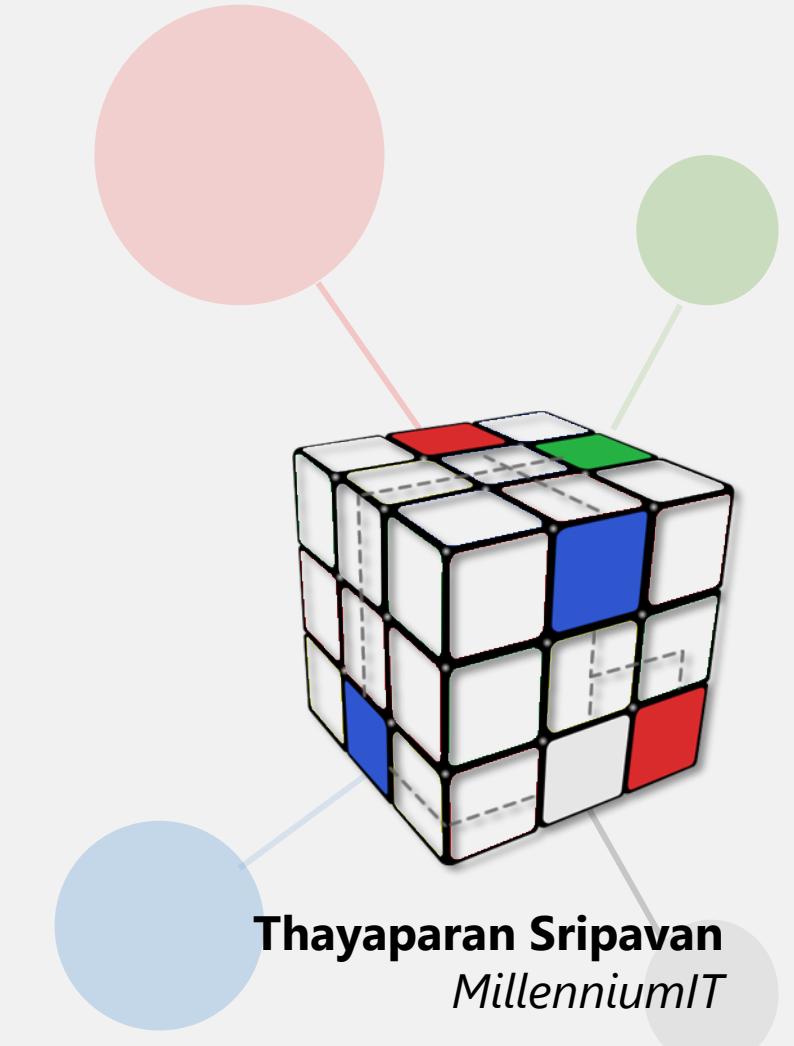


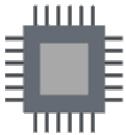
Heterogeneous Computing Trends and Business Value Creation



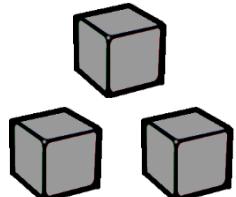
End of '*Free Lunch*'

~2005 - 2007

Technology



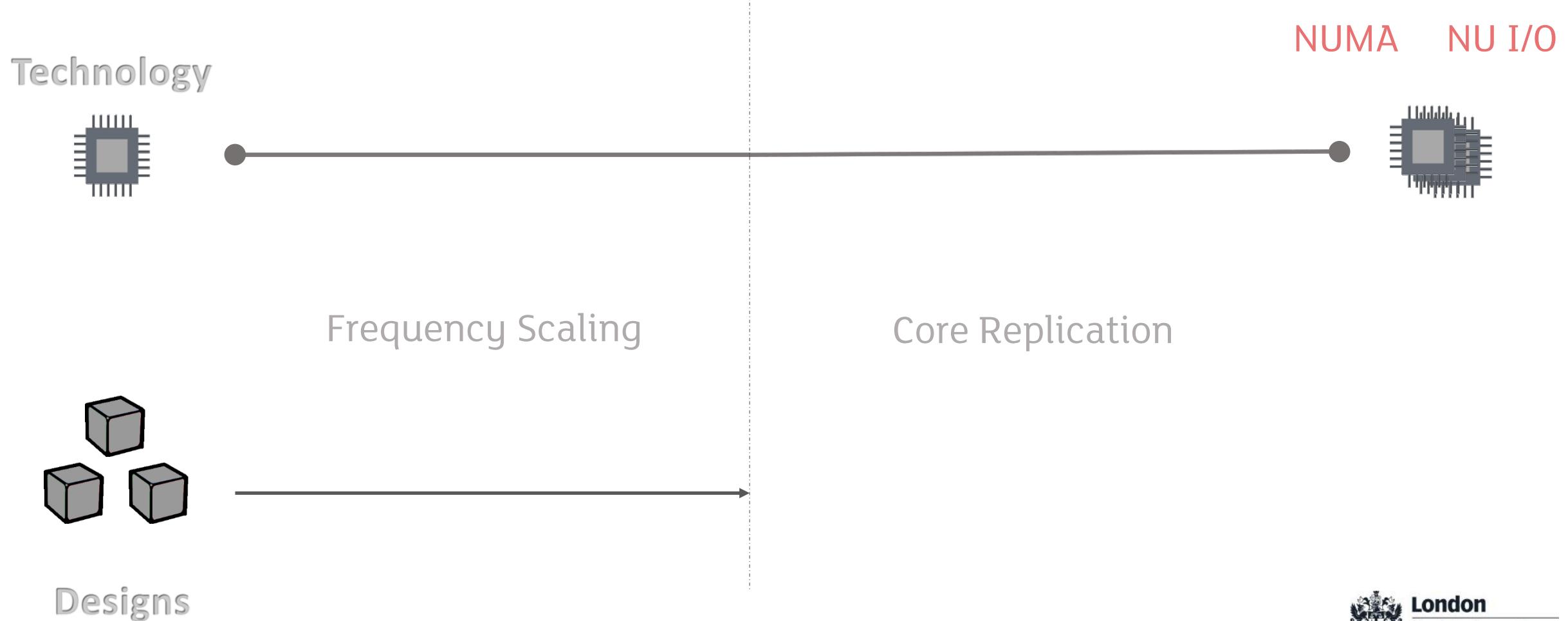
Frequency Scaling



Designs

End of '*Free Lunch*'

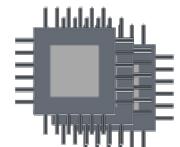
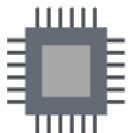
~2005 - 2007



Design for ‘*concurrency*’

~2005 - 2007

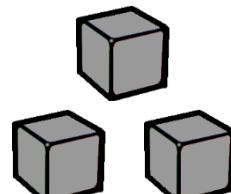
Technology



NUMA NU I/O

Frequency Scaling

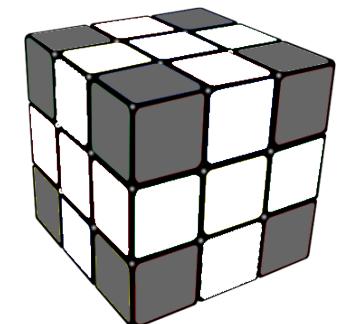
Core Replication



Designs



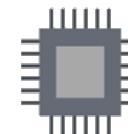
Exploit
Concurrency



Parallel Processors

Gaming / Graphics

GP-GPU
(Data Parallel)

