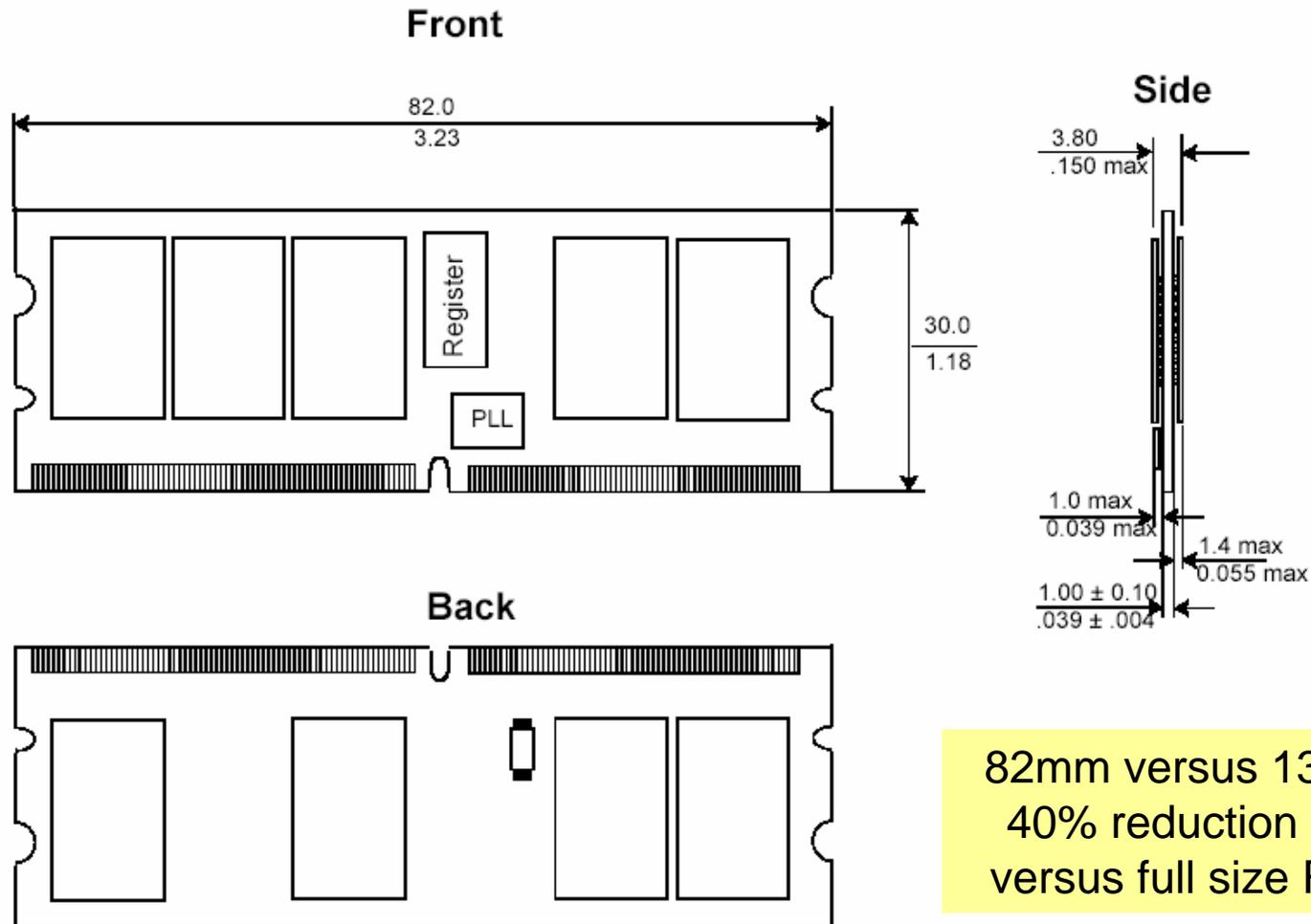


Router & Networking

	2006	2007	2008
High End Routers	DDR2 Mini-RDIMM		DDR3 Mini-RDIMM?
Low End Routers, AMC	DDR2 72b-SO-DIMM		DDR3 72b-SO-DIMM?
ATCA Routers	DDR2 VLP Mini-RDIMM or 72b-SO-DIMM		DDR3 72b-SO-DIMM?



