COOL CODES FOR HOT CHIPS:

A QUANTITATIVE BASIS FOR MULTI-CORE DESIGN

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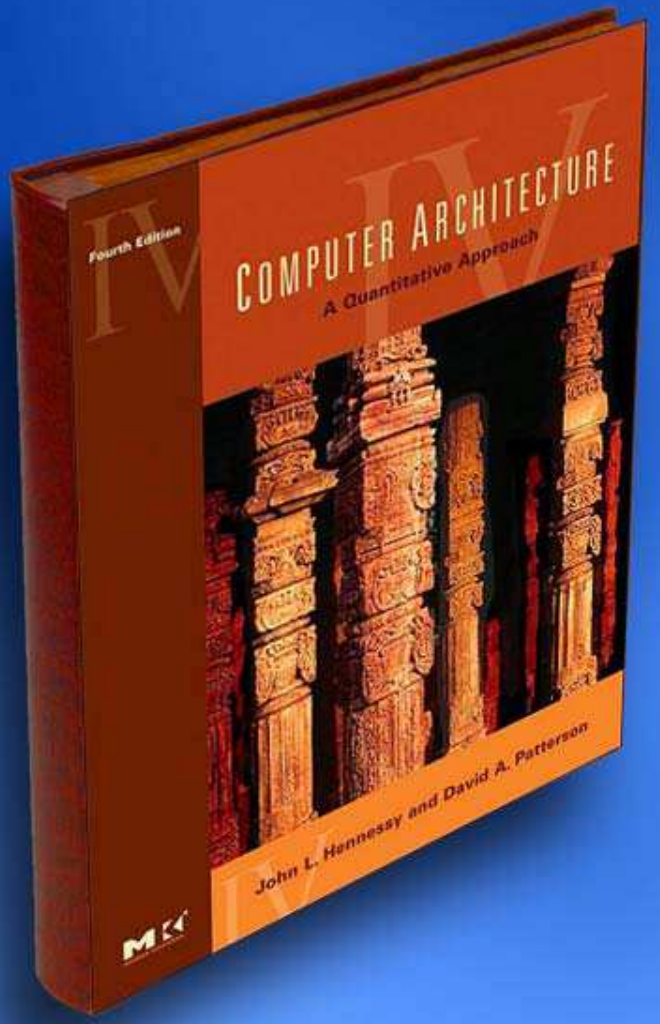
Intel Senior Fellow | Chief Technology Officer

Two Decades of Quantitative Design



intel inside pentium PROCESSOR

TPC Transaction Processing Performance Council

spec

intel inside pentium 4

SYSmark 2004 SE

MobileMark 2005

intel Core 2 Duo inside

3DMARK06 The Gamers' Benchmark

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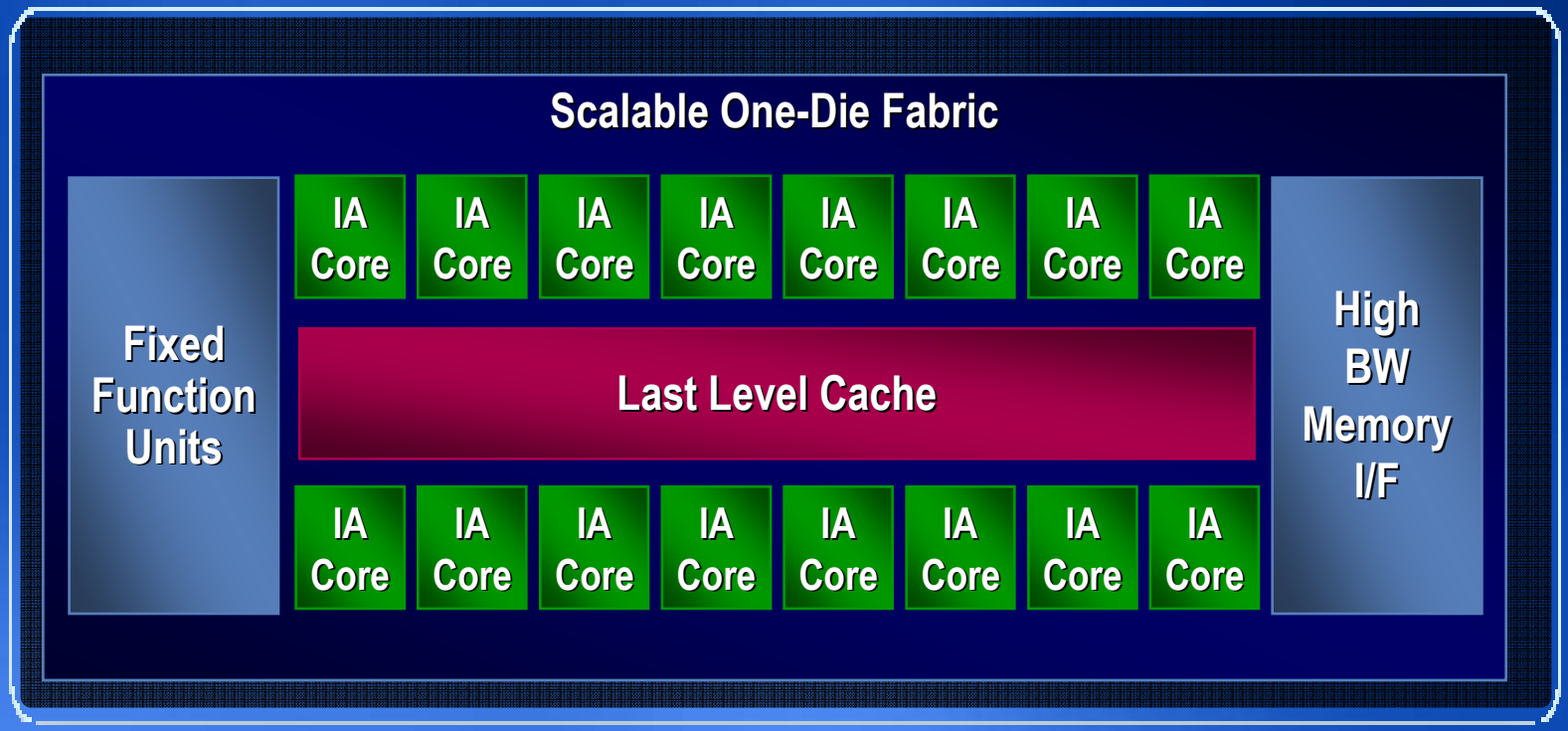
Multi-Core Transition Accelerating

"We notified customers we're pulling in both the desktop and server (launch) of the first quad-core processors into the fourth quarter of this year from the first half of 2007"

"The UltraSPARC T1 processor with CoolThreads technology is the highest-throughput and most eco-responsible processor ever created."

