Energy Aware Memory Technology and New Memory System Hierarchy

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Align with your imagination

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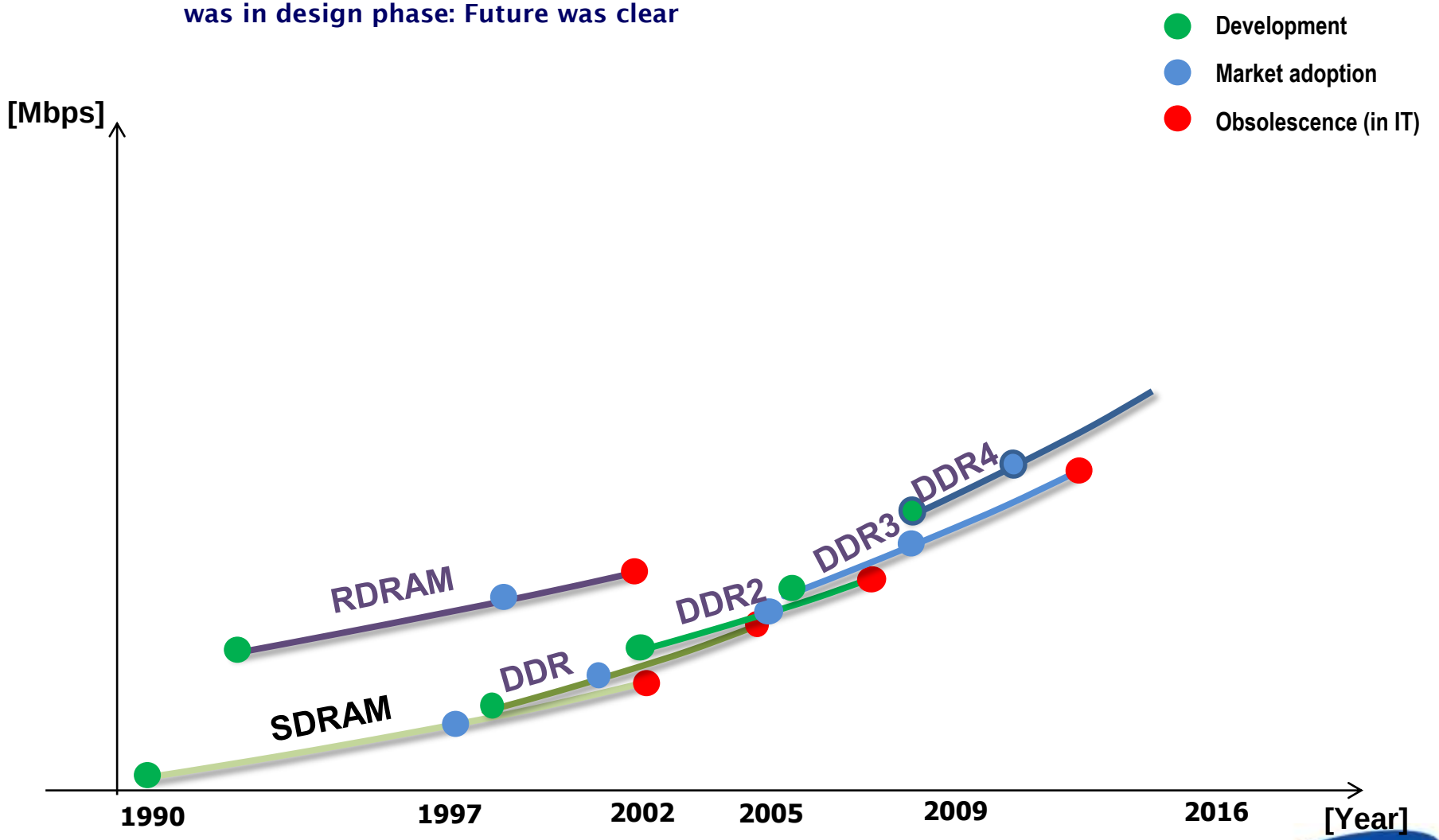
Waking up from long lethargy

- **What we know today**
  - So far: when new technology was on starting block, next generation technology was in design phase: Future was clear