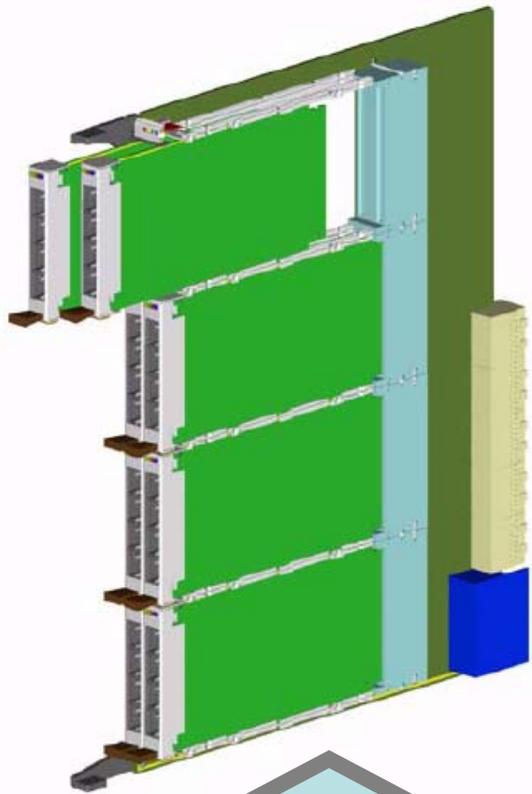
244 pin Mini-RDIMM Form Factor



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



Advanced Mezzanine Card



Standard for telecom blades

Airflow bottom to top

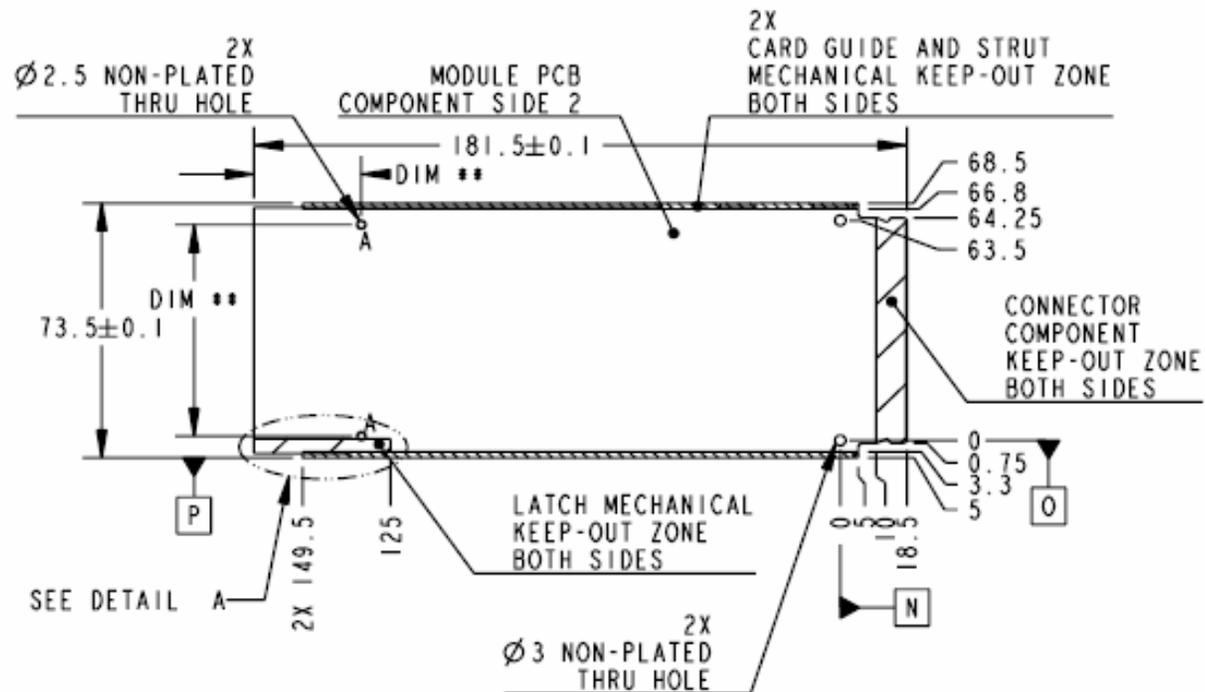
Memory module at front edge

AMC Width Limitation

HOLE CHART:

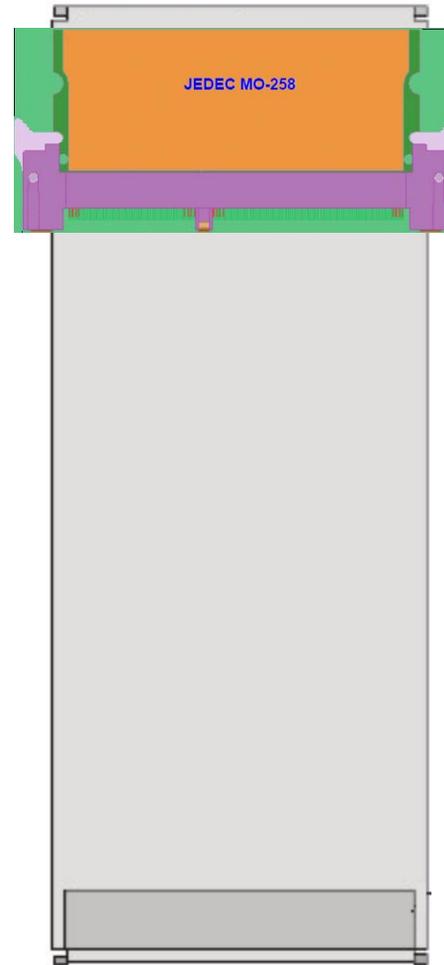
