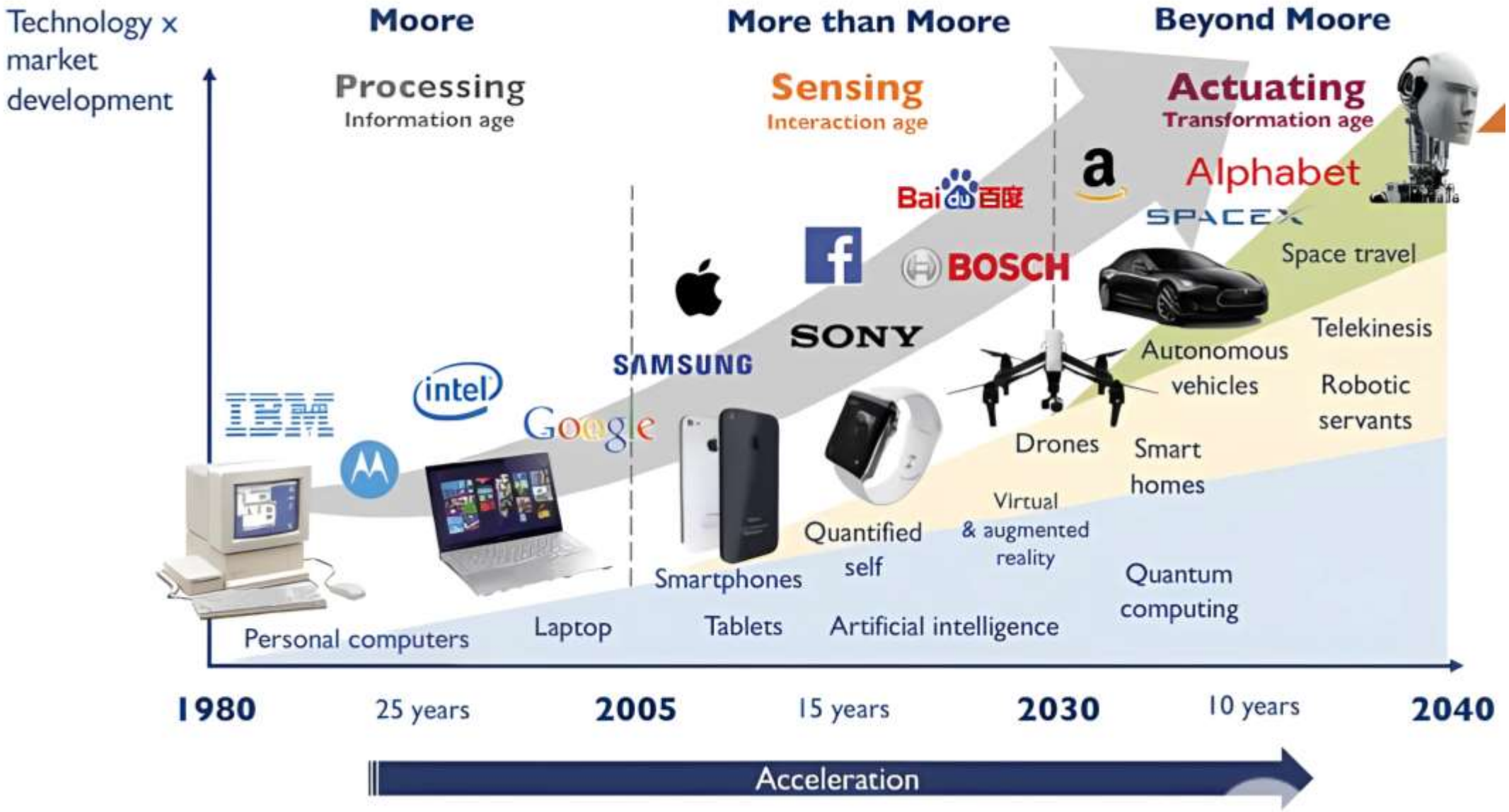
Early-Stage SoC Design Exploration for Domain-Specific Applications

Tapas Rout
Junior Research Fellow (PhD)
School of Electrical and Computer Sciences (ECE)
tapas@asicbyte.com