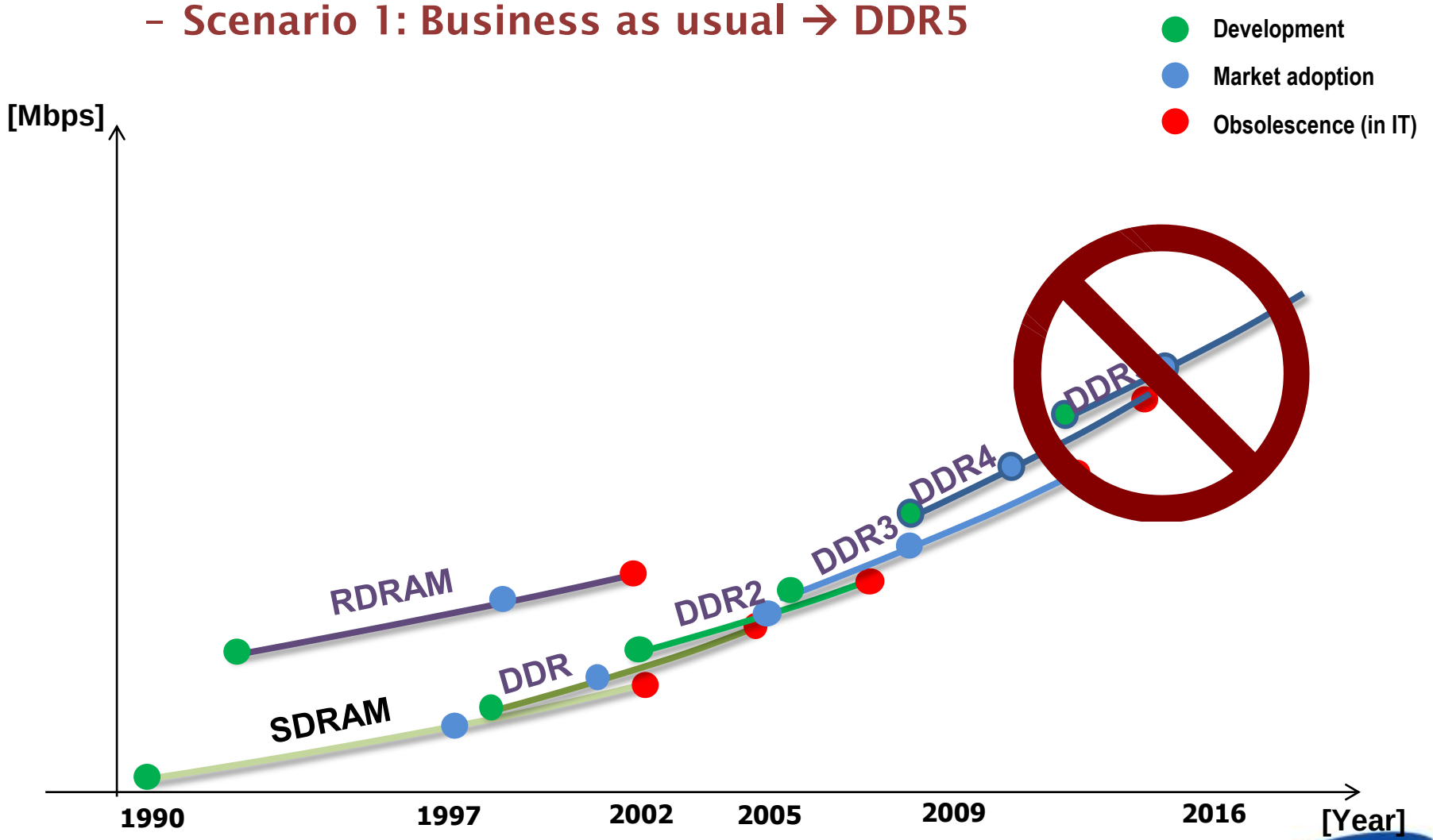


*Highest speed in that year

Waking up from long lethargy

- **What will come next?**

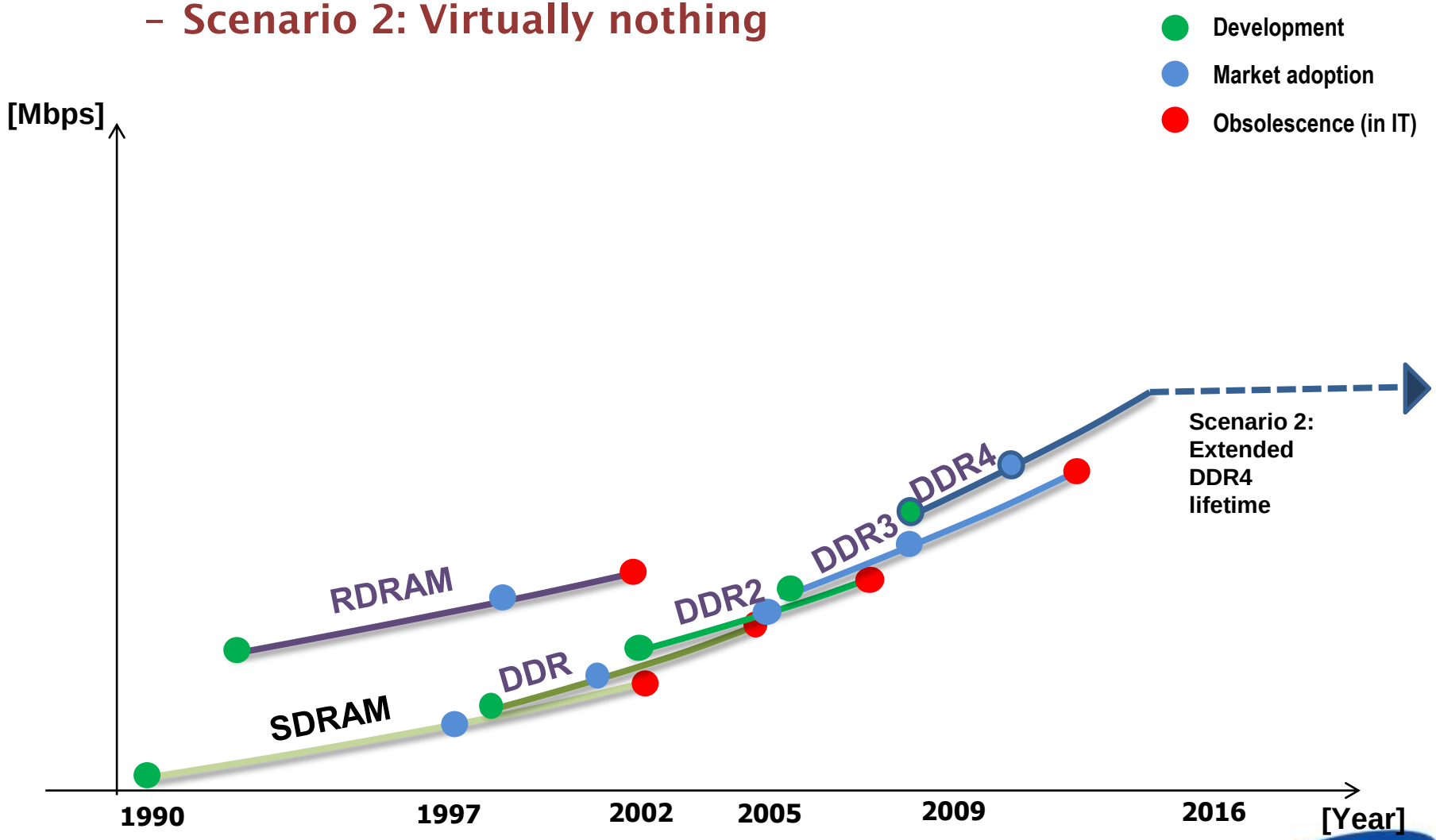
  - Scenario 1: Business as usual → DDR5