"Azul has been able to pack an industry-leading 24 processor cores on a single-chip, which means that each processor is able to run 24 simultaneous parallel threads"

Tera-Scale Strawman



Opening up new classes of applications

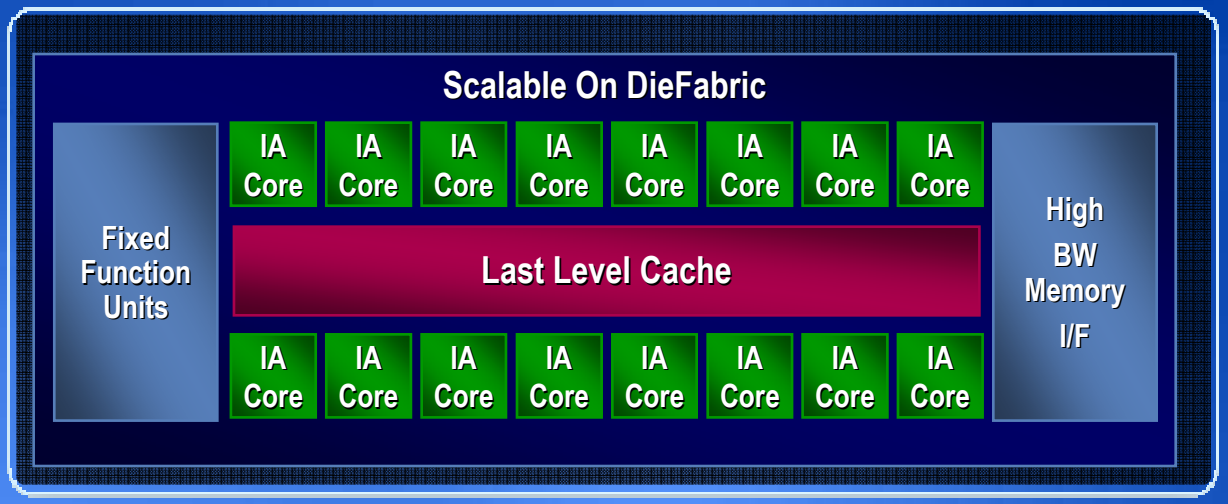
Synthesized output

Source: Intel

Camera 1 input	Camera 2 input	Camera 3 input	Camera 4 input
			

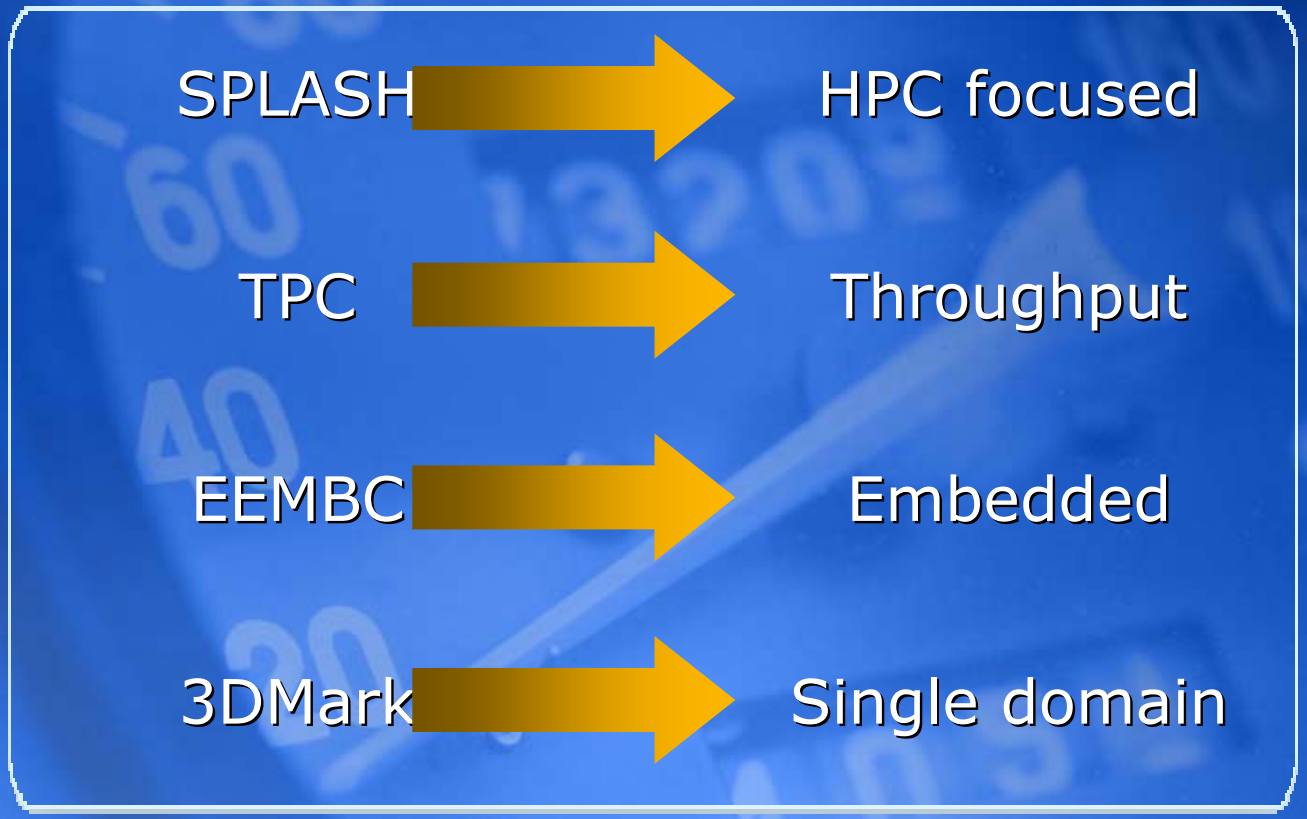
Design Challenges

- Complex memory hierarchy
- Sophisticated on-die fabrics
- Explicit thread support
- Fixed function acceleration

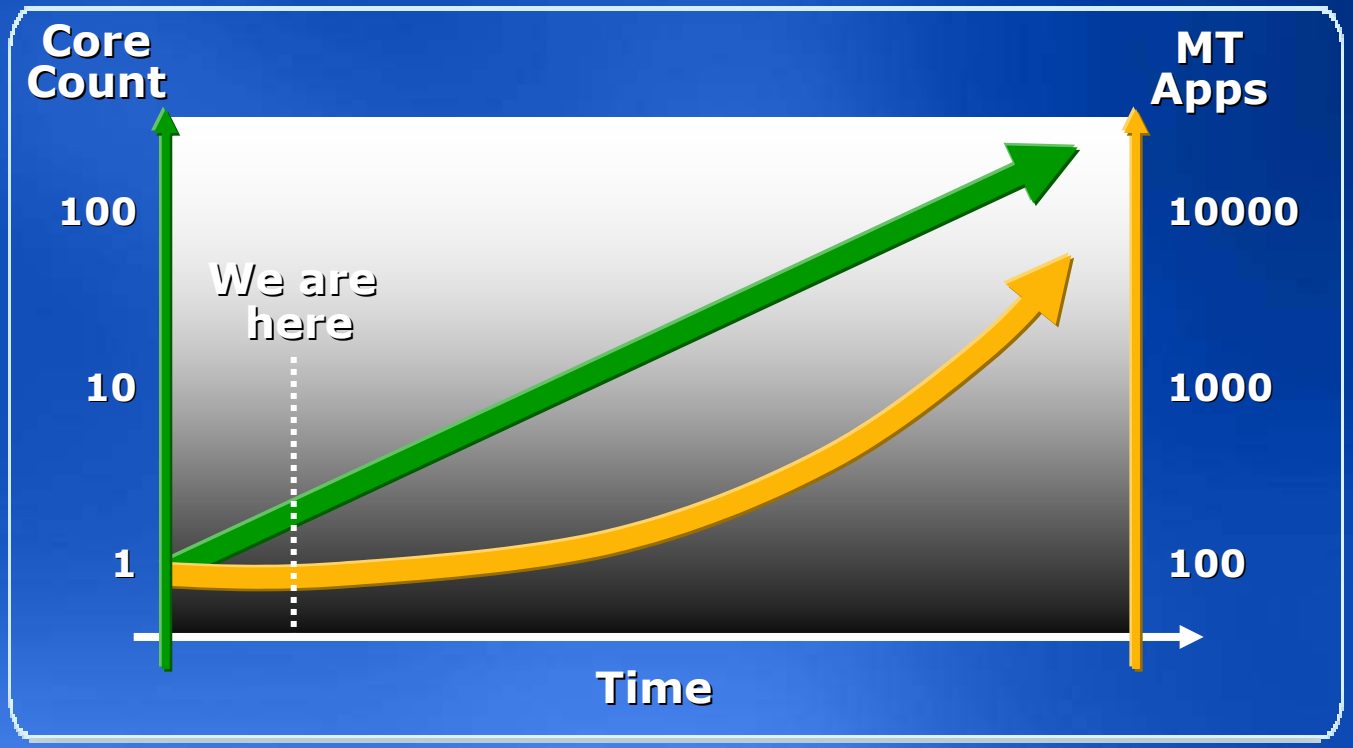


Lacking The Quantitative Tools…

No Multi-Core Metric?



