USModular
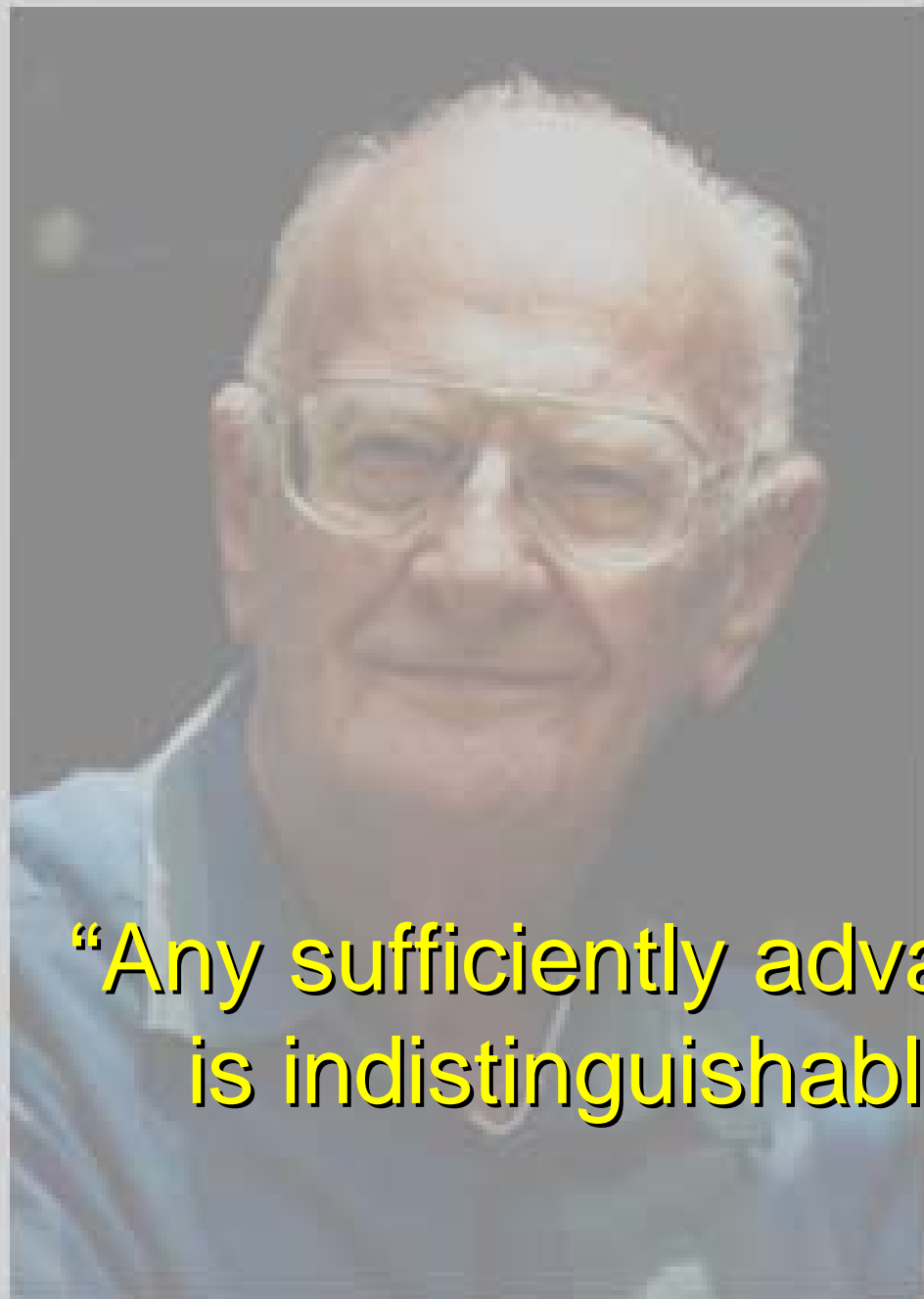
DDR3 Memory Modules

Bill Gervasi

Vice President, Engineering

Chairman, JEDEC JC-45.3

July 2007

"Any sufficiently advanced technology is indistinguishable from magic."
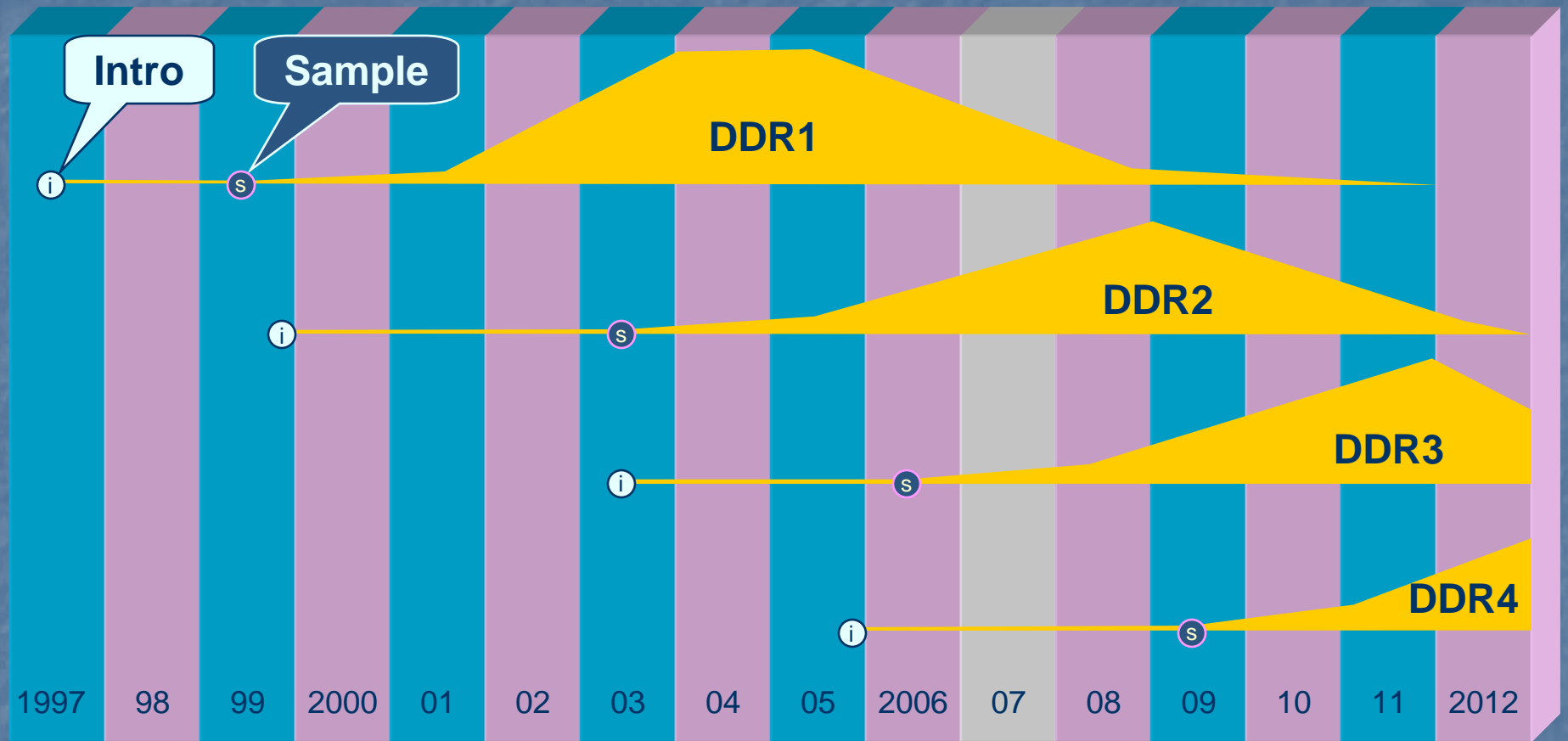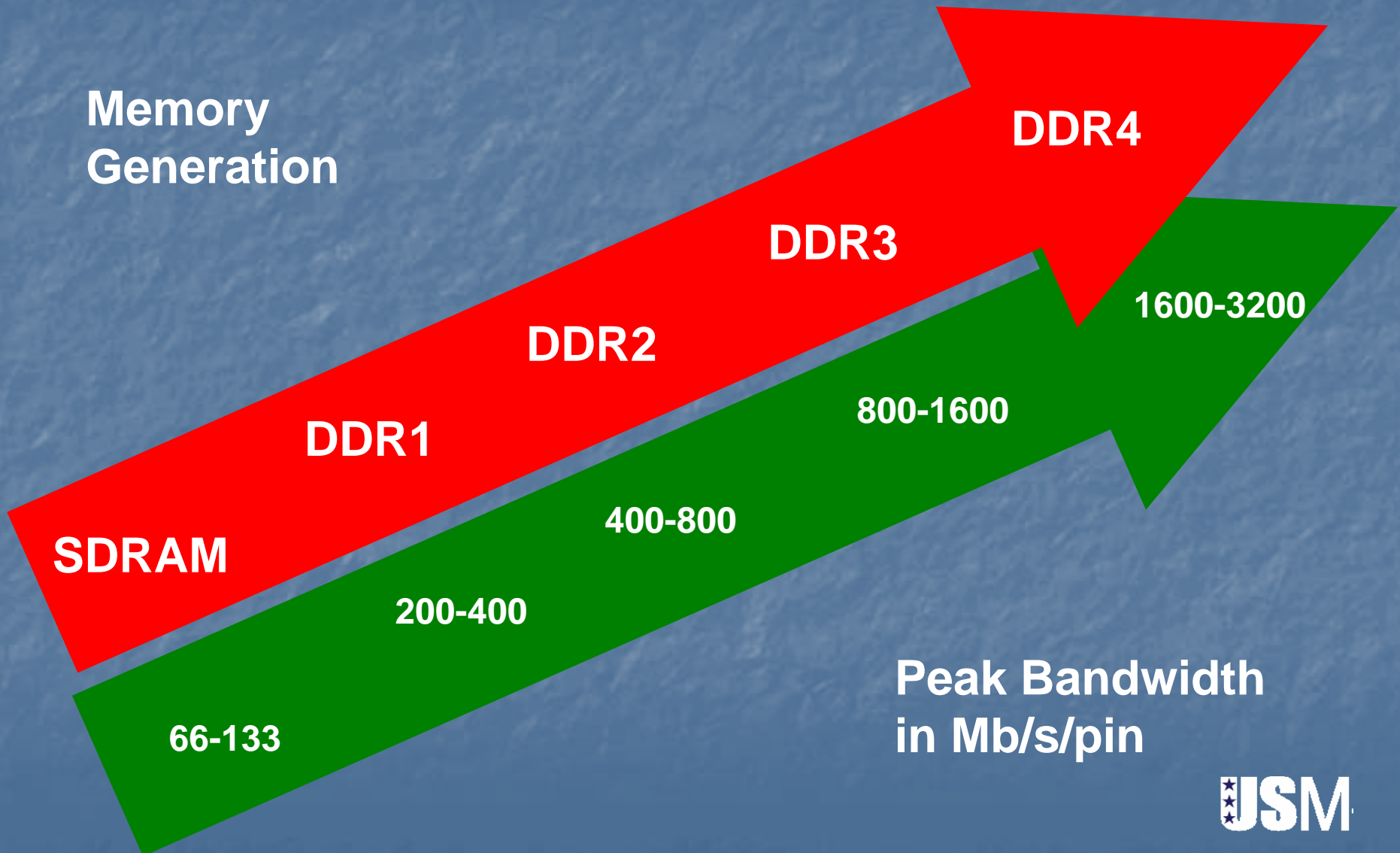
Arthur C. Clarke