*Highest speed in that year

Waking up from long lethargy

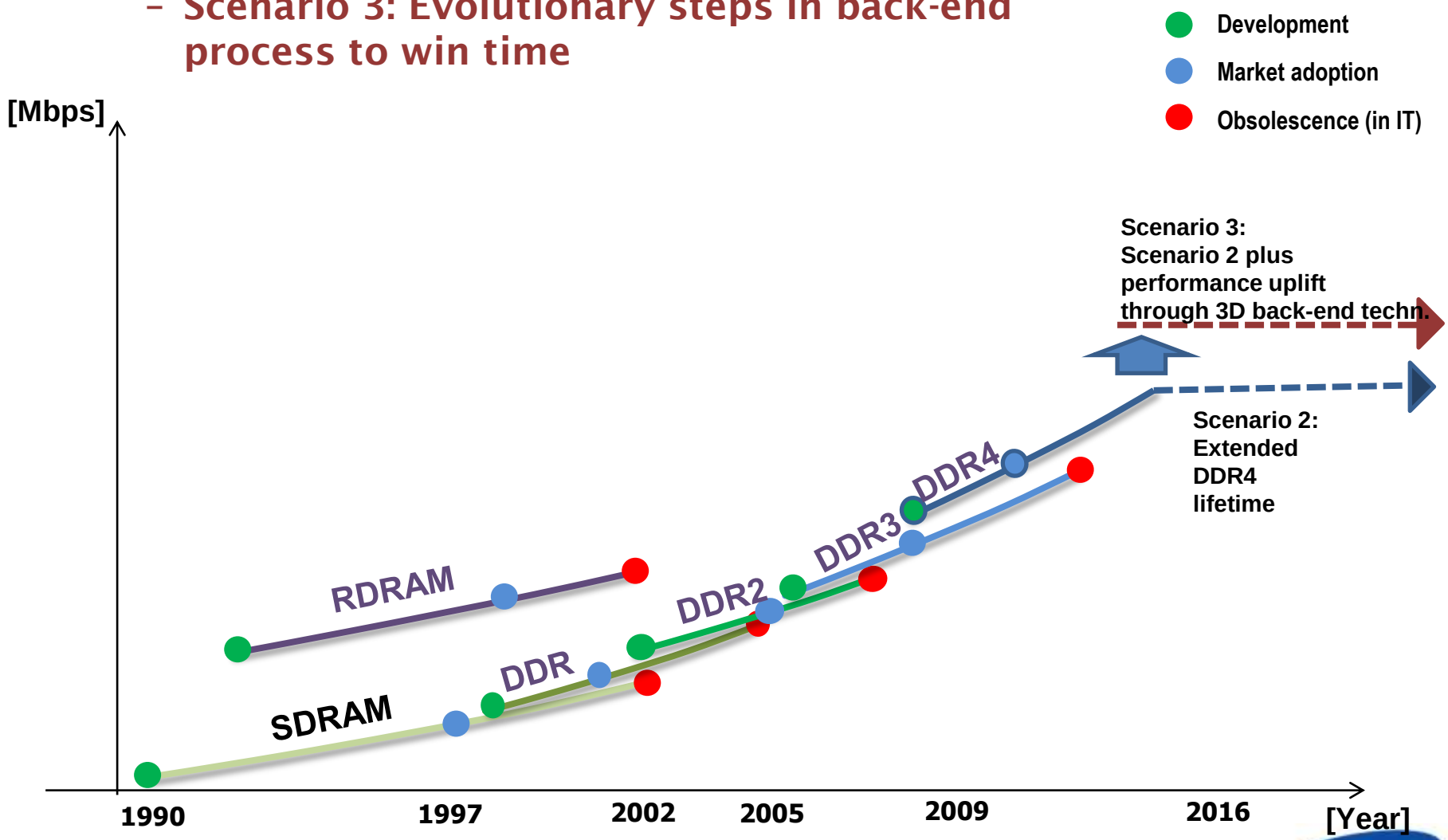
- **What will come next?**
  - Scenario 2: Virtually nothing



*Highest speed in that year

Waking up from long lethargy

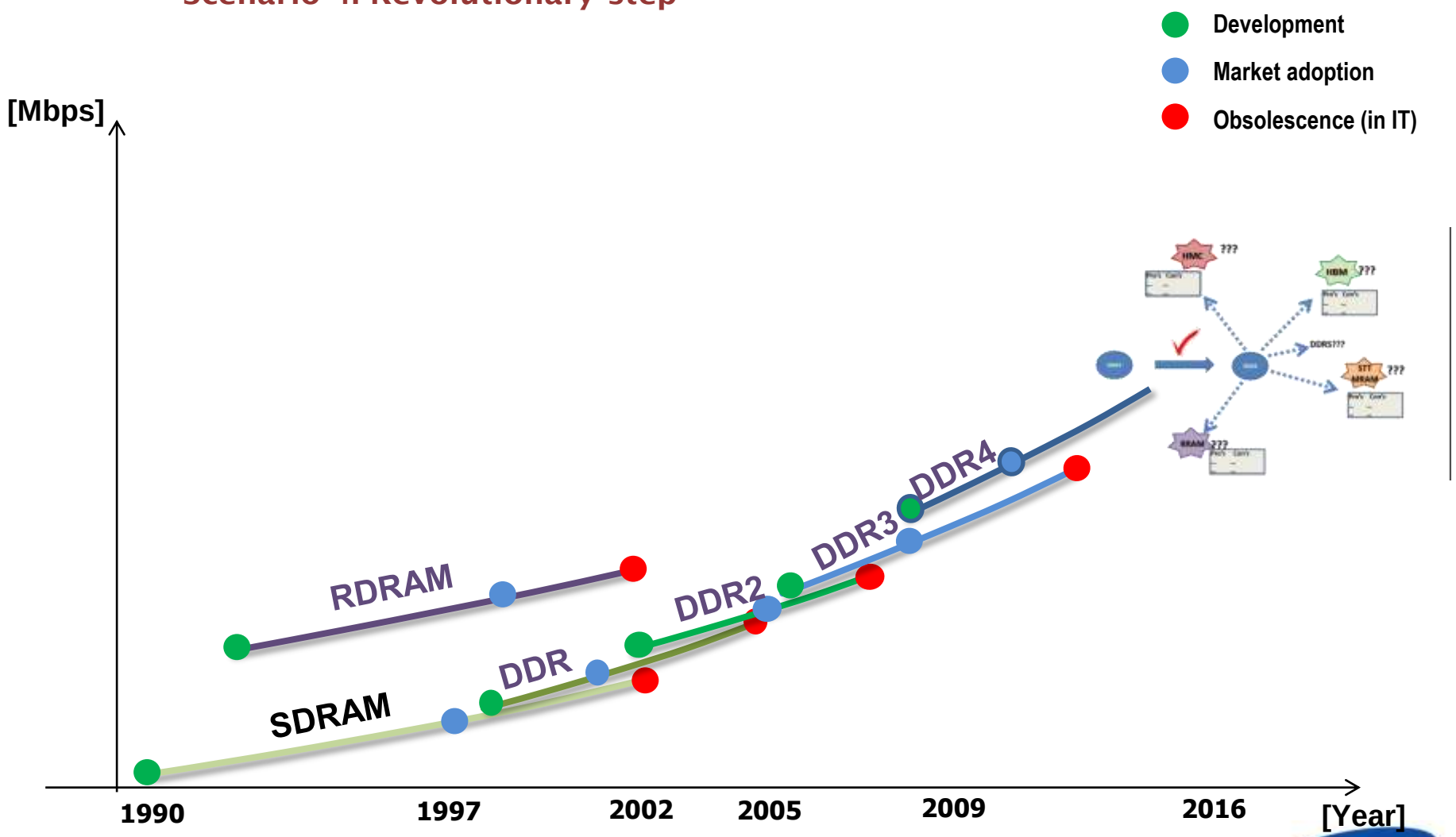
- **What will come next?**
  - Scenario 3: Evolutionary steps in back-end process to win time