The Waiting Game

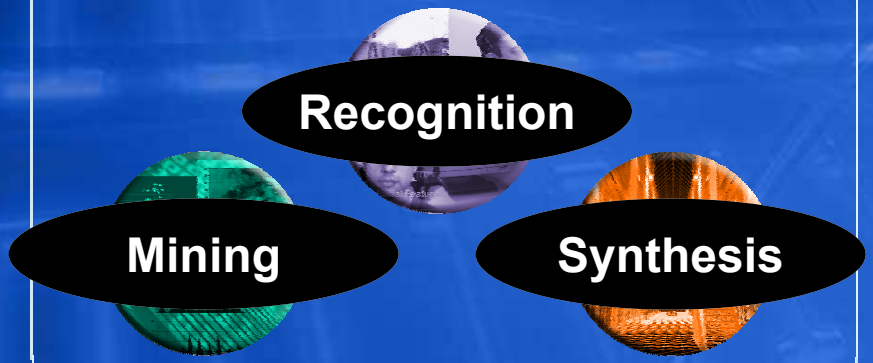


Designing **2010** Processors Today

Must **Anticipate** Future **Applications**

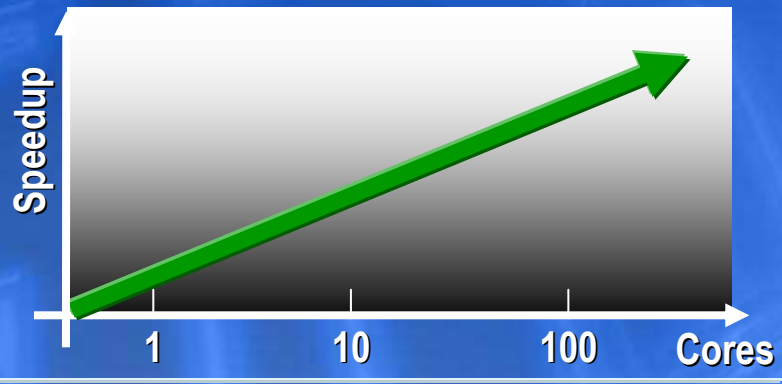
Creating a Multi-Core Benchmark

Established & Emerging

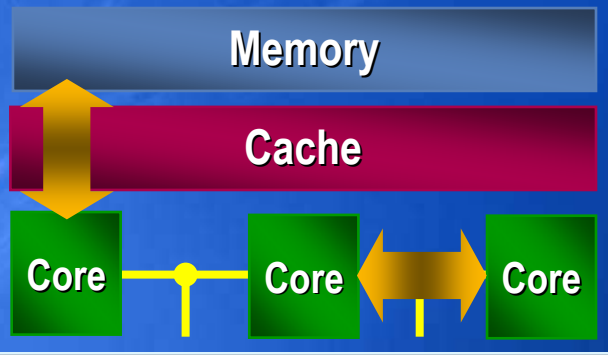


Performance & Energy Aware

Highly Threaded & Scalable



Differentiated and Stressful



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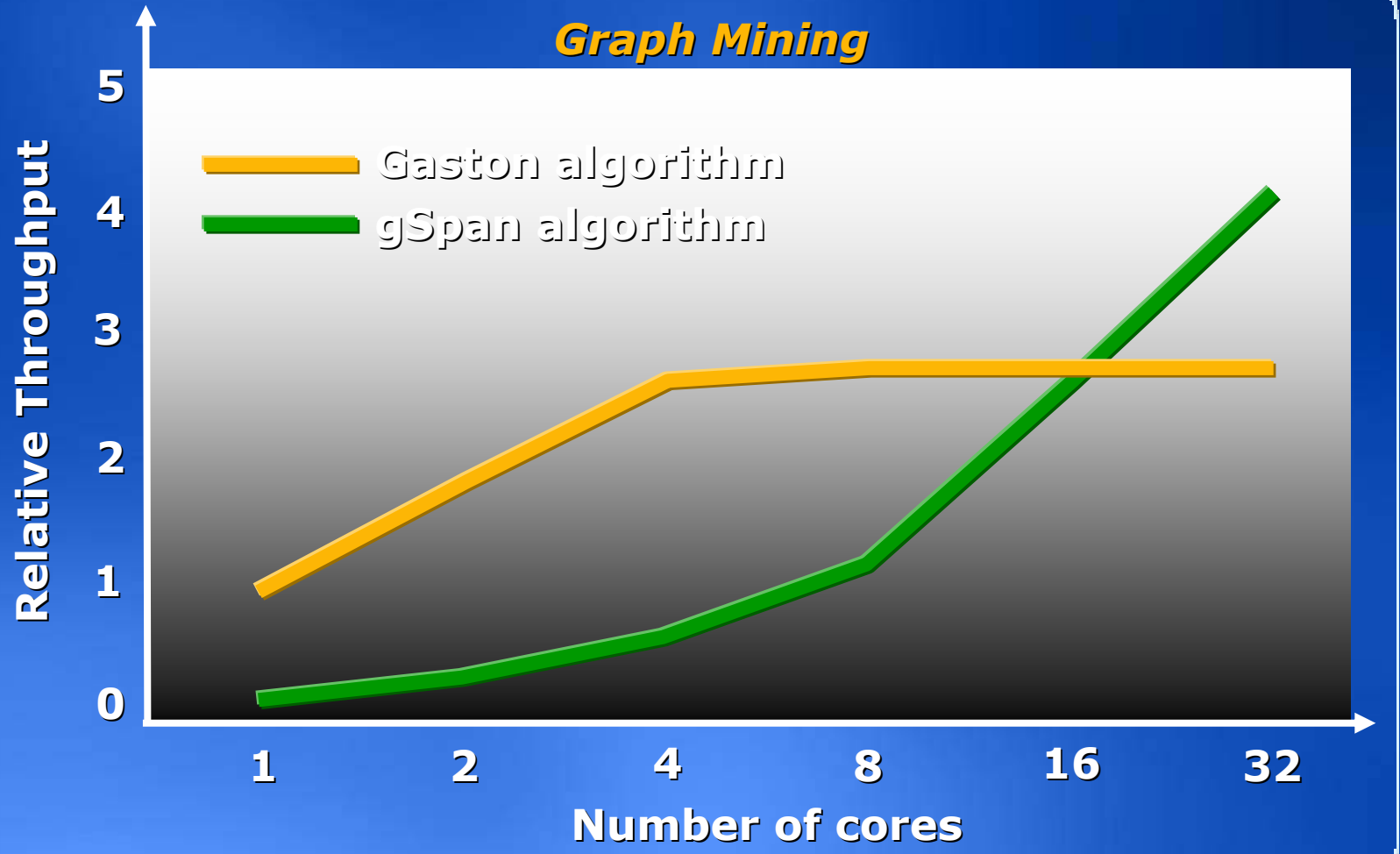
Unique Challenges