USM

2

- Driven by market factors

- 7 year technology projections

- Minimum changes to achieve next goal
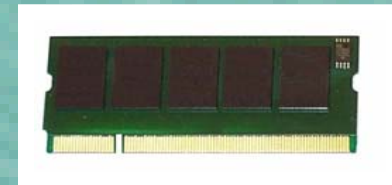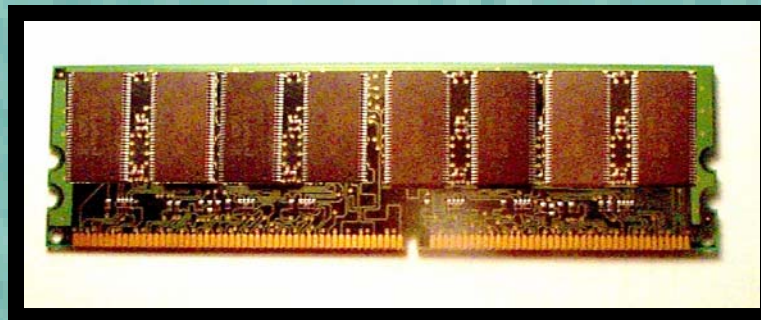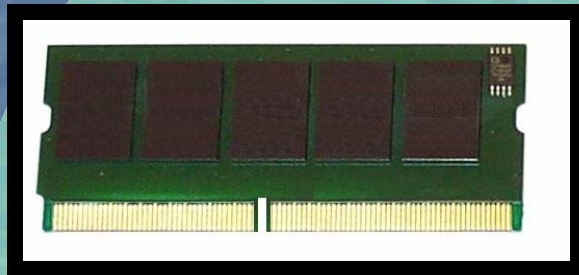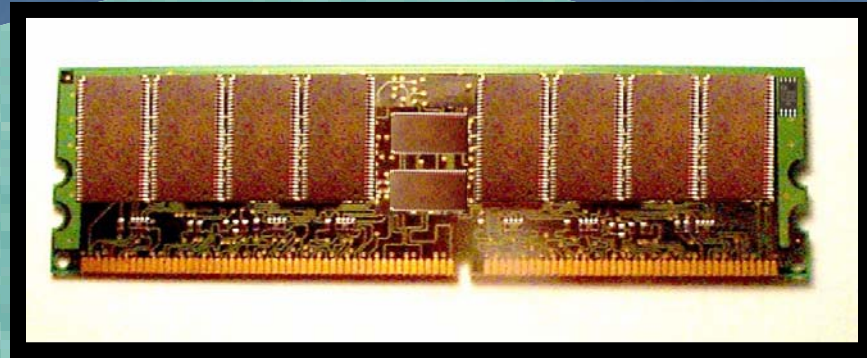
DDR Family Timelines

Generations

Memory
Generation

DDR4

DDR3

DDR2

DDR1

SDRAM

1600-3200

800-1600

400-800

200-400

66-133

Peak Bandwidth
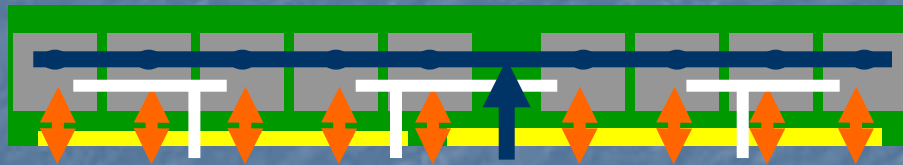in Mb/s/pin

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Many Applications,

Many Configurations
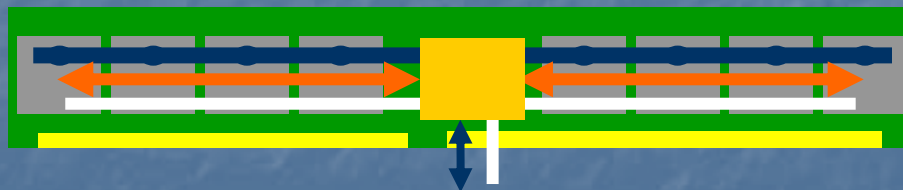
Terminology: Module Types

DIMM = Dual Inline Memory Module

- **UDIMM** = Unbuffered
Address bus and clocks connected directly to DRAMs

- **RDIMM** = Registered
Address bus and clock redriven to DRAMs

- **FB-DIMM** = Fully Buffered
Address and data buses packetized and redriven to DRAMs

Opportunities By Market Segment

Portable	**DDR3 SO-DIMM, Micro-DIMM**
Desktop	**DDR3 UDIMM**
Workstation	**DDR3 RDIMM**
Server	**DDR3 RDIMM, FB-DIMM**
Blade	**DDR3 VLP RDIMM**
Telecomm	**DDR3 Mini-DIMM**
Peripherals	**DDR3 16b-SO-DIMM, 32b-SO-DIMM**