*Highest speed in that year

Waking up from long lethargy

- **What will come next?**
  - Scenario 4: Revolutionary step

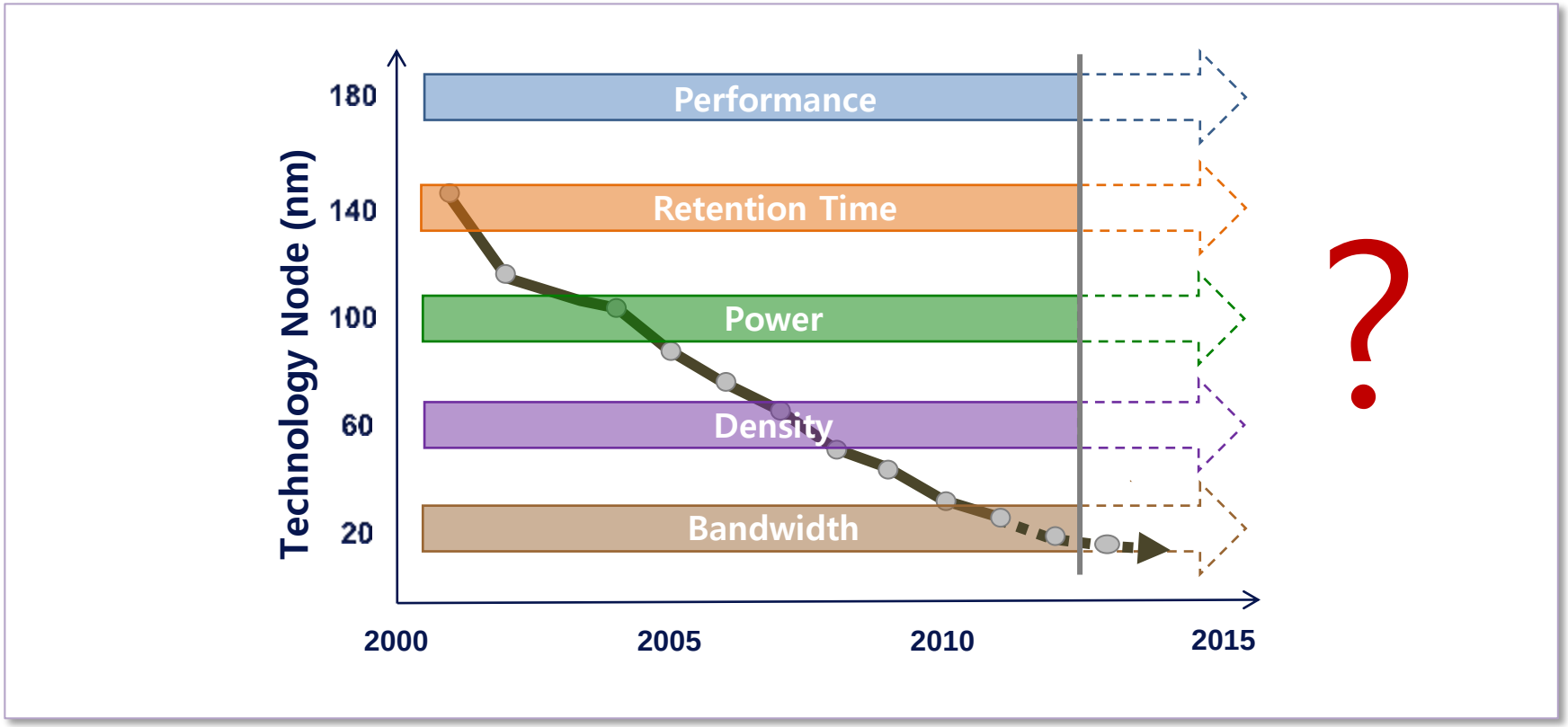


*Highest speed in that year

Contents

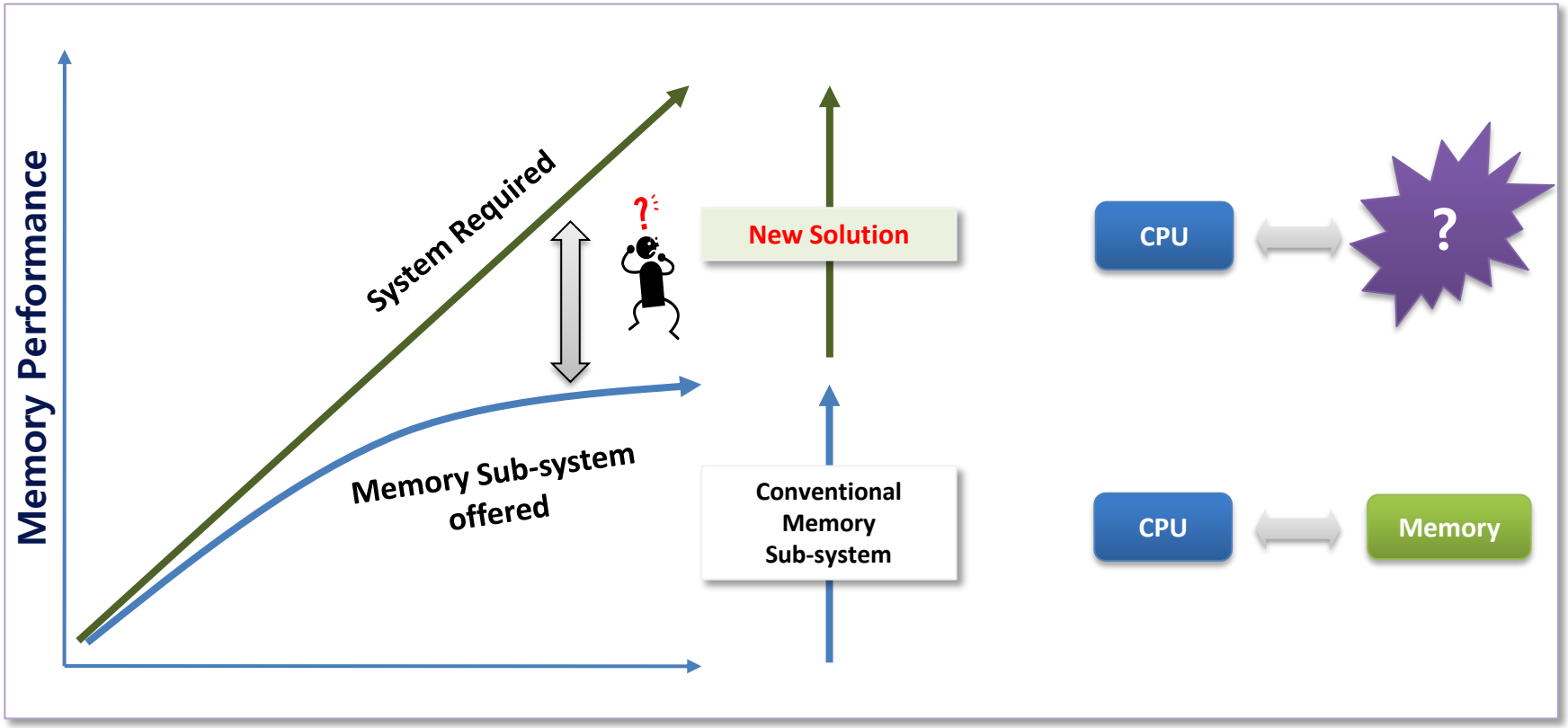
DRAM Scaling

- **Scaling approaches a physical limitation**
  - Technology difficulties & large investment