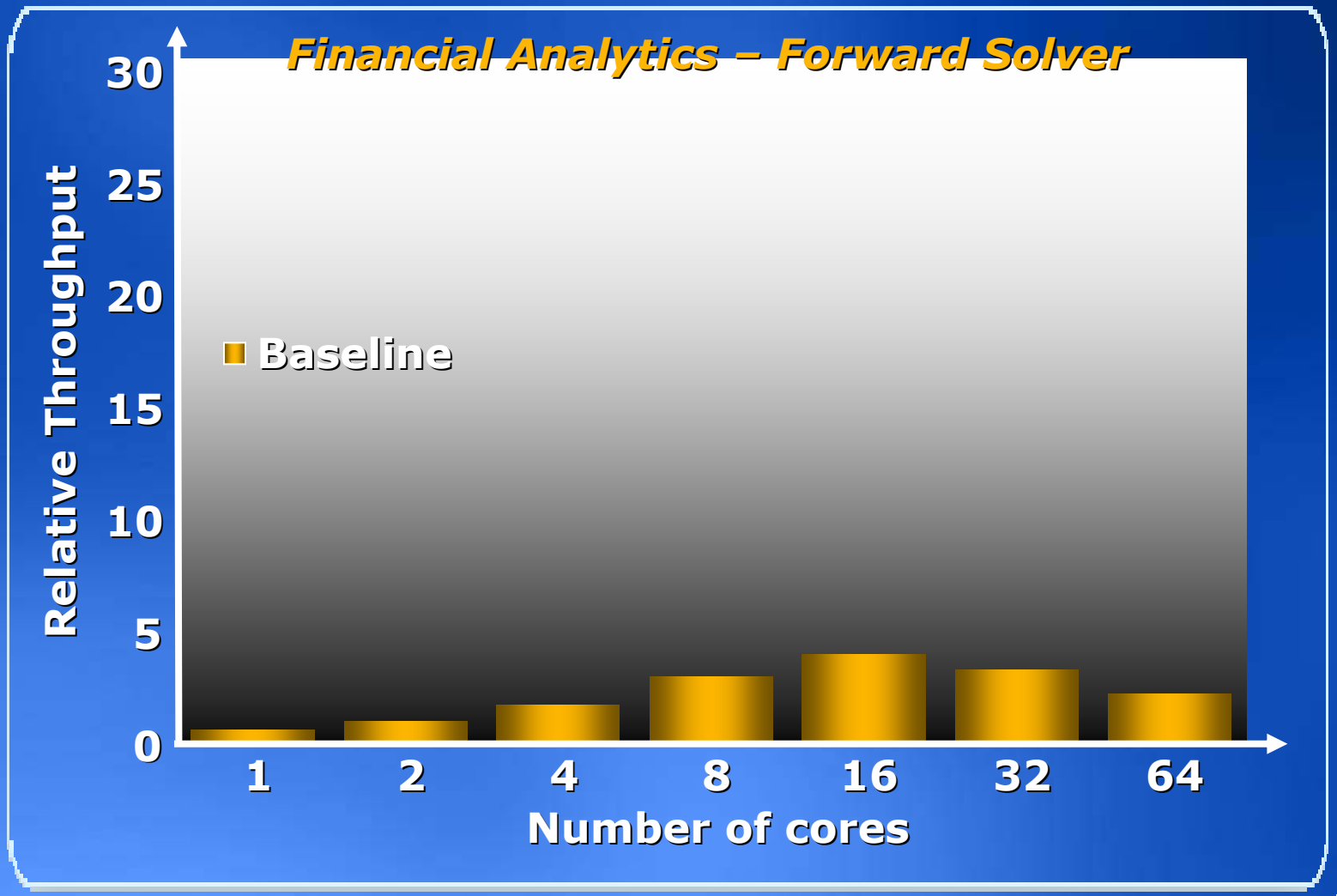
Do We Target…

- Bigger *OR* Smaller Cores
- Performance *OR* Scalability
- Compute *OR* I/O Intensive
- Cache Friendly OR Memory Intensive

Performance vs. Scalability



Architecture-Algorithm Co-Design



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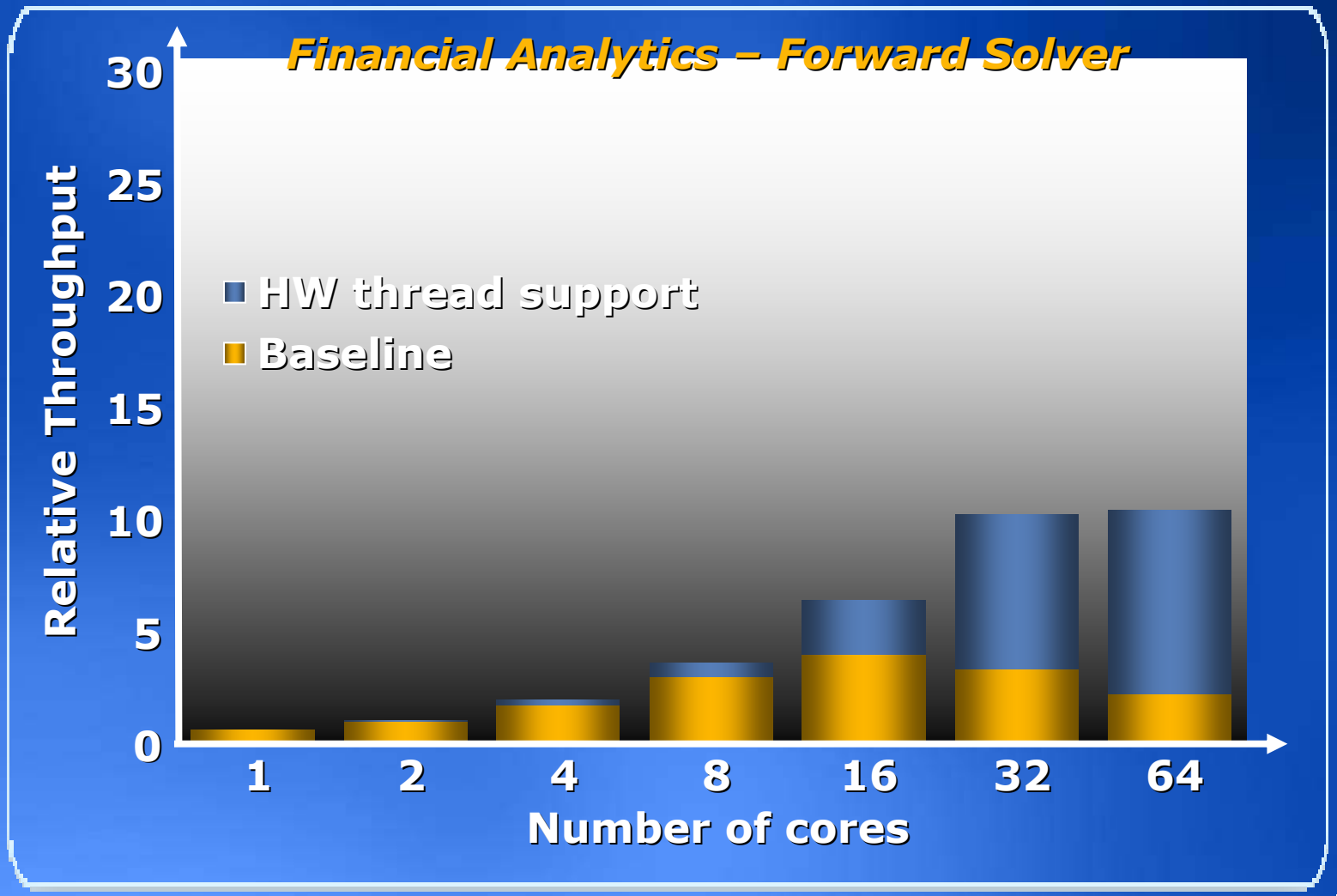