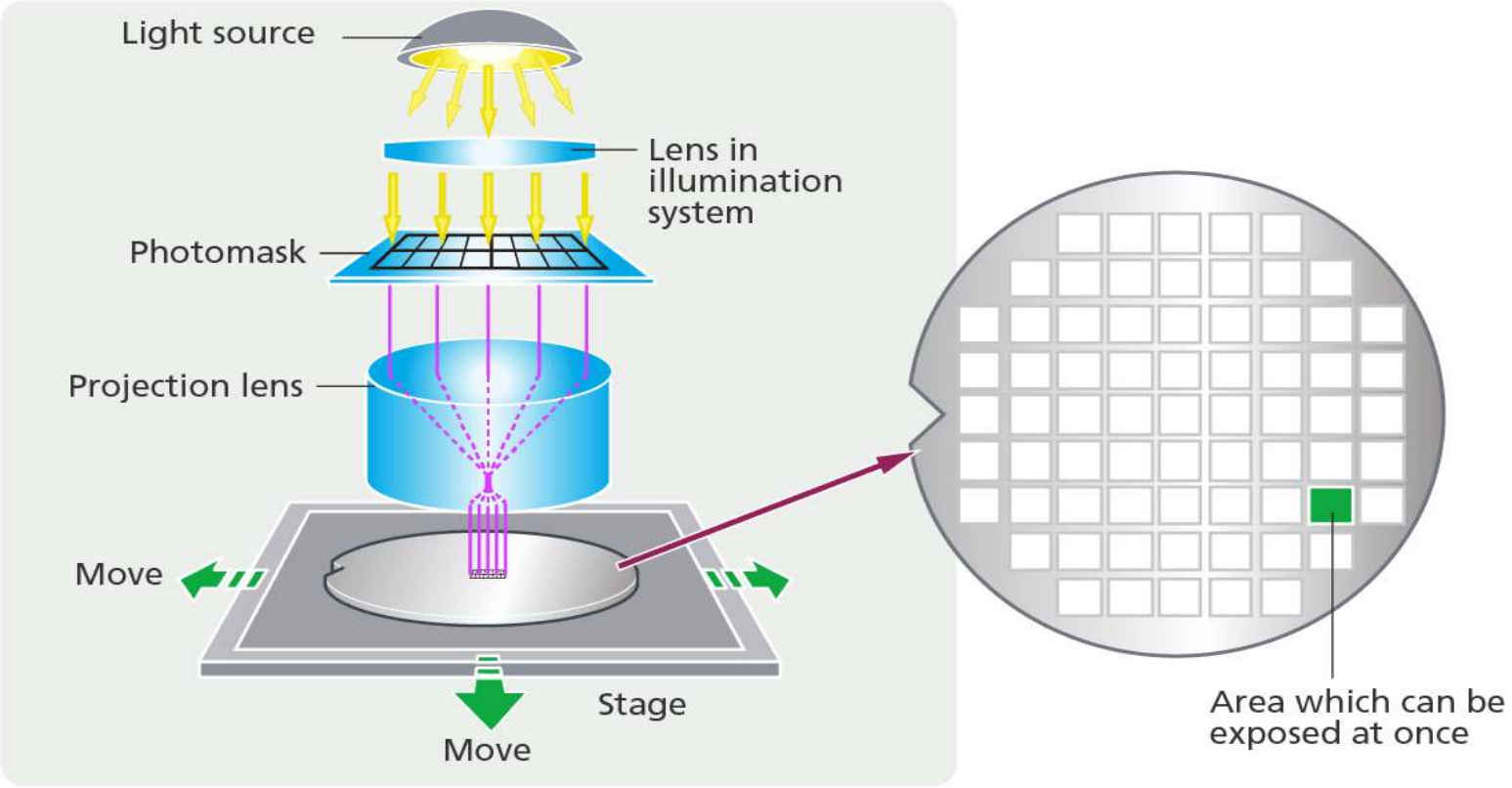
Intuitive Questions

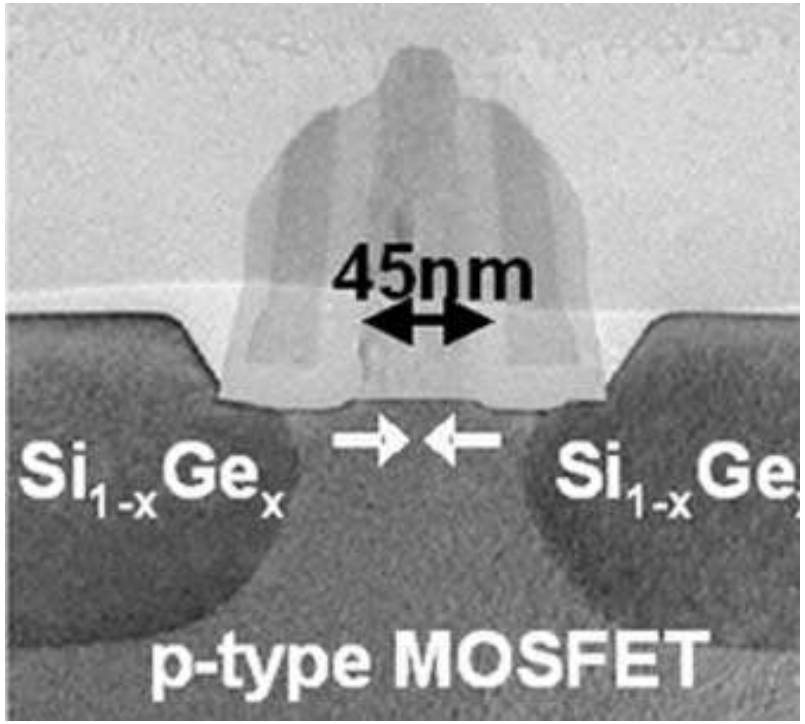
- *What is the meaning of Design Space Exploration (DSE) ?*
- *Can System on Chip (SoC) be designed without DSE ?*
- *What is the big deal about Domain Specific Applications ?*

Evolution of Consumer Electronics

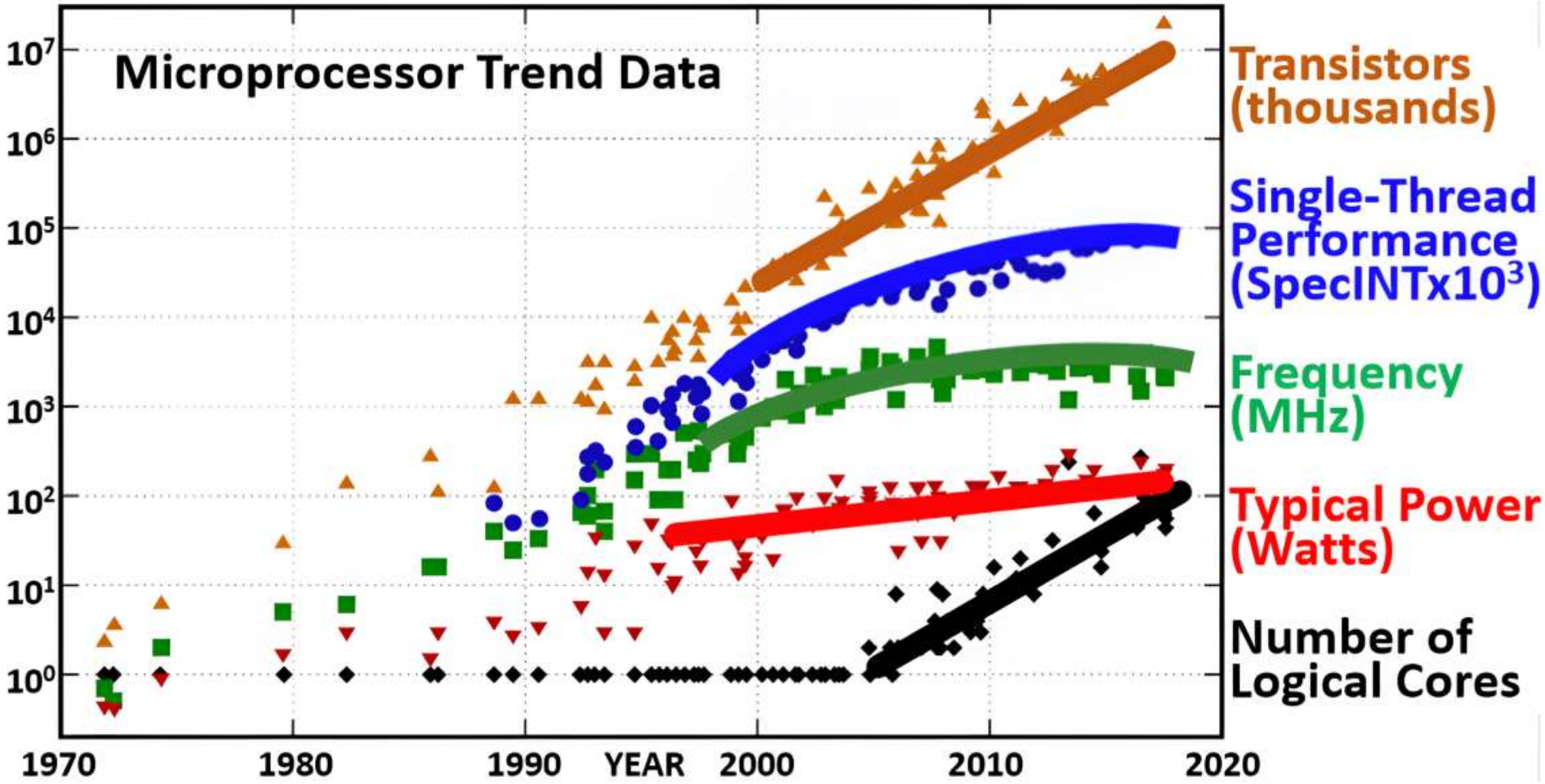


How Chips Are Made?