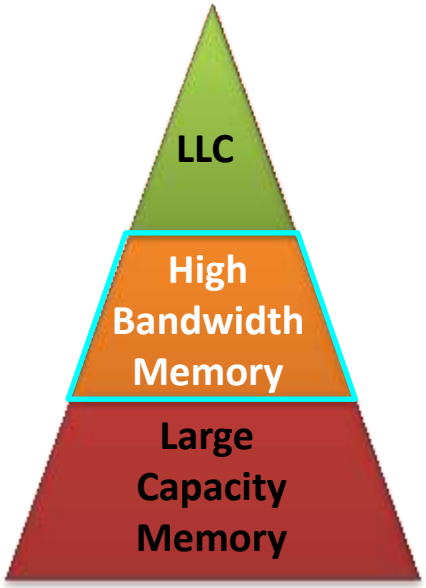
Memory Wall

- **The performance gap between required and offered is ever-increasing**
  - **Disruptive approach is required to overcome**

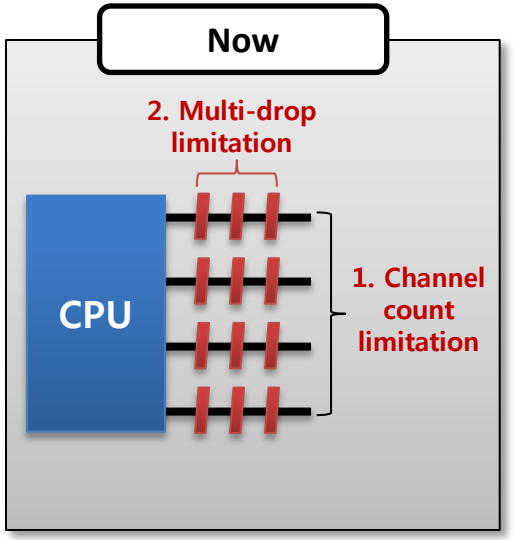


Memory Hierarchy Consideration

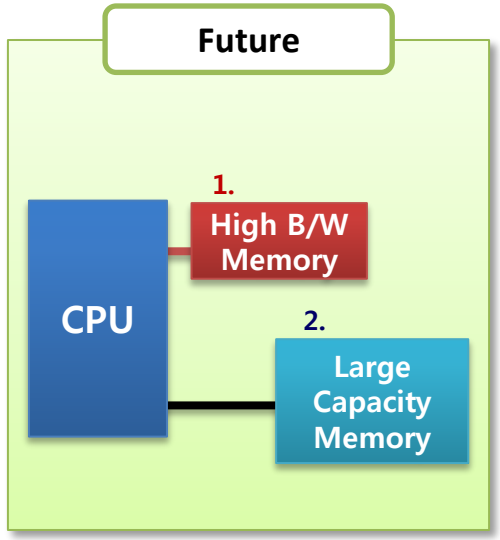
- **How to fit into the requirements of performance, capacity, power and etc.**
  - Role assignment by purpose



Additional Layer for fast feeding



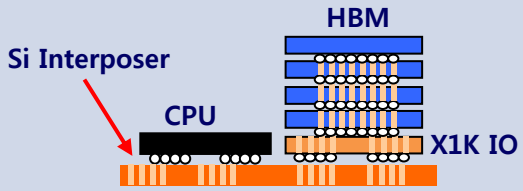
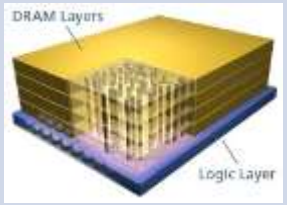
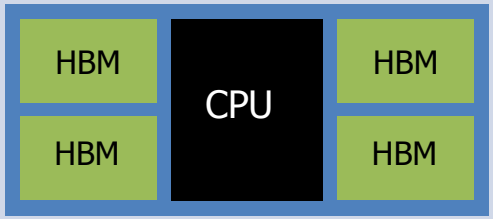
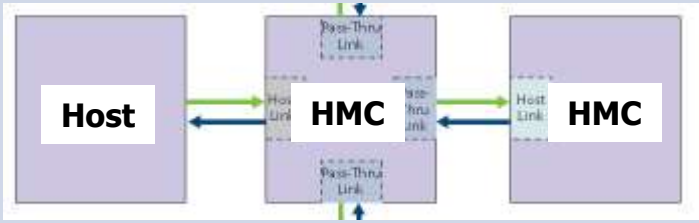
1. Channel count limitation
2. Max speed limitation
   - Parallel interface
   - Multi-drop
   - Single-ended I/O



1. High-Bandwidth Memory (HBM)
   - Bandwidth driven
   - Latency advantage
2. Large Capacity Memory (LCM)
   - Capacity driven
   - Non-volatility

Candidates for High-Bandwidth Memory

HBM (High-Bandwidth Memory) vs. HMC (Hybrid Memory Cube)

	HBM	HMC
		
PKG type	MPGA(Micro Pillar Grid Array)	BGA
Logic function	Buffer / Rerouting	Memory controller, SERDES
CMD protocol	Deterministic	Non-deterministic
Max. bandwidth	128~256GB/s	4link: ~160GB/s, 8link: ~320GB/s
Power* / Chip size	1X / 1X	1X(USR**) / 1.1X
Capacity per cube	2/4GB	2/4/8GB
# of bank	~128banks (@4GB)	~512banks (@8GB)
Capacity extension		