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

Fragmented Server Roa

May never happen

	2006	2007		2008
HE Server	DDR2-400 RDIMM	DDR2-533 FB-DIMM/RDIMM	DDR2-667 FB-DIMM/RDIMM	DDR3-800 FB-DIMM/RDIMM
Mid Server	DDR2-400 RDIMM	DDR2-533 FB-DIMM/RDIMM	DDR2-667 FB-DIMM/RDIMM	DDR3-1066 RDIMM
LE Server	DDR2-400 RDIMM	DDR2-533 FB-DIMM/RDIMM	DDR2-667 FB-DIMM/RDIMM	DDR3-1066 RDIMM
HPC	DDR2-533 UDIMM	DDR2-667 UDIMM		DDR3-1066 UDIMM or RDIMM

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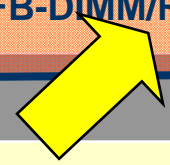
Router & Networking

	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

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

- Small footprint is desirable

- Common pinout for DDR1/2/3 and 16/32 bits

USM

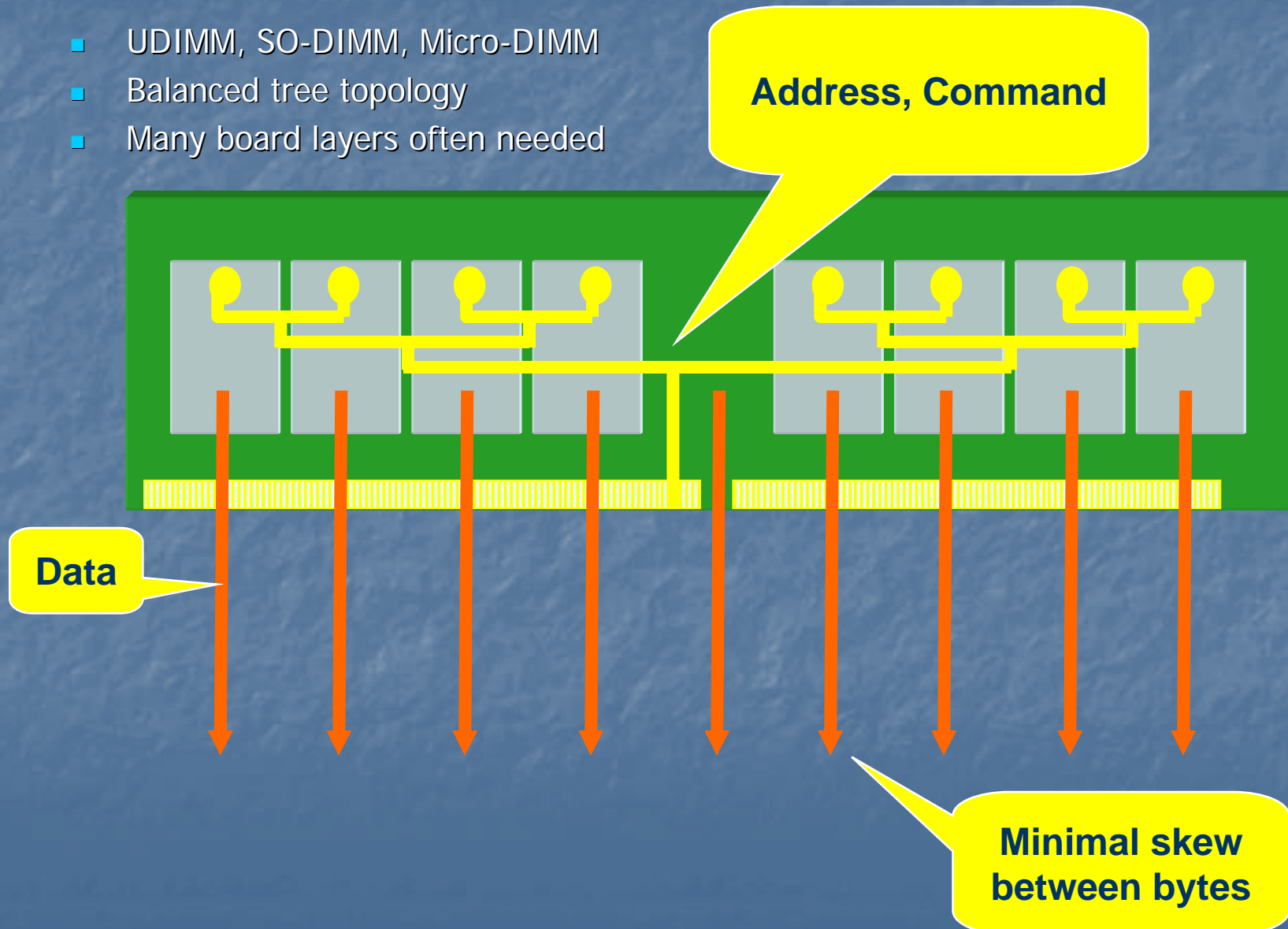# 2 Slots per Channel for Unbuffered or Registered

DDR3 Dual channel CPU memory controller
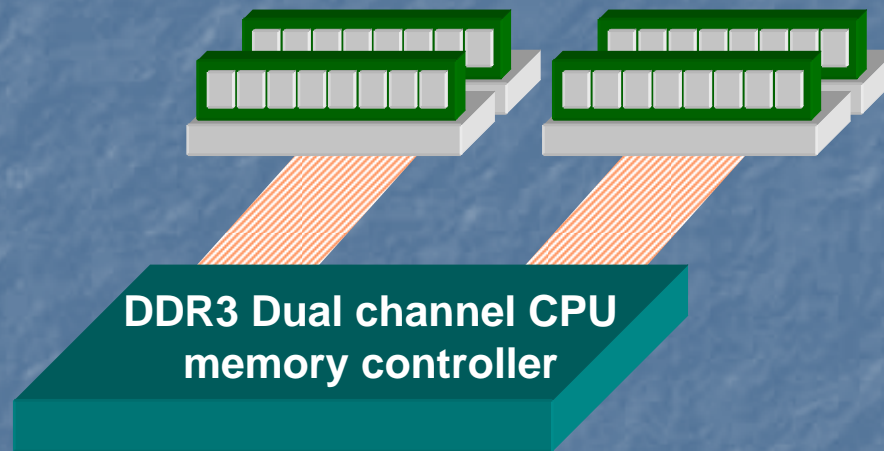
Original plan was for one slot per channel, 2 ranks per slot

