Where Will Processor Performance Come From in the Next 10 Years?

Frank Fox

Rambus Inc.

Mountain View, California, USA

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ffox@ieee.org

Clock Frequency: 10x

- **Process Scaling: 0.7/2-3 years ~ 4.5x**
  - **0.18 to 0.04 microns ~ 4.5x**
  - **Low k dielectrics, Cu**
- **SOI ~ 1.5x**
  - **Raw Speed ~ 1.25x**
  - **SOI Circuit Techniques ~ 1.20x**
- **Circuit Innovations ~ 1.5x**
  - **Multi-threshold**
  - **New/better devices?**
- **Clock Frequency ~10x**

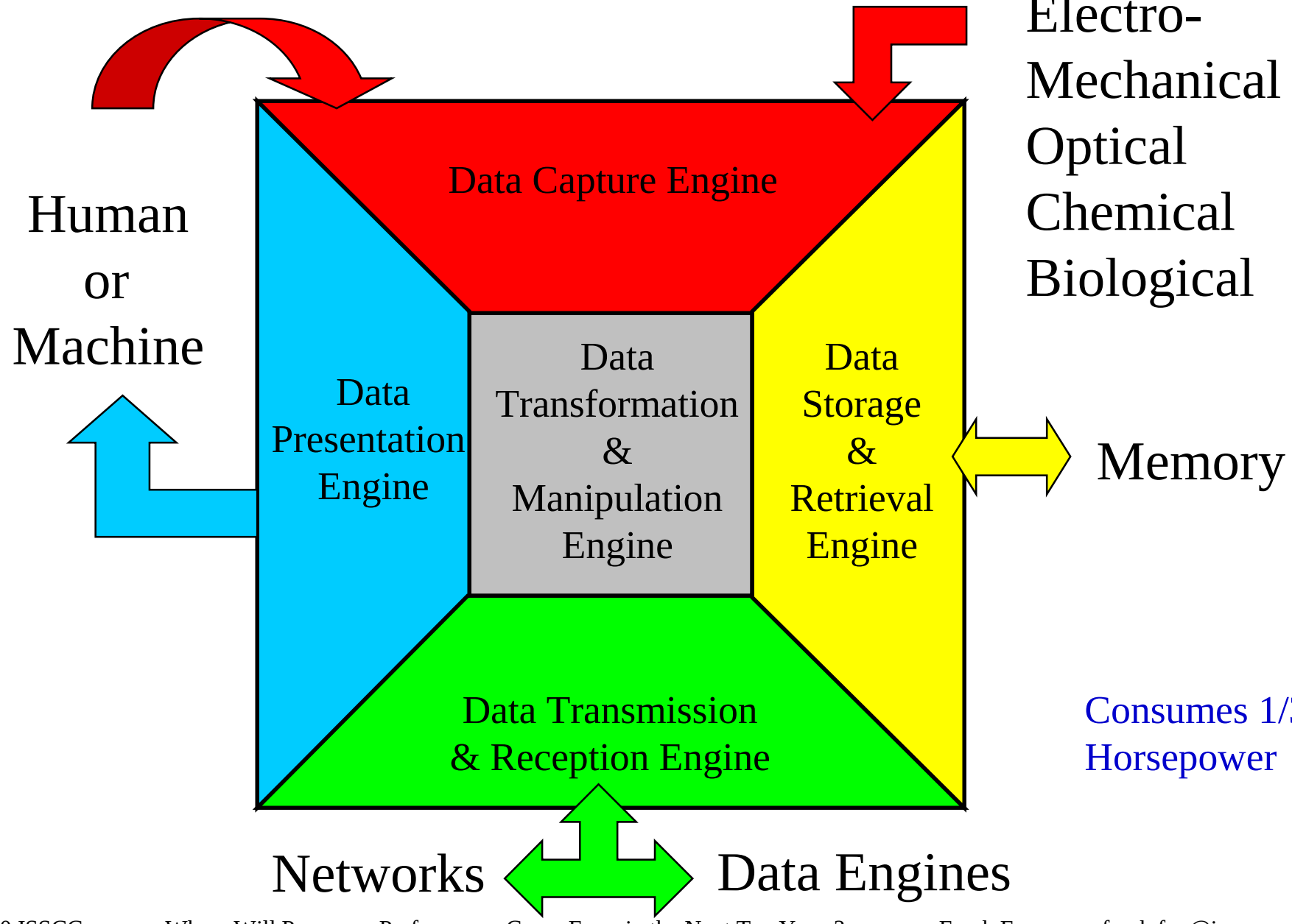
Parallelism: 10x

- **More Hardware** **~ 2.5x**
  - **Bigger Caches**
  - **Wider Issue**
  - **Better Predictors**
  - **Chip Multi-Processing**
- **Better Use of Hardware** **~4.0x**
  - **Improved Out of Order / VLIW**
  - **Deeper Pipes**
  - **Simultaneous Multi-Threading**
  - **Parallel Compilers**
  - **Parallel Algorithms**
- **Parallelism** **~10x**

100x is possible... but

- Very large high-skill design team
  - Keen competition for talented designers
- Power delivery and dissipation
  - Electrical issues
  - Thermal issues
- On- and off-chip wire delays limit performance
  - Very high-speed signalling techniques

2010: Data Engine



Consumes 1/3
Horsepower