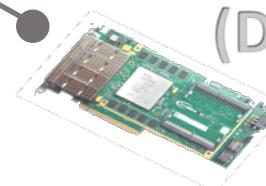


CPU (Multi-Core / Many-Core)
(Thread Parallel)

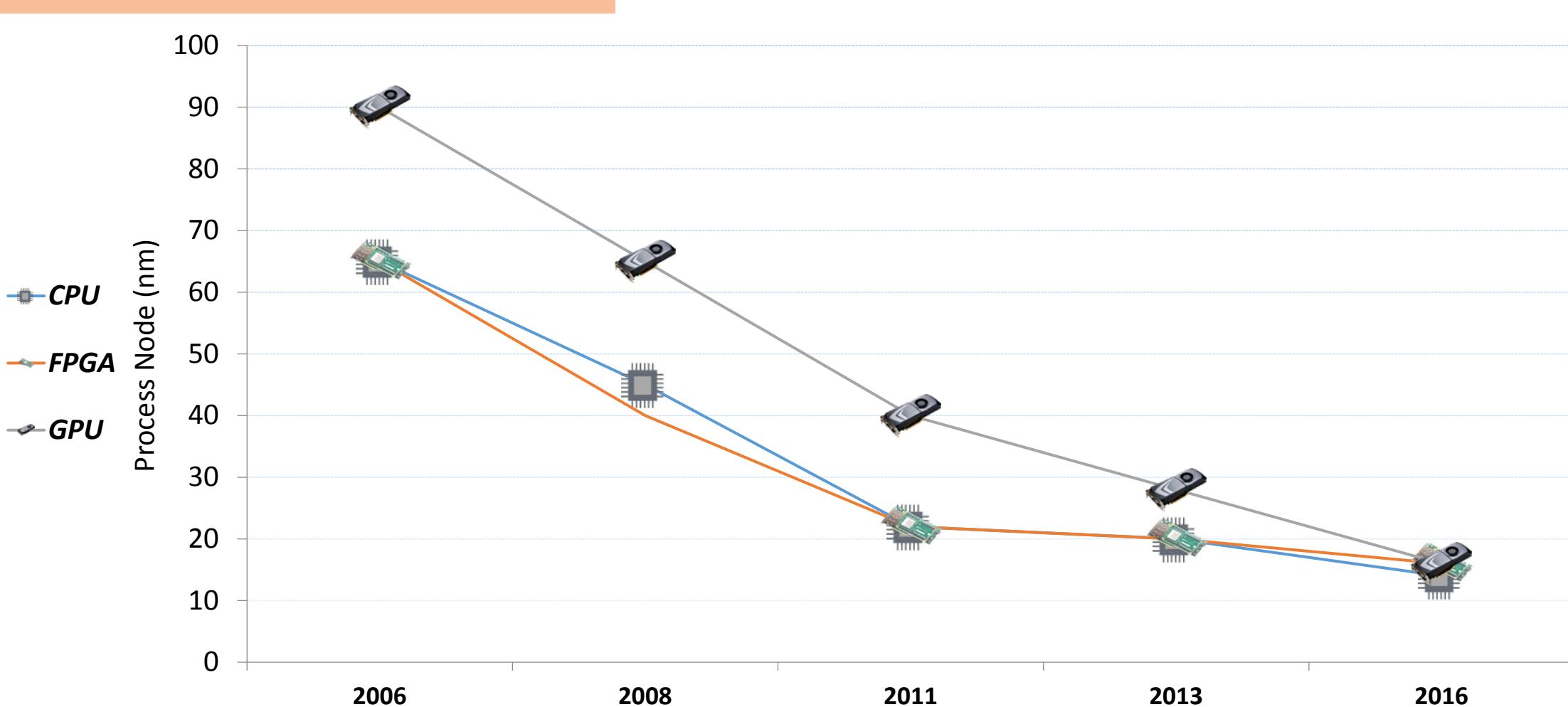


Reconfigurable Digital Systems

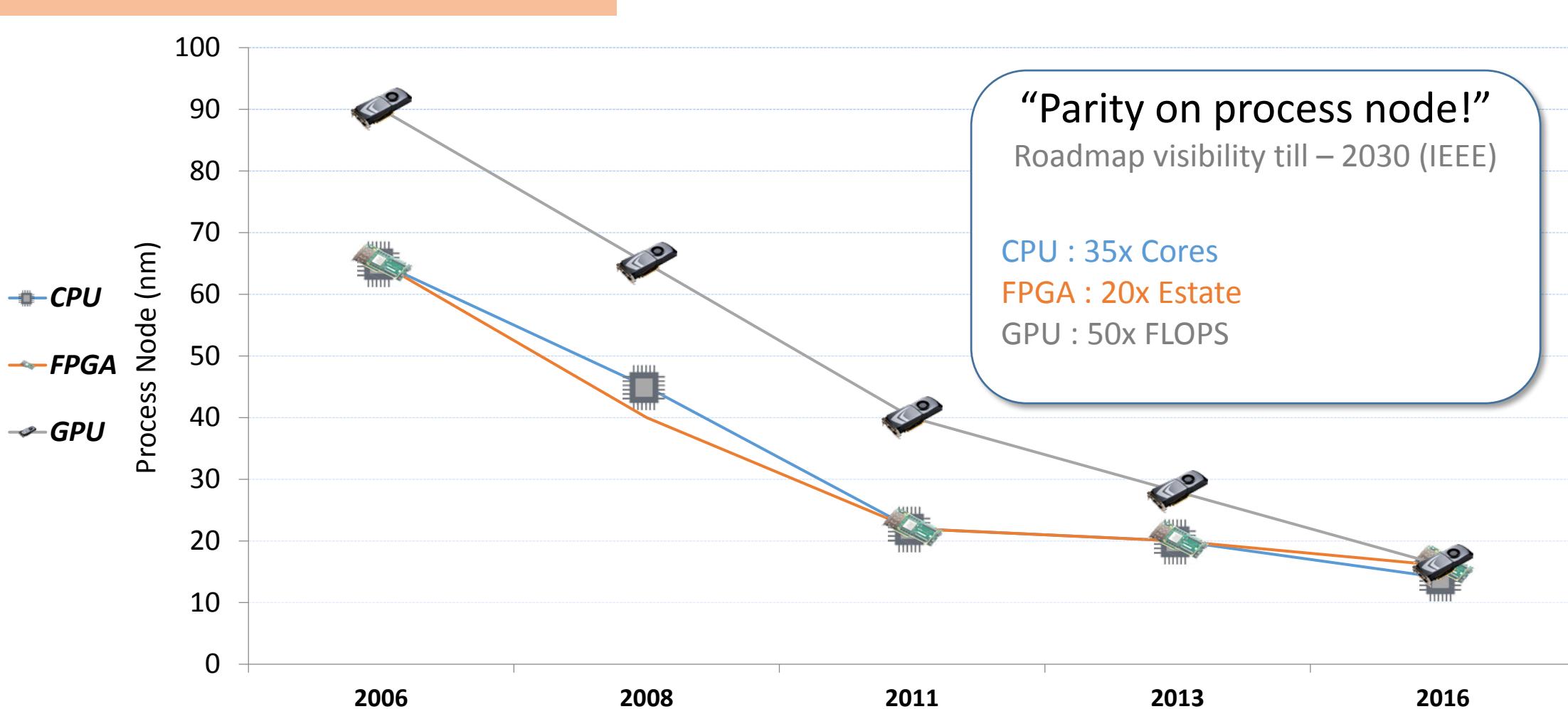
FPGA
(Data Flow Parallel)



Fabrication Technology



Fabrication Technology



Evolution

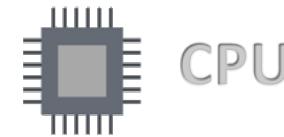
2006 – 2016

Models, Languages, Libs ...