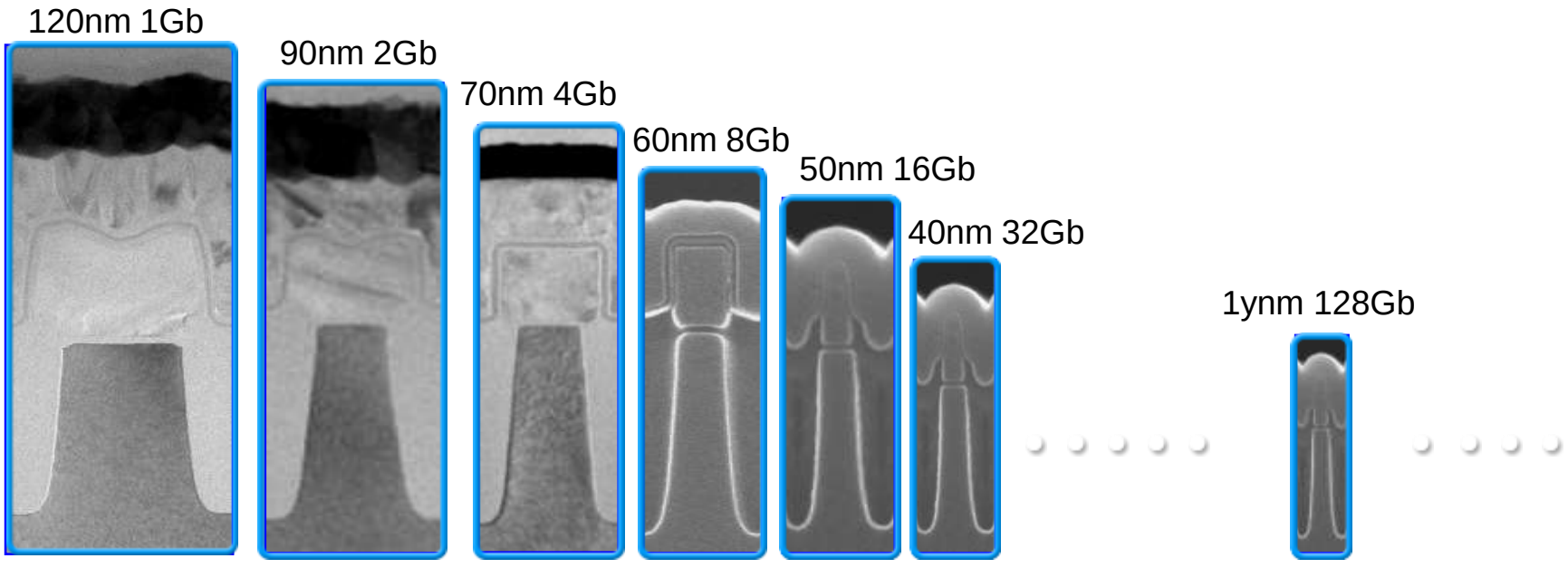
***Ultra Short Reach*

**Assume IDD4R condition*

Contents

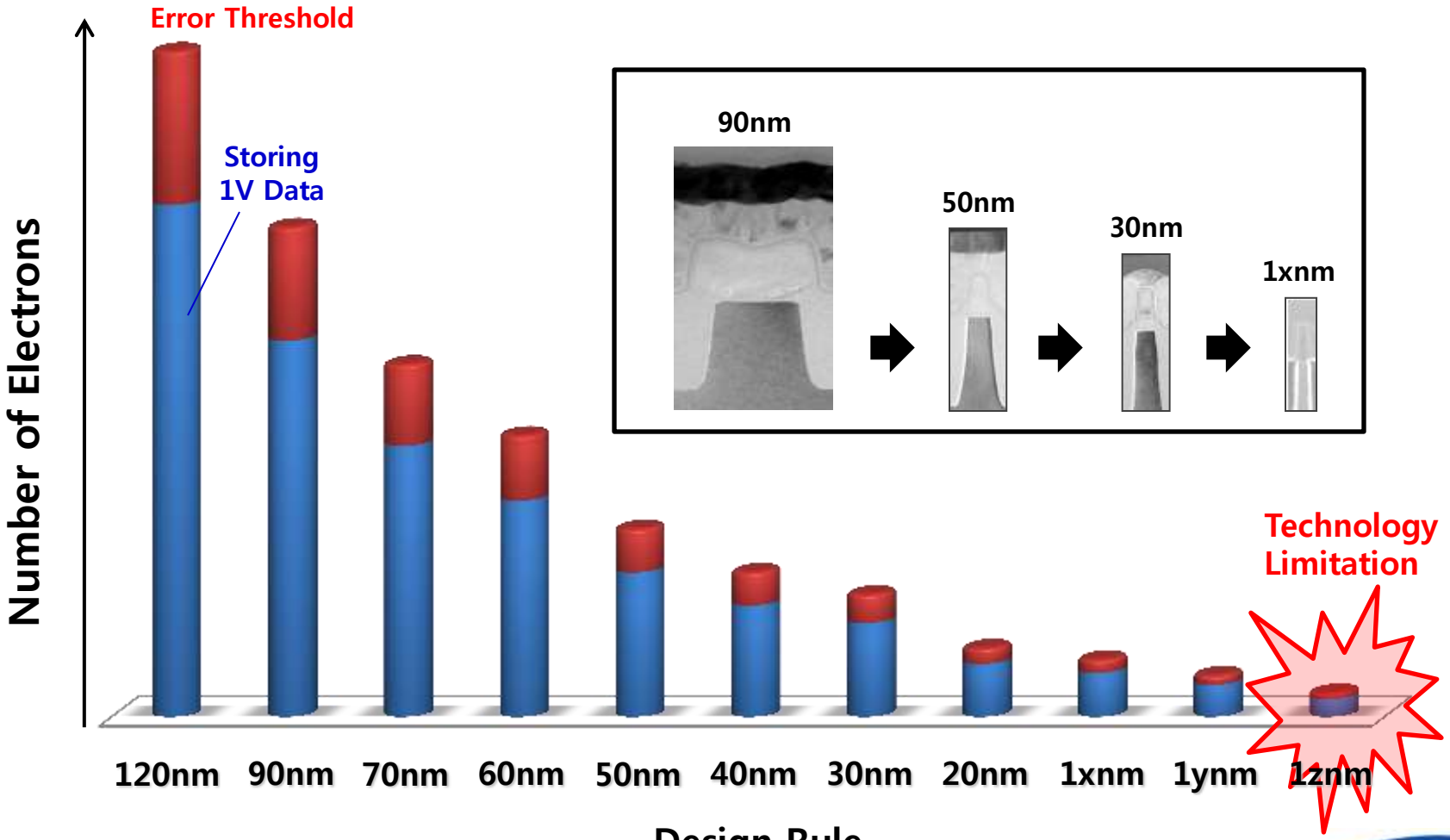
History of Samsung NAND Flash

- **Keep the technology leadership through continuous scaling**
  - **Worldwide No.1 market share in NAND Flash since 2002**
- **Scaling is getting difficult**
  - **Need a technical breakthrough to continue after sub-1ynm**



Floating Gate Technology

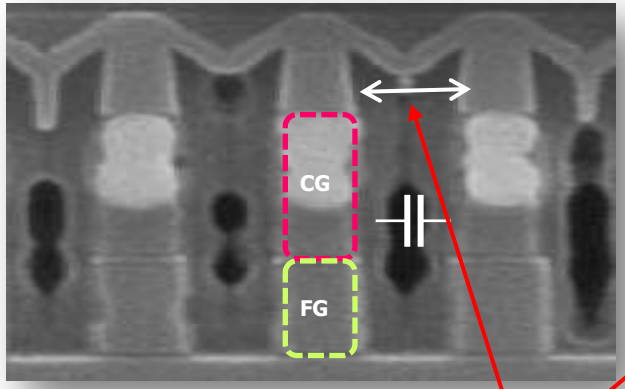
- **The number of stored electrons and error threshold reduce**
  - Cell-to-cell interference is another barrier to move smaller nodes