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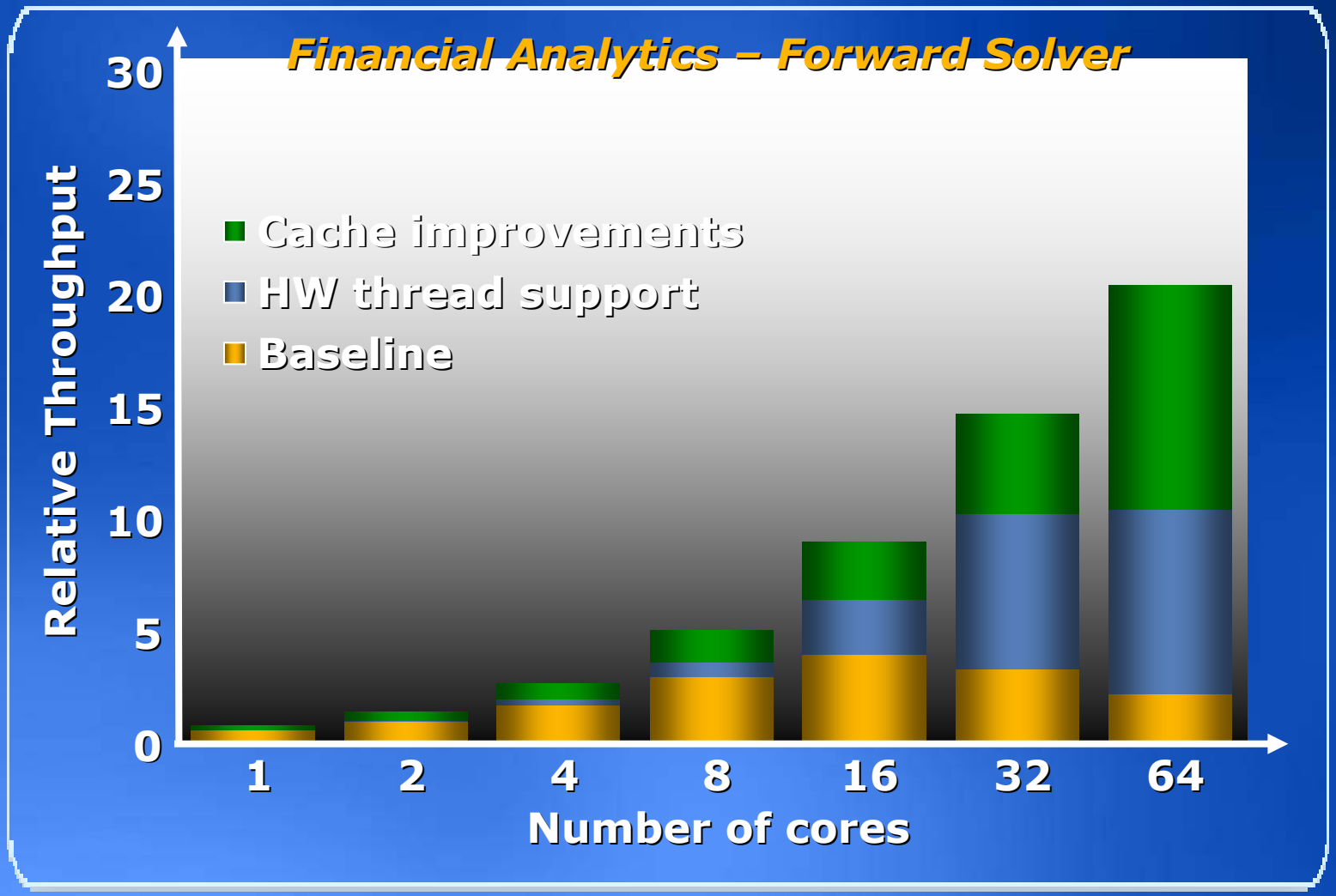
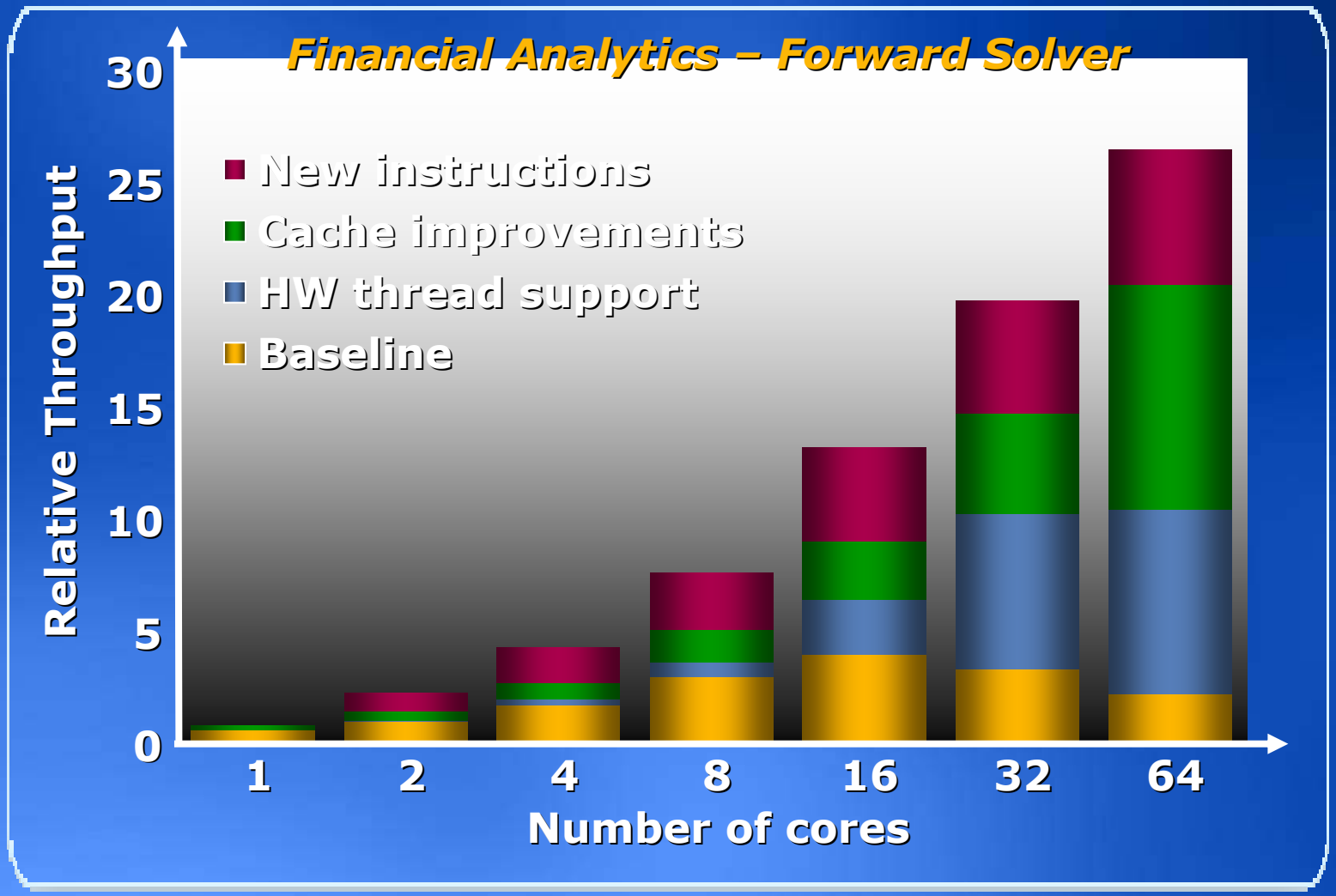