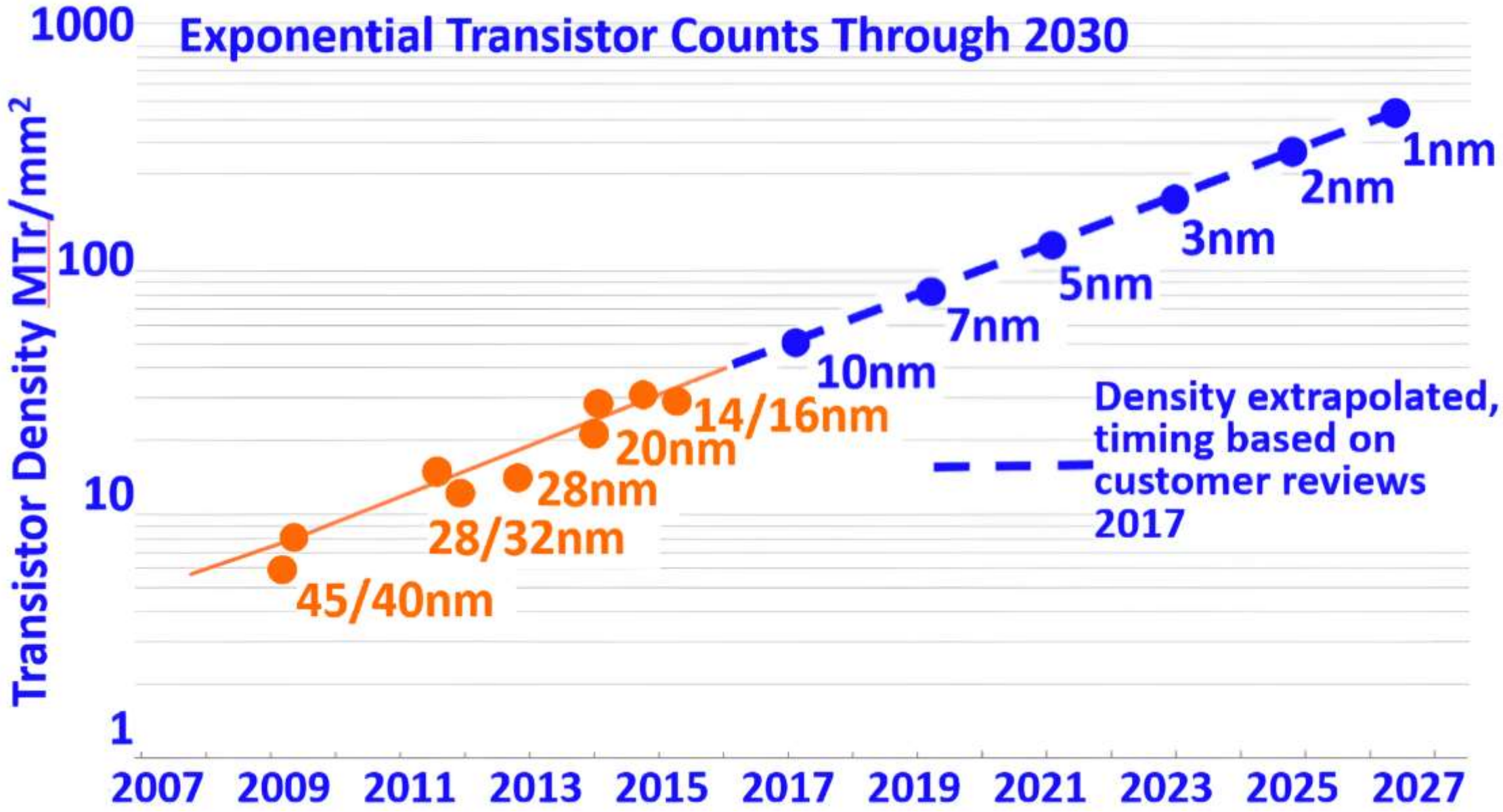


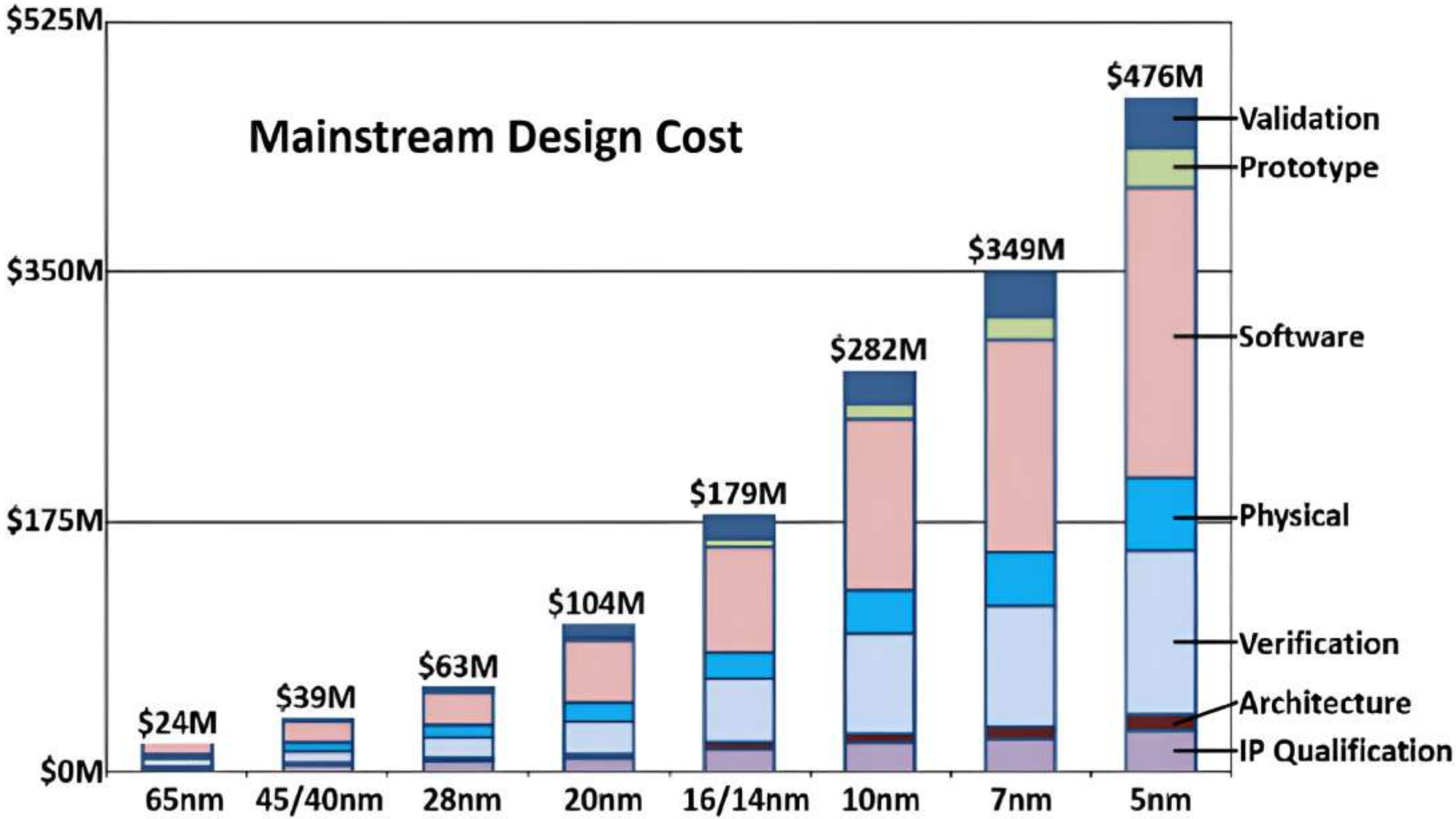


Current Challenges



Moore's Law: Dead or Alive

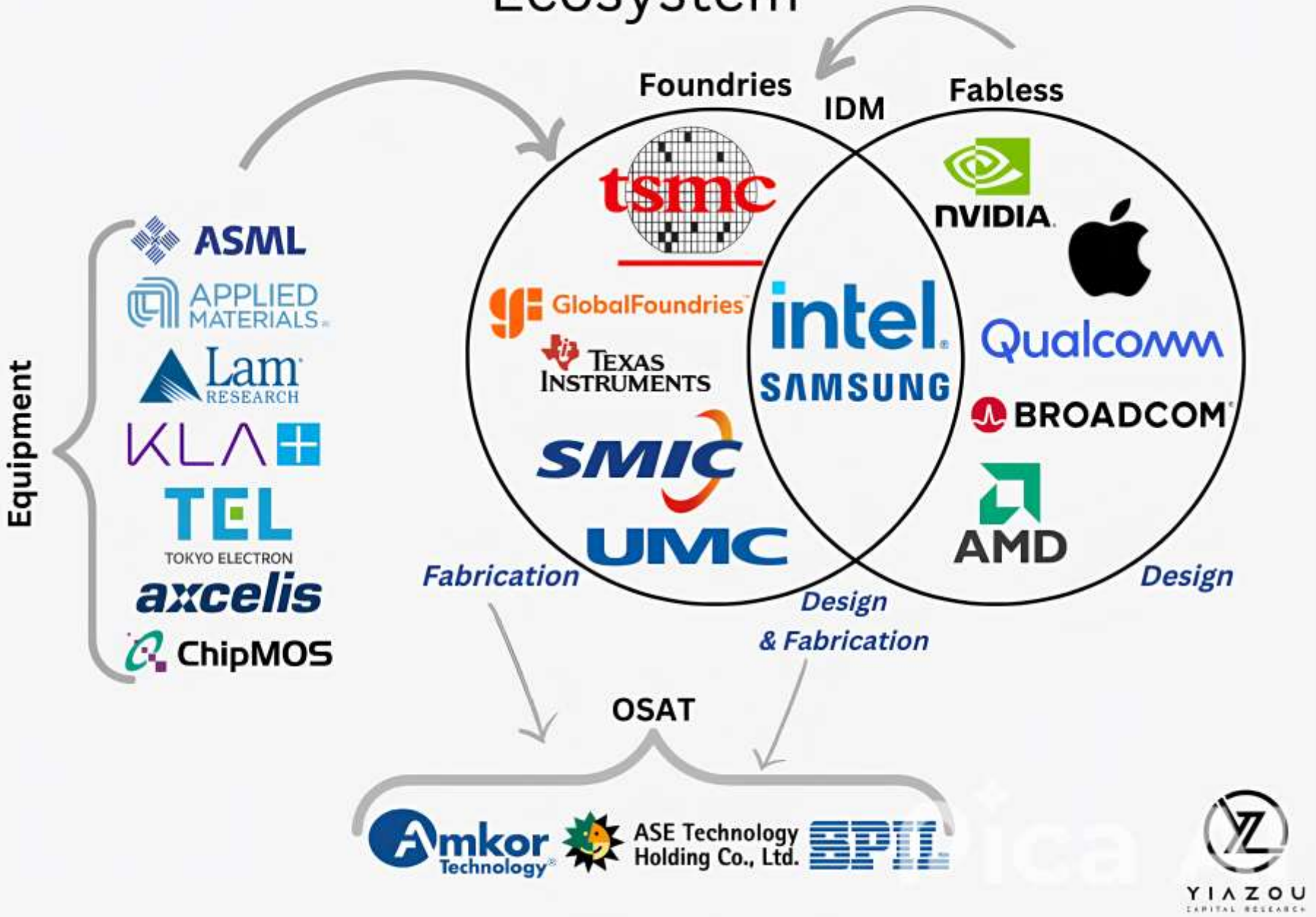



Mainstream Design Cost
$525M
$350M
$175M
$0M
$24M
$39M
$63M
$104M
$179M
$282M
$349M
$476M
65nm
45/40nm
28nm
20nm
16/14nm
10nm
7nm
5nm
Validation
Prototype
Software
Physical
Verification
Architecture
IP Qualification

Fab Consolidation

90nm	65nm	45/40nm	32/28nm	22/20nm	7nm
Dongbu HiTek	Infineon	SMIC	UMC	Globalfoundries	TSMC
Grace Semi	Sony	Toshiba	STMicroelectronics	TSMC	Intel
Seiko Epson	Texas Instruments	Fujitsu	Globalfoundries	Intel	Samsung
Freescale	SMIC	Renesas (NEC)	TSMC	Samsung	
Infineon	Toshiba	IBM	Intel		
Sony	Fujitsu	UMC	Samsung		