GP-GPU



{Transformation}



CPU



More Cores , Integrated Memory, I/O & Graphics...
{Scaling / Efficiency}

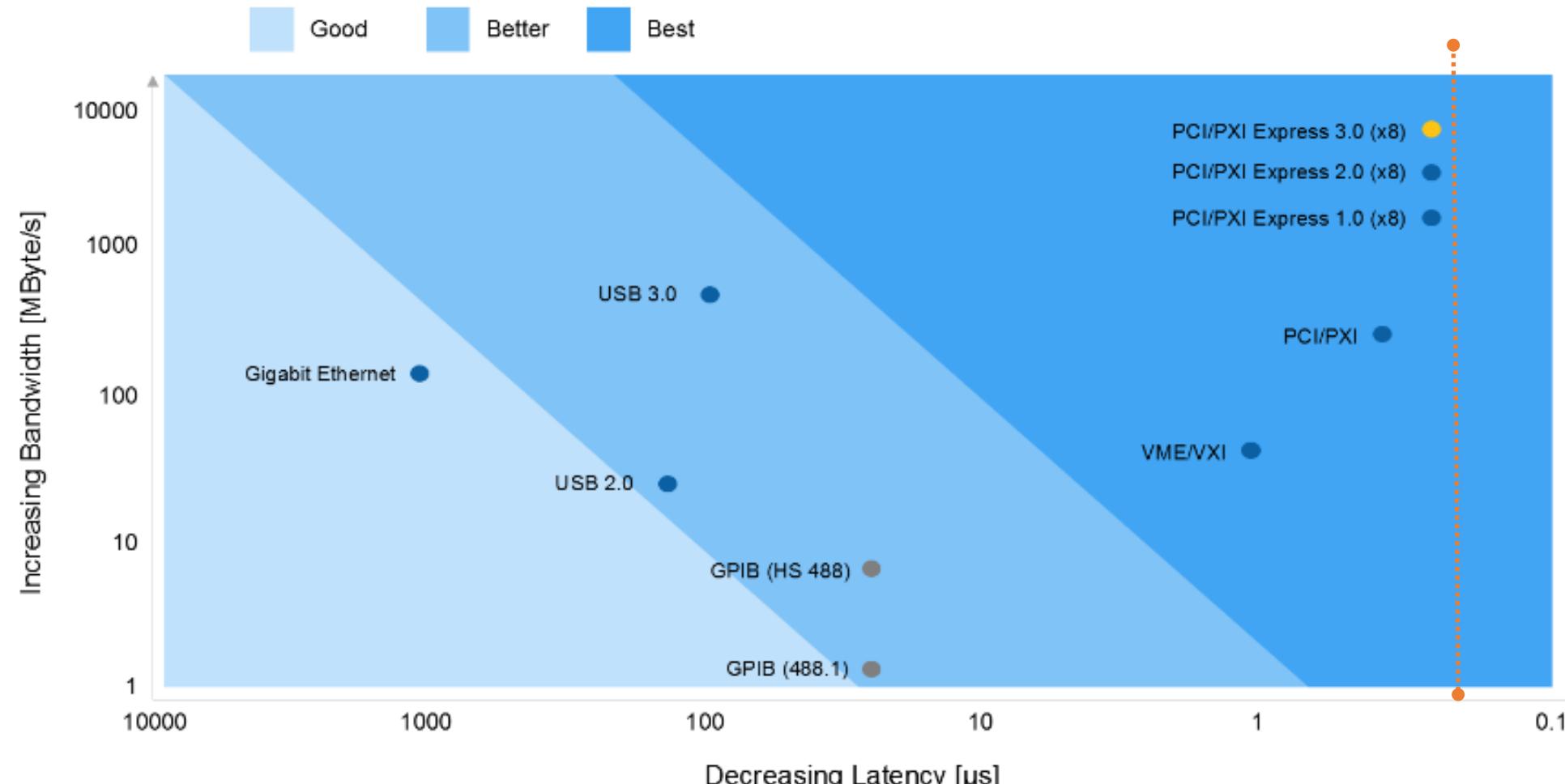
Hard IP, Soft IP, SoC, High Level Synthesis...