Architecture-Algorithm Co-Design

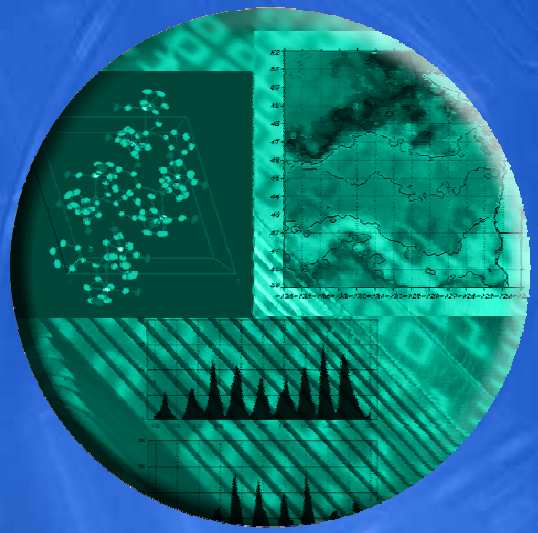


Emerging 'Killer' Applications

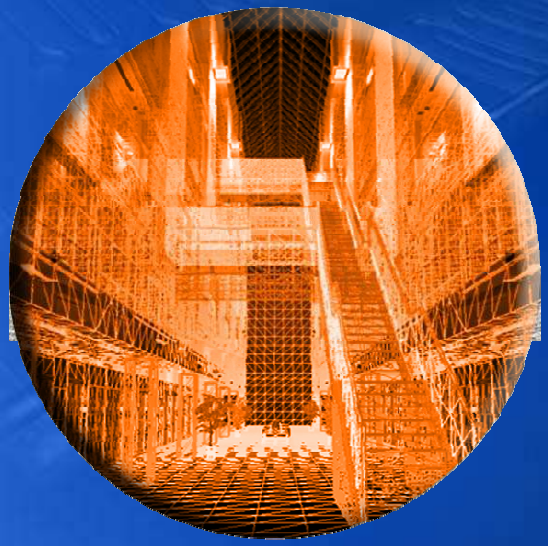
The RMS Suite

Recognition

Mining



Synthesis



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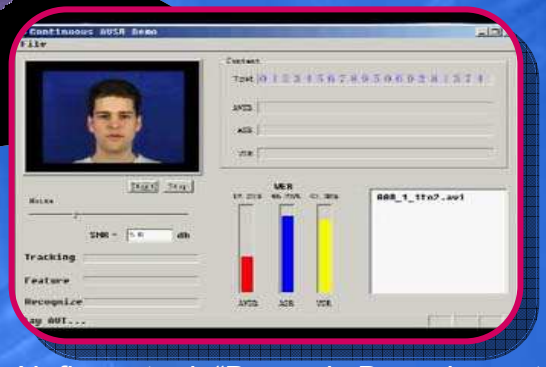
Emerging "Killer Apps" (R)

"What is it?"
Modeling and identifying using multi-modal data

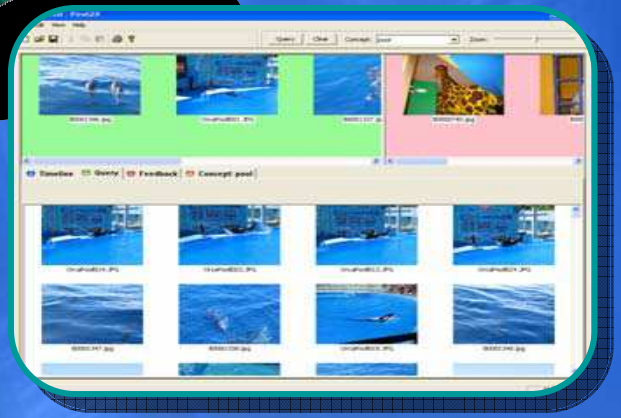


Source: Intel

Nefian, et. al, "Dynamic Bayesian networks for audio-visual speech recognition," Journal of Applied Signal Processing, 2002

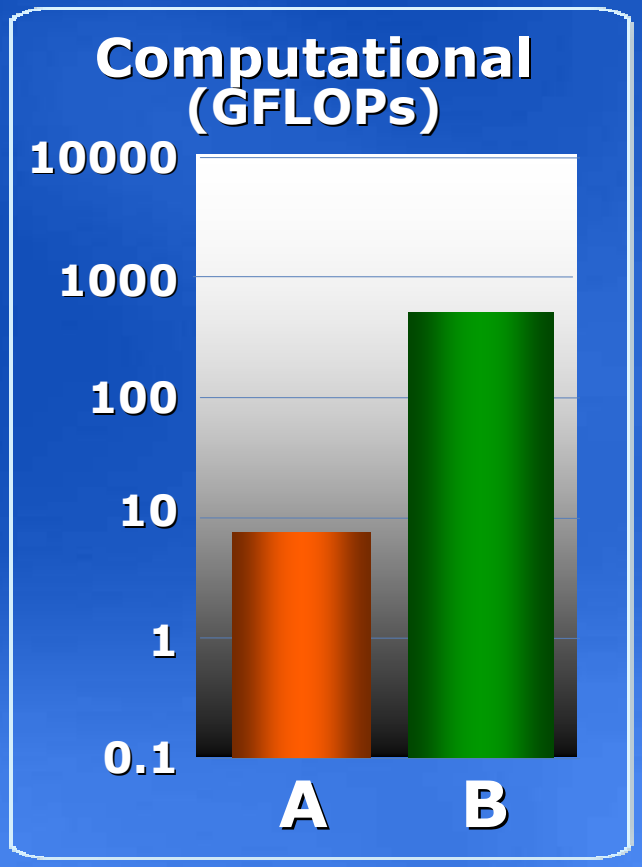
Emerging "Killer Apps" (M)

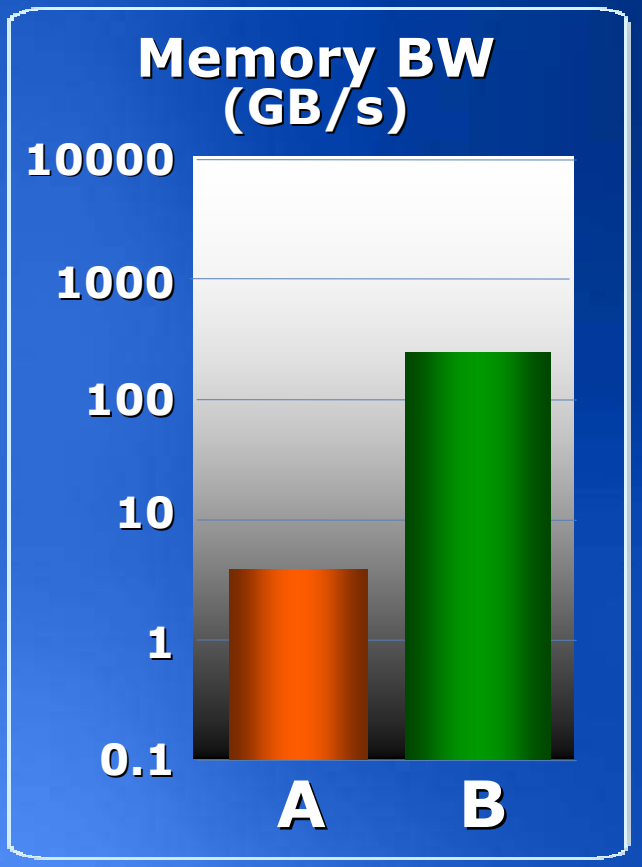
"Where is it?"
Search for a similar instance