Texas Instruments	Renesas (NEC)	STMicroelectronics			
SMIC	IBM	Globalfoundries			
Toshiba	UMC	TSMC			
Fujitsu	STMicroelectronics	Intel			
Renesas (NEC)	Globalfoundries	Samsung			
IBM	TSMC				
UMC	Intel				
STMicroelectronics	Samsung				
Globalfoundries					
TSMC					
Intel					
Samsung					

Ecosystem



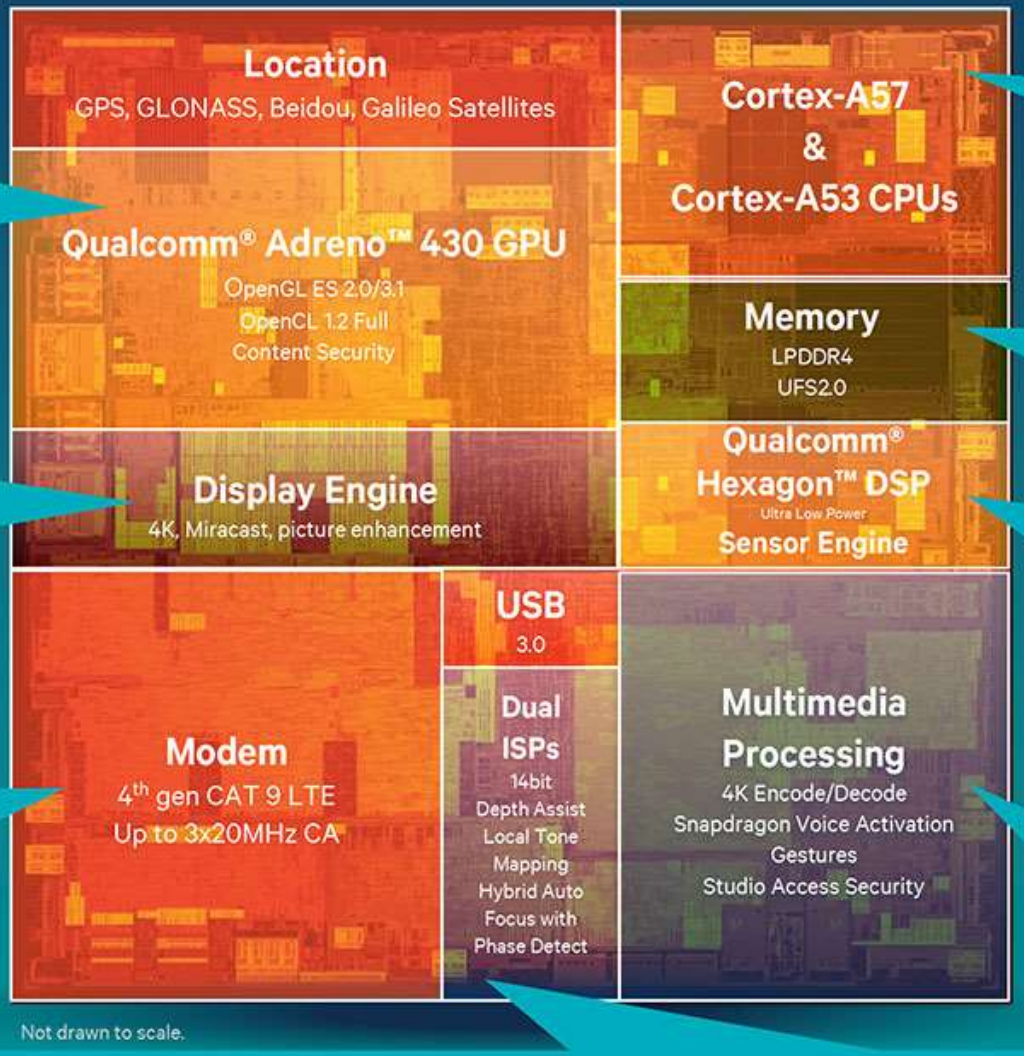
YIAZOU CAPITAL RESEARCH

Introducing the Snapdragon 810 Processor

Advanced Graphics & Compute with the Adreno 430 – the best GPU Qualcomm Technologies' has ever made

4K primary & external display support with ecoPix and TruPalette and 3:1 pixel compression

Mobile industry's FIRST announced multi-channel 4G LTE SoC supporting Category 9 Carrier Aggregation



Not drawn to scale.