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

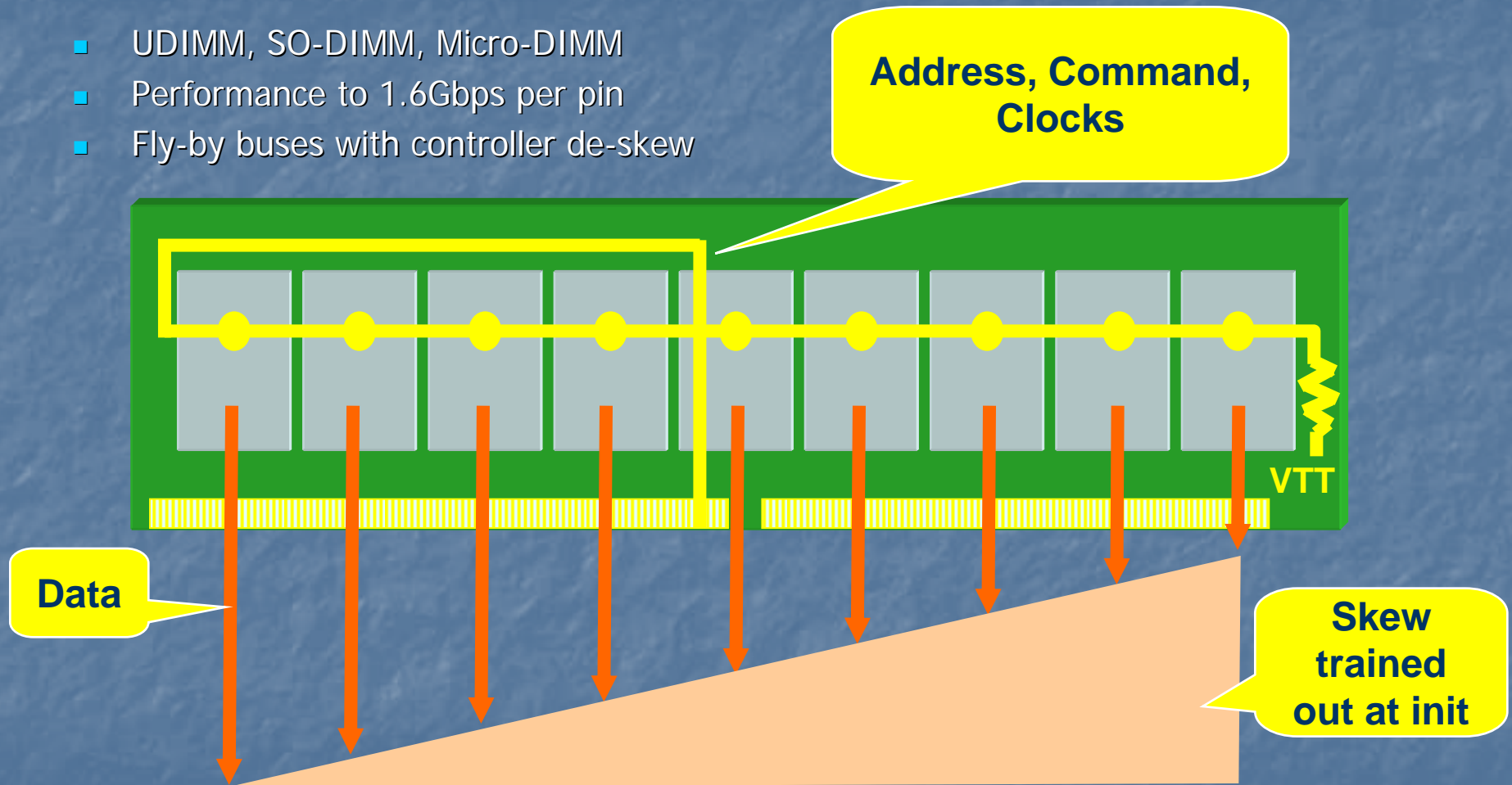# DDR2 Unbuffered Modules

- UDIMM, SO-DIMM, Micro-DIMM
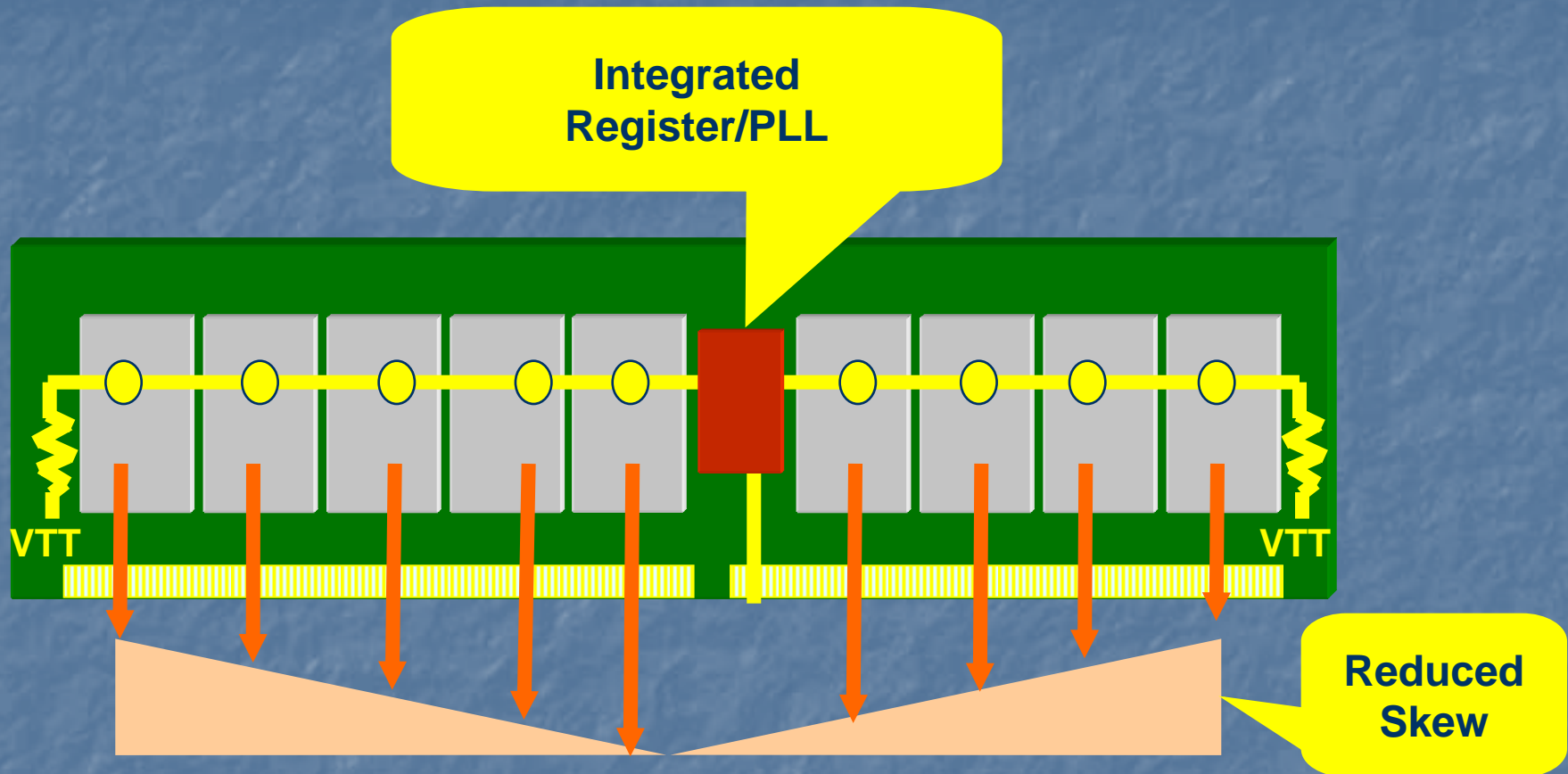- Balanced tree topology
- Many board layers often needed