A = REQUIRED HOLE FOR MODULE FACE PLATE MOUNTING

DIM ** = DIMENSION DEPENDS ON FACE PLATE
AND LATCH IMPLEMENTATION. SEE APPENDIX
FOR EXAMPLES



AMC With 200 pin SO or Mini

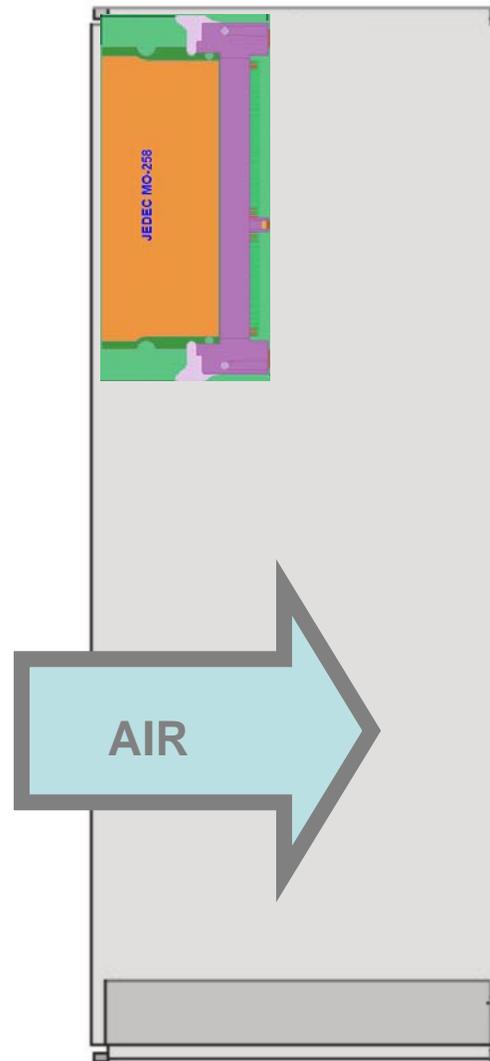
- 70mm width Mobile socket just fits



- 83mm width Mini socket hangs over the edges

Rotate Memory Module?