FIRST Announced ARM®v8-A/64-bit using Cortex®-A57+ Cortex®-A53

Mobile industry's FIRST announced dual channel 1600 MHz LPDDR4 memory

Qualcomm Technologies' FIRST UFS 2.0 Support

Greatly improved power management for DSP/Sensor Engine, Low Power Snapdragon Voice Activation (SVA), 12-channel surround sound decode

Qualcomm Technologies' FIRST hardware implementation of 4K HEVC/ H.265 video encode. HEVC designed to deliver up to 50% better video compression

Qualcomm Technologies' FIRST 14-bit Dual ISP for highest quality, depth enabled photography. Up to 21MP for main camera with depth assist, phase detect, for sharper dual camera user experiences

Qualcomm Adreno and Qualcomm Hexagon are pro

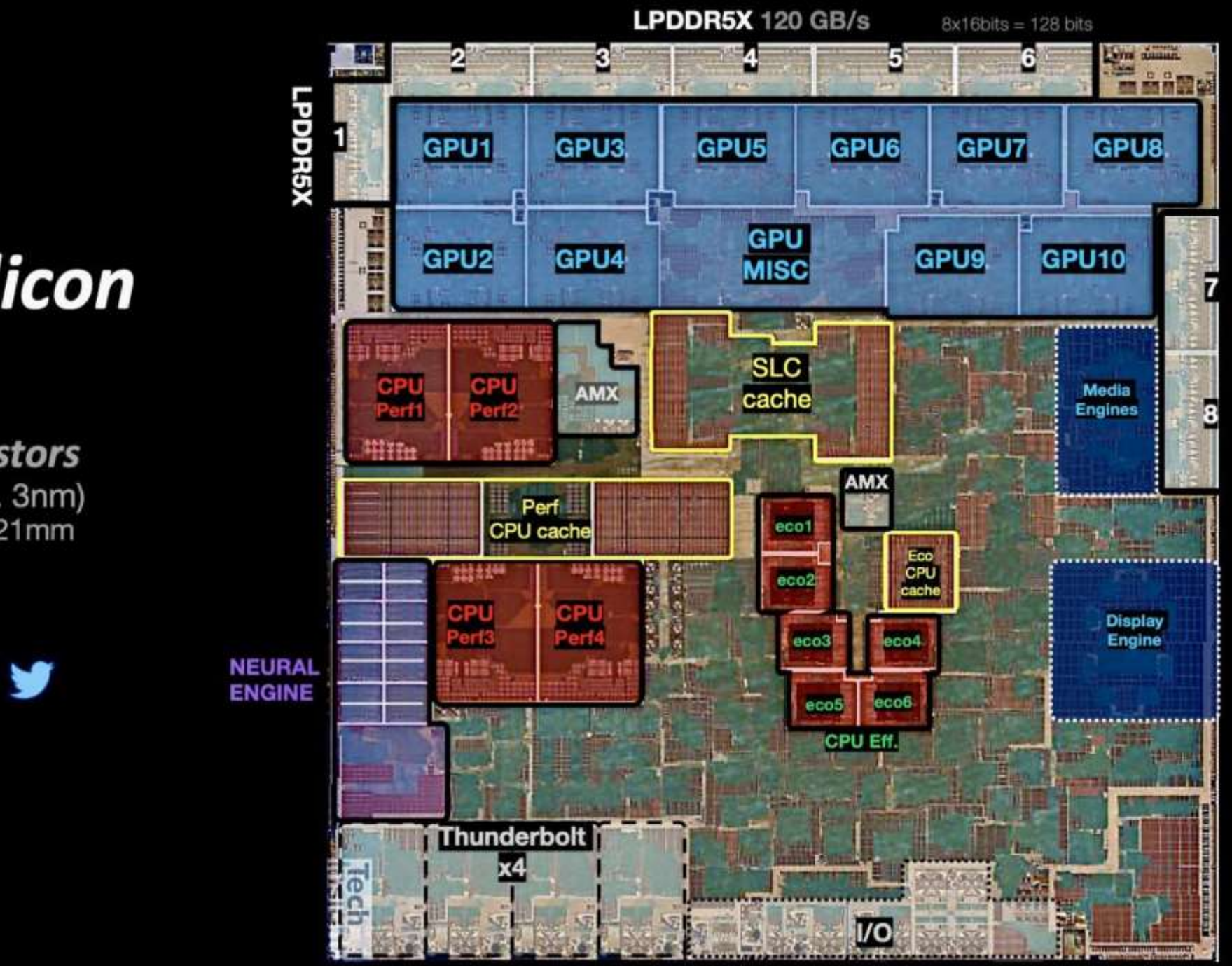
Apple Silicon M4

28 billion transistors

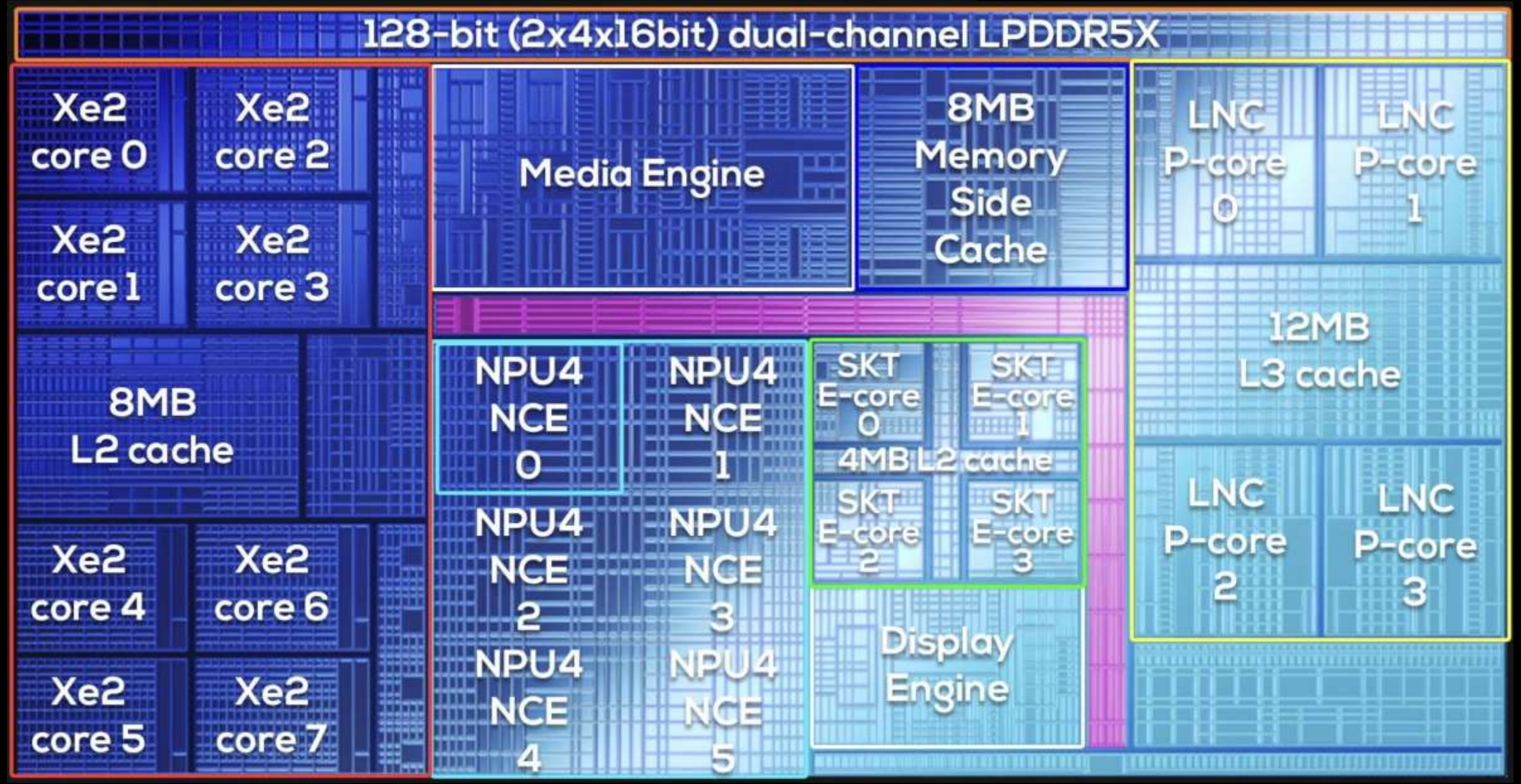
N3E TSMC (2n gen. 3nm)