Address, Command

Data

Minimal skew between bytes

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DDR3 Unbuffered Modules

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

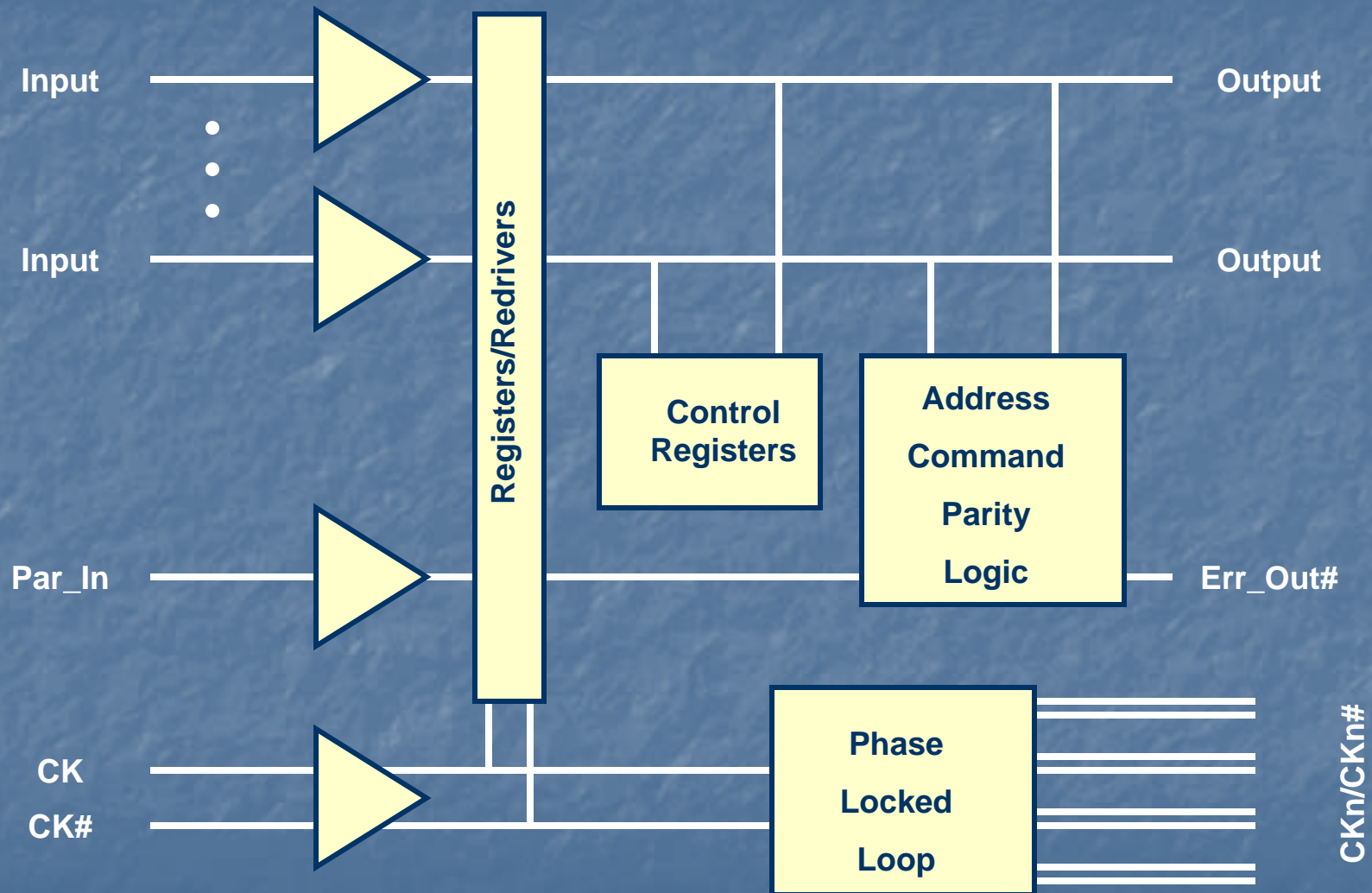**Address, Command, Clocks**

VTT

Data

Skew trained out at init

DDR3 RDIMM Inside-Out Fly-By

Integrated Register/PLL

Reduced Skew

VTT

VTT

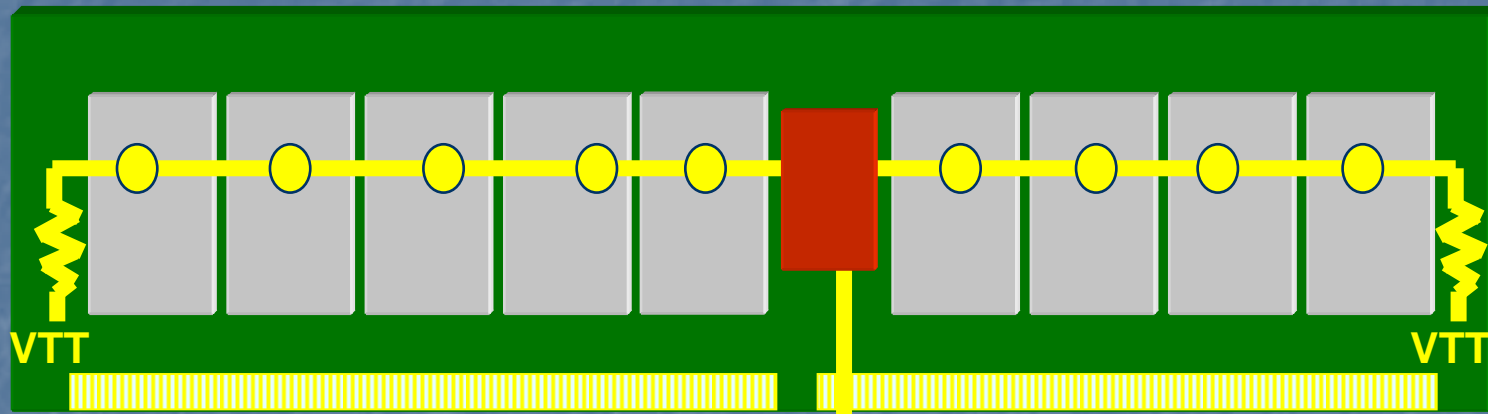**Support for 2 ranks (36 DRAMs) and 4 ranks (72 DRAMs) – VLP enabled**

Registering Clock Driver

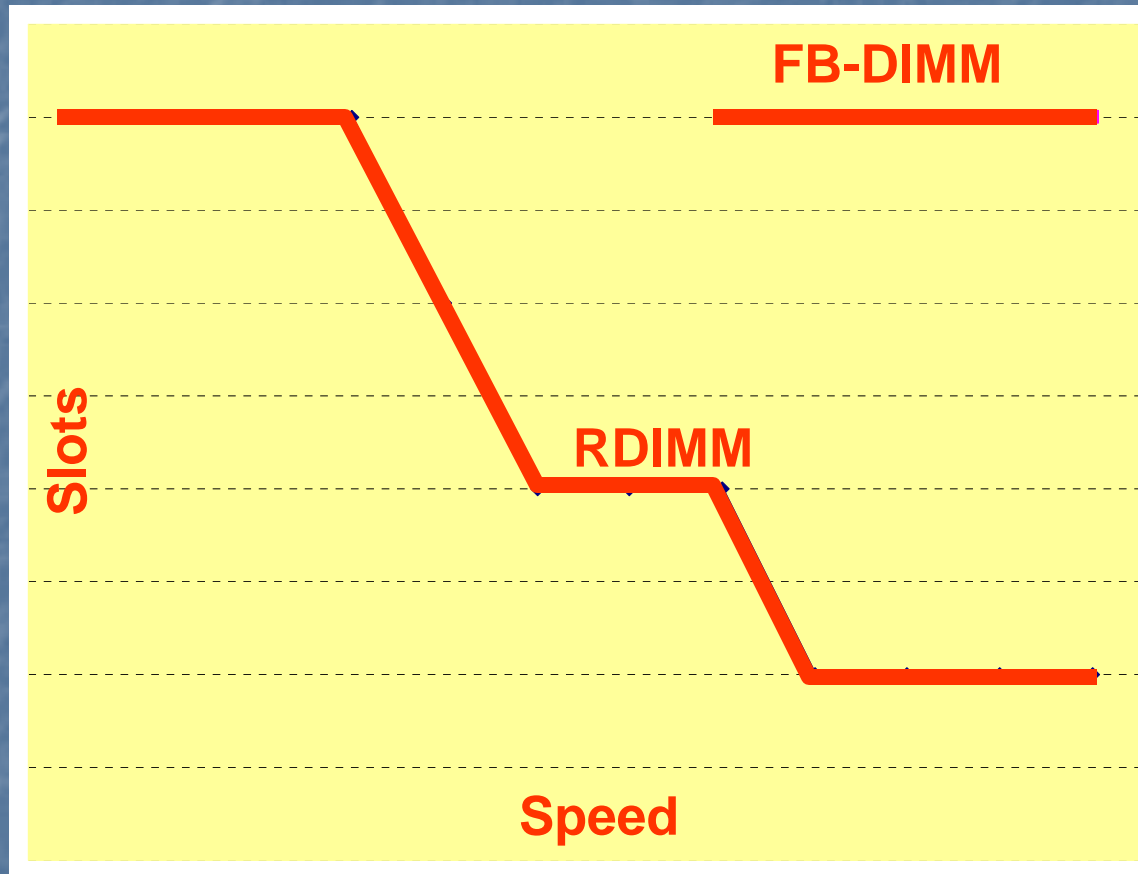# DDR3 Register Programmable Features

- Separate drive strength by signal group
  - Clock
  - Address
  - Control

- 4 rank support designed in

When Does RDIMM Enter Desktop?