FPGA



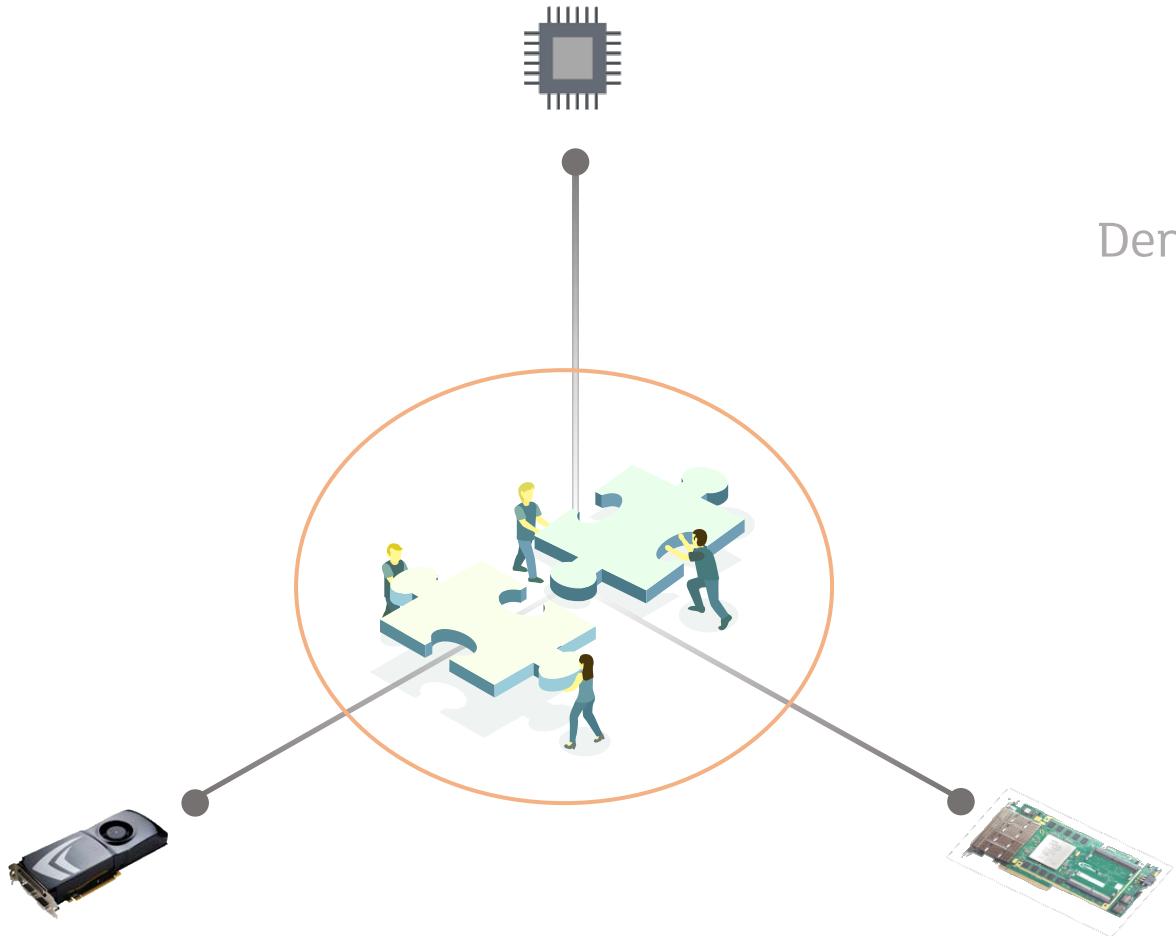
Interconnects

8000x BW ; Latency Wall @ ~300 ns

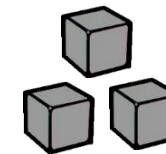


Source : National Instruments

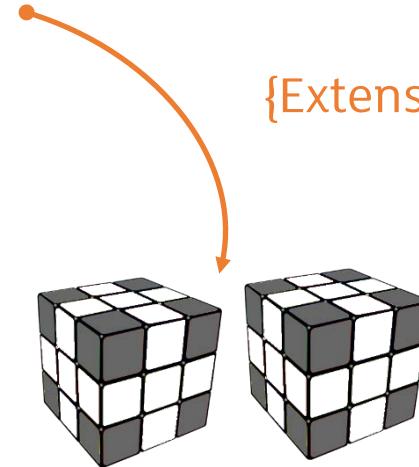
Goldilocks Problem



Dense – Homogeneous &
Distributed

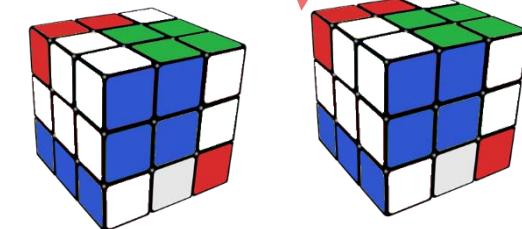


Distributed



{Extension}

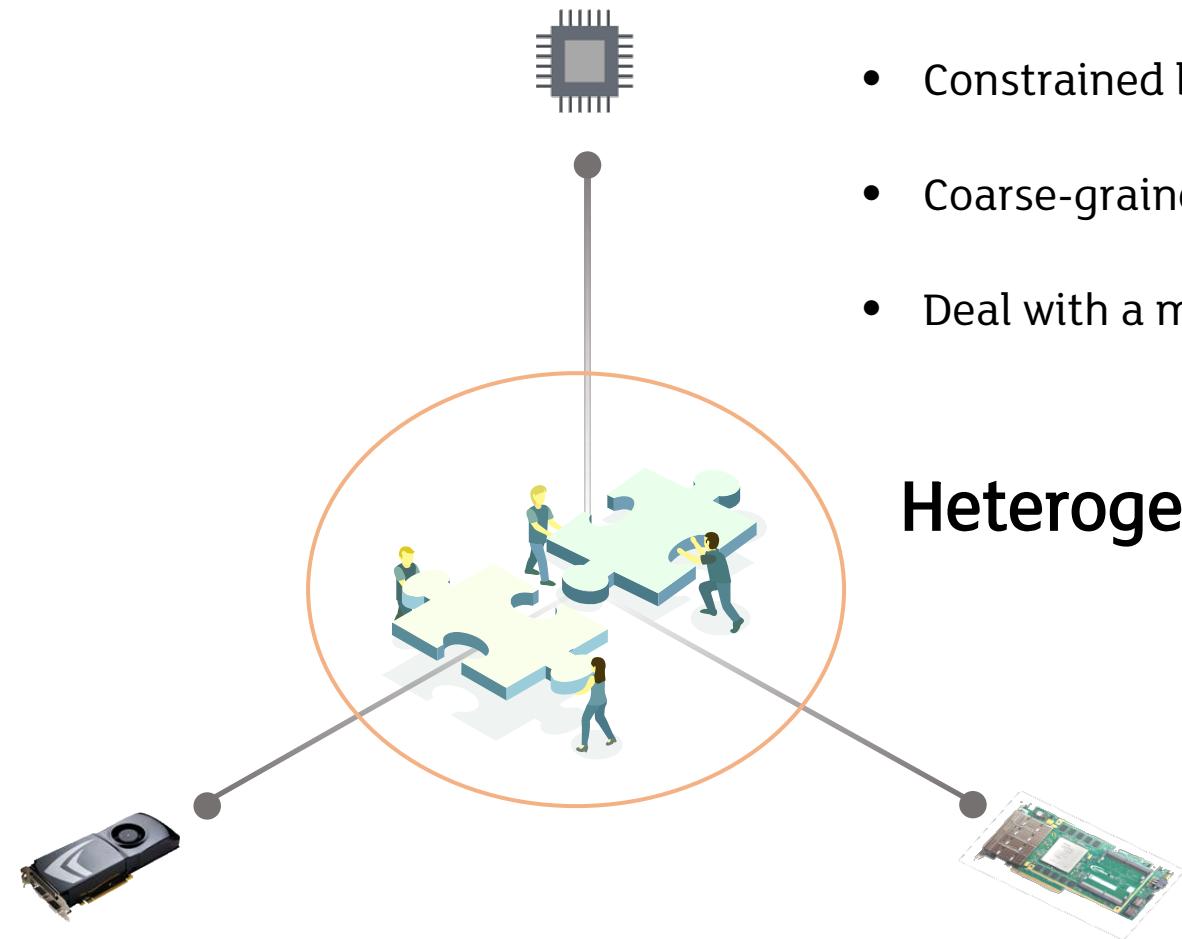
Heterogeneous &
Distributed



{Transformation}