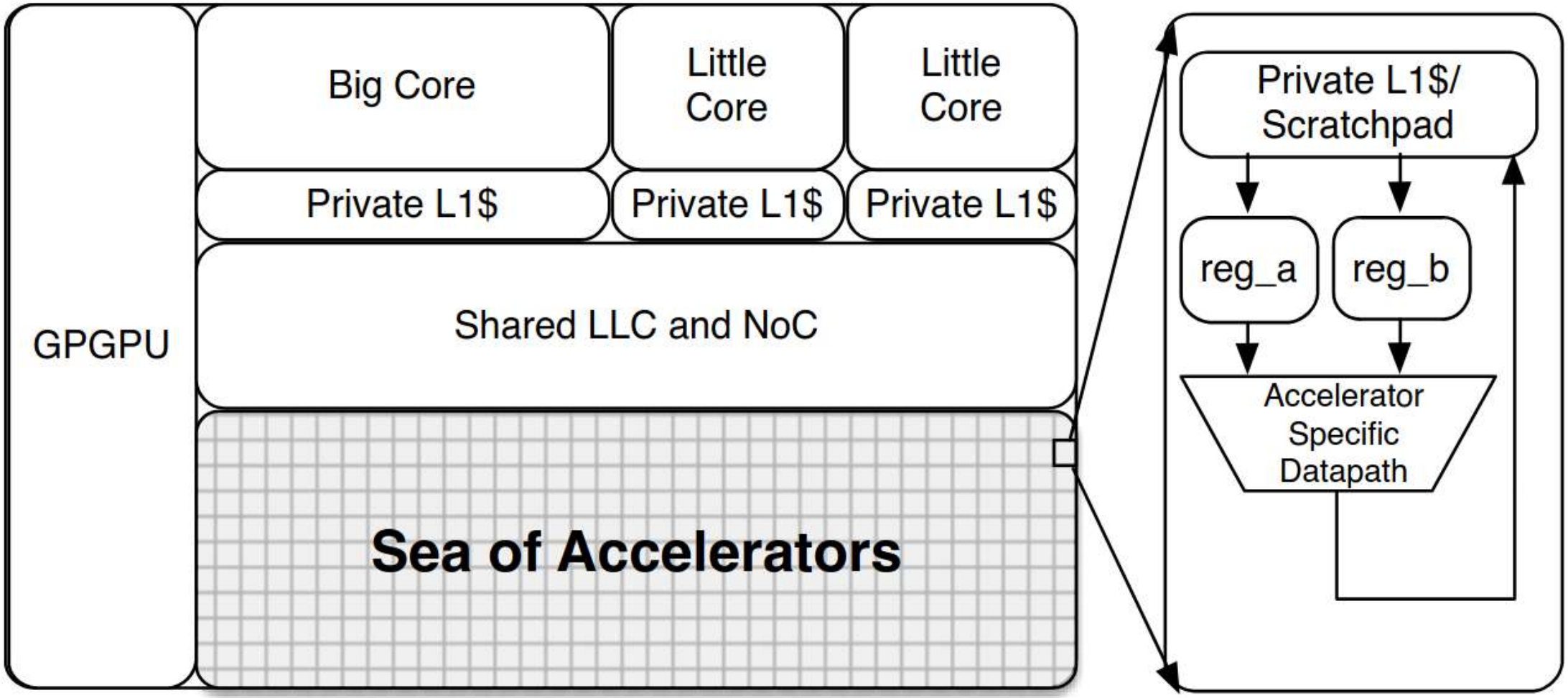
Die zise : 1.28mm x1,21mm

Frederic_Orange

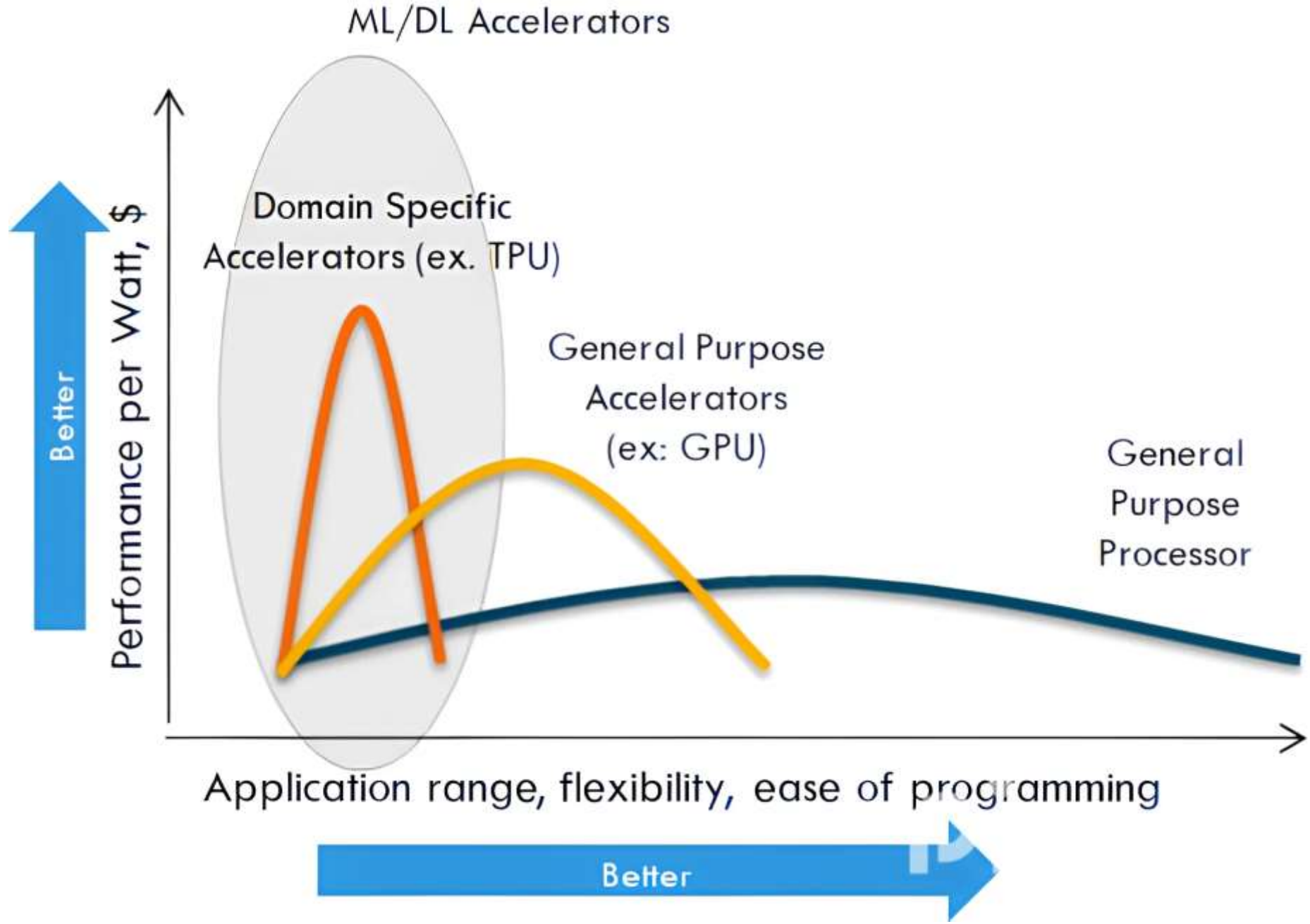


Intel Lunar Lake Die Shot



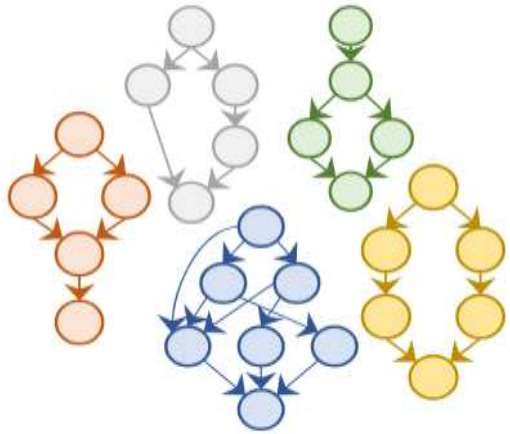


Shao, Y., Reagen, B., Wei, G., & Brooks, D. (2014). Aladdin: A Pre-RTL, Power-Performance Accelerator Simulator. ISCA.


