





### IBM Is Serious About Games



### Every New Game Console is Powered by IBM



\* Chips not to scale



Sony

PlayStation®3



Nintendo Wii®



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# Why Does IBM Care About Games?

- IBM makes high performance servers, so why games?
  - Servers are high margin, but low volume
  - Technology investment for server leadership is very expensive
    - e.g. 300mm fab in East Fishkill, NY = \$3B

#### Game chips are high volume

- Game chips expected to generate big revenue for IBM
- Help amortize the cost of server investment
- Provide high volume part numbers for line learning / efficiency



## Games Are BIG Business

# U.S. computer and video game DOLLARS sales growth



Source: Entertainment Software Association, "Essential Facts about the Computer and Video Game Industry," 2006 sales, demographic and usage data.

### As games get more popular...

Video games sales are driven by the games-console cycle. Every five to six years, console manufacturers such as Sony, Nintendo and Microsoft introduce a new generation of equipment, triggering new growth in games sales. This year marks the start of a new console cycle. According to In-Stat/MDR, next-generation game-console shipments will hit 17m in 2006, 27m in 2007 and 33.5m in 2008.



### Games Generate Great Press for IBM



"It was originally conceived as the microprocessor to power Sony's [PS3], but it is expected to find a home in lots of other broadbandconnected consumer items and in servers too." -- IEEE Spectrum





"...Cell could power hundreds of new apps, create a new videoprocessing industry and fuel a multibillion-dollar build out of tech hardware over ten years." -- Forbes





# Why Did the Game Companies All Choose IBM?

#### Deep architectural and design experience

- 50 years of server leadership

#### Technology Leadership

- Industry leading Si process
- Earliest introduction of new technologies SOI, Cu, low-K, strained Si

#### Open architecture

- Power architecture is now the de facto architecture for games
- 'We'll do it your way'

#### Platform partnership manufacturing

- Deep fab partnership
- Multiple sources of supply





# **Technical Challenges of Games**





# Performance is Everything !



#### **Business Unit or Product Name**

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### Performance - Moore's Law of Semiconductors



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### Materials Innovations to Keep Up

hydrogen 1 H	Before 90's										helium 2 He							
lithium 3	beryllium 4						S	ince	e the	<u>90'</u>	S		boron	carbon	nitrogen	oxygen	fluorine	neon 10
Li	Be						-				- -		5 B	C C	7 N	Ő	F	Ne
sodium 11	magnesium	Beyond 2005								chlorine	argon 18							
Na 22.990	12 Mg												13 Al	14 Si	15 P	<b>S</b> 32.065	17 Cl	<b>Ar</b> 39.948
potassium 19	calcium		scandium	titanium	vanadium	chromium	manganese 25	iron 26	cobalt	nickel	copper	zinc	gallium 31	germanium	arsenic	selenium 34	Bromine	krypton 36
K 39.098	20 Ca		21 Sc	22 Ti	23 V	24 Cr	<b>Mn</b> 54.938	Fe	27 Co	28 Ni	29 Cu	30 Zn	<b>Ga</b> 69.723	32 Ge	33 As	<b>Se</b> 78.96	35 Br	<b>Kr</b> 83.80
rubidium 37	strontium		yttrium	zirconium	niobium	molybdenun	technetium 43	ruthenium	rhodium	palladium	silver 47	cadmium 48	indium 49	tin 50	antimony 51	tellurium 52	iodine 53	xenon
<b>Rb</b>	38 Sr		39 Y	40 Zr	41 Nb	42 Mo	TC	43 Ru	45 Rh	45 Pd	<b>Ag</b>		<b>In</b>	<b>Sn</b>	<b>Sb</b>	<b>Te</b>	128.90	54 Xe
caesium 55	barium	57-70	lutetium 71	hafnium	tantalum	tungsten	Rhenium	osmium <b>76</b>	iridium	platinum	gold 79	mercury 80	thallium 81	lead 82	bismuth	polonium 84	astatine 85	radon 86
<b>Cs</b>	56 Ba	*	Lu	72 Hf	73 Ta	29 W	75 Re	<b>OS</b>	77 Ir	78 Pt	<b>Au</b>	Hg	204.38	<b>Pb</b>	83 Bi	Po	At	Rn
francium 87	radium 88	89-102	lawrencium 103	rutherfordium 104	dubnium 105	seaborgium 106	bohrium 107	hassium 108	meitnerium 109	ununnilium 110	unununium 111	ununbium 112	204100	ununquadium 114		1200	12.101	
Fr	Ra	**	Lr	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub		Uuq				
[223]	[226]		[262]	[261]	[262]	[266]	[264]	[269]	[268]	[271]	[272]	[277]		[289]				
			lanthanium	cerium	Praeseo	neodymium	promethium 61	samarium	europlum	gadollinium	terbium	dvsprosiur	holmium	erbium	thullium	vtterbium		
	*lantha	noids	57	58	dymium <b>59</b>	60	Pm	62	63	64	65	66	67	68	69	70		
			La	Ce	Pr	Nd	[145]	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb		
			89	90	91	92	93	94	95	96	97	98	99	100	101	102		
	**actine	oids		232.04	<b>Pa</b>	U 238.03	Np	Pu	Am		Bk	Cf	<b>ES</b>	Fm	Md	NO		