- 2 slot/channel requirement complicated the UDIMM design, may cap performance

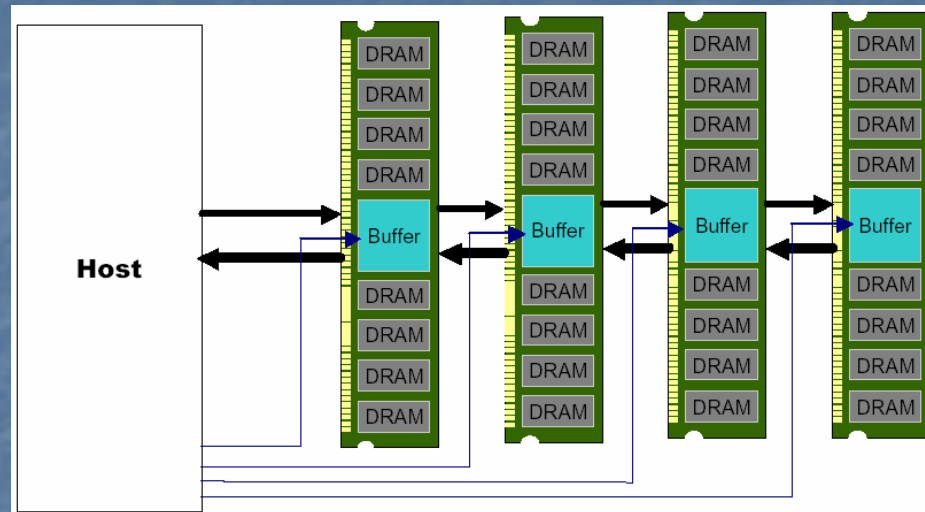- At some frequency, transition to RDIMM may be required

Motivation for FB-DIMM

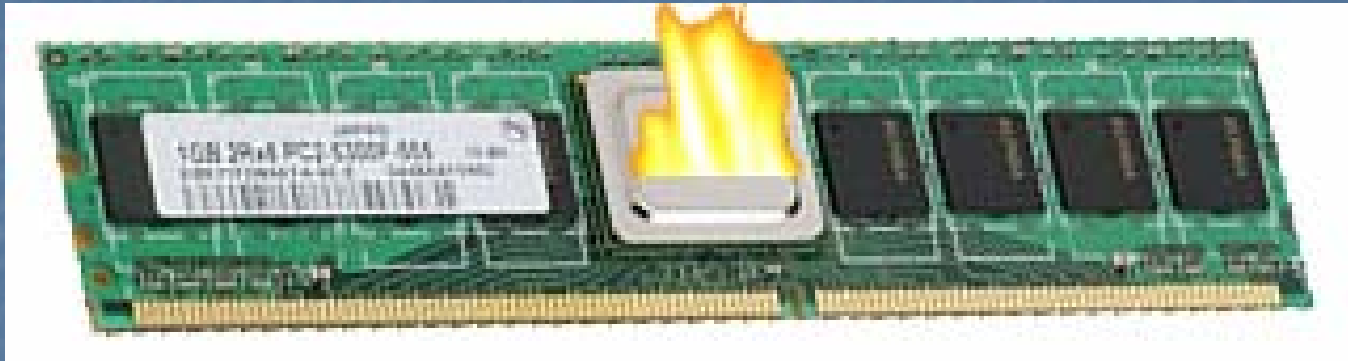
FB-DIMM supports 4 slots per channel at any speed

As speeds increase, the number of RDIMMs per channel decrease

Fully Buffered DIMM

- **Solves stub bus timing challenges**
- **4 DIMMs per channel**

What Went Wrong?

AMB too hot

   Latency limited # slots to 4 per channel

      RDIMM @ 2 slot per channel

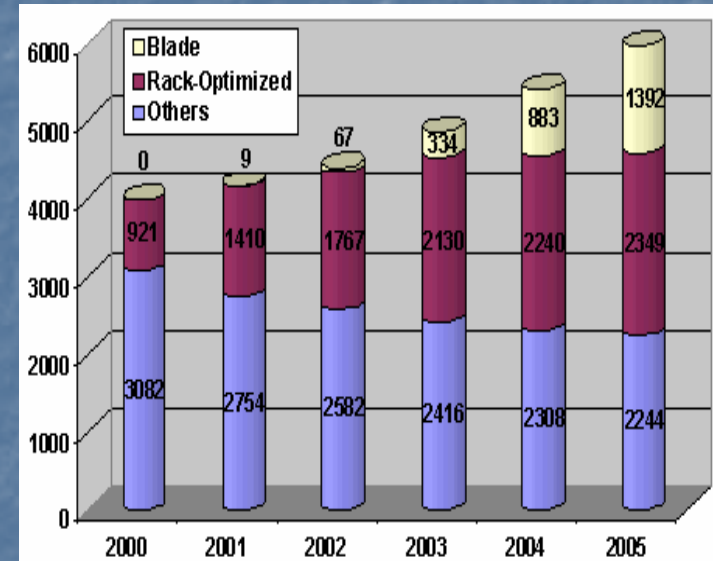   **Register cheaper than AMB**

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Form Factor Wars

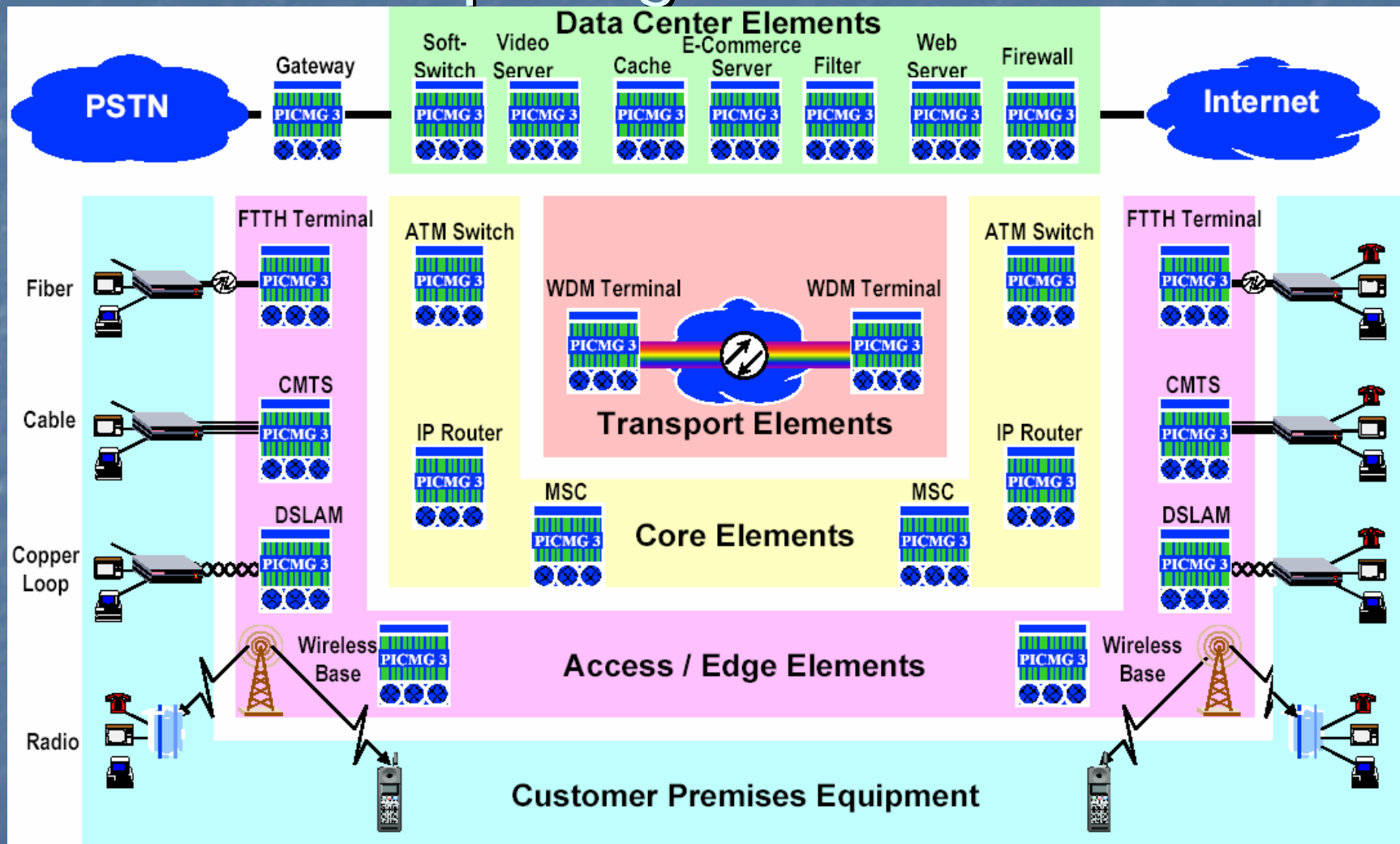1.2" (30mm) standard chosen in 1999 based on 1U server market projections