ML/DL Accelerators
Domain Specific
Accelerators (ex. TPU)
General Purpose
Accelerators
(ex: GPU)
General
Purpose
Processor
Better
Performance per Watt, $
Application range, flexibility, ease of programming
Better

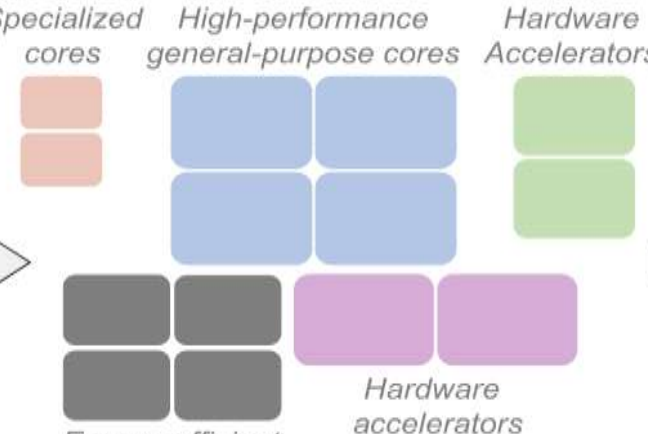
Domain applications

Extraction of parallel data flow graphs from monolithic codes



Extraction of key computational kernels and communication info. between kernels

Identification of specialized hardware elements from kernels



Domain Representation

Domain representation used to:

Identify candidates for hardware acceleration
Section 3

Provide design-time information to resource management algorithms
Section 4

Interface with software
Section 5

Hardware Components for DSAs

Fixed-Function Accelerators

Targeted acceleration of a particular kernel

Examples:
- Fast Fourier transform (FFT)
- Neural network inference
- Matrix multiplication
- Encryption and decryption

Specialized Processors

Accelerates a set of kernels in a specific domain

Examples:
- Systolic array processors
- Coarse-grained reconfigurable architectures
- General-purpose GPUs

General-Purpose Processors

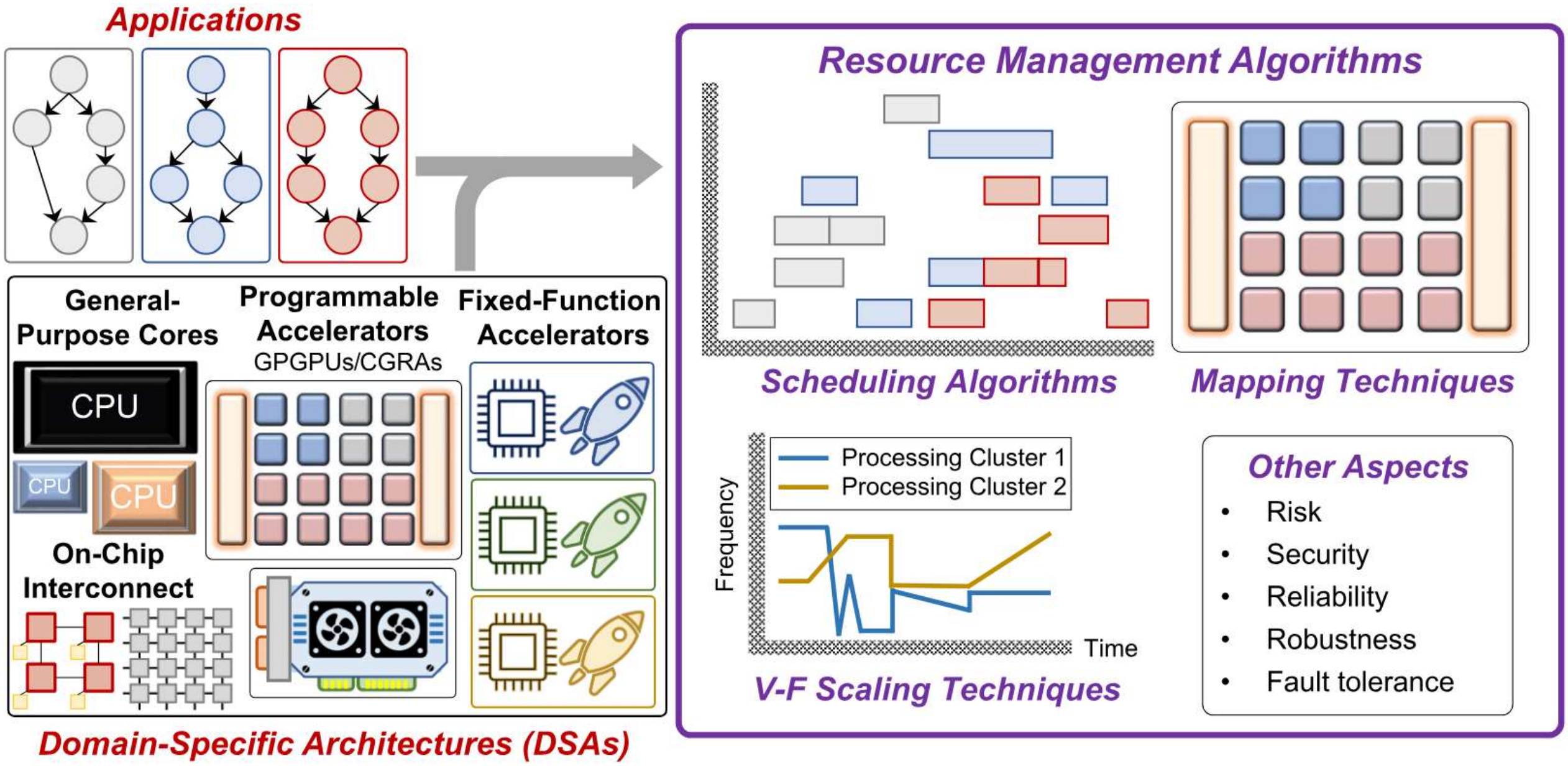
Provides flexibility in quickly implementing new kernels or kernels from unknown domains