Technology Breakthrough for NAND

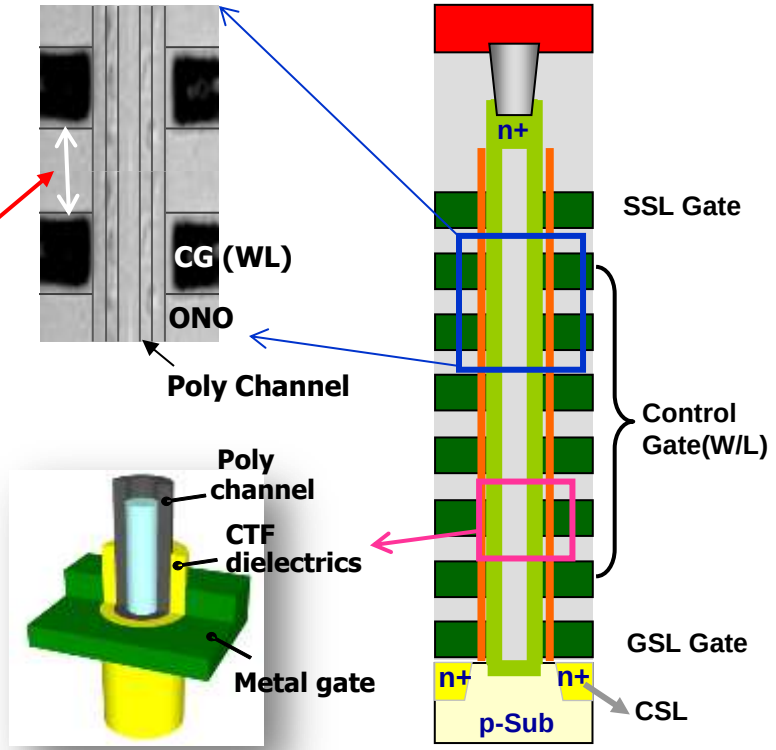
- Less costly technology and relaxed design rule
- Reduce coupling noise by structural changes

2D Planer NAND



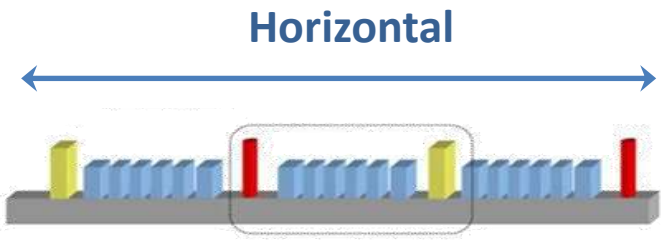
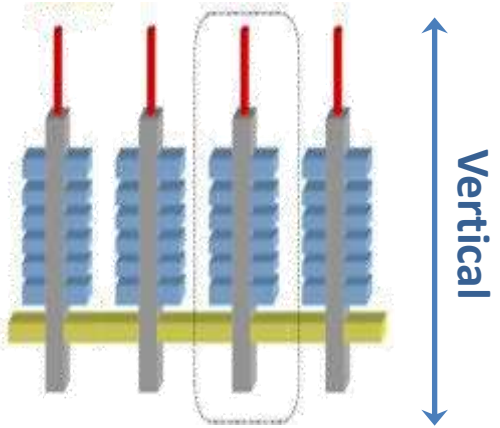
Widen the gap by structure change

3D-NAND



VNAND (Vertical NAND)

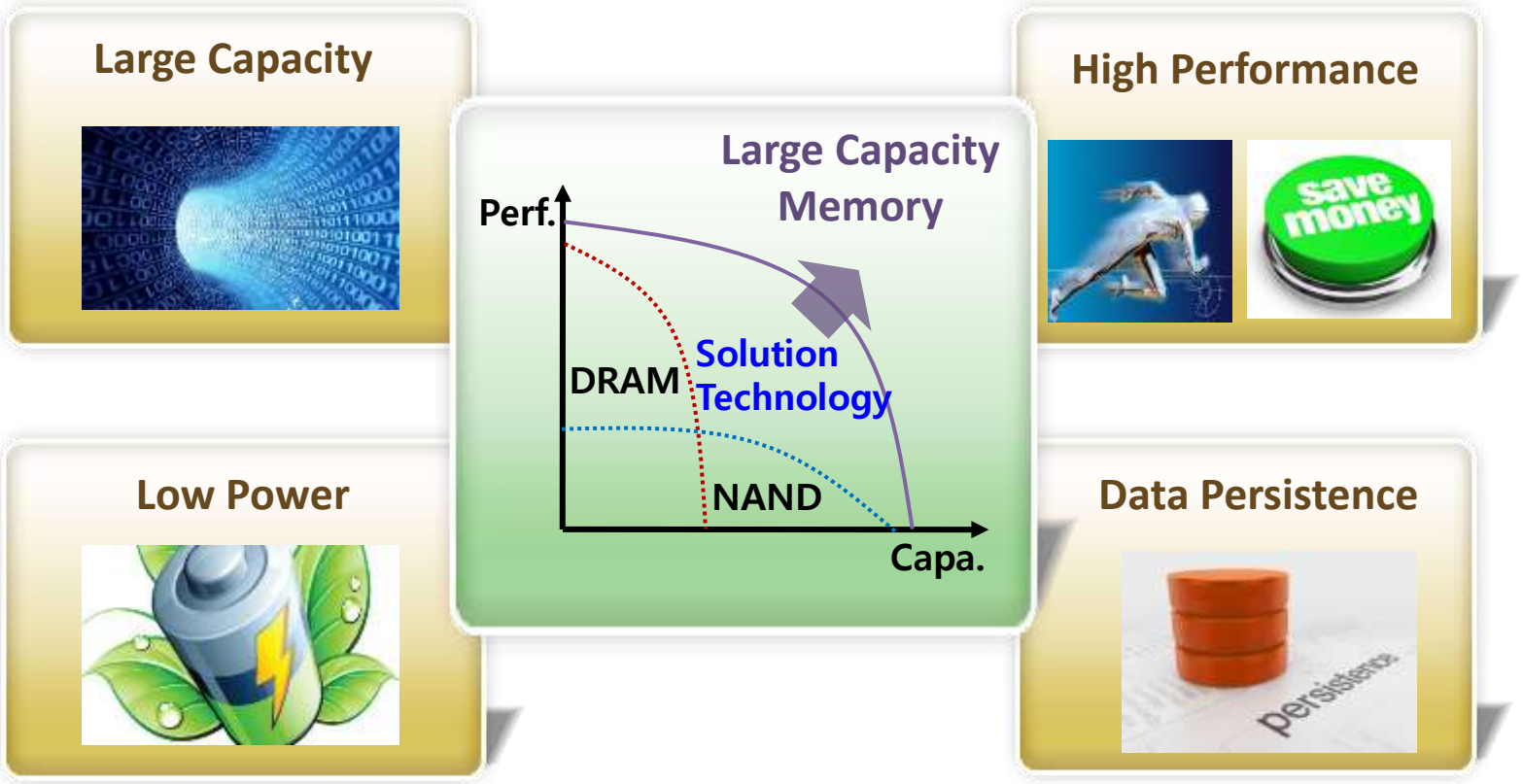
- **VNAND is a good successor of planar NAND**
  - VNAND can continue to shrink less than effective 1ynm
  - VNAND can keep offering higher density with more shrinks

	Planar NAND	VNAND
Cell Architecture		
Advantages	Easy to produce with simple process	High reliability & process reuse
Challenges	Shrinking under sub-10nm	Stacking