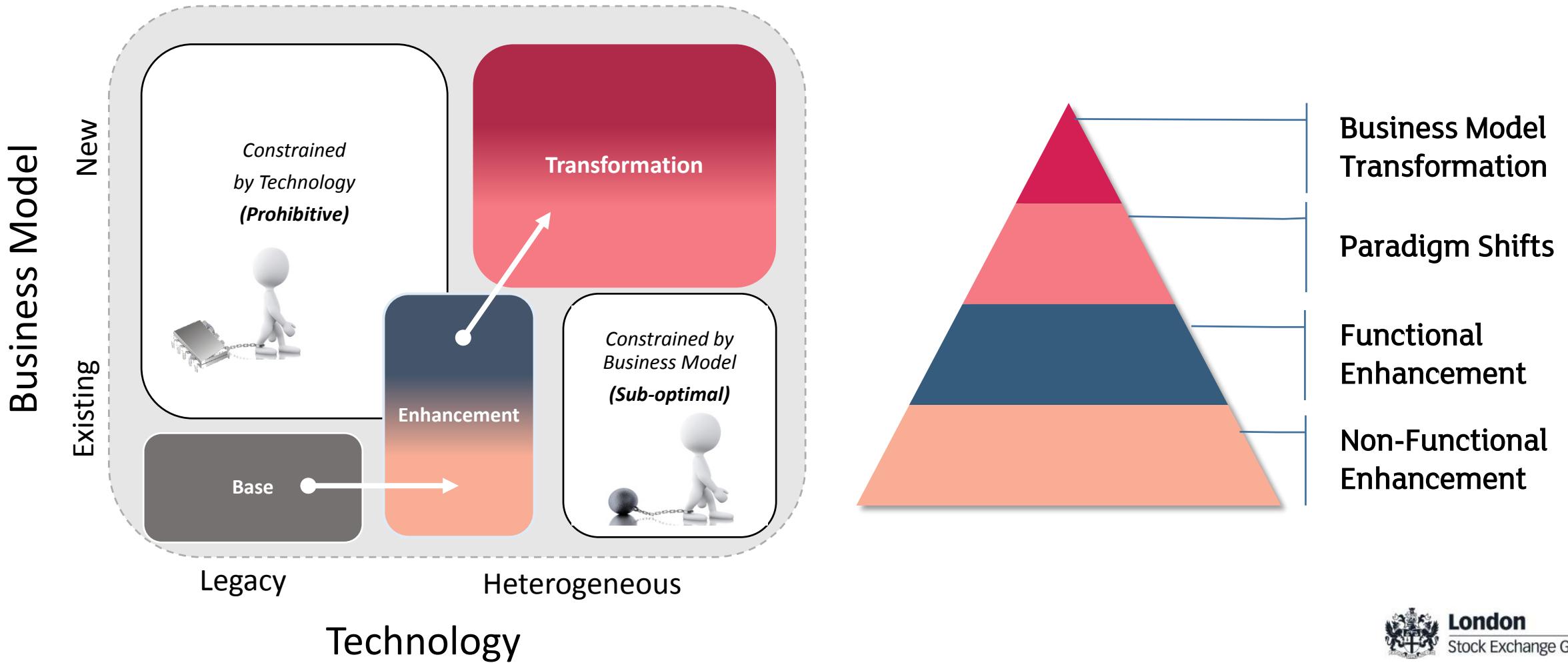
Challenges

- Heterogeneous design space – Continuously Expanding Horizon
- Constrained by interconnect speeds / synchronization – Inefficient Boundaries
- Coarse-grained design partitioning – Compromises in Solutions
- Deal with a mix of tools and methodologies – Complexity / Skill Specificity

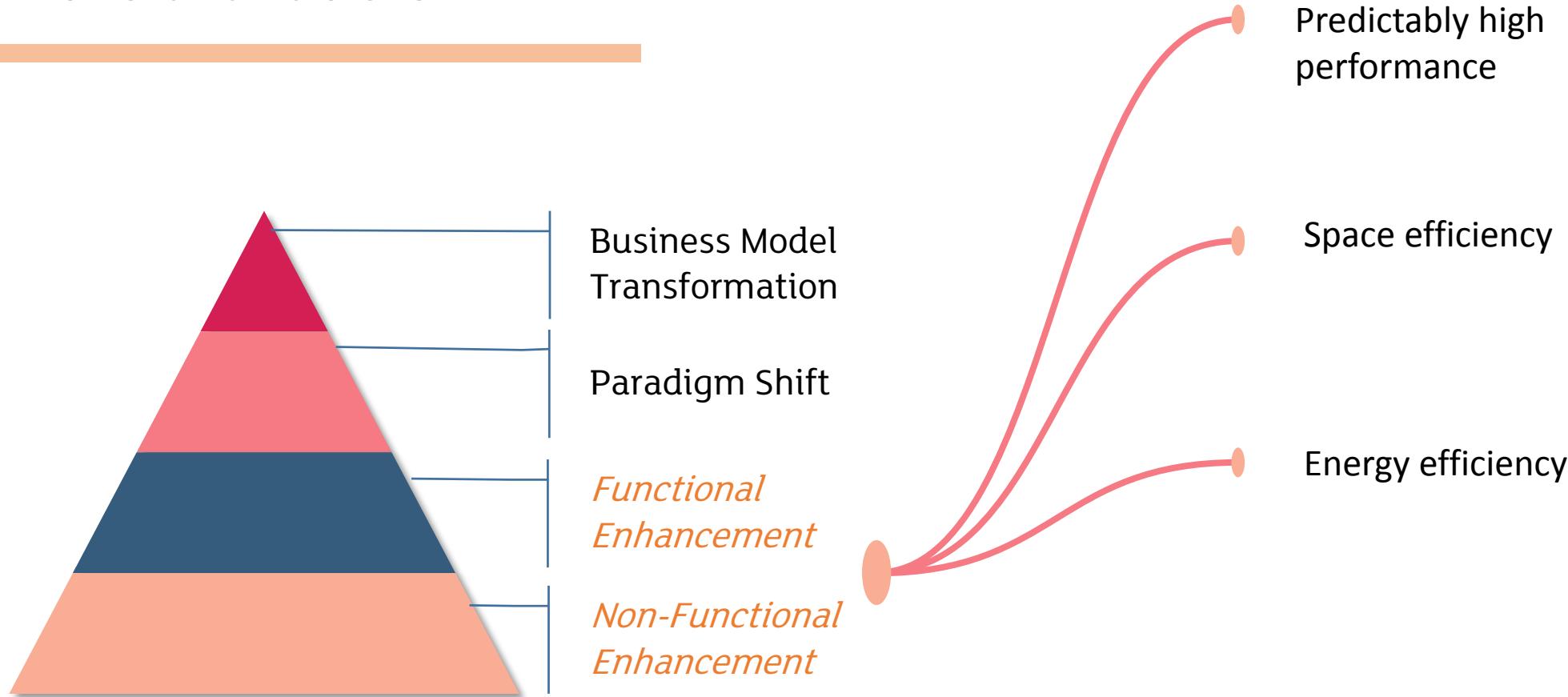


Heterogeneous Approach - Differentiator or Killer?