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

But, market fragmenting
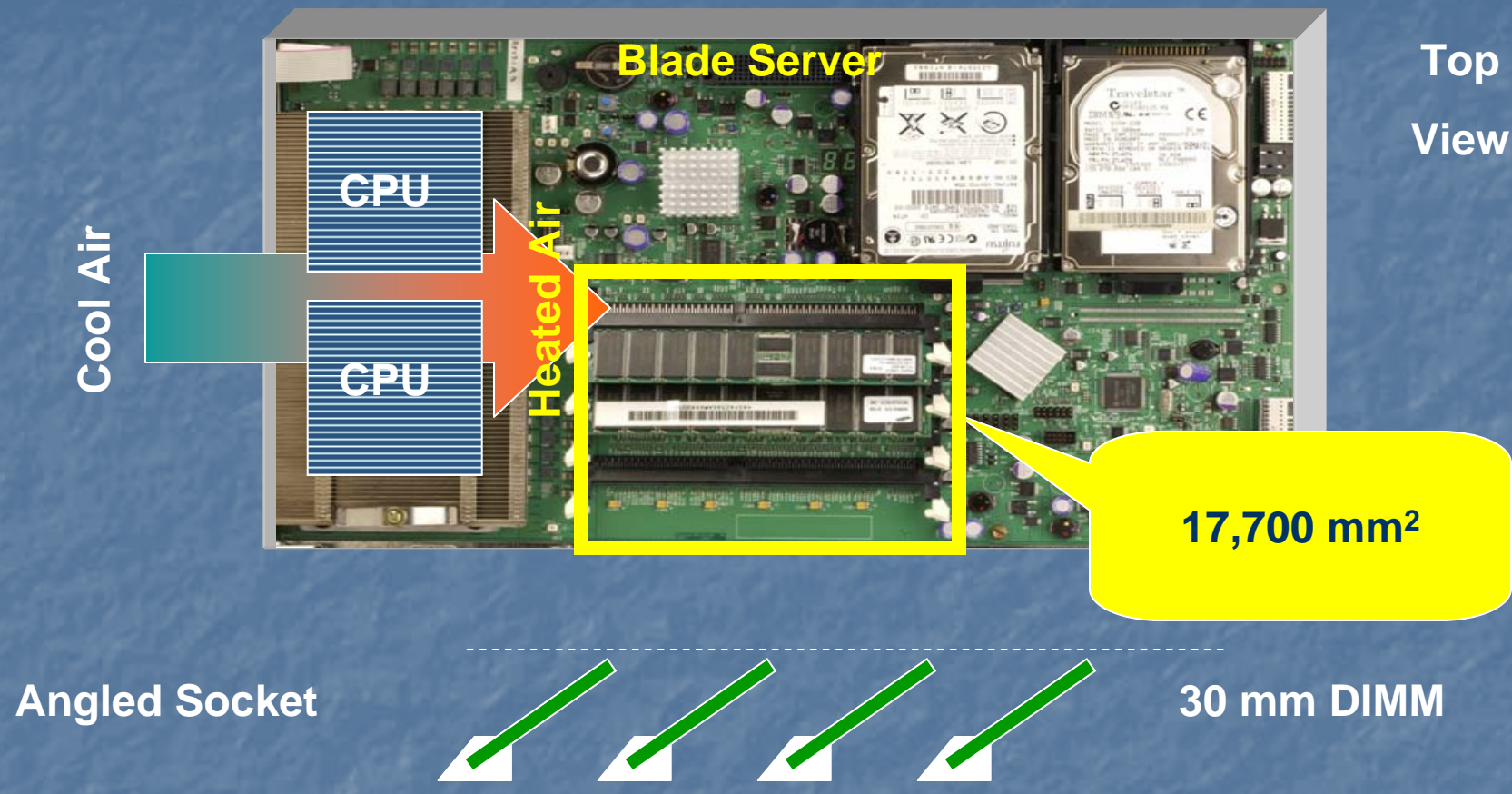
OEMs "demand" one size fits all ... but ...

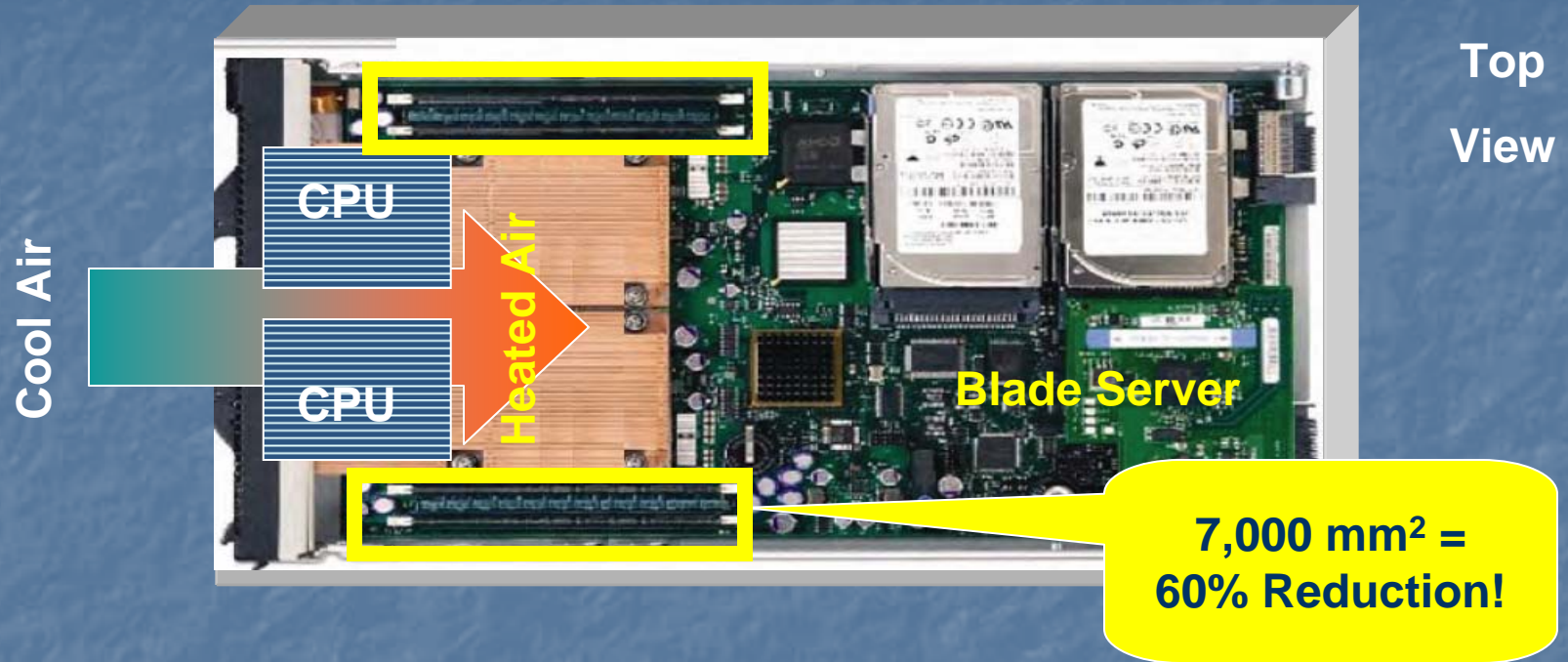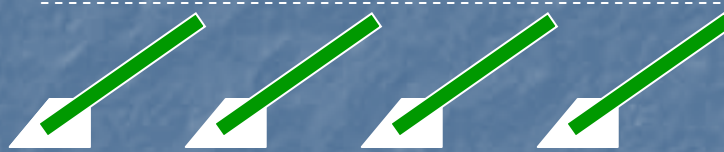# Advanced Telecommunications Computing Architecture

see http://picmg.org

Blade Server, 1.2" Module

Blade Server

Top View

Cool Air

Heated Air

CPU

CPU

17,700 mm^2

Angled Socket   30 mm DIMM

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Blade Server, VLP & ATCA DIMM

Top View

Cool Air

CPU

CPU

Heated Air

Blade Server

7,000 mm² = 60% Reduction!