Contents

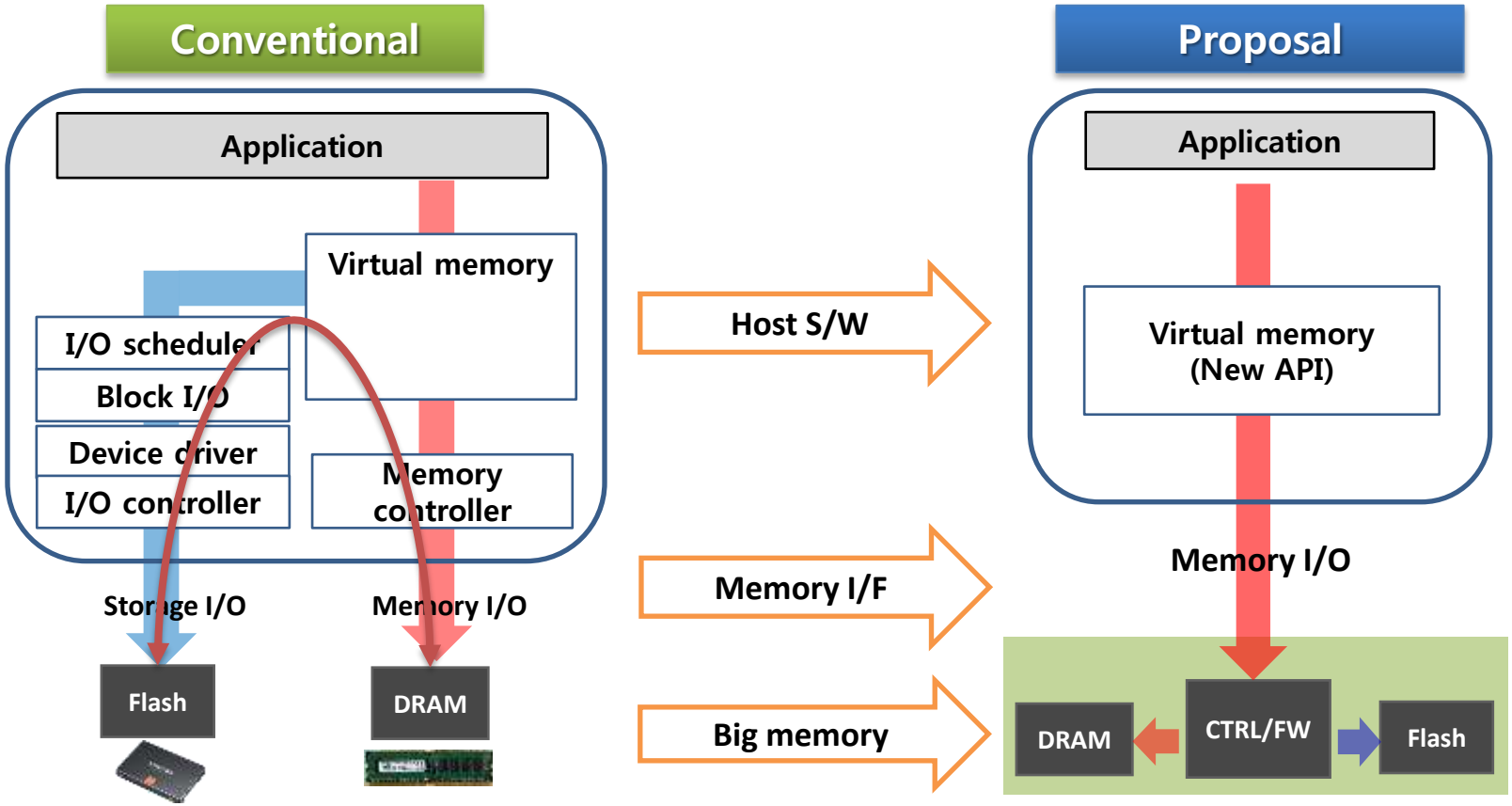
Large Capacity System Memory

- **Integrated solution to provide the large capacity system memory**
  - Utilizing NAND flash memory
  - Solution technology (controller, firmware, and host S/W) should be engaged



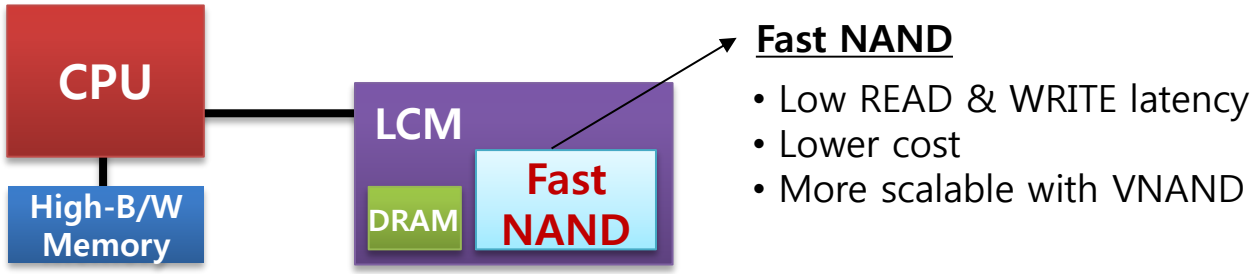
Basic Configuration

- **Large capacity system memory utilizing NAND flash**
  - Improved host S/W response time
  - Data persistency and low power by non-volatile feature



NAND Flash As System Memory

- **Generic solution for storage-class memory(SCM)**
  - Less tight binding to the conventional interfaces
  - Alternative SCM approach utilizing fast NAND
  - The controller of LCM opens up new functions



- **PCIe SSD as another bulk and fast storage, or memory expansion**
  - Easy adoption and expansion with an unified interface standard
  - Enhanced random and sequential performance by reducing latency and enabling high levels of parallelism

Recently Released Products

Samsung Starts Mass Producing Industry's First *3D Vertical NAND Flash*

SEOUL, Korea – August 6, 2013 – Samsung Electronics Co., Ltd., the world leader in advanced memory technology, today announced that it has begun mass producing the industry's first three-dimensional (3D) **Vertical NAND** (V-NAND) flash memory, which breaks through the current scaling limit for existing NAND flash technology.

"By applying our 3D V-NAND … Samsung is providing its global customers with high density and exceptional reliability, as well as an **over 20 percent performance increase and an over 40 percent improvement in power consumption**,"

SEOUL, Korea – July 18, 2013 – Samsung Electronics Co., Ltd., the world leader in advanced memory technology, today announced that it has developed the industry's first 2.5-inch (SFF-8639) NVM Express* (NVMe) **PCIe solid state drive** (SSD) to open up the high-end enterprise storage market.

Samsung Now Mass Producing Industry's Most Advanced DDR4, Using 20 Nanometer-class Process Technology

The 4Gb-based DDR4 has the fastest DRAM data transmission rate of 2,667 megabits per second – a 1.25-fold increase over 20nm-class DDR3, while **lowering power consumption by more than 30 percent.**

Summary

- **Disruptive approaches are required to overcome the DRAM challenges**
  - High-Bandwidth Memory
  - Large Capacity Memory
- **VNAND can prolong the NAND flash scaling**
- **NVM utilization to enable large capacity system memory**
  - Combine the advantages of each memory type, and overcome the shortcomings
  - Solution (integration) technology is a key to success

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Thank you

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