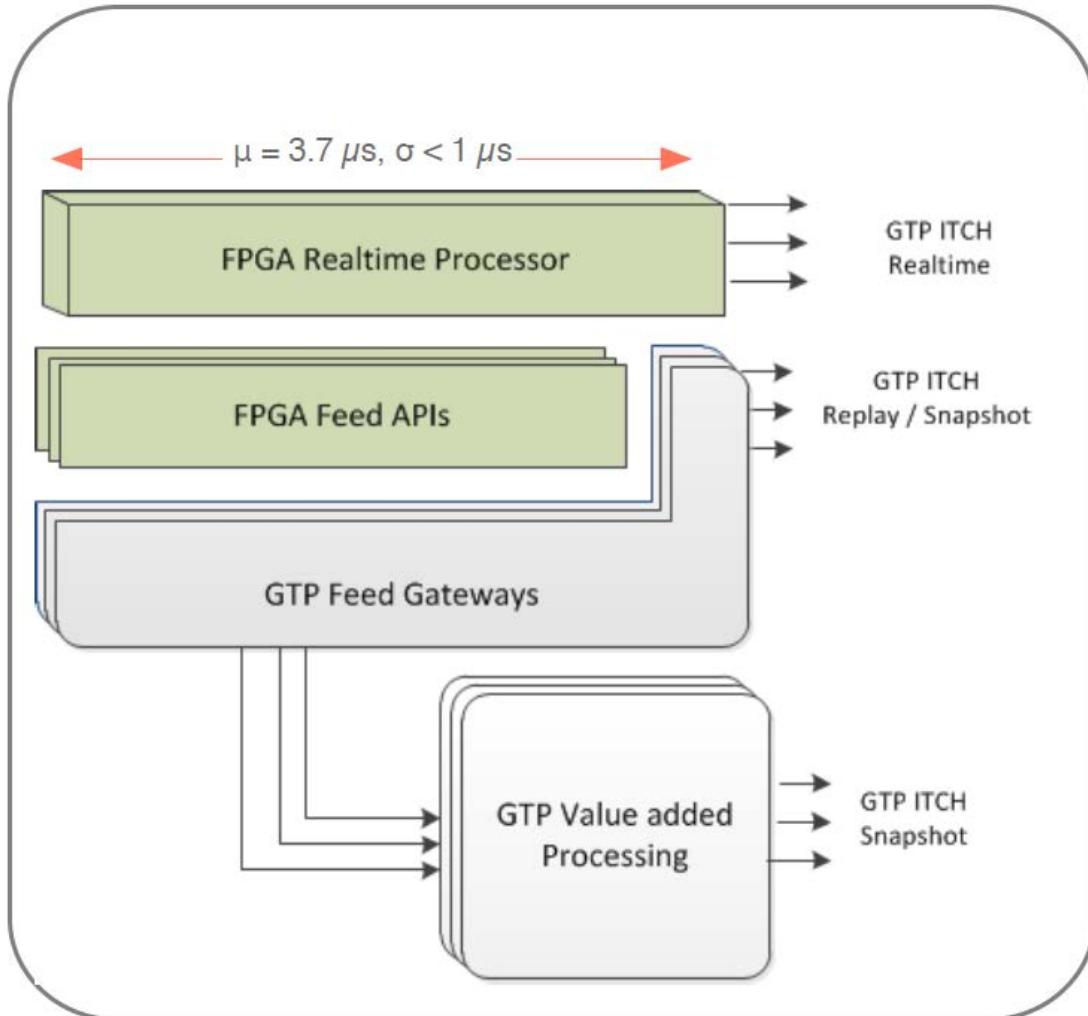
Value Creation



Value Creation



Case : Real Time Market Data

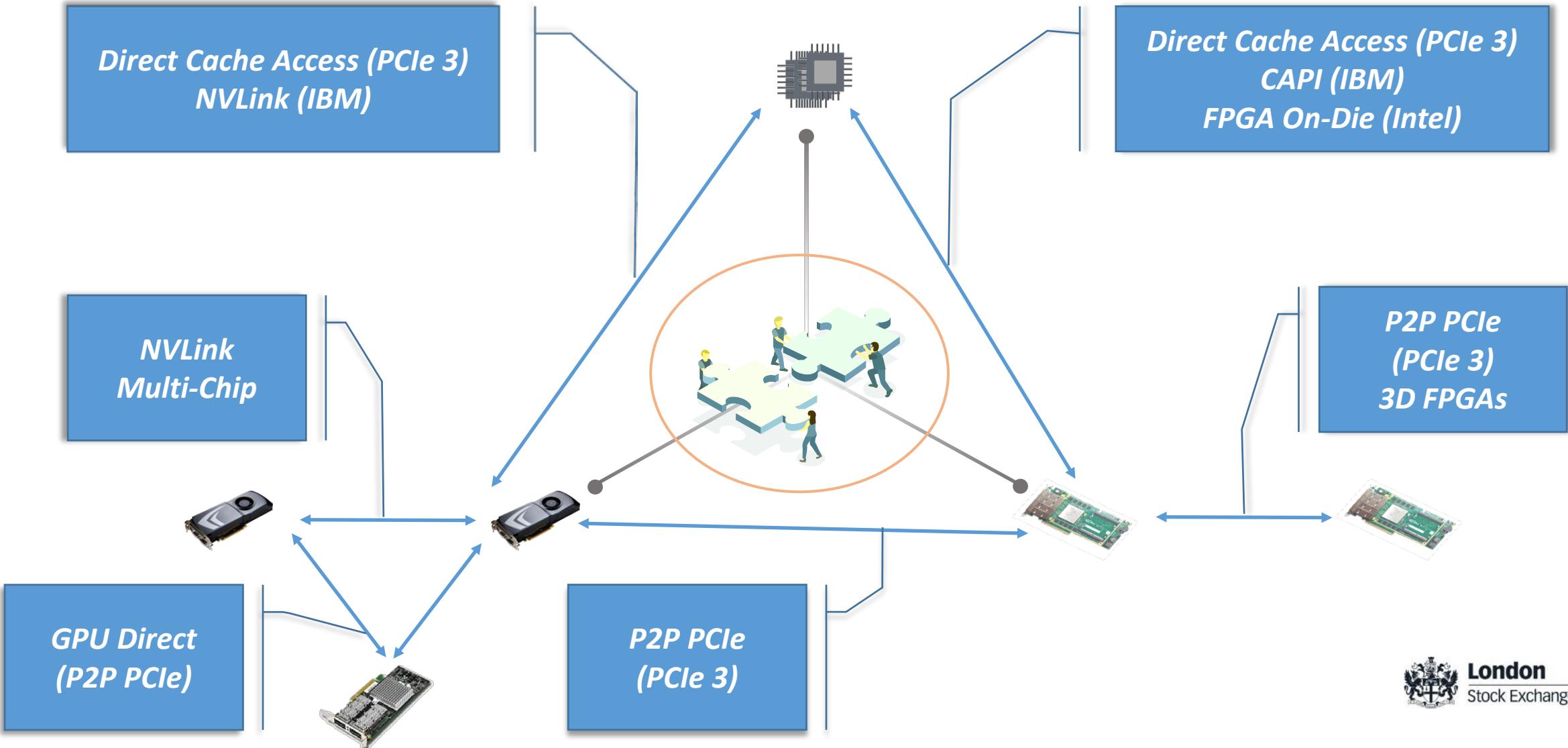


- Coarse – grained mapping to Processors
 - *Realtime – FPGA / Rest CPU*
 - *Sub-component on FPGA*
 - *Matching scalability*
 - *Boundary inefficiency*
 - *Use case based optimization*

Consistent (>10x) performance at best space efficiency.