- Can't rotate due to memory bus routing
- Airflow wrong for this orientation

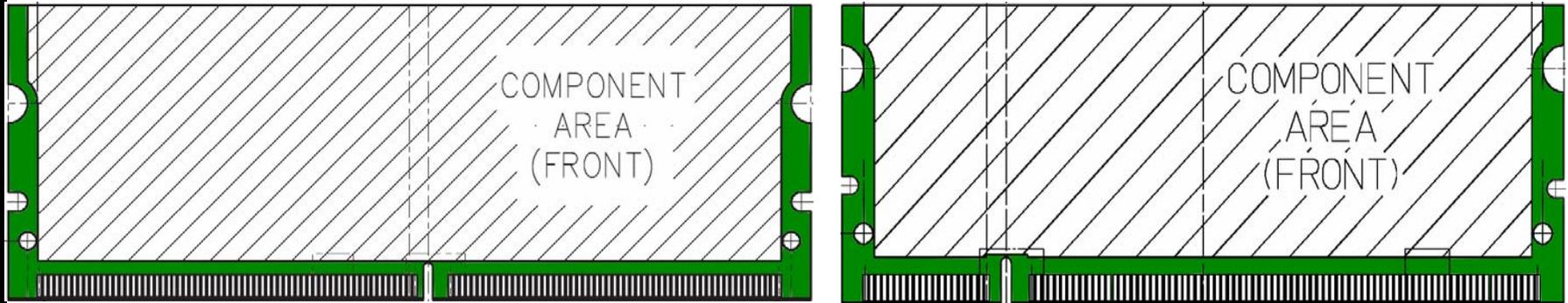


Conclusion

- JEDEC 72b-SO-DIMM Task Group chose the MO-224 compatible module outline



Mini-RDIMM & 72b-SO-RDIMM



- Module = 82 x 30mm
- Component area = 78 x 26mm
- 244 pins, 0.6 mm pitch

- Module = 67.6 x 30mm
- Component area = 63.6 x 26mm
- 200 pins, 0.6 mm pitch

Key Differences

Mini-RDIMM

- x4 DRAM supported
- 8GB max
- 3 clock pairs → unbuffered supported
- Address/command parity supported

72b-SO-RDIMM

- x4 DRAM not supported
- 4GB max
- One clock pair → PLL needed
- Address/command parity not supported

Peripheral Markets



Peripherals

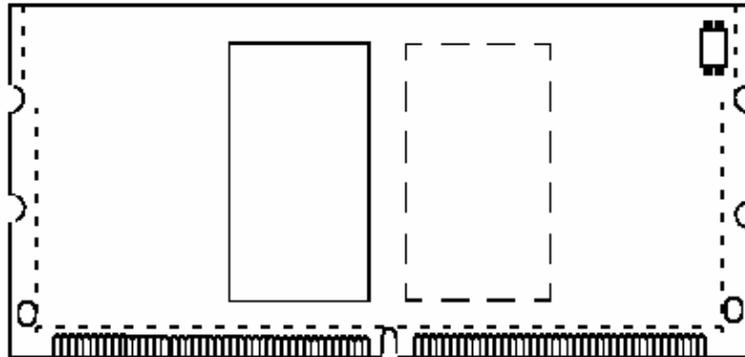
	2005		2006		2007	
Peripherals	DDR1 32b-DIMM	DDR1 16b-SO-DIMM	DDR2 16b-SO-DIMM	DDR2 32b-SO-DIMM		