Source: Intel

Computer Vision

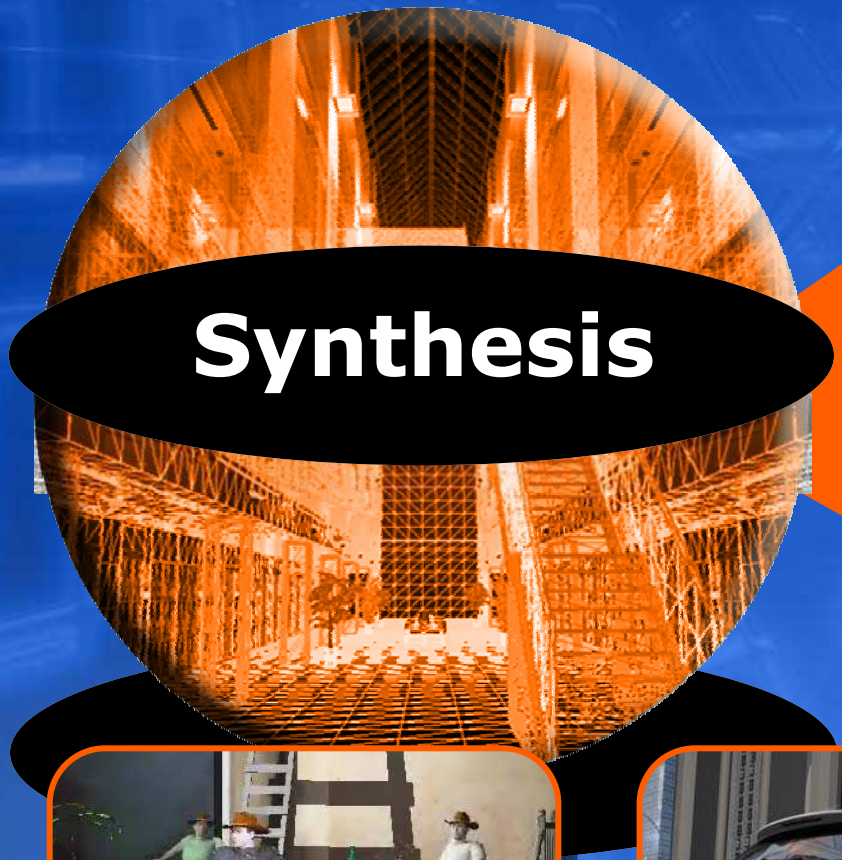




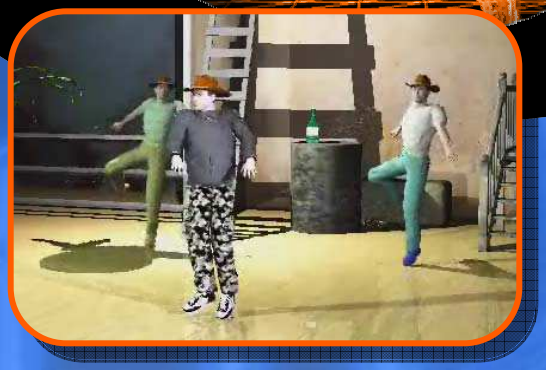
A: Video surveillance, 2 web cams

B: Body tracking, 4 DV cameras

Emerging "Killer Apps" (S)