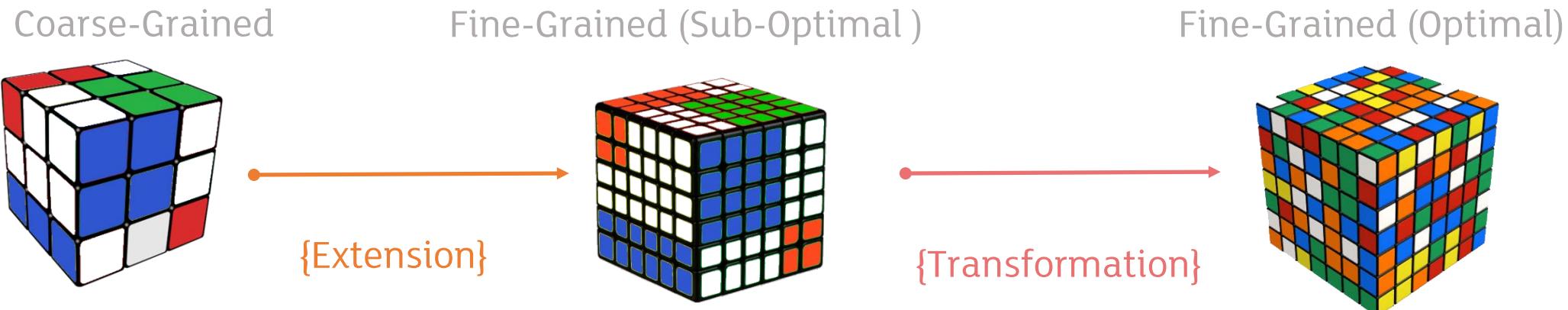
- *Best Execution Transparency*
- *Open Access*
- *Increased liquidity*
- *Balanced Performance & Configurability*

The Convergence



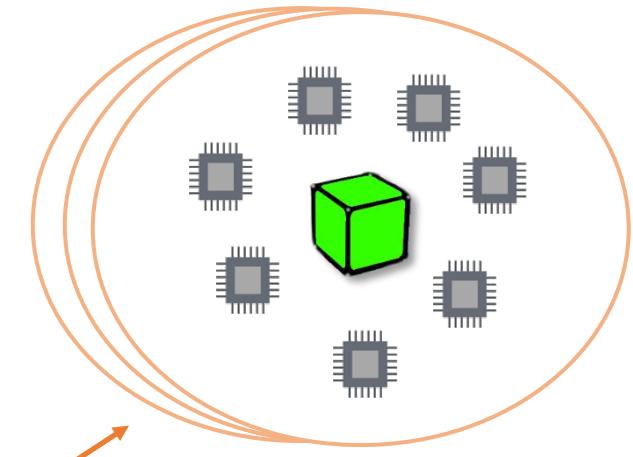
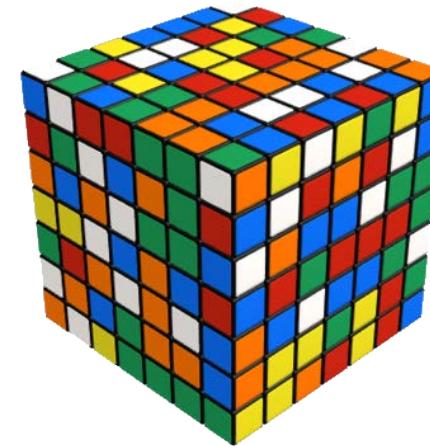
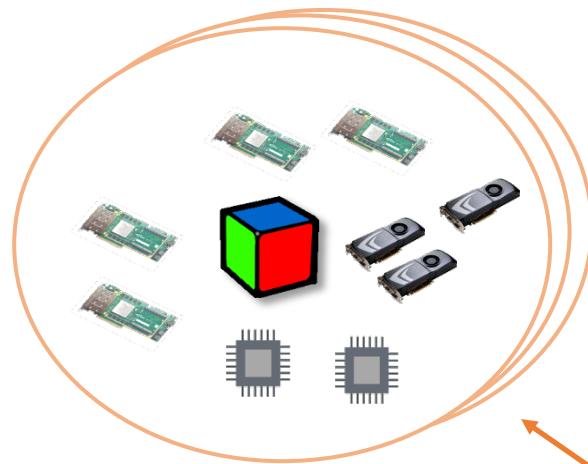
Goldilocks Problem Gets Complex

Challenge!



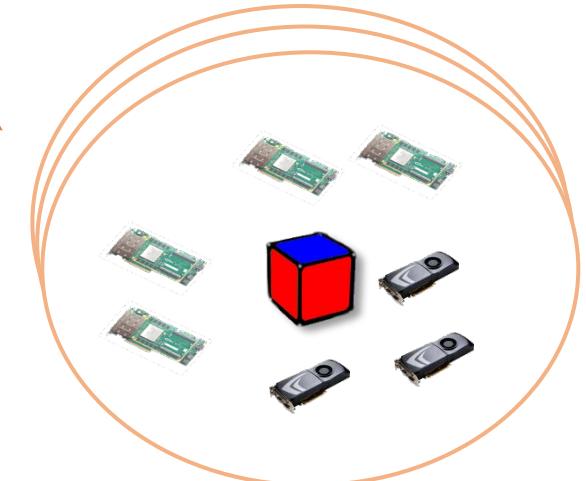
Tackling the Challenge

“Fine-Grained Modular Designs”



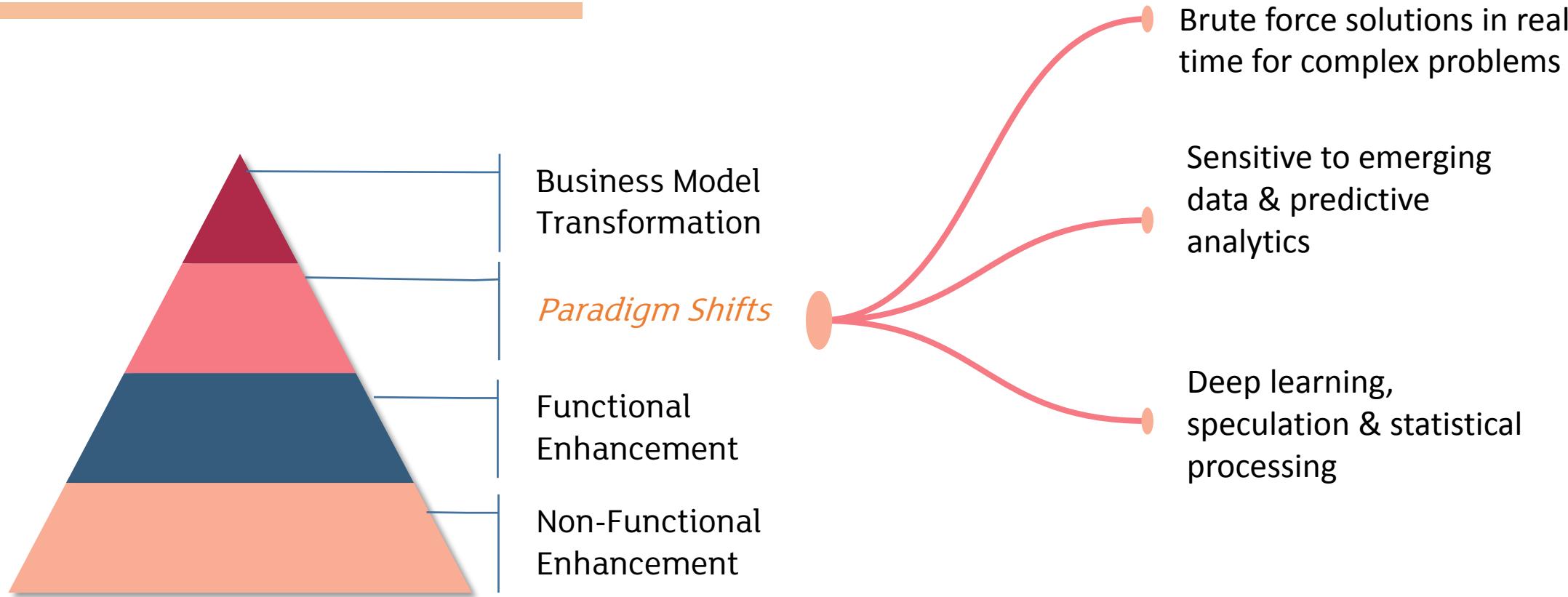
“Domain Specific Descriptions”