Angled Socket — 30 mm DIMM

Vertical Socket — 18.75 mm DIMM

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VLP & ATCA Form Factor

133.35 mm (5.25") × 18.75 mm (0.74")

Memory module labels: 250204 PC1-002, 18400-21269-725MD, 2GB 2Rx4 PC3200R-3331-Z ECC - REG
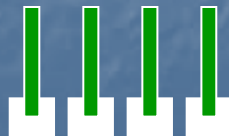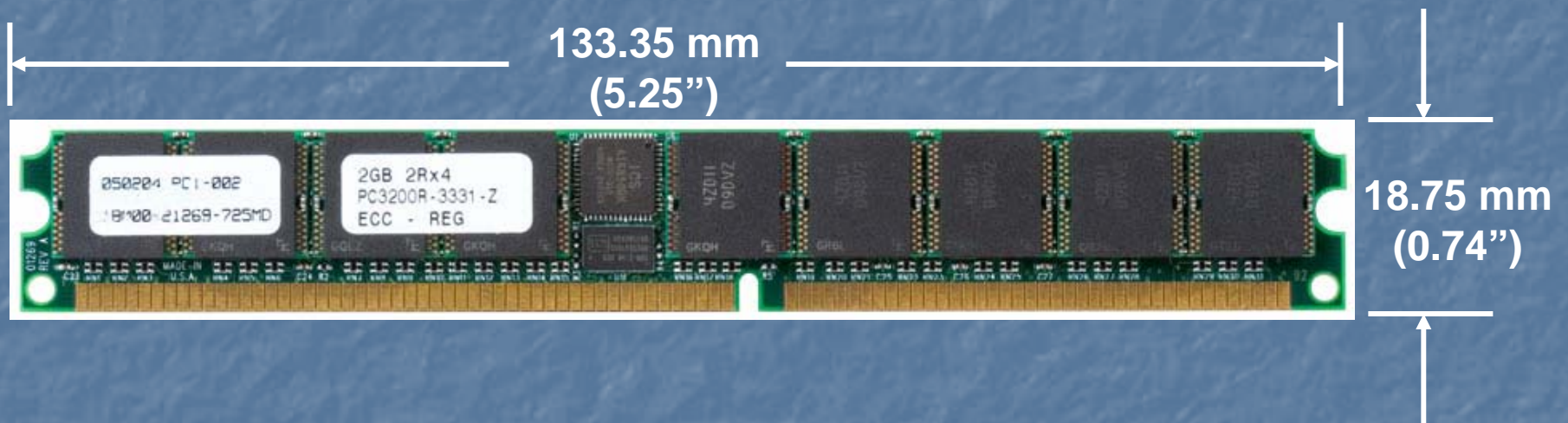
Advanced Mezzanine Card

AIR
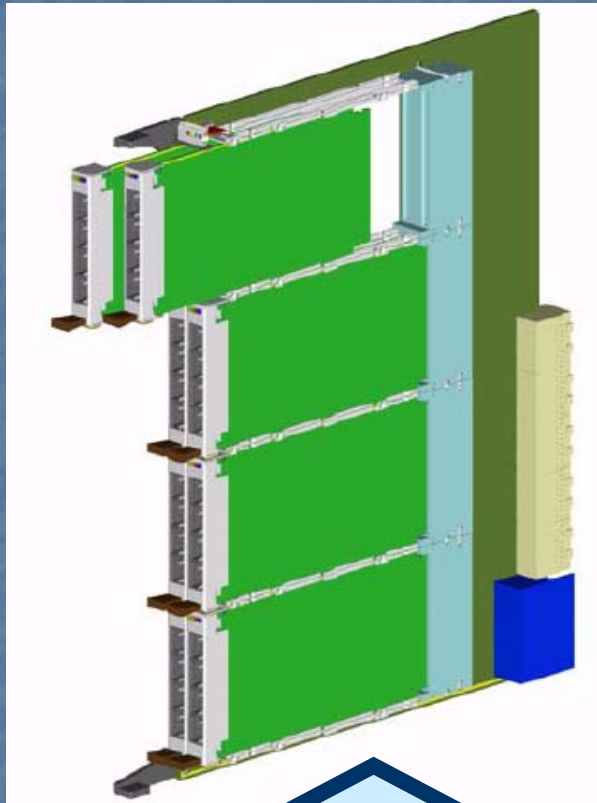
Standard for telecom blades

Airflow bottom to top

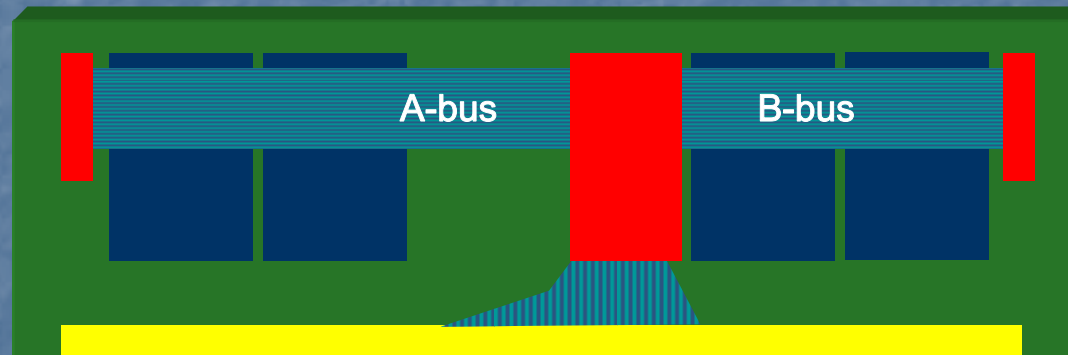Memory module at front edge

Needs smaller DIMMs

Part of ATCA spec

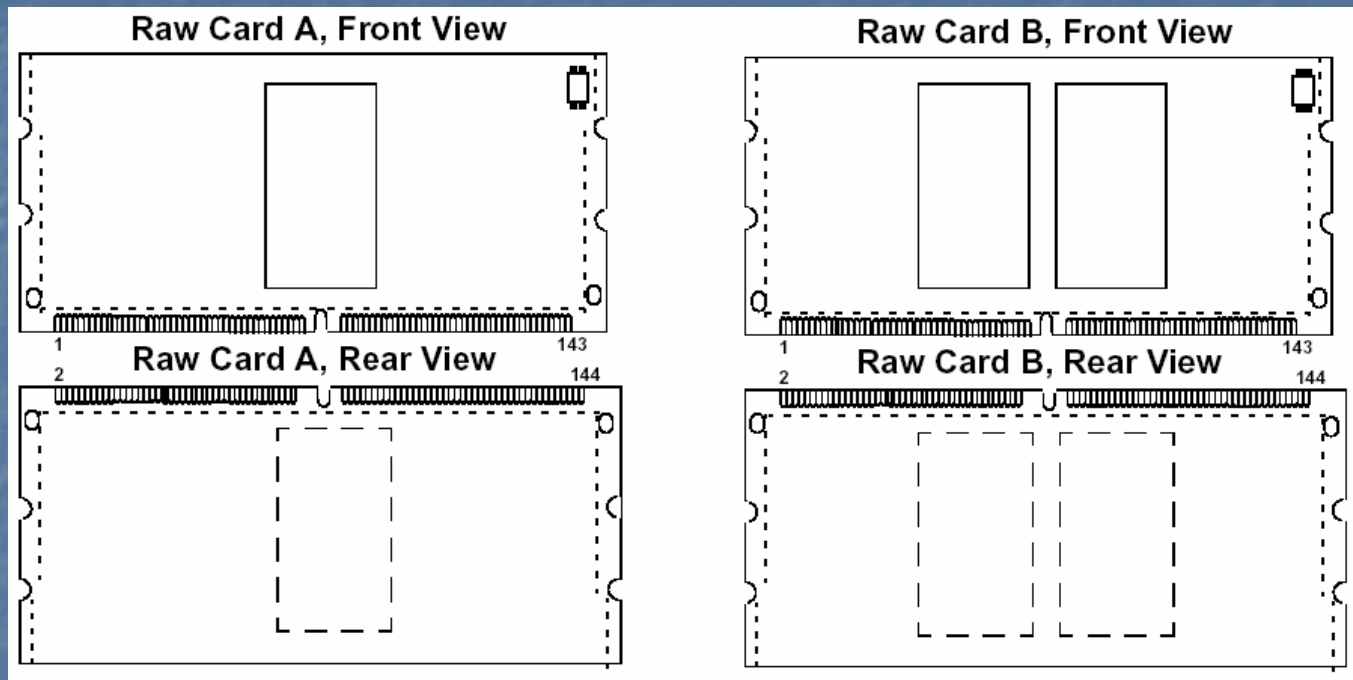USM

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Mini-RDIMM Form Factor

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

Inside-out fly-by topology like RDIMM

A-bus   B-bus

Modules for Peripherals

- 16 & 32 bits wide
- 1 to 4 DRAMs typical
- 144 pin, 67.6 x 30 mm

Summary

- DDR3: an evolutionary step up from DDR2
- One size does not fit all
- Market-specific module form factors
- Some interesting uncertainties
  - FB-DIMM or RDIMM?
  - RDIMM or UDIMM?

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Thank you

Questions?