- 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

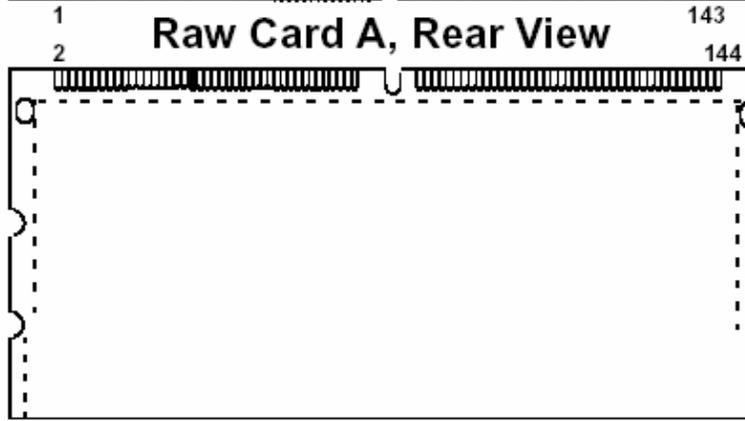


Modules for Peripherals

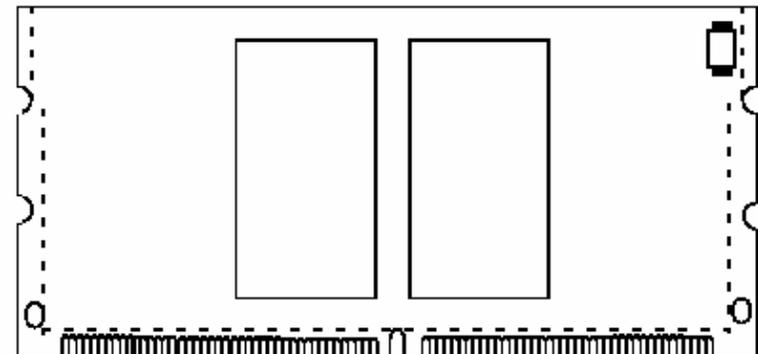
Raw Card A, Front View



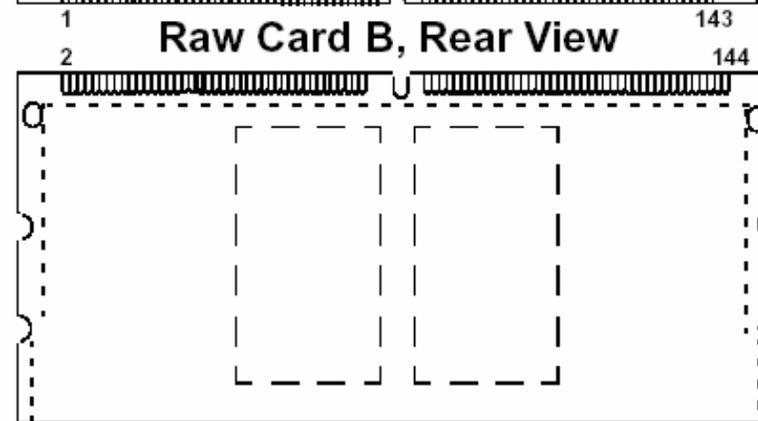
Raw Card A, Rear View



Raw Card B, Front View



Raw Card B, Rear View



DRAM Modules Market Summary



Memory Module Summary

- DDR2 transition finally under way, DDR3 coming
- BGA stacking grows
- PC market form factors fairly stable
 - UDIMM, SO-DIMM, Micro-DIMM
 - DDR2 → DDR3
- Server market fragmenting
 - RDIMM → FB-DIMM or RDIMM → RDIMM?
 - Module height 30mm & 18.3mm (VLP)
- Networking modules: Mini-RDIMM & 72b-SO-DIMM
- Peripheral modules: 16b-SO-DIMM & 32b-SO-DIMM



Thank You

Questions?

Bill Gervasi
bilge@simpletech.com