“User Scheduled”

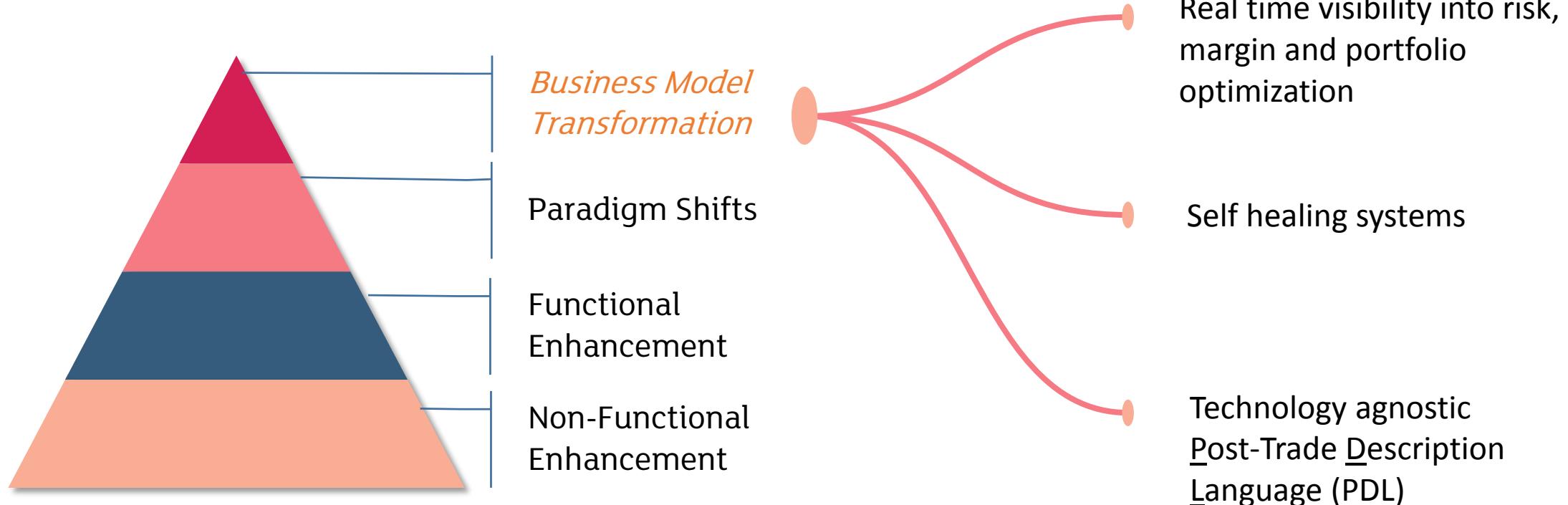


“Dynamic / Late Mapping”

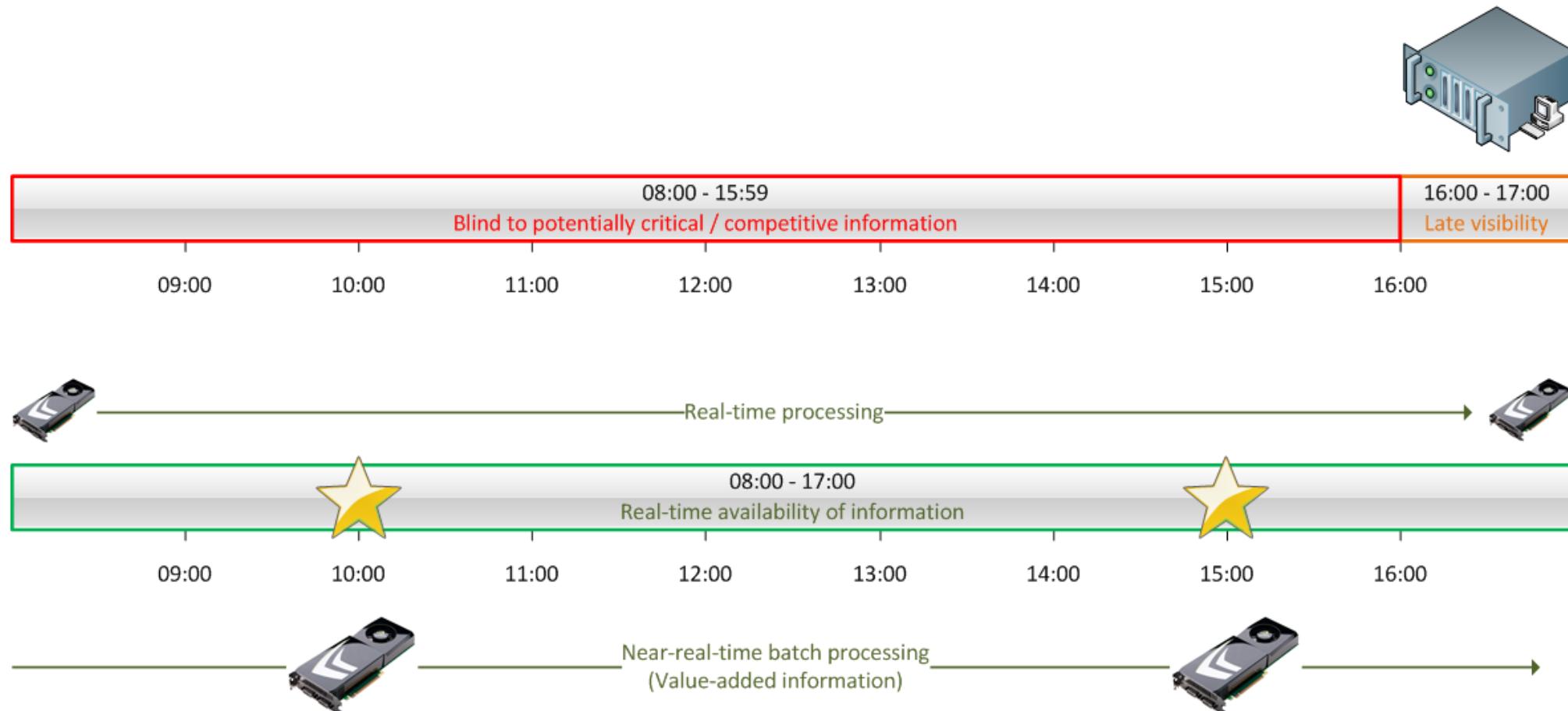
Value Creation



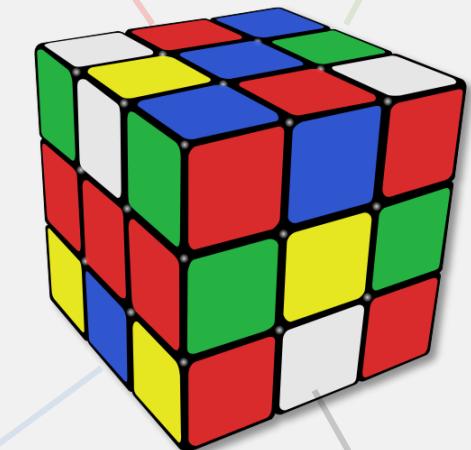
Value Creation



Case : Real Time Risk



Thank you



Thayaparan Sripavan
thaya@millenniumit.com