# To Put That In Perspective ...

### If cars had advanced at that rate:

- A Rolls Royce would cost \$0.18
- It would go 176,000 MPH
- Get 64,000 MPG

### If planes had advanced at that rate

- It would take 5.5 seconds to fly from L.A. to NYC
- -... and would reboot randomly and fall out of the sky

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# But .... Can It Go On Forever ?

#### Blade running

Number of blades per razor system



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# Scaling - The Way it Was

#### The smaller you get

 If lithography dimensions, gate thickness and supply voltage go down by a factor of ~1.4 every 2 years

#### The faster you go

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- Your chip will run 1.4 X faster
- Be ~  $\frac{1}{2}$  the size
- And burn roughly half the power



#### SCALING:

#### **RESULTS:**

Higher Density: $\sim a^2$ Higher Speed: $\sim a$ Power/ckt: $\sim 1/a^2$ 

Power Density:~Constant





# Power – The Emerging Discontinuity

 Passive power continues to explode

### Power components:

- Active power
- Passive power
- Gate leakage

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silicon bulk field effect transistor (FET)



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### **Power Impacts Performance**





### **Further Impacts of Power**

- Power is a major concern as it drives heat, reliability, fan noise
- So we design cores for power constrained performance





# Why Is Cost So Important?

### Chip development costs are significant

- e.g. Building Cell took \$400M (STI), 5 years and 450 people
- Development costs must be recovered by software sales
- Drives longer product lifecycle 💥 5 years





### How Do We Beat Scaling ?

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#### System Design **Integration Driven** Applications System Middleware Level O/SHypervisor Integration Cluster Scaling Driven Multiple Cores Applications Embedded Memory System Middleware **Accelerators** O/S Power Management Compilers Interconnects Chip Bus Switch Fabric Chip Memory Interfaces Cache High Speed I/O Level Semiconductors Compilers Integration **Processor Core** Semiconductors Cache **Processor Core** Processor Packaging Cache I/OPackaging Cooling I/OInterconnect Cooling

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# E.g.: Microsoft Xbox 360

- 3-Way Symmetric Multi-Processor
  - IBM PowerPC Architecture®
  - Specialized Function VMX
  - 3.2GHz
  - Multithreading

#### Firsts:

- First 3-way SMP in volume production
- Silicon tape-out to > 1 million parts in less than one year
- Highest frequency IBM Power Architecture<sup>™</sup> core shipped at the time





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# E.g.: Cell Processor

- 250M transistors ... 235mm2
- Top frequency >4GHz in lab
- > 200 GFlops (SP) @3.2GHz
- > 20 GFlops (DP) @3.2GHz
- Up to 25.6 GB/s memory B/W
- Up to 70+ GB/s I/O B/W
  - Practical ~ 50GB/s

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- 100+ simultaneous bus transactions
  - 16+8 entry DMA queue per SPE







# What Does Multi-Core Really Buy You?



Terragen Intel Pentium Terrain Rendering Engine STI Cell



# Ray Casting



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# Cell B.E. Chip





# Building New Businesses from Game Processors

#### 3D Visualization via Volumetric Rendering for Medical Images



PC Solution ~6 minutes to render entire volume ~2 seconds per slice



Cell Solution ~2 seconds to render entire volume

Courtesy of Mercury Computer Systems http://www.mc.com/cell/media/medium.cfm



# It's Just Ducky





# Summary

- IBM has locked down the games industry
  - We're working hard to keep it
- Innovations are aimed at managing performance, cost, power
  - Multi-core, cost efficient, low power designs
- Leveraging investment in game λP to create new opportunities

#### So What?

- IBM Innovation made these chips possible
- Spread the word Video games are cool and so are we!
- What could you use a small, fast supercomputer for?