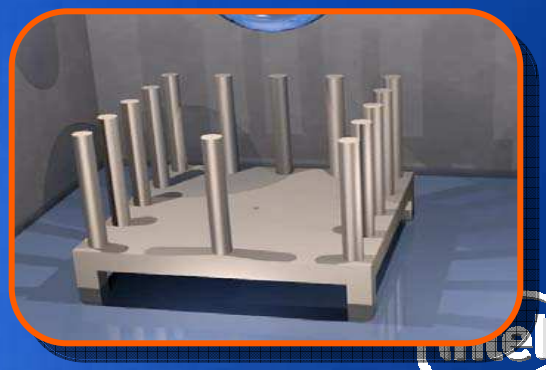


"What if?"
Creating new model instances



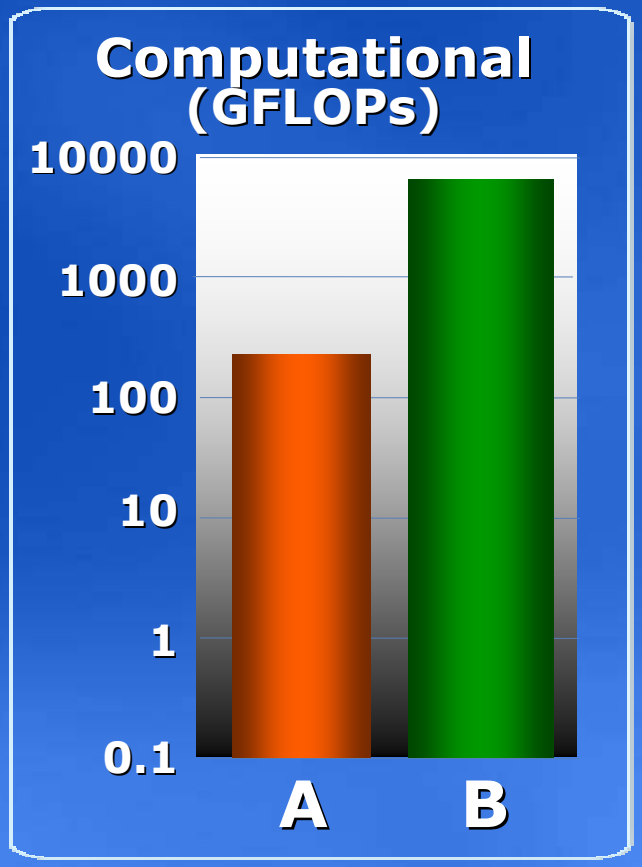
Source: Intel

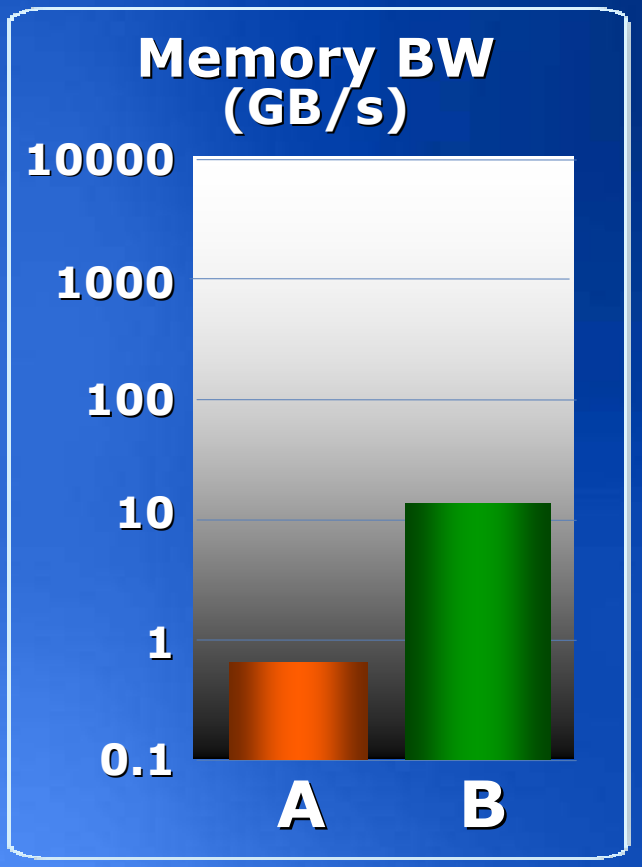
Source: InTrace



Source: Stanford

Ray-Tracing

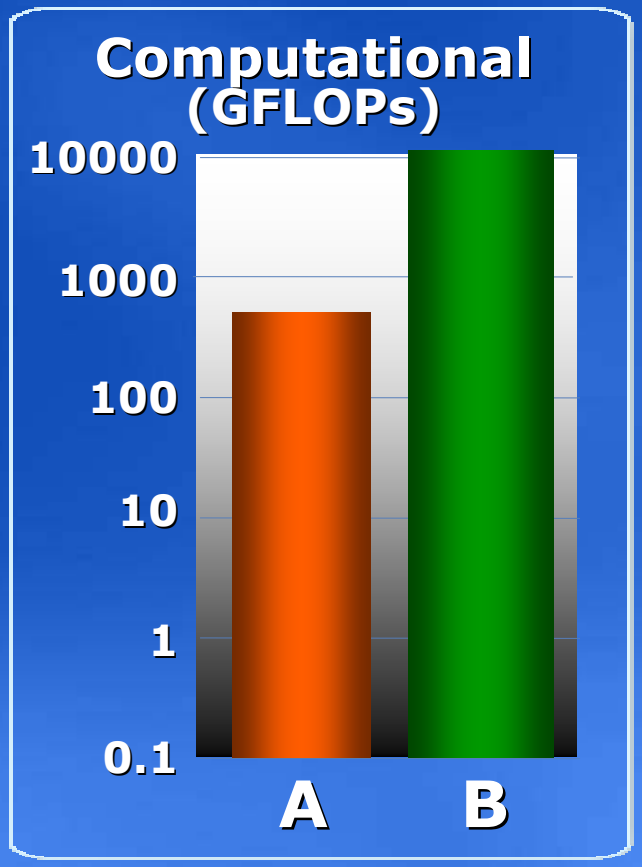


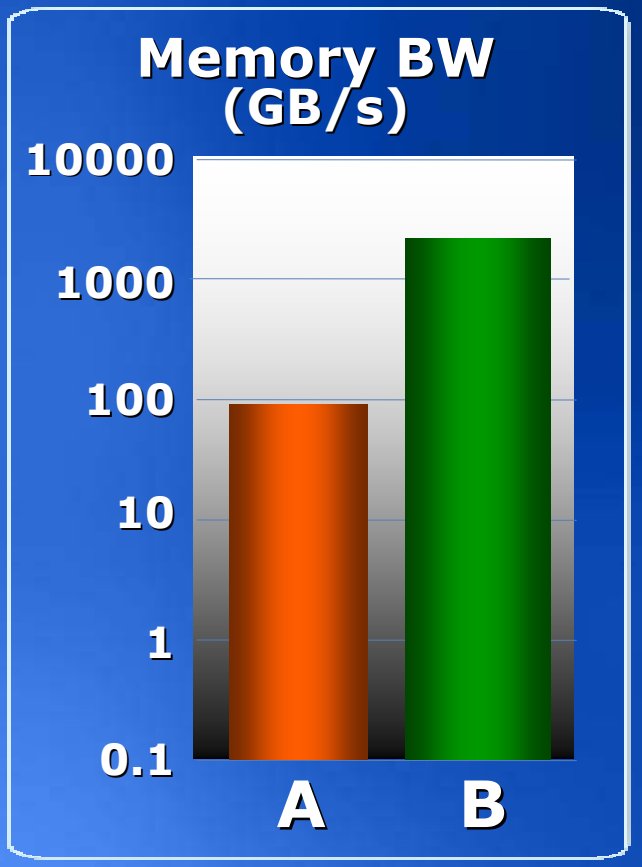


A: Bar scene, 1 mega-pixel

B: Beetle scene, 1 mega-pixel

Physical Simulation





A: CFD, 75x50x50, 10 fps

B: CFD, 150x100x100, 30 fps

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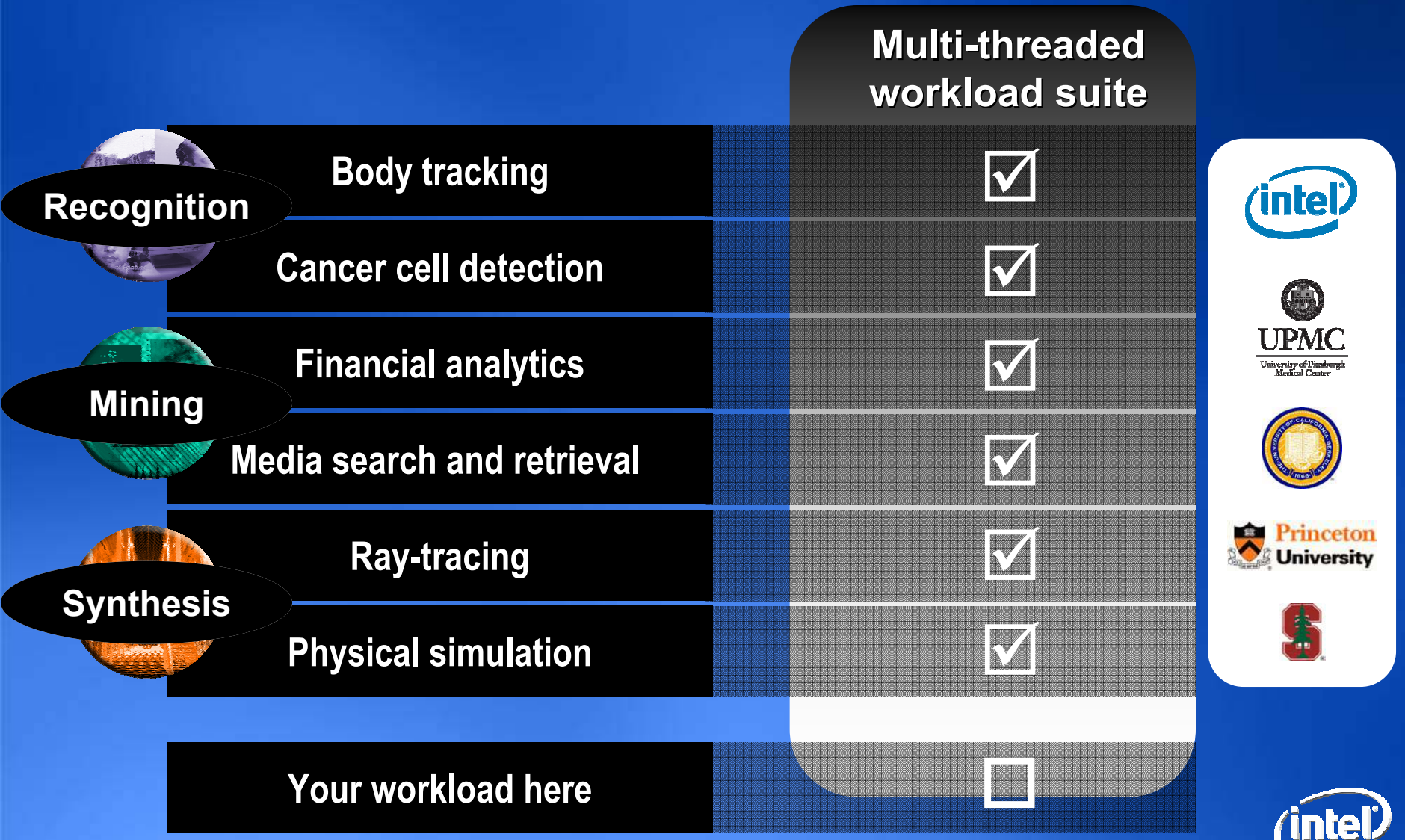
Intel's RMS Application Suite

- Ray tracing / Global illumination
- Rigid body game physics
- Fluid simulation
- Facial animation
- Cloth simulation
- Full body tracker
- Face detection
- Audio-visual speech recognition
- Multi-document summarization
- Text indexer
- Mortgage based security valuation
- Portfolio management
- Bioinformatics suite
- Graph mining
- Frequent itemset mining
- Sports video highlight extraction

Intel's RMS Primitives Suite

- Interior point method
- Machine learning primitives
- Signal / image processing
- Numerical integration suite
- Combinatorial optimization
- Finite element/difference/volume
- Partitioning structure collision tests
- Dense matrix primitives
- FG/BG and Canny edge detection
- Sparse matrix primitives
- Convex optimization
- Stochastic optimization
- Partitioning structure build/traversal
- PCG/Jacobi/Gauss-Siedel/PSCR
- Level set/fast marching method
- Black-Scholes/American options

Creating a Public RMS Suite



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The Future of Multi-core
Processors is in Our Hands
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