Examples:
- x86
- Arm
- RISC-V

On-Chip Interconnect

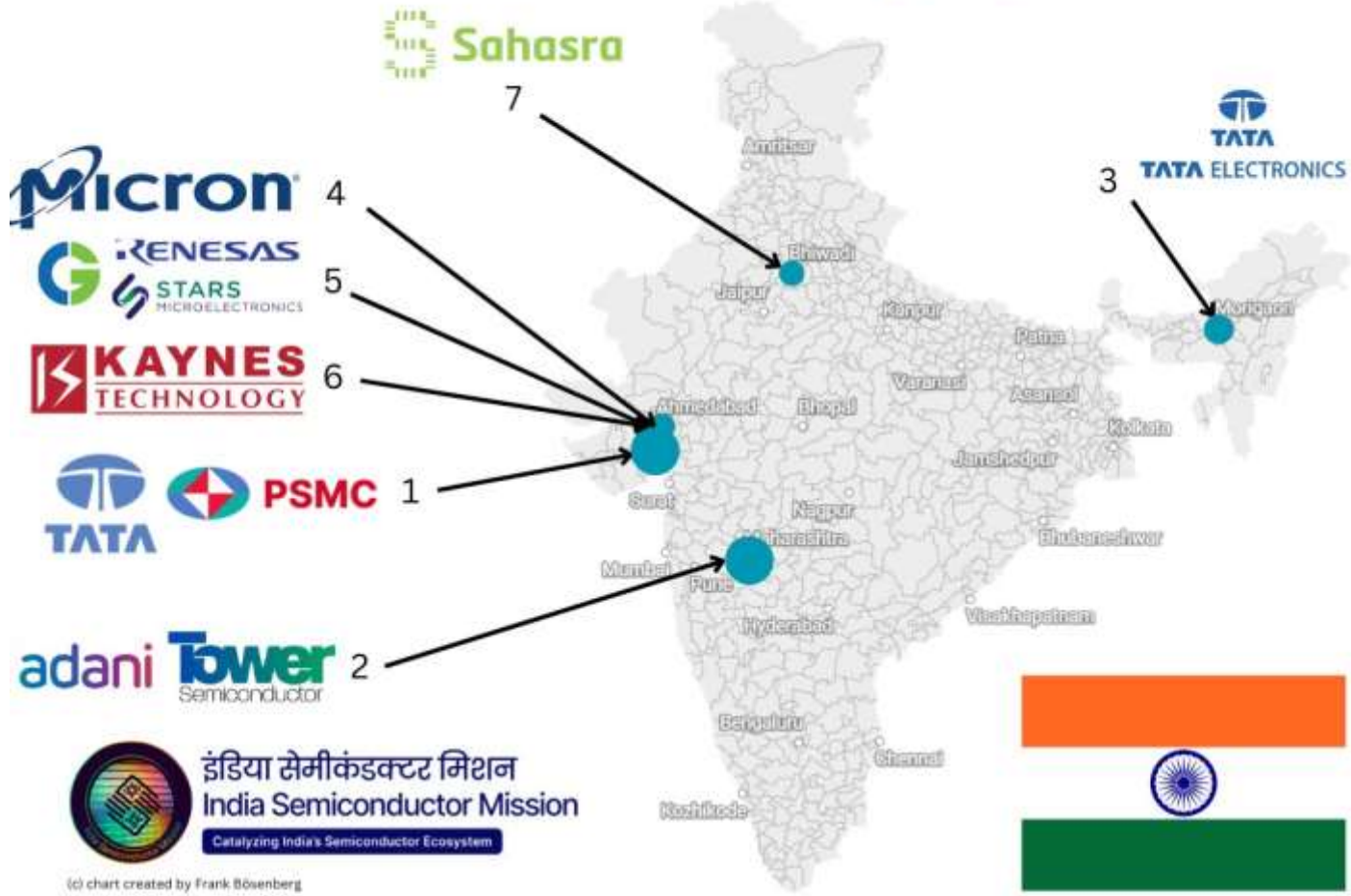
Energy-efficient on-chip data movement between different processing elements

Examples:
- Crossbar
- Network-on-chip
- Bus, point-to-point



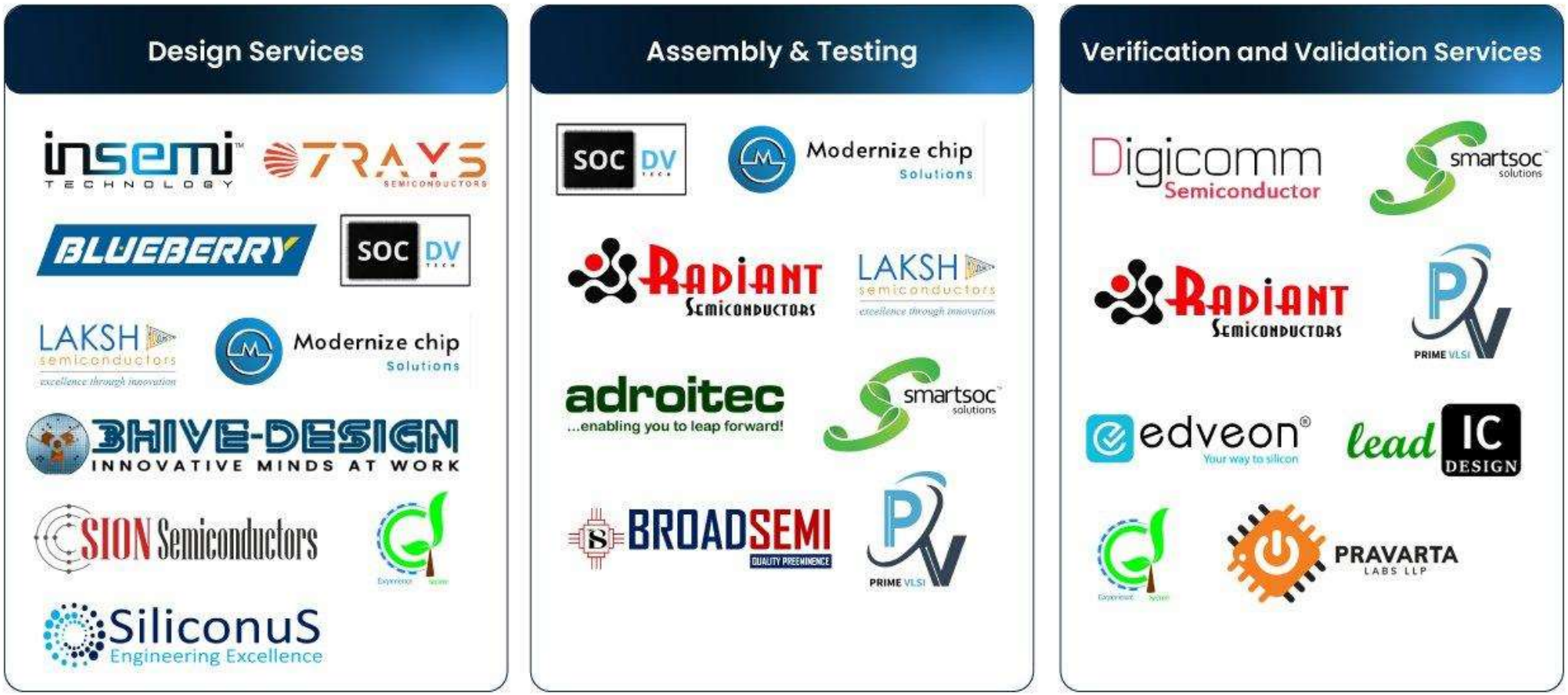
Boroujerdian, B., Jing, Y., & Tripathy, D. (Year). FARSI: An early-stage design space exploration framework to tame the domain-specific system-on-chip complexity. ACM Transactions on Embedded Computing Systems.

Semiconductor manufacturing projects in India



No	Location	What	Invest
1	Dholera, Gujarat	Frontend - up to 28 nm	$ 11 bn
2	Taloja, Maharashtra	Frontend - up to 40 nm	$ 10 bn
3	Jagiroad, Assam	Backend - wirebond, flipchip, ISP	$ 3,2 bn
4	Sanand, Gujarat	Backend - DRAM + NAND assembly + test	$ 2,75 bn
5	Sanand, Gujarat	Backend - OSAT, legacy + advanced packaging	$ 900 Mio
6	Sanand, Gujarat	Backend - OSAT, 70% advanced packaging	$ 394 Mio
7	Bhiwadi, Rajastan	Backend - Assembly, test, packaging - Memory	$ 42 Mio

Landscape Of Semiconductor Services Startups In India



Thank You

tapas@asicbyte.com